EXPLORATIONS IN TURKESTAN

EXPEDITION OF 1904

PREHISTORIC CIVILIZATIONS OF ANAU

Origins, Growth, and Influence of Environment

EDITED BY

RAPHAEL PUMPELLY

DIRECTOR OF THE EXPEDITION

IN TWO VOLUMES—VOLUME TWO

WASHINGTON, D. C.

Published by the Carnegie Institution of Washington

1908

TABLE OF CONTENTS.

SECOND VOLUME.

PART V. PHYSIOGRAPHY OF CENTRAL-ASIAN DESERTS AND OASES. R. WELLES PUMPELLY.

LIST OF ILLUSTRATIONS.

SECOND VOLUME.

STONE IMPLEMENTS FROM THE NORTH AND SOUTH KURGANS.

SKELETONS FROM THE NORTH AND SOUTH KURGANS.

PART V.

PHYSIOGRAPHY OF CENTRAL-ASIAN DESERTS AND OASES.

BY R. WELLES PUMPELLY.

[CHAPTERS XIV, XV. PLATES 61–70.]

TURKESTAN

From a map issued by the Military Topographic Division of the General Staff of the Russian Army, 1886

CHAPTER XIV.—DESERTS.

As the earliest traces of man in Central Asia show him living in oases, as he does to-day, the archeology of that region is centered on a study of the oases of antiquity, and this study must include surrounding deserts, for climatic and topographic changes have been everywhere so pronounced and have left records so intimately interwoven with the records of man that no comprehensive search into the conditions of his past life in Central Asia can be undertaken without some fundamental ideas about the cause and effect of desert changes.

For our purpose a map of Asia should be regarded as no more than a passing picture of a struggle between land and sea, and mountains and storms—but one phase in the evolution of a continent. And it is not only the archeologist and physiographer or those who probe into the remote past who must assume this dynamic point of view. The pace of continental change is so fast that a man in his lifetime can watch the trend of great events, the change of great features, and know that hardly a branch of human affairs exists but must feel the effect.

THE DESERT BASIN AS AN ORGANIC WHOLE.

Already in early Pliocene time Asia in her immensity had developed a vast interior region of desert basins, into which were spread the wastes of then large existing mountain masses, the cores of which still remain as worn-down granites of the Tian Shan, Pamir, and Tibet. When treated as an organic whole a desert basin forms one of the most interesting features of our planet, and the laws of Nature, under which its oases are controlled, must be of vital interest to man.

THE ESSENTIAL CHARACTERS OF A DESERT BASIN.

For our purpose this organic whole includes the area that drains thereto and may be divided into two parts—the inclosing mountains, ever worn into new relief by the storms of geologic time, and the plains they have created by the slow building, layer on layer, of their débris brought down by the waters and winds of those storms. The first requisite of a desert basin is aridity, sparsity of vegetation, and too little rainfall to carry the products of erosion away to the ocean. From the beginning of its definition as a desert basin self-contained, or hydrographically isolated from the ocean, each basin was destined to accumulate on its plains the débris of erosion sent from its inclosing ranges, and the inevitable sinking of the earth's crust that yielded as that load increased to a thickness of many thousand feet appears to have resulted in a corresponding upward displacement of its border ranges. How long this great process has been in operation may be conjectured from the immensity of beds of fine red desert strata that reach a thickness of many thousand feet where exposed on the uptilted borders of the

Gobi basin. There, as in Fergana and along the base of the Kopet Dagh, these uptilted piedmont formations are a magnificent corroboration of the idea of displacement, as well as of Suess's theory of the encroachment of mountains on plains.

A desert basin, then, is organically divided between mountains and plains, but this is only the beginning of our classification. Functionally, the plains are a vast geologic mill in which the material received is differentially assorted into layers of fine and coarse alluvium, whereof the surface is further sifted into loess and flying sands ere it comes to rest under succeeding layers; and this mill is worked by wind and water. It is a plain whereon the muddy floods of spring and fall give rise to momentary shoals of water spread over many scores of square miles, welcome lakes that vanish under the burning sun, to leave mirage and windswept barrenness of sandstorms and yellow days. But of this water some remains more permanently wherever the supply is in excess of evaporation. The life of a desert lake or sea is, according to circumstances, anything from a day to a cycle of geologic time; anything from the momentary existence of a thin watery sheet far out among the dunes to the history of an Aral Sea.

Thus arise four marked subdivisions of deposition—alluvial, lacustrian, flying sands, and loess—two of water and two of wind. Lastly, but perhaps most important in records of Quaternary change is the fifth subdivision of deposition, glacial "till." A desert basin is thus divided into areas of erosion and deposition, mountains and plains; the plains are divided into four zones—alluvial, lacustrian, flying sands, and loess—and the loess zone includes a portion of the mountains, while a fifth subdivision of deposition, glacial, is found on the higher mountains.

THE THREE AGENCIES OF EROSION AND FIVE DEPOSITION ZONES.

There are three agencies of erosion and transportation, ice, water, and wind, and five deposition zones, glacial, alluvial, lacustrian, flying sands, and loess arising therefrom.

Rising among the glaciers and snow-clad peaks of the inclosing mountains, small and large silt-laden streams discharge upon the plains. Flood gives way to the drought of a burning sun that stirs the atmosphere into vast cyclonic storms and spiral dust-whorls—tall, shadowy forms that come and go in ever-changing shape, born out of the horizon to wander a while and vanish. By these atmospheric disturbances the surface materials are consumed and sifted over, digested into drifting sands and far-blown dust. Most of the dust is borne far away to rest as loess in the grass of high valleys and plateaus flanking the peripheral mountains, for it can not survive a wind on barren surface; but sand moves slowly to and fro in the shifting winds, and only that which gets beyond the ultimate shores of alluvial activity accumulates to form the larger masses we call dunes. Probably the most important source of this sand lies in the more or less impure sandspits that are invariably to be found after flood along distributary channels of silting streams. Any shifting aggregations that have not found their way onto an area more or less permanently free from alluvial activity must suffer rearrangement by the next flood, but in the vast nuclei of flying sands that characterize the desert plains we have ample proof of the large scale at which the wind has been successful.

Interior brackish seas and lakes, fed by the more constant flow of larger rivers, have played an important rôle in the history of the two great desert basins of Eastern and Western Turkestan. The surface area of a landlocked sea is a direct function of the climate of its basin. Its salinity varies (1) according to antiquity, (2) in some instances according to whether overflow took place, and (3) the relations between its surface area and amount of salt in its supplying streams.

Although at first thought these appear to be the only controlling factors of salinity, there are yet four considerations, four ways in which an interior sea may diminish in salinity or totally lose its salt. It may dry up entirely for a while and the salt thus precipitated over its bottom be either (4) blown away or (5) so perfectly buried by sand or silt that future water is unable to redissolve it; (6) much of the salt may be precipitated in a gulf with such a narrow and shallow strait that water evaporates faster than it comes in from the mother sea, as it is now doing in the Kara Bugas and other gulfs of the Caspian. There the supersaturation is death to all sea life that comes in with the current—a graveyard of floating fish. Lastly, (7) as a theoretical possibility, sufficiently rapid sinking of the bottom or falling-in of the earth's crust, such as appears to have taken place in the southern half of the Caspian, would give rise to a greater volume for the original surface area. Therefore, since the surface area is a definite function of climate, it is obvious that if the volume were increased rapidly enough dilution would take place if the rainfall remained constant over the catch-basins of its supplying streams. To sum it up in a more general way, it may be said that, *with a given topography and given chemical nature of rocks drained to start with, both the salinity and surface area of a landlocked sea depend upon the variations of climate and crustal movement that may take place over its basin.* These facts are of fundamental importance in the consideration of lake-shore oases or type V.* It is from a study of the ancient shore-lines, sediments, soundings, and fauna of now shrunken seas and dried-up lakes that important records bearing on the archeology as well as physiography of Central Asia are to be drawn.

The whole peripheral area of surrounding mountains is, in the long run, subjected to erosion and worn down to build the plains; but for closer analysis it is functionally subdivided into areas of erosion and deposition, with limits more or less temporary or unstable in definition. First, the high crests and valleys of greater ranges give rise to glacial zones of ice mantles and valley glaciers of which the interior portions are seats of glacial erosion, the margins and termini seats of glacial deposition. Second, the lower plateaus and foothills of pasture land have been the chief seat of loess accumulation—the settling-ground of dust blown up from the plains and down from the more arid heights of deflating rocks. Third, the greater areas of peripheral mountains have developed intricate basin-systems, some as half-closed valleys tributary to the great plains, others isolated or wholly inclosed, imitating on a small scale the greater scheme of which they form a part.

*Chapter xv, Physiographic Classification of Oases, p. 301.

Wind, water, and ice erode the mountains and have particular deposition areas within the highlands, where part of their products accumulate more or less temporarily to form loess, alluvium, and moraine. But as these positions are, in the course of long time, unstable, practically all the products of erosion must ultimately find repose in strata of the great interior plains. Moraines, however, are very resistant to transportation from their zone, and massive remnants of those deposited in even the beginning of the glacial period still survive *in situ;* and it is still possible to recognize sections of alluvium and its wind-blown derivatives, sand and loess, deposited during the glacial period on now dissected highlands and broad valley terraces.

Within the latitudes of Central Asia, glacial deposits are confined to the peripheral mountains of desert basins. Areas of alluvium, loess, flying sands, and lacustrian deposits are found more or less unstable on the highlands, while the great alluvium, flying sands, and lacustrian deposits have their special, well-defined, and concentric zones respectively one within the other on the great interior plains of a basin. Loess and flying sands are in large part the wind-blown derivatives of spread-out alluvium, but they are undoubtedly much added to from direct deflation of the more arid highlands—a fact to be demonstrated in the section on the Northern Pamir. As lake deposits are simply modified alluvium, there are only four primary derivatives of the original mountain masses—moraine, alluvium, loess, and flying sands; and much of the alluvium is modified moraine and the direct charge of glacial grindings.

An ideal desert basin, not over about 100 miles across from crest to crest, would be completely inclosed by mountain ranges. Its glacial zone would be a periphery of ice mantling the crests and extending into the heads of high valleys; its loess zone would flank the base of the mountains thus encircling the plains; its alluvial zone would lie next inside as a piedmont belt of the plains; while the flying-sands zone would lie next within as a wide belt surrounding the lacustrian zone or brackish sea of the middle of the basin, reached by large streams rising in the glacial zone and crossing the loess, alluvial, and flying sands.

In Western Turkestan the lacustrian, alluvial, flying-sands, and loess areas are now four well-defined zones, respectively one within the other, loess on the outside, while glacial deposits are naturally confined to the higher mountains and nowhere reach below an elevation of 7,000 feet. As an exception to this generality, the rivers Amu and Syr penetrate to their inland sea, the Aral, thus dividing the zone of flying sands with two narrow extensions of the alluvial. The lacustrian is thus united with the alluvial zone, and this is more often the case in Eastern Turkestan, where flying sands are divided into several wide nuclei by long rivers that traverse the basin. Although it is to future exploration that we must look for comprehensive records, a general outline of past conditions may be construed from our observations on the five zones, together with sections in earlier layers, exemplified and checked by a study of the topography of erosion.

THE INTERLAPPING OF DEPOSITION ZONES EFFECTED BY CLIMATIC OSCILLATIONS.

Owing to their low altitude and the hot column of air rising from them, relatively little rain falls on the plains and precipitation is for the most part confined to snow upon the mountains. Obviously, a regional decrease in precipitation involves a general shrinkage of glaciers, lakes, and areas of alluvial activity, and a sympathetic expansion of flying sands over abandoned portions of both lacustrian and alluvial zones, while the alluvial zone would recede mountainwards, encroaching on the loess zone, itself undergoing shrinkage for lack of rainfall on areas where grass had scarcely existed under the old supply. And it would be *vice versa* with increased precipitation. Continued oscillations, then, would bring about a column with alternating lacustrian sediments and modified dune-sand on the inner belt of overlap, one of alluvium and dune-sand on the middle belt, and one of alluvium and loess on the outer belt of overlap, while buried erosion surfaces of dead loess should be indicated in sections of loess where it has felt the change. And there would be successive moraines of different epochs overlying each other in the glacial zone. If these oscillations were sufficiently great, the middle belt of overlap would alternate with loess, alluvium, and dune-sand repeated in that order, unless the topography was such that an interior sea would expand to consume the whole area. Thus would climatic change record itself.

The task of finding records in the mountains is in some ways easier than on the plains, in others harder; records there are on a large scale, but those of climatic variations are so tangled with those of crustal movements that, if it were not the constancy of upward movement, which in itself seems to involve a peculiar kind of climatic change, the task would be well-nigh impossible. Moreover, data like that of the shifting of man's abode, so often found on the plains, are almost lacking in the mountains. It is to the topography and glaciology that we must turn. If uplift of the mountains had only been so simple as an equal and unbroken uplift of all the ranges together, it would be an easy thing to trace the stages of topographical developments; but unfortunately it is the inequality of recent uplift that gives the mountains some of their most striking features, fault-scarps and high-tilted blocks.

THE CYCLICAL DEVELOPMENT OF AN IDEAL DESERT BASIN.

To throw any light on those changes enacted by the deserts of Central Asia since the advent of man upon them, it is necessary to incorporate a reconstruction far back into the four controlling and more or less interdependent variables—uplift, erosion, aggradation, and climate. The most vital question is, What was the climate at any given time? But its solution depends much on the other three. Beginning with a theoretical development of these variables, let us picture the life of an ideal desert basin of the simplest kind. Born under the impulse of terrestrial forces, spontaneous adjustments in the stresses of our planet's crust, its complete periphery of high mountain ranges would then be left to the tools of solar energy; and the aspect of such a basin as a whole would alternate between the extremes of a grand cyclical evolution worked by solar energy under the direction of gravity, a geologic drama enacted by mountains and storms round the plains whereto the mountains crumble. Picture its massive ranges slowly wearing away into their rivers and the steady building of the plains till naught but the low relief of a gently rolling surface, half-buried in its own piedmonts remains of their once colossal heights. The shores of its wide interior sea are after this not so desolate but that sufficient rain falls to nourish grass over the surrounding steppes, rain from the moisture that would have been combed out by the mountains when they were higher. It is a basin worn to low relief and, therefore, receives a precipitation more evenly distributed over space and time. But though this does mean that some of the water which formerly found its way into the rivers and sea must suffer direct reevaporation on the steppes, and thus expand the loess zone, we must believe that so much more will find its way from the oceans to the basin that its rivers and sea would swell to relatively high shores.

This brings us to a critical point, the end of the first cycle—a point of minimum relief, when so many thousands of feet have been unloaded from the mountains and loaded onto the plains that the ultimate strength of the already warping earth's crust is reached, and the shearing stresses set up along the borders of the plains result in far-reaching faults. Then begins the second cycle with a long period, during which the plains sink slowly and the mountains rise by displacement. We can watch the gently graded hydrographic systems thus uplifted changed into torrential streams deep canyoning the rising peneplain and gently rolling slopes of worn-down mountain cores, while on the higher masses the acceleration of glacial conditions is reexpanding remnant ice-domes and even giving birth to advancing valley glaciers. This process continues till the crust has almost reached an equilibrium and regains its old rigidity.

The first cycle is completed; and we have returned to a relatively greater concentration of precipitation on the mountains and intense aridity of the plains. Less moisture finds its way from the oceans to the basins and a shrinkage of rivers and sea has lowered their shores. Once more there is a desolate expanse of flying sands and relatively little grass and loess on the steppes. Our second cycle now is drawing to a close; a rapid carving of the mountains into deep canyons soon widened into immense gorges floored with broad flood-plains develops into the graded conditions during the crustal rest in the end of the second cycle.

The continued shifting of load thus brought about ultimately results in a second yield more or less near the old lines of weakness, and a third cycle is ushered in as the plains go down and the mountains rise again. New canyons thus incised in the old valley-floors have cut down, leaving a terrace above. The mountains are perhaps higher, but sharper in relief, and the interior sea has shrunken. Continued cycles result in manifoldly terraced valleys and a series of abandoned shores or terraces along the coasts of our interior sea, and an interlapping of the deposition zones.

The actual course of Central Asia's development has been more complex than that of ideally simple basins. The Eastern or Tarim basin is, to be sure, practically closed around by high ranges of the Tian Shan, Pamir, Karakoram, and Altin Tagh, and comes near to an ideal type. But the Western basin, the one most studied by us, still lies open out over the low steppes of Siberia and Southern Russia, with but little protection from the Ust-Urt, or low-domed ending of the Urals. It is, therefore, a basin less isolated and less independent in its variations of climate than Tarim and other divisions of the Gobi. We must expect to find that it was more directly influenced by the Quaternary ice mantle over Russia, as well as by the mundane change that brought about that ice. And, as already hinted, the cyclical uplifting of mountains was by no means simple, but took place in huge block-masses rising and tilting in various degrees and relations.

Other facts not brought out by our imaginary basin, but of marked importance in all large ones, are the disturbances resulting from unequal loading of different areas and the encroachment of mountains on plains by migration of the tilted piedmont belt. This is especially well exampled in the western part of Tarim, where the strata have been tilted up, forming long ridges several hundred feet high with fault-scarps facing mountainwards and surmounted by gentle slopes towards the center of the basin. There are sometimes several parallel to each other and 30 or 40 miles apart, the innermost youngest in appearance as though migrating from the mountains inwards, stage by stage, to follow the zone of maximum deposition-load as it moved inwards from cycle to cycle. Why this encroachment took place we can only guess, but that guess must fit in perfectly with the whole scheme.

I have spoken of the mountains rising by displacement, and there may have been some doubt as to how that displacement took place. Was it flow in the hard crust of the earth, which is thought to be miles deep? Or was it a displacement in the supposed magma beneath? There has been a prevalent idea that some ranges piled up from overriding folds supplied by horizontal thrusting from both sides, and that others formed by simple folding on lines normal to horizontal compression, thrust in either case arising from a general contraction of the earth and wrinkling of its crust. That such was the primal origin of our Central-Asian ranges may be assumed, as far as this report is concerned. Indeed, the structure of their interior portions would lead to that conclusion. But without entering at all into a discussion of their primal origin, a thing that lies back in one of the earth's great mountain-building epochs, we are still confronted by that series of peculiar secondary movements of a desert basin with its mountains.

Then, to explain the hypothesis of shifting-load displacement hitherto assumed: The plains sank with their load of sediments; of that we have ample proof both in the fault-scarps of high-uplifted blocks along their borders, and in the Askhabad well-boring, 2,200 feet deep, which penetrated the plains to 1,400 feet below the sea-level, and even then remained in red alluvium and loess like that laid down on them to-day. It is absurd to suppose they sank into a cavity; we must assume that matter was displaced. The obvious corollary is that whatever displacement took place was to the nearest zone of weakness of the earth's crust, and there is twofold reason for supposing that the mountains lay over that zone. To begin with, their existence resulted from a tendency to yield along that line and a great load once borne by them has been taken off. So the plains sink and it would seem the mountains tend to rise and that the displacement is to beneath the mountains. Assuming this, we still have to account for uptilting of piedmonts along the border, and often two or more such lines nosed up with fault-scarps facing the mountains.

This fact is the key to a deep-seated process that forms an important corollary to such displacement. Deep-buried, flat formations are under an enormous pressure that will squash the strata into thinner layers, if horizontal expansion is possible. There is, therefore, reason to believe that such a sinking of the plains of a desert basin involves a deep-seated squashing of the layers, a flat squashing out into folding in the nearest zone of yielding weakness, *i. e.*, under the bordering ranges that rise therefrom. And the crust being broken along the shearing lines, this zone dies out into bending moments somewhat under the plains, so that minor folding may take place under there also and bend up the piedmont edge. It is also conceivable that more outlying folds would result with their surface phenomena; that is, the fault-scarps of our uptilted piedmonts probably pass beneath into monoclinal continuity or other folding of our squash-thrusted layers.

One of the most striking facts about Nature, especially geology, is the pertinacity of habit and the accumulative power of habit to overcome its obstacles. It is to this that we must attribute the fact that in reality each succeeding cycle of our process appears to have occupied less time than the one before, and that the first was vastly the longest. Moreover, it is only logical to suppose that it took a much greater shifting of load and, therefore, a much longer time to shear the crust on a virgin line than to renew that shearing in an already weakened zone. We do not intend to assume that no other terrestrial movements took place during all this time, nor that some more regional or mundane change of climate did not have its influence on these more local changes. All that is possible now, even in a tentative way, is to trace the influence of a desert basin on itself and try to superimpose its climatic cycles on those phases that it felt from the mundane glacial period.

Having offered these explanations and methods of attack with the above working hypothesis, we may analyze a series of notes on land forms. Beginning with the Pamir (Roof of the World), the following sections of this chapter will take up certain valleys and the chief basins of Central Asia, and each section will close with a tentative physiographic reconstruction of the past.

THE NORTHERN PAMIR.

GREAT FEATURES OF THE PAMIR.

As a general key to what has been happening in the mountains, the Northern Pamir with its border ranges stands paramount. On a map of Asia it appears as a massive knot of intersecting ranges, where high members of the Tian Shan system conflict with a northwestern extension of that immense plateau of mountains called Tibet. Offhand, we should expect to find a heavy precipitation of snow upon such a high uplifted mass. But looking down upon it in reality we behold a desolate expanse of barren clay and stone, with only here and there a small white blotch of snow, and some few desert lakes; a very high plateau crisscrossed by mountain ranges inclosing a multitude of broad barren steppes that sweep in graceful curves from range to range. While some of these are traversed by streams, many of them are undrained depressions with or without lakes. We look upon a vast, extremely arid wilderness, void of trees and almost without any vegetation; a nude expanse of gray desert steppes and worn-down mountains with many-colored cliffs, of which the higher rise to white-crusted domes of ice.

Fig. 431.—Lake Kara Kul (North End).

This remarkable aridity is perhaps the most emphatic demonstration of Central Asia's isolation from moisture. In the Pamir we have a region whose depressions lie from 13,000 to 15,000 feet above the ocean, and whose mountains rise to from 18,000 to 24,000 feet in height. Similar latitudes elsewhere record a snow-line of 10,000 feet elevation, but now we are dealing with an interior region surrounded by the greatest mountains and deserts of the world. It is, therefore, logical to find the snow-line at 16,000 feet with Sven Hedin's report of less than 1-inch precipitation over Kara Ḳul, the salt lake of its widest basin. The Southern Pamir is less arid, as it receives about all the precipitation of southern winds left after the Hindu-kush and Karakoram have had their share.

THE BASIN OF GREAT KARA KUL.

The basin of Great Kara Kul was studied on two expeditions; the first in 1903, under the auspices of the Carnegie Institution of Washington, the second in 1904, an independent exploration, from which much of my data on other regions will be drawn. And though the basin has been discussed in my first year's report some repetition is important for the sake of correlation.

It is an undrained depression 20 miles in diameter, with a lake 8 miles wide nearly divided by two hilly peninsulas of ledge rising from the sediments of its northern and southern shores. Whether it is wholly the result of moraine damming or in part a genuine structural basin is not certain. The bottom of the eastern half of the lake slopes as a continuation of a 3-mile-wide belt of abandoned sediment on that side, to a depth of only 50 feet near the peninsula. But a deep trough of 700 feet of water with steep ledge shores forms its western half and appears to be a continuation of a narrow gap in the mountains to the south. The inclosing mountains are of granite and highly tilted shales and crystalline limestones, while the peninsula is of granite and vertical slate. We are dealing with the core of an ancient mass.

Kara Kul is a lake of bitter salt water. Its sloping shores are white with salt accumulated into low ridges, where the brine from each wave wetting has dried out after the recession. And behind some of these there are lagoons of

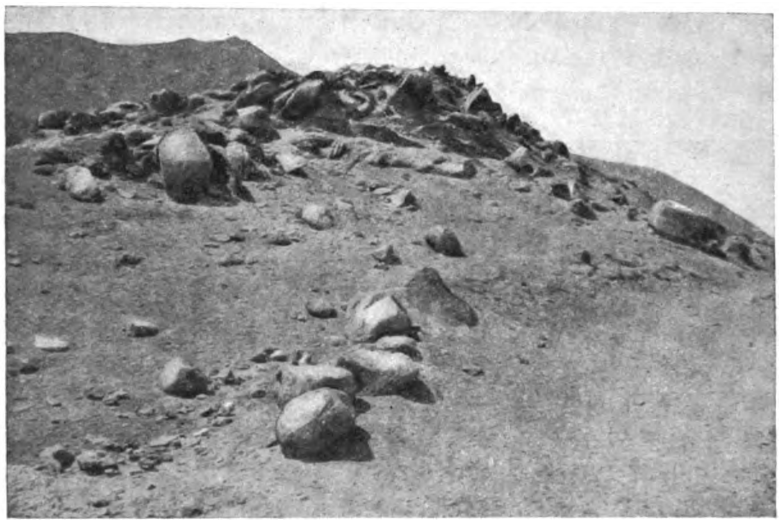


Fig. 432.—A Granite Ridge at Kara Kul (showing the secular Deflation of the Pamir).

brine, collected from the overflow of large waves, thus extending the white salt belt 100 feet or more on shore. During summer there are ducks and water-fowl that feed on the wide-bladed slimy grass growing in shallow water.

On this high desert no man lives, and those who cross by caravan have difficulty in finding fodder and water, as but little grass is found below the water-courses on high moraines, and even larger streams are dry by day. It is 10 o'clock at night ere the glacial water melted by day has accumulated and reached the steppes to run off before sunrise. A few small areas of thin, scattered wire-grass are found in shallow depressions near the lake, and a scrubby desert weed with long roots serves for fuel. Otherwise, the plain is void of life in summer. During winter large herds of *Ovis poli*, the great-horned wild sheep for which Kara Kul is famous, descend from their snow-bound mountains, to hunt for these rare bits of grass. By summer they live with the rabbits and marmots high up under the snow-line. I have counted over a hundred in sight at once, ten of them big old rams standing apart, and the rest all ewes and younger ones. Save for the Kirghiz hunters who appear at rare intervals to stalk them with medieval fuse-guns, they live unmolested.

Nowhere is there a more desolate land. It is a desert of unexpected forms, time-crumbled mountains and wind-worn cliffs, strange hollow and pitted bowlders, and sand-polished stones, efflorescent salt-plains and drifting dunes, with here and there the scattered remnants of an old bleached skeleton with sun-cracked horns. Limestone bowlders dropped on the plain by floating ice, when the lake stood higher and glaciers came far down, have cracked in the sun and crumbled to conical piles, while whole mountains of the same rock stand shrouded in their own remains. Perhaps the most remarkable example of desert disintegration is found in the granite mountains ranging on the east. There whole mountains are fast crumbling to arkose and sand from which some few honeycombed slabs project as remnant wind-worn ridges. Such are the features wrought by an arid sun and shade, with a range of 80° F. from day to night; the records of diurnal change revolving through long time.

Fig. 433.—Sand and Arkose Residuum of Deflation (Kara Kul).

And what has become of all the fine stuff, the dust inevitably given off in such a colossal crumbling of the land? It is nearly absent from the surface, as, indeed, it could not long remain on barren, wind-swept ground. The few inches of loess found here and there below the ice and in tiny patches of grass along its streams can not account for the dust of ages. It must be somewhere, and, if not here, we must conclude that it was ever blown away by the storms that come and go, blown away to settle in the grass of other, less arid, regions.

Around the lake we find evidence of its former wide expansions in beaches, respectively 60, 120, and 200 feet above the present surface, and apparently one at 320 feet nearly obliterated. The lower ones are comparatively fresh and indicate but short existence at their levels. These expansions seem to correspond in relative magnitude and antiquity to the moraines that now lie in front of various surrounding valleys, and which are clearly divided into at least three glacial epochs, and a fourth much more recent advance.

My report of 1903 has set forth many reasons for correlating the expansions of Lake Kara Kul with its glacial epochs. Avoiding a repetition of detailed explanations, the trend of events may be summarized as follows: During Pliocene time the Pamir was a region of high mountains which by early Quaternary time had been eroded to the core with a topography of worn-down, rather gentle slopes and wide valleys. Then took place that vast uplift which throughout most of Central Asia's mountains seems to have been the first event of Quaternary time, as its completion marks the advent of the glacial period. Streams cut down, deep-gashing the old topography; the Markan Su evidently developed its gorge back where Kara Kul is now. They had apparently graded and begun to widen their valleys, when everything on the high Pamir was interrupted by the glacial period. Elsewhere dissection has nearly obliterated the old topography, but on the northern Pamir it never got beyond the early stage of a system of gorges perhaps from 1,000 to 3,000 feet deep, with wide intervening areas left intact.

It is quite possible that, as Professor Davis suggests, the first epoch expansions of which we find such immense moraines were ushered in by a series of one, two, three, or more epochs of increasing magnitude, though all smaller than that great one by which they might have been obliterated. However complex may have been the transition to this maximum expansion, it seems unlikely that we shall ever know of them in this region, for even its moraines have lost all trace of their topography and are recognized only by their structure of mixed-up till with huge sub-angular bowlders and occasional striated fragments.

During this great ice-epoch, which for our purposes may be named the first, the mountains around Kara Kul and the Trans-Alai, and I suppose all high areas of Pamir, were wholly mantled with ice comparable to small continental ice-caps of whose marginal moraines there still remain masses over 1,000 feet thick. When at length these widespread glaciers withered, deep gorges were left choked with "till" and the Northern Pamir thus isolated into basins and blocked around into a zone of held-up detritus. And though we may suppose that in succeeding glacial epochs some detritus may have escaped even from Kara Kul, the aridity of interglacial times, if at all comparable to the present, could not allow of transportation from there by water.

The Northern Pamir is thus characterized by a persistence of old topography. In its colossal isolation from moisture-bearing storms and with its glacier-made obstructions to stream erosion, it has stood in shape scarce altered through a period of geologic time; it has defied change while lands all around have suffered fast development of gorges, fast erosion of the old (first-cycle) topography which now remains elsewhere only on mountain tops and high spurs flanking them. Only the wind can succeed in getting much of anything out of the region. Otherwise, no débris can have been transported far since the first glacial epoch, excepting that shifted a few miles by glaciers and increasing the obstruction to subsequent erosion. Even part of the Alai valley and the first 20 miles of the Markan Su are no deeper than during the first ice-epoch. Thus one of the world's highest mountain regions was given long ago a shape so nearly dead to change that it has stood from early glacial time till now with one fixed expression of rock features, sun-crumbled and wind-worn.

It seems possible that when the ice of that first expansion had so far melted that the moraine-blocked depression it left, where Kara Kul is now, was free of glacier ice, the lake thus created may have risen to the older terraces 320 feet above its present surface. But they are so much rounded off and altered by erosion that it would not be safe to say definitely that the lake ever stood at that level.

A following interglacial epoch was of such long duration that the first-epoch moraine had lost its old topography, was gashed by wide valleys, and in the lake depression lay buried by lake clays when glaciers of the next expansion pushed down upon them in places, where piled-up and distorted layers may still be seen in front of overriding moraine.

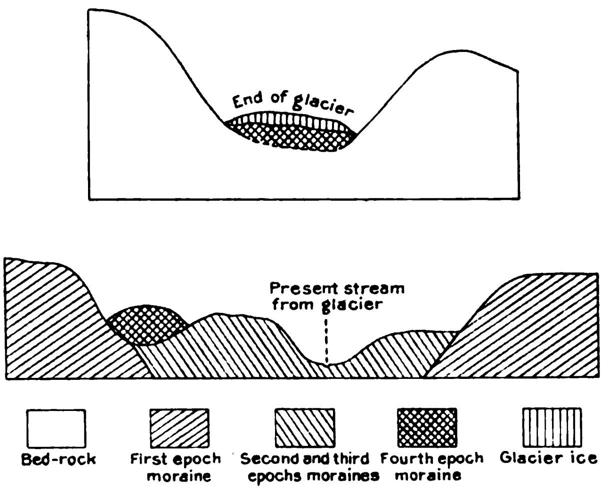


Fig. 434.—Glacier of the Kara-at and a Section of its Valley 1.5 miles below (Kara Kul).

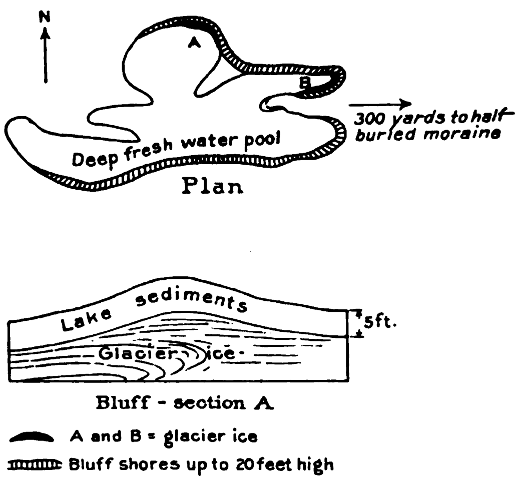


Fig. 435.—A Pool where Kara Kul Sediments have caved in over Melting Lobes of Glacier Ice.

The general limits of ice in the second epoch are sufficiently traceable to indicate a remarkable difference of outline between it and the first. It may be doubted if much, if any, of the region of Kara Kul was free from ice during the first epoch's maximum expansion. A snow-line 3,000 feet lower than its present would cover all the Northern Pamir with ice. During the second epoch mountains around Kara Kul were mantled with ice apparently reaching about 1,000 feet lower than their present ice-dome margins; and from this extended valley-flows through gorges cut in massive moraine heaped along the mountain flanks during the first epoch. Reaching the plain they spread out as coalescing fans, which in some way or other became buried by lake clays.

There appears to be no doubt of the glacial origin of these lake clays, as they are characteristic of glacial grinding, light gray or non-oxidized, with flakes of mica and layers containing small angular fragments. They are finely laminated and cover a wide area east of the lake. A large proportion lie horizontal, as shown in sections of deflation, but there are significant fan-shaped areas of much-disturbed stratification spreading out from the main valleys. Within these, the surface is broken into irregularly distributed mounds where wind-carving has exposed an arched structure, conformable to the original surface. Among them are miniature lakes of clear, fresh water, up to a few hundred yards in width and 10 to 20 feet below the plain, their walls extending vertically into the water.

All these facts, together with the utter lack of external hydrographic relations, led Professor Pumpelly to suggest their origin to be a caving-in of sediments on to underlying lobes of melting ice. And that seemed a logical explanation of the whole disturbance. It was corroborated in 1904 by my discovery of actual exposures of that ice, sections of ancient buried lobes in the bluffs around some of these pools; characteristic glacier ice lying beneath 5 to 10 feet of lake sediments

Fig. 436.—An Ice Dome, and its Third and Fourth Epoch Moraines in the foreground (Kara Kul).

where exposed. At first it may seem too extraordinary that the ice of an ancient glacial epoch should exist to-day, but, when realizing that the temperature over these steppes falls to 10° and 12° F. at night during the warmest part of the summer, it appears more natural. We shall have to attribute it to the second of our glacial epochs, having found it towards the limits of that expansion and 7 miles from the end of the glacier to-day.

So in some way or other Kara Kul rose to drown the piedmont sheets of ice and bury them with its sediments of glacier-ground stuff. The corresponding shore-lines are on the peninsula well-preserved beaches of wave-action 200 feet above the present level. The open water for wave-action and sedimentation of glacier-ground stuff, together with vegetable life—grass like the present—all this during the second glacial epoch is of great significance. We must believe it was a period of heavy precipitation, but no colder than now. Otherwise, no lake could have existed, for even now it is frozen nine months out of twelve. We have to face a climate as warm, if not warmer than now, and ascribe the greater ice accumulation to more snowfall. Indeed, it appears unlikely that any moisture to speak of could reach a region so isolated by range beyond range of the world's highest mountains, if the climate were much colder. On the other hand, there would probably be more precipitation now if it were warmer, and it would have to be a great deal warmer to raise the effect of melting seriously. An ordinary temperature of 10° F. in midsummer nights on the lake-shore means a very low average for higher portions.

It is sometimes difficult to separate moraines of the third epoch from those of the second, whose higher portions they overlie. Those on the east barely reached the plain and did not quite fill the second-epoch gorges in the first-epoch moraine, but must have lasted nearly as long as the second, for their moraines

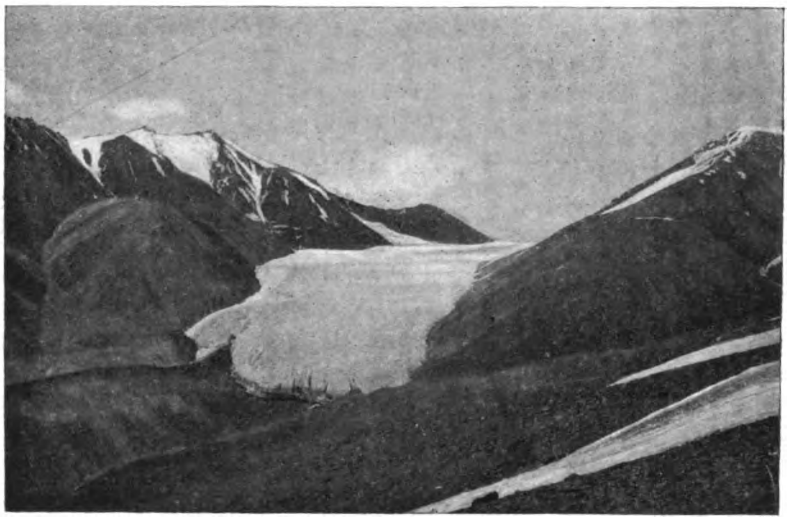


Fig. 437.—A Glacier Northeast of Kara Kul.

reach a great thickness. During this epoch the lake appears to have stood at the 120-foot level, and these beaches are worn fully as long as those of the second epoch. The third epoch, therefore, appears to have lasted for the same order of time as the second, though its glaciers were only half as long. In fig. 436, the fourth-epoch moraine is seen as a mass of loosely piled angular blocks overlying the third-epoch moraine of which the smooth surface forms the base of the picture.

Long after these three had come to a close, there came a fourth advance to about one-half the distance of the third, but of far less than half the same duration, for its moraines are insignificant when compared to them. And this one came to a close so recently that its moraines have suffered scarcely any surface weathering, whereas those of preceding epochs have been much worn by wind; even the third one can be ridden over, while granite moraines of the first epoch have been smooth-planed into mosaic floors, the interspaces filled with the arkose residuum of long time. One can ride all day over the old ones, but no horse dares set foot on the loose blocks of the recent fourth-epoch moraines. The very fresh beaches from 60 feet down to the present lake level might be coupled with this last advance.

All the Kara Kul glaciers of to-day lie in part on moraine, over which they have advanced from some more contracted stage, and they all terminate with a vertical or overhanging ice-cliff, from which large cakes of ice break off from time to time. I am inclined to think that their overhanging termini indicate that they are at present advancing. Most of them are mere valley tappings or tongue-shaped flows from high ice-fields, smooth-mantling the old worn-down granite mountains. Nowhere has nature been more graceful than in the making of these ice-fields, with high domes and troughs, and winding flows, all glare and clean and coalescing into the meandering striæ and cross-ribbing of more rapid motion where they are drained by valley glaciers. In this region there is no true snow-field, such as in the Alps. At no time did I find more than the 1 or 2 inches of snow of some recent fall, and under that was glare ice. Climbing on the domes is for the most part from step to step, while, with gun and camera, one balances and chops. When considering the power of solar rays felt directly through an arid atmosphere of 16,000 to 20,000 feet elevation, we understand why snow changes so rapidly that in a few days after storms all is transformed to a crust of ice that coalesces with the underlying dome. Another remarkable feature of these mantles is the utter lack of surface débris over their clean, white expanse. This must be attributed to the gentle slopes of their underlying topography, none of which can rise above to shed débris. We shall have more to say about that topography. Their expansions during the older epochs were, as stated, somewhat similar to that of a continental ice-sheet and resulted in widespread accumulations of moraine now characterizing the slopes of all high mountains around the basin.

Obviously no reconstruction of past events in the Northern Pamir can be undertaken without data from without its zone of held-up detritus; for, to decipher its orogeny, we must study its surroundings of erosive activity, where terraces of rejuvenated valleys fall under distinct erosion cycles belonging to periodic uplifts, and, where these valleys debouch, look for marginal deformations of the flanking piedmont zones. Everywhere beyond the borders of the Pamir's relatively dead topography deep gorges and canyons, torrential valley systems, and sharp land forms are met with. Already the Markan Su has cut through the last tributary moraines that blocked its course, and below them changes into a corrading stream. The Pamir's old preglacial topography is only 500 feet above the stream at the junction of its headwaters of Kizil Kul, but diverges rapidly with the stream to several thousand feet above only 60 miles eastward, where only the flat backs of mountains and massive spurs of soft red strata flanking the Trans-Alai remain of the ancient continuities of gentle slopes and inflected surface.

This is in general the state of valley systems developed into border ranges of the Pamirs. My studies of several of these valleys (Kizil Su west, Kizil-Art Darya, Markan Su, Kizil Su east, Taldic Darya, and Zerafshan) follow under the headings Alai Valley, Karategin and Hissar, Zerafshan, Tarim Basin, and Fergana Basin.

In order to close our section on the Pamir with a tentative reconstruction of its Quaternary history, we may, in prevision, assume a subdivision into erosion cycles justified by these valleys.

TENTATIVE RECONSTRUCTION OF QUATERNARY SEQUENCE OF EVENTS.

First cycle (Pliocene).

- Pliocene mountains with the present Aralo-Caspian and Gobi basins defined in a general way. Erosion to low relief of Central Asia's peneplain and piedmont stage. Remnant ridges still rising out of Pamir's worn-down topography of rolling uplands.

Second cycle (Quaternary).

- High uplift of mountains.
- Deep gashing of old Pliocene topography.
- Expansion of first epoch of glacial period with alluviation of valleys.
- Recession of first epoch of glacial period, leaving transportation in the Northern Pamir blocked around by moraines and its valleys converted into lake basins.

Third cycle (Quaternary).

- Uplift (block-tilting of Alai).
- Narrower gorges incised in second-cycle flood-plains of lower valleys, but Pamir still isolated with second-cycle topography intact.
- Expansion of second epoch of glacial period; lake Kara Kul filled to about 200 feet above present shores; alluviation of valleys of border ranges.
- Recession of second epoch, shrinkage of lakes, but plains aggrade back into valleys bearing old moraines.

Fourth cycle (Postglacial).

- Uplift, warping, etc.
- Narrower gorges incised in third-cycle flood-plains of border ranges, but Pamir's second-cycle topography intact.

THE ALAI VALLEY AS A BASIN.

A DISTINCT TYPE OF VALLEY.

In passing north, east, or west off the high central mass of Pamir, we encounter a remarkable type of valley—a wide basin-like trough contained, often nearly inclosed, by longitudinal ranges and floored with a steppe of gently sweeping concavity. This is a type well exampled by the Alai valley and Keyak Bashi and common throughout the highlands of Asia, giving rise to their most fertile pastures. On a large scale it resembles the basins of Pamir, but differs from them because of lower elevation. The origin of these valleys may lie far back in Pliocene time, as a result of migration of the zone of piedmont upheavals, periodic encroachments of mountains on plains through successive upheavals parallel to the primal highlands. As their streams average about 10,000 feet in elevation, they are within the zone of held-up detritus and have the aspect of deeply filled troughs.

The Alai valley—the high eastern catch-basin of the Kizil Su (the first great branch of the Oxus)—is a long, broad, east-west depression between the Pamir's northern border ranges or Alai and Trans-Alai Mountains. As a basin, it is 110 miles long from the Taun Murun divide to its canyon outlet at Katta Kara Muk and attains a width of 30 miles from crest to crest of its inclosing ranges. The even steppe resulting from its deeply filled state has a width of 15 miles for a distance of 75 miles. Less isolated from moisture than the higher Pamir, it receives sufficient precipitation to form one of the most luxuriant pastures of Asia.

In the higher Alai valley there are but two seasons—winter and spring. For nearly ten months of the year it lies deep-buried in snow, a vast expanse of white from range to range. Then no man lives upon the plain and its gray wolf-packs are free to hunt the wild sheep and wandering ibex. By July the snow has melted and like magic the grass turns green; a myriad of marmots leave their holes to visit one another in the warm sunlight, uttering their shrill notes of warning when the caravans come down. A thousand Kirghiz families descend from the passes round about, with their long camel trains caparisoned and rich-laden with nomadic wealth, and each caravan with its flocks of sheep and goats, herds of camels and cattle and horses, proceeds to its traditional camping-ground. For a while it is all life and merriment in a world of grass and wild flowers, a wonderful valley of green with poppies and buttercups and peopled by men and animals, with here and there a group of round felt-domed kibitkas; a land whereover days of mist give way to skies of blue purity. But through it all the mountains stand colossal and cold, reminders of soon-coming snow, and from their ice-domes, 15,000 to

Fig. 438.—Springtime in the Alai Valley.

23,000 feet in height, it creeps fast down upon the grass. Ere spring has finished bloom, winter has come and the valley is left frozen in snowbound emptiness.

But, though it is a remarkably rich pasture, there is scarcely rain enough—too little over the western or lower part. It is to the shortness of summer and relatively heavy snow of winter that the richness of its grass steppes must be attributed. There is enough water from melted snow in the ground to keep things fresh with the occasional help of mountain mists; enough in the upper half and all is full green there when winter falls to bury it, but in the lower half, the sun dries out all the water and leaves a plain of parched grass.

The Alai valley is thus a semi-arid type of desert basin. Of all the basins to be considered by us, it is unique in that it yields four of the deposition zones, so interwoven and interlapping that alluvium, moraine, and loess are found one over the other, and correlation becomes relatively easy. Kettle-hole pools are found on its widespread moraines, but they do not belong, organically speaking, in the lacustrian division of a desert basin; so that the lacustrian zone is here lacking. But the alluvial, flying sands, loess, and glacial zones are all especially well represented. Its nuclei of dunes, though small, are not very disproportionately so, and become of great interest as a demonstration of the origin of such nuclei in greater basins. Its wide gravel-plains sloping from the Trans-Alai are strewn here and there with dunes and other areas of loess, while in the lower half of the valley there are sand nuclei several miles in length. Several feet of loess have accumulated over its old moraines and along the lower slopes of its border ranges.

GLACIOLOGY AND EVIDENCES OF MOUNTAIN MOVEMENT.

The glaciology was described in my first report. The same oscillations and the same greater advances and recessions took place here as in the Kara Kul basin. During the two first epochs much of the valley steppe was occupied by wide piedmont ice-flows extending all the way across it from the Trans-Alai. Moraines laid down during the first have lost all topographical characteristics and their worn-down surfaces now form broad, low, transverse undulations of the valley floor and massive foothills of the Trans-Alai. Those laid down during the second

Fig. 439.—Kirghiz making Felt in the Alai Valley

epoch are now spread in the form of broad lobes covering immense areas and made up of vast numbers of conical mounds. In one remarkable instance, a second-epoch glacier spread all the way across the valley, piling up the slope of its northern side, just west of the Kashka Su. Through this moraine the Kizil Su has cut a channel, exposing a section of till resting on alluvium barely above the level of the stream. This section is of especial importance, for it is clear proof that the Kizil Su flood-plain was at about the same level there during the second glacial epoch as it is to-day, and that terraces, which leave the flood-plain about half-way down the valley and attain a height of 300 feet near its outlet, belong to some earlier age.

On a visit to the glacier of the Tokuz Kungei, one of the greater Trans-Alai tributaries to this valley, some ideas were formed about the third and fourth epochs and their relations to the older. This glacier still terminates piedmont fashion, deploying—over a massive accumulation of moraine filling the mouth of its mountain valley—as a flat sheet of clear ice, perhaps over half a mile wide and 100 feet thick. Its waters discharge into a valley over 1,000 feet deep with an estimated width of three-quarters of a mile. This valley is excavated entirely in moraine composed, for the most part, of huge subangular blocks with glacial striæ, and belonging to the first epoch, as it has lost all topographical characteristics, having been graded with a surface sloping towards the middle of the Alai and gashed by this great tributary valley. In this valley of discharge there are two terrace levels bearing kettle-holed moraines, and a less definite third terrace below. These, it would seem, belong respectively to the second, third, and indefinite fourth epochs. From out of the valley of discharge its second-epoch moraine spreads clear across the Alai with broad lobes, each composed of conical heaps 100 to 300 feet high. Between the first and second epochs, time enough elapsed for the excavation of this wide valley of discharge to within 200 or 300 feet of its present depth.

Fig. 440.—The Tokuz Kungei Glacier (Alai Valley).

As a severe buran (snow blizzard) blew up and darkened the region, I was unable to complete my observations on the third and fourth epochs, but it is a locality worthy of careful exploration.

The glaciers of to-day are of a different character from those about Kara Kul. To begin with, the snow-line on this side of the Trans-Alai is only about 13,000 feet, and we find true snow-fields—that feature for which the mountains of Kara Kul are so remarkably in want. There the snow turns to ice as fast as it comes down; but on this side there is more of it and a less arid sun to transform it. Two of the present glaciers studied might almost be called piedmont flows. They descend with a steep grade and spread out fan-shaped upon massive accumulations of moraine, in part at least belonging to the third epoch (a mass that must be from 1,000 to 2,000 feet in thickness), and spread upon the flat floors they have planed over these old moraines, to terminate in wide sheets of pinnacled ice, possibly less than 100 feet in thickness. And these glaciers, like those of Kara Kul, are remarkably free from surface moraine; and for the same reason, viz, that the mountains above are almost wholly mantled with ice. We must believe that the old epoch moraines, in spite of their immensity, were accumulated and brought forward under the ice and by its margins.

In my report of 1903 it was shown that considerable mountain movement took place apparently between the first and second glacial epochs. The northern flank of the Trans-Alai is truncated by what appears to be a fault-scarp, displacing the first-epoch moraines and broad-trough valleys and dissected by the narrower trough valleys of later glaciation. The Kizil Art valley, principal Trans-Alai tributary, has the twice-troughed form due to uplift, from its heading cirque nearly to its mouth in the Alai; there the bottom of its lower trough sinks under the flood-plain of later alluviation, half-drowning the great second-epoch moraine that rises at the mouth of the valley to stretch 10 miles out into the Alai.

Fig. 441.—Alluvial Terraces in the Lower End of the Alai Valley.

Portions of its second-epoch moraine lie apparently faulted up on the terraces of its upper, broad-trough stage. Half-way down the Alai there is an uptilted mass of alluvium jutting out from its northern side as though more complicated deformation took place. In the eastern half of the valley tributaries from the north are deeply drowned in alluvium, as contrasted with those from the south, uplifted Trans-Alai, which have been canyoned postglacially. Terraces begin to flank the Kizil Su toward the outlet of the valley; and of these the higher are, as shown above, the result of cutting down since the first glacial epoch, while the lower appear to have been since the second. By early explorers these were taken for shores of an ancient lake; but they incline gently downstream, diverging somewhat above it, ascend into tributary valleys from the north as characteristic alluvial terraces, and in no way resemble those of a lake. It is, therefore, obvious that the Alai valley has suffered two distinct periods of mountain movement—

one between the first and second glacial epochs, another after the second glacial epoch. The first movement appears to have given a relative uplift to the southern range, the second to have been an uplift of the whole valley, raising its western end at least 200 feet, probably several times that amount, and causing its outlet to cut down a narrow canyon. The Kizil Su is still corrading there rapidly on rock bottom.

The first movement, it was shown, might be explained as a transverse block-tilt of the valley plain with the Alai Mountains north, on a dislocation along the Trans-Alai scarp; and one north of the Alai Mountains tilting the Alai valley down while the mountains north of the rotation axis were raised (see plate 63). This might have resulted because of the heavy load of moraines and alluvium piled in the Alai valley during the first epoch. Then, if the whole block was set in motion, it necessarily sank down on the Alai valley side, while its northern side was raised by displacement from the sinking Fergana plains. If the Alai valley had been larger, it probably would have gone through an independent set of movements; but, being a basin of small dimensions, it appears to have acted as a dead weight, an increasing load against surrounding mountain movements.

There appears to have been some deviation from this general geodynamic scheme. Midway between the two ends of the valley and by the northern edge of its steppe the Kizil Su is truncating a low spur composed of displaced Alai valley alluvial gravels with a slight dip diagonally to the valley axis. This local departure merely indicates that though the Alai Range probably moved as a whole it was at the same time (or perhaps afterwards) more or less broken up.

TENTATIVE RECONSTRUCTION OF EVENTS IN THE ALAI VALLEY.

First cycle (Pliocene).
- Uncertain as to whether the valley was defined.

Second cycle (Quaternary).
- Uplift of Pamir with differential block uplift of border ranges.
- Alai valley defined.
- Expansion of first-epoch glaciers, and piedmont ice-flows from the Trans-Alai reach all the way across the valley.

Third cycle (Quaternary).
- Transverse tilting-down of the Alai Mountains and Alai valley with dislocation along the northern base of the Trans-Alai.
- Expansion of second-epoch glaciers and deepening of glacial valleys with troughs narrower than those of the first.

Fourth cycle (Postglacial).
- Uplift of whole region.
- Cutting-down in the lower half of the valley.
- Loess and sand-dunes now accumulating.
- Glaciers have recently (probably during the last few hundred or a thousand years) receded between 200 and 300 feet.

KARATEGIN AND HISSAR.

The highlands of northeastern Bokhara are portioned between Karategin and Hissar, two remote provinces still surviving as feudal tributaries of the ancient khanate. Ethnographically, this is a region of high valley oases similar to those of the Zerafshan, remarkably isolated, and preservative of a distinct type of man, the Galcha, still speaking a relatively pure Aryan dialect—rare survivals of a primitive sedentary stock, elsewhere diluted or exterminated by the nomads. Physiographically, it is an important portion of the Oxus drainage system, which, in Quaternary time alone, has enacted a series of both hydrographic and topographic changes of astounding magnitude.

Fig. 442.—The Kizil Su where it leaves the Alai Valley.

KARATEGIN AS SHAPED BY THE KIZIL SU.

The Kizil Su now follows a course of three physiographic divisions: (1) The Alai valley, (2) the valley of Karategin (Katta Kara Muk to Obu-garm), (3) the Vaksh valley (Obu-garm to the Oxus). We have studied the Alai valley as a basin, and as a whole it is a basin from which but a small proportion of the materials of its Quaternary erosion can have escaped; but in the western half there begin alluvial terraces flanking the Kizil Su flood-plain and gaining height toward the outlet. At a point 12 miles east of Katta Kara Muk, the old floor narrows rather abruptly from a width of 8 miles to about 1 mile and the valley becomes of normal aspect. And at Katta Kara Muk, where the true outlet canyon begins, there are three terrace-levels, respectively 70, 100, 200, and 300 feet above stream and continuing up the tributaries. There can be no question as to their alluvial origin, as they slope with the stream at a rate of over 30 feet per mile and continue up its tributaries, and on the Trans-Alai side are composed of truncated fans sloping from high up in the mountains.

When the river flowed at its highest or 300-foot terrace-level (first glacial and part of first interglacial epoch), its wide valley-floor was continuous into Karategin. The 200-foot terraces are also continuous, forming a narrower stage, while the present outlet gorge, into which the river plunges in a torrent state, is carved in the 200-foot floor. This narrow gorge is cut in the strike of a southeasterly dipping series (hard limestone on the north, soft gypsiferous beds on the south) and continues for 15 miles, whereupon the valley opens out and its terraces widen into the broad grade-plains of Karategin.

Fig. 443.—A Galcha Beg of Karategin with his Hunting Eagle.

The Kizil Su valley of Karategin is, in a general way, 25 miles wide and over a mile deep, as measured from the lower passes of its border ranges—a valley on the large scale characteristic of the highlands of Asia. Flanking it on the north is a branch of the Alai, on the south the Peter-the-Great Range, whose giant ice-clad peaks stand 10,000 feet above the oases scattered along the terraces and grade plains of its ancient valley-floors. The southwestern half lies open to a scanty precipitation of moisture from storms born up the Oxus embayment to nourish a moderate pasture over the grade-plains and flanking mountains below their snow. And there even grain is raised in fields patching the high slopes, with no irrigation; but the eastern half of the valley is barren of vegetation, a desolate land of sharp red and gray or black declivities rising from the dazzling gravel-plain of its "braided" stream. There the higher peaks of the Peter-the-Great Range are less often seen mantled with clouds than as naked pyramids of white outlined against an arid blue. Karategin is essentially desert.

Physiographically, the great features of this spacious valley arise from its ancient terraces and grade-plains. In general, there are three past erosion stages represented and these with the present river channel make four erosion cycles. But for over 30 miles, midway between Obu-garm and Katta Kara Muk, the third and fourth stages merge into one; or rather the third-cycle flood-plain warps under present alluviation and the river spreads out with no channel. Often the second-stage terrace is found obliterated and the valley becomes a simple wide gorge with tributaries cut into the old topography of its first stage, the pene-plain stage of these regions.

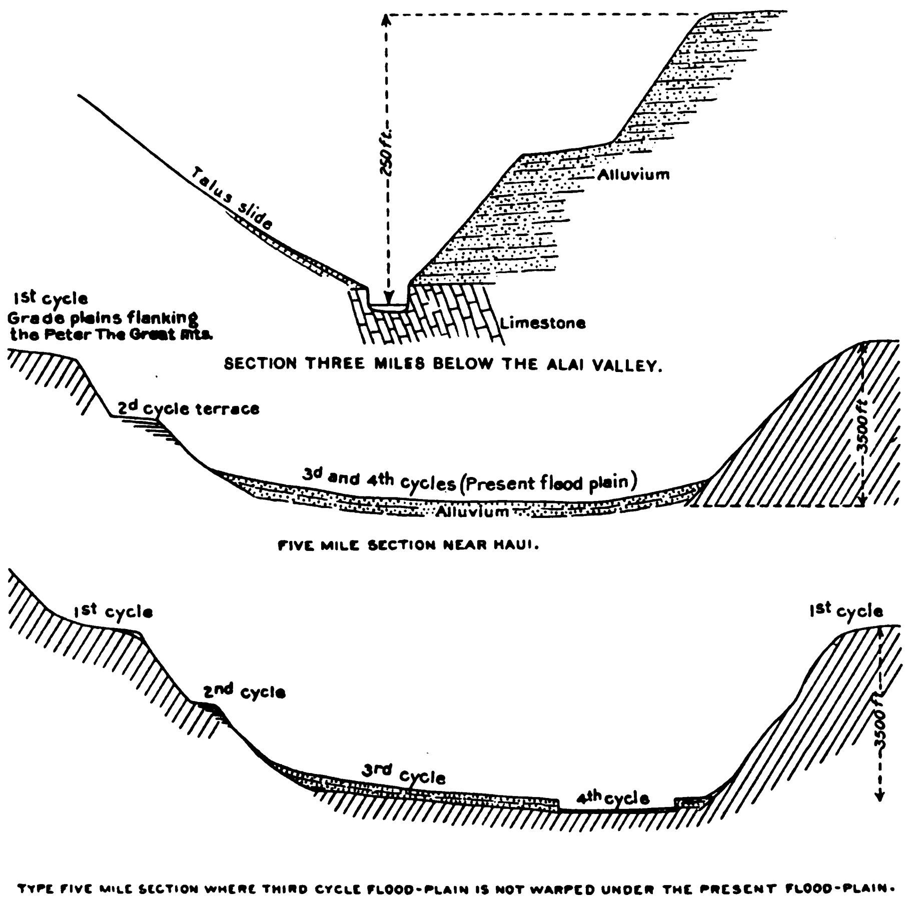


Fig. 444.—Terraces of the Kizil Su in Karategin.

As the first-stage topography has been uplifted and dissected by this great gorge and all its tributary systems to a depth of from 3,000 to 4,000 feet, only limited areas of its original slopes now remain. It is to be inferred from a conformity of grade-plains and flat-topped spurs flanking the Peter-the-Great Range and dissected remnants of a one-time half-peneplained belt of the Alai Mountains north. When uplift began, it was by no means a peneplain, but rather a mature topography grading into the wide, shallow valley of the Kizil Su and peaked here and there with low monadnocks and bordered by the Alai and Peter-the-Great Range. But to attain even that stage of maturity in the heart of a great mountain region; to erode what in Pliocene time must have been a region of colossal ranges to its metamorphic cores, must have taken vastly longer than all three succeeding cycles of erosion taken together. The sum total of these later cycles has resulted in no more than an immature dissection of the ancient topography, and, though for our purpose they should be termed erosion cycles, they are by no means comparable to that which closed the Pliocene and should be regarded as mere phases of a Quaternary striving towards base-level. We shall find corresponding phases of Quaternary erosion over other regions and term them cycles for the sake of a tentative correlation.

Fig. 445.—A Bridge over the Third-cycle Terrace in Karategin.

Terraces of the second stage lie about half-way up the valley sides, but are found only at rare intervals, usually where tributaries join, and badly preserved because the third-stage valley-floor has widened to nearly obliterate the transition. But those of the third stage are in remarkable preservation and form the great feature of Karategin, the spacious plains and gentle slopes of its oases. Broadly speaking, it gives a concave sweep to the valley bottom, for the most part 4 miles across and traversed by the present river channel, about half a mile wide, of rectangular section, varying up to nearly 300 feet in depth.

At Damburachi (junction with the Muk Su), this stage widens into a triangular junction-terrace* of over 30 square miles area, traversed by abandoned distributary channels of the Muk Su between 200 and 300 feet above stream. Two

*A terrace in the angle or junction-spur where two rivers join. I venture to offer "junction-terrace" and "junction-spur" as terms I have found essential.

or 3 miles below Damburachi the river flows through a narrow cut, skirting the north side of the valley, while the lower terrace rises as a plateau on the south with an old channel of the Kizil Su on it. Below there it converges with the present flood-plain and just below Pildona, 6 miles above Hawee, it sinks under. From there on nearly to Garm, it lies buried in the present flood-plain and the river at high water swings against the valley sides it scoured during the third erosion cycle. Just above Garm the lower terrace rises out again and the river enters a channel that deepens steadily to Obu-garm, the westernmost point of observation, where this terrace is about 300 feet high as cut into by the present channel, that of our fourth erosion cycle.

In defining the third stage we inevitably defined the fourth, the channel of to-day. But some important facts should yet be noted. The present channel is cut in alluvial gravels all the way, excepting for occasional glimpses of bed-rock bottom. Obviously, then, the stream had cut down as far as it is now during the third erosion cycle, which, however, closed with a re-filling and valley-widening to the third stage. The earth-movements which wrought its fourth and last erosion cycle were of such a nature that about 35 miles of the valley, that portion between Garm and Pildona, was negatively affected, that is, aggraded instead of corraded. This would appear to indicate warping, and that idea is reinforced by observations on tributaries. Two large tributaries converge to Hawee, where they debouch in the Kizil Su. One comes in from the west, the other from the north. If the great valley suffered a longitudinal warping, we should expect to find the one from the west rejuvenated, the one from the north aggrading in sympathy with the main river. This is precisely the condition at Hawee. One more important fact remains: the Kizil Su has not yet graded its fourth-cycle channel, excepting over the 35-mile stretch of relative depression. The present flood-plain is divided into several long stretches where the river splits into a braided stream. Between these the channel narrows into short shoots, where it plunges over sills of bed-rock. The fourth erosion cycle is, therefore, the result of a warped uplift still in process, or so recently completed that corrasion has not yet attained an even grade.

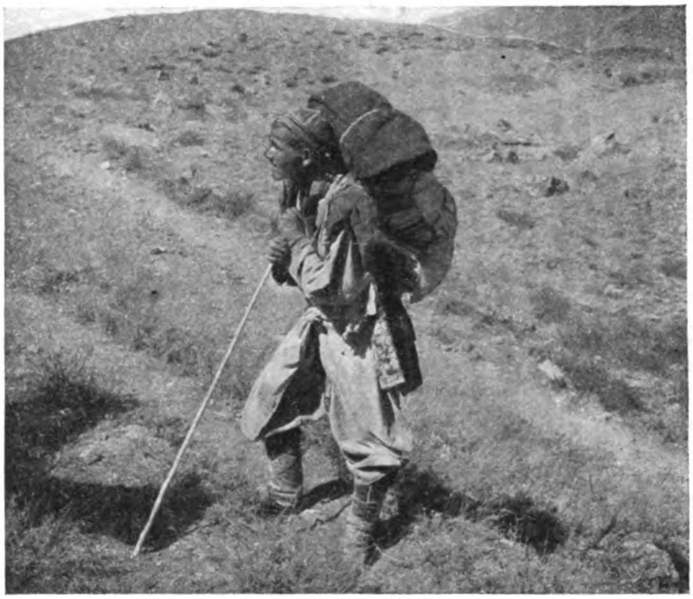


Fig. 446.—A Galcha of Karategin.

GREAT FEATURES OF THE HISSAR VALLEY.

Hissar becomes of interest because of the extraordinary hydrography of its great valley. Opposite ancient Bactra a 15-mile wide strip of steppe sweeps up from the Oxus embayment into this valley, continuing northward up the Surkhan River as far as Karatagh, then bending due east into the wide open valley of Hissar. This portion of the valley-floor averages 2,500 feet in elevation, and is distinguished for its utter lack of a trunk-stream. It is, on the other hand, crossed by three tributaries, the Kanaka, Dushambeh, and Kafirnigan, converging to near the city of Hissar, where they break through the southern side and flow to the Oxus.

Fig. 447.—A Swimmer of Rapids, with an Inflated Goat-skin (Karategin).

The valley has a mixed population, divided between Usbeg camps and Tadjik villages. Throughout the old khanate it is famed for its wealth of pasture and the grace of its horses. The streams descending from the mountains north are diverted to irrigate a wide continuity of rice and grain-fields, while the silk woven in Karatagh and Hissar is prized throughout the cities of Central Asia.

Ten days were spent in attempting to decipher the remarkable physiography of the Hissar valley. The more open part of the valley east from Karatagh is about 40 miles long and floored by a grass plain with an average width of 5 miles, but of irregular definition. On the northern side this plain is often bounded by a loess cliff, surmounted by a narrow belt of steppe rising north. From this it inclines transversely or southwards on a grade of about 20 feet to the mile, and sweeps up again to meet the mature topography of the southern side. The loess cliff varies up to 100 feet in height, and running along the northern side of the main valley truncates tributary spurs and tributary valleys in one plain; but is interrupted by the broad flood-plains of larger tributary valleys dissecting it; in general, it runs east and west, sometimes perfectly straight for several miles; sometimes gives way to a dissected deformation of the plain, and has the appearance of a recent fault-scarp. From near Dushambeh it runs straight east for 8 miles, dissected by local streams at rare intervals.

The Hissar valley is all loess, except where crossed by the gravel flood-plains of the three larger streams. These streams cross in wide channels, beginning with a depth of about 100 feet, decreasing till near the southern side, where flood-plains merge into the great valley-floor. It is essentially a valley of deep loess accumulation, a grassy settling ground of dust blown up from the Kizil Kum. On the other hand, its great dust-beds undoubtedly alternate in depth with the flood-plain deposits of its cross-streams. Out of ten days, during seven there was a

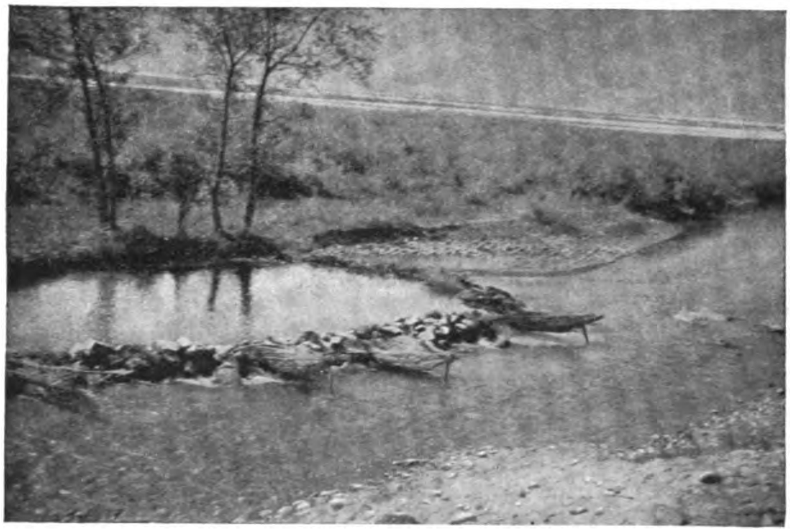


Fig. 448.—Fish Traps of the Kizil Su.

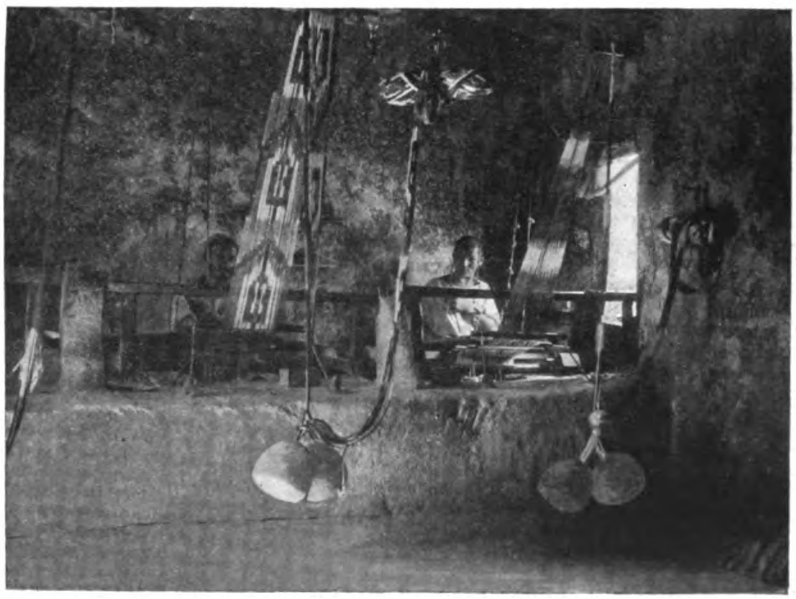


Fig. 449.—Silk Factory in Karategin.

yellow haze, and of these days two were so gloomy that a few hundred yards was the range of vision. It is, therefore, a region of still living loess. The kurgans and burial mounds left by its more ancient inhabitants are now mantled with 2 feet or more of loess.

These questions arise: What is the explanation of this valley, of which a part has no trunk-stream? Was it ever a true river-valley? Is it the lower portion of a valley of which the head-waters have been captured by a higher branch of the Oxus? Was it possibly the valley of the Kizil Su, now captured at Obu-garm by the Vaksh River?

East of the open plains the valley-floor has been uplifted and dissected by the Hyak Darya, which plays the part of a true trunk-stream for that portion. Following it up to about 18 miles above Faizabad, we find the channel made by this stream, at first deep with high terraces, decreases in depth and finally opens out onto the ancient valley-floor again. Here the floor is a sweeping concave about 3 miles wide between the mountain sides, with spacious tributary fans and talus cones, and there are no terraces. It stands at an elevation of 6,100 feet and forms a rich summer pasture, resorted to by Usbeg nomads.

The remarkable fact about this floor is that it continues rising east beyond the heading tributaries of its stream, and we thus confront another portion of the valley with no trunk-stream. For 3 miles it is a wide grass plain with not even a tributary descending to its borders. Then, while it is still rising east, there begin

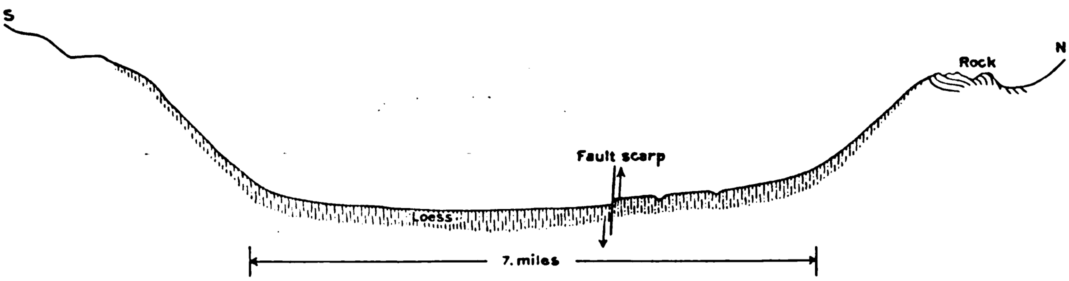


Fig. 450.—Cross-profile of the Hissar Valley.

gully systems developed back into it from a stream which joins the Kizil Su near Obu-garm. These gullies join into a gorge deepening rapidly with terraces inclining east, while the old floor above apparently still rises east. The gorge finally develops into a canyon 2,000 feet deep in hard limestone and softer rocks; then widens again at Obu-garm and debouches into the Kizil Su with a total depth of 3,000 feet.

The high-grade plains or first-stage terraces of the Kizil Su appear to have a height of about 3,000 feet at this point, and, if so, conform with the old uplifted floor of the Hissar valley. Here there is no doubt that the gorge of Obu-garm has captured the head of the Hissar valley. The valley at the divide is so broad that it must have been formed by a large stream. It is possible that the Kizil Su was that stream and that the mountain movements that first broke up the mature topography wrought this change in its course.

In connection with the valley of Hissar it is important to know the valley form of its northern tributaries. One of these, the Sardai-miona, was briefly studied in descending from Kak Pass over the Hissar Mountains. For 40 miles it is a gorge over 2,000 feet deep, of which the last 25 miles narrows to a granite canyon with cliffs rising often 1,000 feet sheer and sometimes 500 feet overhanging. Its population in the more open portion, the first 15 miles, is divided between shepherds and villagers. There the valley sides rise 2,000 feet at an angle of 25° to 30°, but are luxuriantly clothed with grass. On terraces along the bottom are its villages of square huts with flat mud roofs and cobblestone walls cemented with clay. These are usually seen incased with cakes of dung fuel, piled carefully up against the walls or heaped in cones on the roof to dry.

The granite gorge beginning about 15 miles below, though for the most part a canyon with sheer walls, widens out occasionally, especially where tributary valleys come in. Here we find villages of sloping thatched roofs, recalling those of Europe, and a variety of trees. The mountains above the granite walls are sparsely forested with scrubby cedars. Willow, sugar-maple, yellow birch, hickory, poplar, cedar, black elm, wild cherry, and wild plum grow along the bottom. It is an extraordinary fact that all excepting the cedar had a familiar aspect,

Fig. 451.—Kak Pass over the Hissar Mountains.

recalling similar varieties in America; and even more surprising was it to find true maple-sugar, made into flat cakes like ours. Their sugar-maples and yellow birches would pass for the rock-maples and yellow birches of New England.

In its upper portion the Sardai-miona is a terraced valley. Terraces diverge from the flood-plain near its head and increase in height downstream till the granite canyon begins, and there they vanish to reappear about 8 miles below Romette, where the valley opens out again. There we find them of loess and loess-capped alluvium in bluffs rising over 100 feet above stream. Below Romette the mountains are mantled with loess and patched here and there with grain-fields, some of them on slopes too steep for a horse to plow, and the land has to be hoed. The crops are brought down on wooden sleds that slide easily down these steep slopes of smooth loess. All the hillsides are scarred by tracks running straight down, as the same ones are used year after year. On the plains of Hissar similar sleds are used, but drawn by oxen instead of descending by gravity.

The Sardai-miona valley has no high terraces, no terraces comparable to those of Kizil Su. It is essentially a simple gorge, beginning with a V shape with low terraces at the bottom, then changing to a canyon and finally opening again to a V shape with low terraces at the bottom. These low terraces which mark its last transition undoubtedly resulted from the recent uplift which faulted up the northern side of the Hissar valley, breaking off the border of its floor with the scarp of loess. The river, which is of nearly clear water, as its region is of crystalline and metamorphic schists, is a rapid and copious flow, but hardly a torrent. Its grade is fairly even, though at intervals it becomes more rapid and passes chutes. It may, therefore, be said that its last phase is still uncompleted.

Any explanation of the Hissar valley must explain why the Kafirnigan with the other streams breaks through its southern side, instead of flowing east to join the Karatagh, thus continuing the valley to its proper outlet. It may be that the Hissar valley is not a valley, but no more than a belt of the Oxus embayment, shut off by uplift of the plain south, and that the Kafirnigan cut down as the mass rose. This is not likely, because the hills south of Hissar are by no means sharp in outline, but are, on the contrary, of mature form. It would seem that a regional tilt, raising the northern side with the Hissar Mountains, would account for the canyons of tributaries there and the cutting back of an Oxus tributary to capture the cross-streams at Hissar. The same process might account for cutting back of the Vaksh to capture the Kizil Su at Obu-garm, thus leaving the Hissar valley from there west without the great stream that belonged to it.

TENTATIVE RECONSTRUCTION OF EROSION CYCLES IN KARATEGIN AND HISSAR.

First cycle (Pliocene).

Erosion of Pliocene mountains to low relief, while Kizil Su flows straight through the Alai valley, Karategin, and the valley of Hissar, and then south to the Oxus. Cycle closes with valley widening and a many-mile wide flood-plain continuous from the eastern end of the Alai valley to the Oxus embayment, a distance of nearly 500 miles.

Second cycle (Quaternary).

High uplift; Hissar region tilted, raising north more than south. The Kizil Su captured at Obu-garm, the valley of Hissar at Hissar; the Kizil Su deepens the western end of the Alai valley and canyons its valley in Karategin; the Sardai-miona develops its canyon cycle.

Closes with the valley widening.

Third cycle (Quaternary).

High uplift. The Kizil Su deepens the western end of the Alai valley and canyons the second-cycle floor of Karategin to a depth of 2,000 to 3,500 feet below the first-cycle grade plains. Cycle closes with prolonged valley widening and glacial alluviation. Great accumulation of loess.

Fourth cycle (Postglacial).

Warped uplift of a few hundred feet. Faulting up of northern side of Hissar valley. Present channels incised in flood-plains of third-cycle alluviation. Now up to 200 or 300 feet in depth and still cutting down. Loess still accumulating.

THE ZERAFSHAN VALLEY.

On the Northern Pamir and in the Alai valley we found a good field for glaciology, and would, off-hand, expect to find record of corresponding climatic change on outlying ranges, nearby members of the Tian Shan. But although no such extreme difference as the variation of from one to six glacial epochs, found by

Fig. 452.—Thatched Roofs in the Sardai-miona Gorge.

Mr. Huntington, was met with on my journey, there was an unmistakable discordance between certain valleys. We hope to show that a differential glacial record was inevitable on mountains subjected to the differential uplift such as we find recorded by various degrees of block-faulting and tilting. With the Alai Mountains, we have a region that has been uplifted some thousands of feet, faulted on the north and bordered there by rows of uptilted piedmonts. It is a significant fact that Mr. Huntington found a universal correspondence of variations in climate (by attributing valley terraces to climatic change) and yet no correspondence at all between valley glaciers. We can not, however, believe that the glaciers of Central Asia were independent of Central Asia's climatic change. If it were merely a disagreement between valleys of different elevation, between high valleys now occupied and low ones now glacier empty and between empty valleys of different height, the matter might be argued independent of uplift. But such is not the case. Out of twenty-four valleys scarcely any two of the same height agree; and there are instances of valleys near together and of the same height disagreeing several epochs. It will be understood that most

Fig. 453.—A Sled in the Hissar Valley.

of Central Asia's valley terraces have resulted from widespread cycles of uplift, in some parts locally interrupted, and that just such a variable glaciology would arise from a differential uplift.

THE ZERAFSHAN AS A LONGITUDINAL VALLEY.

The Zerafshan valley is perhaps the most valuable of longitudinal valleys for our purpose. Rising in the ice cave of its wonderful glacier, amid Alpine peaks up to 18,000 feet in height, at the forking of two westernmost members of the Tian Shan system, its river flows west for 150 miles as a thundering torrent, between the rock walls of its canyon carved in the bottom of a gorge several thousand feet in depth. Out of this it abruptly emerges onto the broad steppes, to nourish the great oasis of Samarkand and those bordering it for 200 miles, till the last of its waters filter away in the gardens and rice-fields of old Bokhara. Once it probably joined the Oxus and only about a thousand years ago filled the canals of Paikent, then the most powerful city of Central Asia, but now abandoned to the desert dunes, from which project its ruined walls. As a longitudinal and structural valley that of the upper Zerafshan has responded to uplift differently from those carved transversely in uplifted ranges. To begin with, it could not much feel any transverse tilting such as so affected the Taldic valley to the east and, since it debouches from between the ends of two ranges where they die out and seem to have risen but little, it responded slowly up the 150 miles to its source. Moreover, there is more chance for a warp in a long valley than in a short one. Lastly, the grade of such a long longitudinal valley is necessarily much less than that of transverse valleys heading at the same height on the same range. It therefore had more tendency to fill with the waste of glacial alluviation, especially during long interruptions of crustal movement when aggradation of the plains could raise the base-level back upstream, either case giving rise to massive terraces of alluvium after the cutting-down of a succeeding uplift.

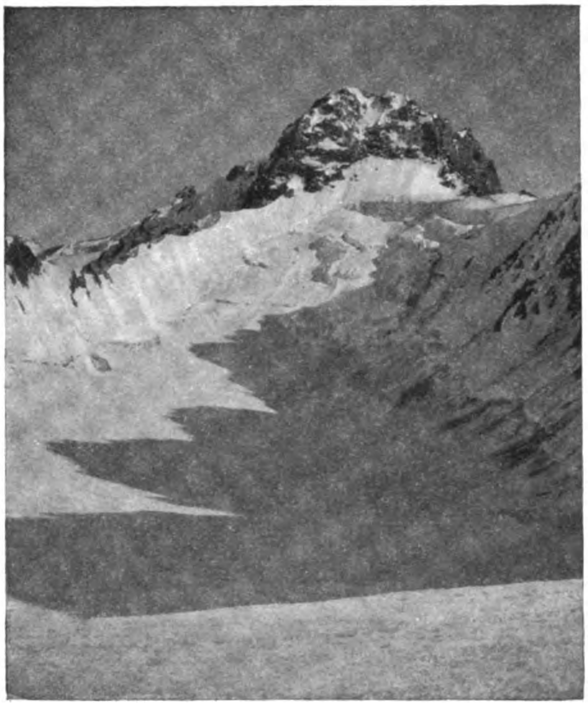


Fig. 454.—A Peak South of the Zerafshan Glacier.

All the above distinctions are characteristic of the Zerafshan as well as the Kizil Su gorge of Karategin. In general, there seem to have been three cycles of erosion before the present, which makes a fourth, as the stream is now rapidly corrading.

SECTION OF EROSION CYCLES.

First cycle (Pliocene).
  High relief (Pliocene).
  Base leveled in part (the peneplain stage of Central Asia).
Second cycle (Quaternary).
  Uplifted.
  Graded to G − 25 feet (first epoch of glacial period?).
  Alluviation to G + 500 feet.
Third cycle (Quaternary).
  Warped uplift.
  Graded to G − 300 feet (extensive landslides).
  Alluviation to G − 100 feet (close of second epoch of glacial period).
  Aggraded to G (third and fourth epochs obliterated by present glacier).
Fourth cycle (Quaternary).
  Warped uplift.
  Cut down to G − 300 feet.
  Still cutting down. (Present glacier and tributaries have made considerable advance in this cycle. During the present oscillation glacier has receded about 250 feet.)

FIRST EROSION CYCLE.

The vertical degree of cut and fill referred to G level, or the broad floor into which the canyon has cut, varies throughout the valley in such a way as to indicate warping. The values given are about average for the exaggerated portion of the valley, that from Urmitan to Oburdon. Of those far-reaching gradual slopes forming the 20-mile wide valley established by the close of the first cycle, but little now remains and must be looked for surmounting high spurs and whole mountains dissected from it between the present gorge and its two containing ranges. That uplift which ushered in the second cycle of erosion seems to have been especially great through this region and the rest of the Alai Mountains and, though probably contemporaneous with a general breaking up of our first cycle's topography throughout Central Asia, may have been somewhat sooner here where comparatively little of the old topography has survived. The Kopet Dagh, on the other hand, appear to have lagged behind the general uplift, while the remarkable peneplain of the Bural-bas-tau in the Tian Shan, so well described by Professor Davis, may have risen still later. Indeed, it is unlikely that all ranges throughout a region so vast as Central Asia would rise simultaneously. If these uplifts, all secondary movements posterior to the birth of the mountains, were, as we suppose, connected with loading and consequent sinking of their adjacent plains, the mountains originally highest ought to have risen first. And this appears to have been the case, for the Pamir and its border ranges, the Trans-Alai, Alai, and those on its east were already deeply gashed with well-developed valley systems long before the first glacial epoch.

SECOND EROSION CYCLE.

The second cycle appears to have lasted a long time after its uplift had ceased, for during it the river widened its floor, which seems to have been somewhat below the surface of terrace G, till it was in places even wider than that terrace is now. Even after this, erosion continued till by aggradation of the plains the base-level had risen up into the valley, filling it to a depth of some 500 feet with waste. But probably this refilling was partly a glacial alluviation in the first glacial epoch.

THIRD EROSION CYCLE.

To us the third cycle is most interesting, as it overlaps the second glacial epoch and less time has elapsed to obliterate its records. As a result of its uplift, apparently warped, the river cut down through the alluvial fillings of the second

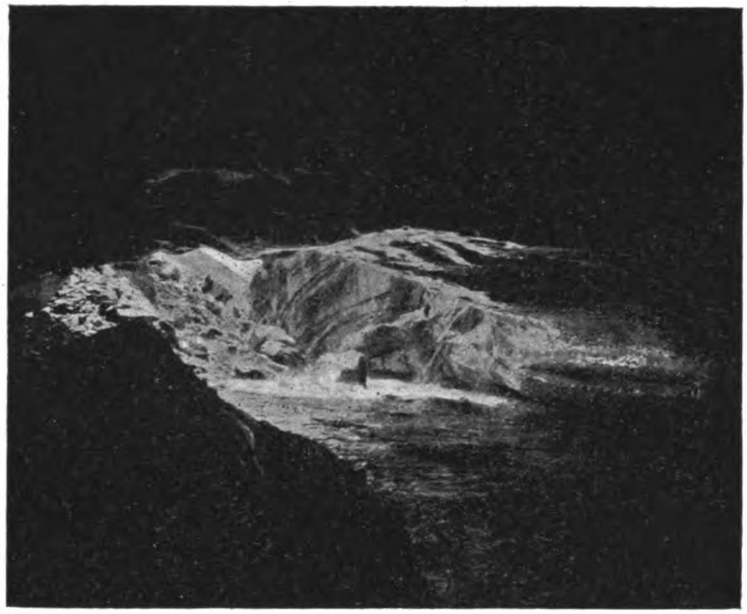


Fig. 455.—Ice-cave of the Zerafshan, Looking from within.

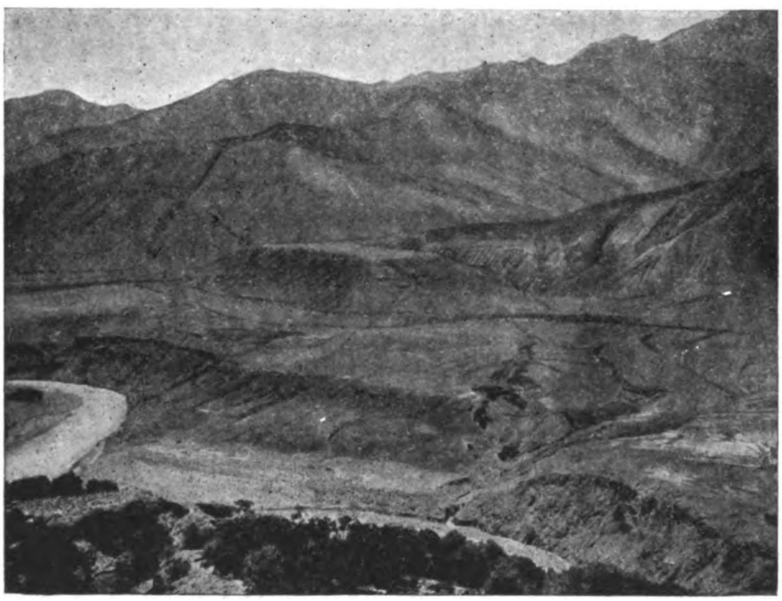
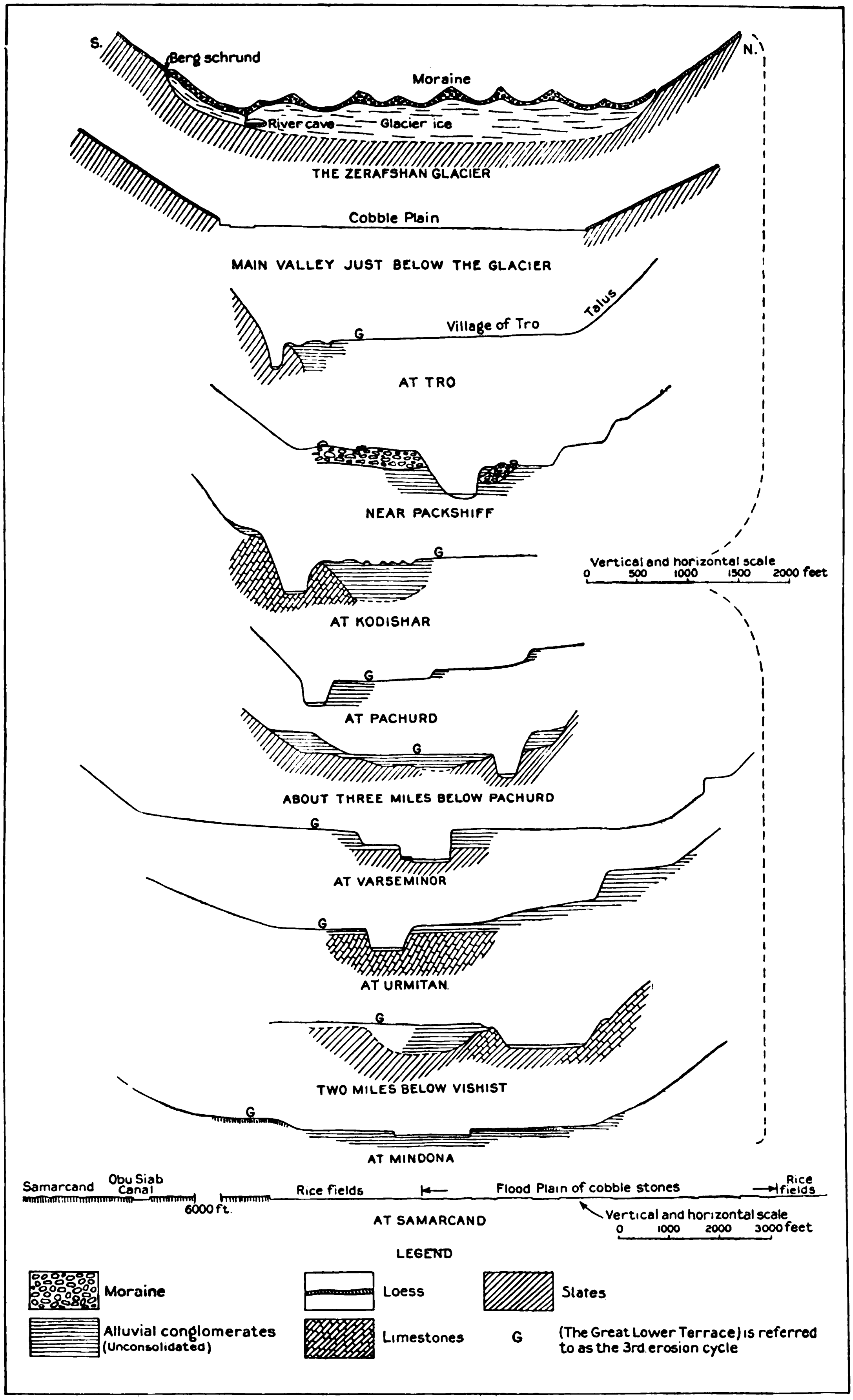


Fig. 456.—Terraces of the Zerafshan.

cycle and into the old rock bottom to a depth of from 50 feet in the lower to 300 feet in the mid-warp part of the valley with a canyon about as wide as the present and reaching about the same depth. Then the uplift appears to have stopped



Twelve Cross-sections of the Zerafshan Valley.

short and the base-level aggraded back into the valley again, refilling it with waste. During this process, and when it had refilled to a height of about 250 feet some three-quarters of the way upstream, the second-epoch glacier advanced to 45 miles below the present ice front. This ultimate point is near the oasis of Madrushkent. There, in the face of a 300-foot deep canyon section, may be seen a thickness of some 20 feet of finely stratified light-gray clays, contrasting in lightness and texture with 20 feet of overlying and 200 feet of underlying coarse gravels. But the important feature is its distorted stratification, evidently having resulted from a pushing of the ice front, which also beveled the distorted layers with a surface declining upstream or against the river's grade, the very thing to be expected under the frontal margin of an advancing valley glacier. At intervals for about 20 miles above this point there are moraines scattered over terrace G standing half-buried in its alluvium, and in a tributary canyon section (see plate 62) oppo-

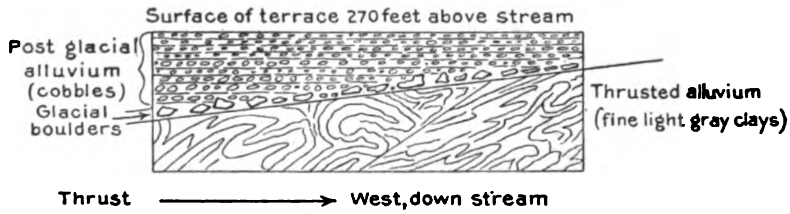


Fig. 457.—Section of Glacier-thrusted Alluvium in the Zerafshan Valley, 45 Miles below the Glacier.

site Packshiff some of this moraine is seen standing on an irregular surface of alluvium scraped over by ice and partly buried by later waste. So the second glacial epoch came to a close as the third-cycle gorge continued filling. While aggrading, the valley had widened and, ere the next uplift came, established the present terrace G.

FOURTH EROSION CYCLE.

Cycle 4, with the last uplift, has resulted in the present canyon, a channel incised from the last meander held by the river at stage G and thus crossing often the old-filled valley of the third cycle. And in its present torrential fall of nearly 6,000 feet in 150 miles it must be rapidly cutting down. Indeed, the deep rumble and grinding of cobbles heard beneath the river's roar is ample indication of corrasion.

The Zerafshan glacier, with its ancient moraine, its relation to other glaciers and uplift, the fine grindings it has supplied to loess steppes, and its influence on civilization, becomes of great interest. Only one epoch of abandoned moraine could be distinguished, and that remarkably far-reaching and of such antiquity that it must be classed as belonging to the first or second of the glacial periods. I have attributed it to the second, because it still rises from terrace G in good preservation. Nowhere has the first epoch moraine been seen with its topography preserved. Recently the glacier has advanced into a part of the valley that had been ice-free for so long that its sides had struck an even slope to the flood-plain and received a thick coat of loess mixed with talus. Directly in front both valley sides come down to the flood-plain in this fashion. Time enough has elapsed for accumulation of huge deltas and gradual loess-mixed talus-cones, some of them truncated by the river, and the cutting-down of tributary once-hanging glacier valleys to sharp V-sections and canyons on a regular grade to the river since any time when the ice was farther forward than now. As an exception to this it may be said that the glacier is at present in the process of a minor oscillation that makes it about 200 feet short of a cross-ridge of moraine deposited probably some few years ago.

Owing to the depth of its gorge and alpine character of surrounding mountains, the Zerafshan glacier, unlike those of the Trans-Alai and Pamir, is wholly covered with moraine longitudinally banded with the various colors of its different tributary glaciers. But the most significant difference between it and those others lies in its being the only one that yielded no evidence of more than one expansion greater than the present. If the old moraine found half-buried in the alluvial terraces down to 45 miles below the present ice belongs, as seems most likely, to our second epoch, it is easy to understand how that of the first epoch was washed

Fig. 458.—The Zerafshan Glacier.

away by the river during the latter part of the second and early part of the third cycle of erosion. It is not so easy to understand how the fourth erosion cycle could have obliterated third- and fourth-epoch moraines without obliterating that of the second epoch. Indeed, it seems impossible under the conditions involved. There remain two alternatives: either local conditions were such that little if any expansions took place, or the present glacier is greater and obliterates them. But since the glacier is now less than 15 miles long, it seems necessary to assume that there were local reasons why no considerable advance corresponding to those of the third epoch of Trans-Alai and Pamir took place. It seems quite likely that our fourth-cycle uplift of the Zerafshan glacier and its surroundings took place after the third glacial epoch farther east, where glacial conditions may have been accelerated by uplift during or before that epoch. The Zerafshan is now much more actively cutting down than any other large stream met with, and its glacier is advancing* as though the uplift were still in process and accelerating glacial conditions also.

* Excepting the minor oscillation of recent years.

The Zerafshan River is one of the few black rivers of Central Asia. Most of them are red from the gypsiferous beds folded into all those ranges; oxidized sediments apparently deposited under arid conditions similar to the present. Its charge of black stuff comes from the black slates and shales around its glacier, from which fully two-thirds to half its water springs. One of the most striking facts about the river is the increase of volume up- instead of downstream, because after about two score miles from its source more water is lost by evaporation than is gained from tributaries. Therefore, most of its sediment is glacier-ground stuff directly from the ice-cave, the rest from tributary glacial streams taken in a few

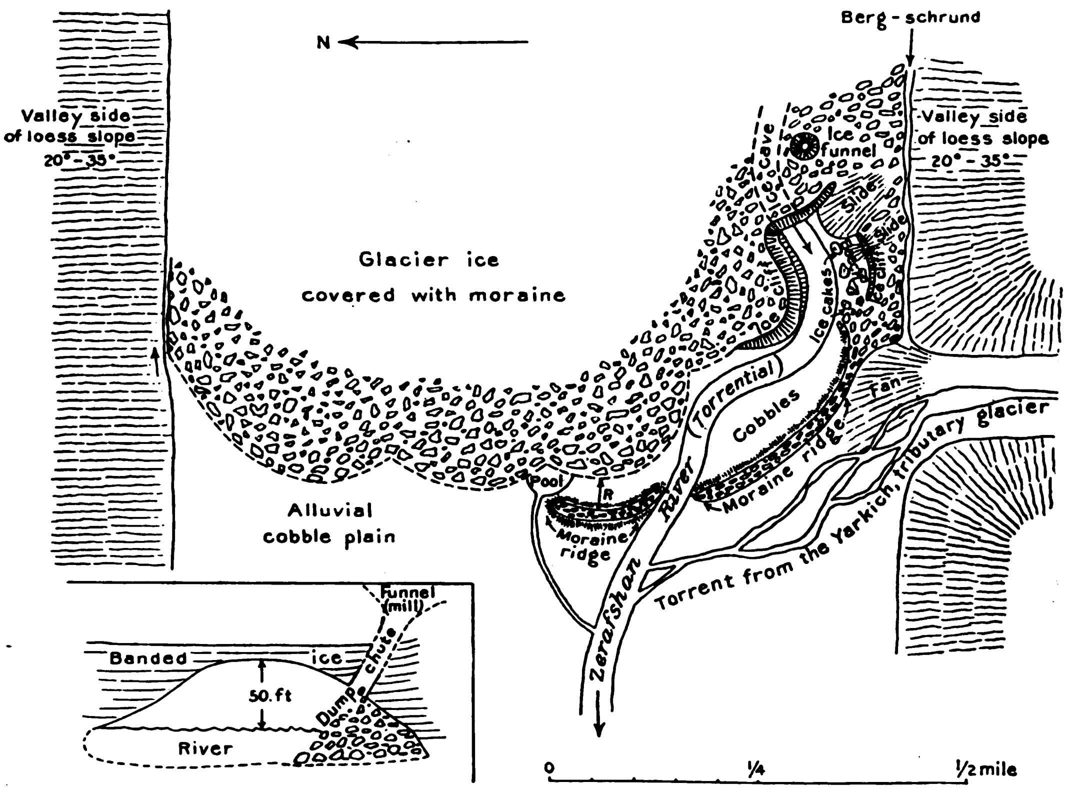


Fig. 459.—Sketch-map of the End of the Zerafshan Glacier (R = Recession).

miles below, and that from cutting-down of its channel. It may therefore be assumed that in total its deposits throughout glacial time till now are mostly of glacial origin, and that the loess derived from it was mostly fine stuff of glacial grinding. In fact, one may attribute a large part of Central Asia's loess to wind-work over the flood-plains of glacial alluviation, especially those of earlier epochs.

The loess steppe of Samarkand has been warped up into a dome about 40 miles across and 100 feet high in the middle and dissected by old distributaries and irrigation canals of the Zerafshan, some of which, notably the Dargum (fig. 461), cross and join again beyond. The interesting structure thus exposed in clean sections up to 100 feet in height reveals an interlapping of pure loess of vertical cleavage with stratified and cross-bedded alluvial grit (fig. 462). Upstream the proportion of alluvium and size of its fragments steadily increase, and about 30 miles above Samarkand the river is flanked by a conglomerate cliff 50 feet high, with an overlying coat of loess as well as some thinner beds of it lower down. Another fact of interest over that same distance is the gradual transition of color from yellow loess at Samarkand to light-gray loess there. Since the flood-plain is necessarily much wider at Samarkand, dust has to drift about more there before coming to rest as loess and thus has more chance to oxidize.

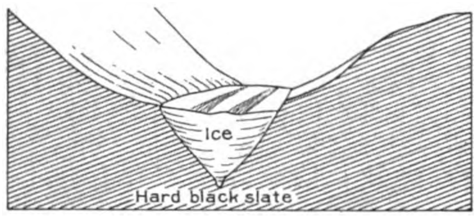


Fig. 460.—Section near the End of the Yarkich Glacier.

THE TARIM BASIN.

EVIDENCES OF PERIPHERAL UPLIFTS.

Passing to the Tarim, western basin of the Gobi, we find its border ranges gashed by gorges with high terraces. The Kizil Su gorge of Tarim and what was seen of its tributary topography is so remarkably similar to that of the Markan Su that one can not help drawing the conclusion that this type is persistent through that region. Uppermost in both we find the old graded-down topography and uplifted piedmont gravel-plains, while between this and the present flood-plain there are various terraces, badly preserved because of the gorge's narrowness. There are also massive remnants of an alluvial conglomerate several hundred feet thick, recording a refilling that took place, a backing-up of waste into the graded widths established after the first uplift and before the second. The region of Aikart Pass, on the Markan Su route to Kashgar, is a massive piedmont formation of half-consolidated gravels from which project some remnant peaks of the underlying highly-tilted red gypsiferous series. It appears to be a piedmont series, laid down during the long preglacial erosion that resulted in the old topography referred to. The whole is now dissected by well-developed valley systems to a depth of over 4,000 feet, having been refilled with 200 feet or more of waste, afterwards reexcavated. Some idea of the amount of silt in these streams was obtained in seeing two basins over half a mile wide, that were formed by landslides only thirty years ago, but now filled with red silt.

At about 25 miles east of Aikart Pass the Aikart valley is confronted by a high transverse fault-scarp of uptilted piedmont. After making a short bend it cuts through this with a narrower and flat-bottomed valley with vertical sides, exposing a piedmont conglomerate inclining gently east downstream. In the mountain valley above there has been a broad refilling terrace cut on one side by a narrow gorge 220 feet deep. But in the uptilted piedmont those traditions do not hold and we have a flat-bottomed channel with narrow terraces rising, perhaps, 30 feet above stream and converging with it downwards.

The principal river which traverses the Tarim basin is the Yarkend Darya, which flows to Lob-nor after having been joined by the Kizil Su from the west, Ak Su from the north, and the Kotan Darya, which heads in Tibet and crosses between 200 and 300 miles of flying sands of the desert nucleus before reaching that trunk-stream. All other streams are consumed in the piedmont zone encircling its vast nucleus of flying sands, and through whose uptilted margins of more ancient alluvium they have carved prolongations of their valleys. The piedmont zone thus becomes of special interest in its exposures of various Quaternary horizons and stands as a structural key to the crustal movements peculiar to its basin as a whole. With its uptilted margins often composing half its width, this zone varies up to a hundred miles across with irregular limits, here and there containing an isolated area of flying sands, no doubt derived from the sifting of its silt.

Fig. 461.—The Dargum Canal in the Up-warped Loess-steppe of Samarkand.

THE UPTILTED PIEDMONTS OF NORTHWESTERN TARIM AS A KEY TO THE PAST.

In northwestern Tarim alluviation of the piedmont zone is nearly confined to that from smaller streams, while the larger systems tributary to Lob-nor traverse or cross it in channels slowly decreasing in depth downstream. If it be crossed on a trail over portions independent of these larger streams and where alluviation from smaller streams is building the playas and gravel-plains of to-day; if we proceed mountainwards over such areas, in the course of 15 or 20 miles from the edge of the great sand behind we come to where no deposition is going on, and there begin shallow channels debouching from the margin of abandoned piedmont to spread below. From there on to the mountains this ancient piedmont slopes up, ever higher, above the streams dissecting it. Riding on to this, we find its dry red silt, left prey to wind, has withered into varied and fantastic forms—a vast deflated area of flat-topped remnants ranged in rows, with wide intervening trenches that are half-choked with heaps of sand. These miniature monadnocks of deflation stand to a general level, while the trenches vary up to 15 feet in depth, exposing red layers of laminated sandy clay, and doubtless range across the direction of prevalent wind, as there is a constancy of leeward overhanging sides. Everywhere they are associated with heaps of sand derived from the silt, of which all finer material has been drifted away, doubtless to settle as loess in grassy mountain valleys. Anyhow, wherever the finer material is now, it has been totally removed by the wind that excavated the trenches and left their sand constituent behind. Another interesting feature is the frequency of large masses of sand piled on top of these ridges, to occupy spaces of calm in the eddies of windwork.

Proceeding still mountainwards, we soon find these trenches of deflation floored by hard gravel-beds, and in the course of a few miles the silt deposit thins out and dwindles into spits and isolated areas on the gravel-plain, giving it a mottled aspect as seen from a distance—mottled only in shade and texture, as both are red. This is the transition from silt to gravel, for in a short distance it is all one vast expanse of gravel or cobbles varying up to 4 or 5 inches in size.

Here, therefore, is record of two significant changes of conditions succeeding each other—first, a mountainward recession of alluviation bringing its zone of fine deposits over its more ancient zone of coarse deposits; second, a dissection of both preceding zones by the channels now occupied, moving alluviation again to a zone farther out than before the first change. It may be that the first resulted from a decrease of precipitation corresponding to that extreme reaction which followed the glacial period, as evidenced by moraine underlying the glaciers of Pamir. That the second resulted from an increase of grade caused by an uptilting of the margins of Tarim will be shown as we proceed.

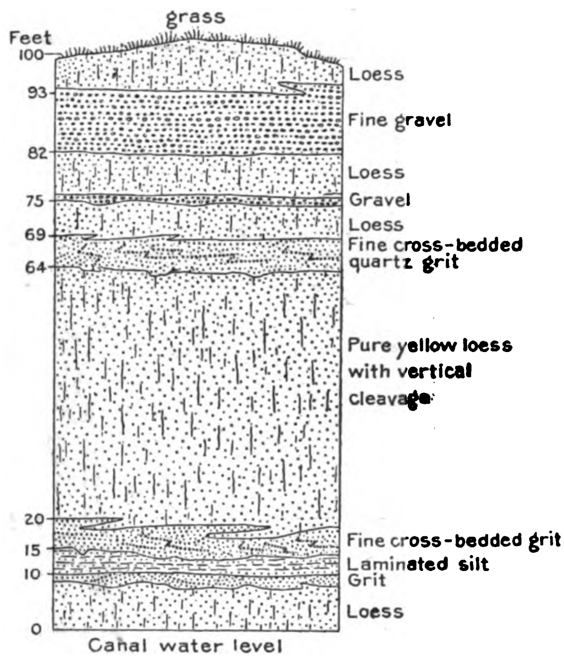


Fig. 462.—Vertical Section of Interlapping Loess and Alluvium in 100-foot Cliff of Obu-siob Canal at Crossing of Road from Samarkand to Kudu Sufi.

Now we are perhaps 25 miles from the great sand, and our abandoned piedmont develops into a bad-land topography, an inclined table-land dissected into a desert of red mountains rising ever higher above us as we ride slowly up the bottom of a canyon. At first the canyon walls are built entirely of piedmont conglomerates with here and there a layer 1 to 3 feet thick of silt, and all in slope conforming to that of the plain above. Then towards the bottom of the wall appears a surface beveling the tilted strata of a still more ancient piedmont series, perhaps the unconformity between Tertiary and Quaternary time. This uptilted series contrasts with that above in being of fine silts and sandstones, with only an occasional bed of conglomerate, and is much more consolidated. But its detailed structure is that of alluvium and appears exactly like those silts deflated on the surface farther out and whose thickness up to 40 feet is exposed in channels cut by larger streams. The beveled strata rise more and more to view with occasional masses rising above their general surface of erosion as monadnocks buried in the later piedmont, and, in time, some ridges rise out into open air, thus taking part in the topography of to-day.

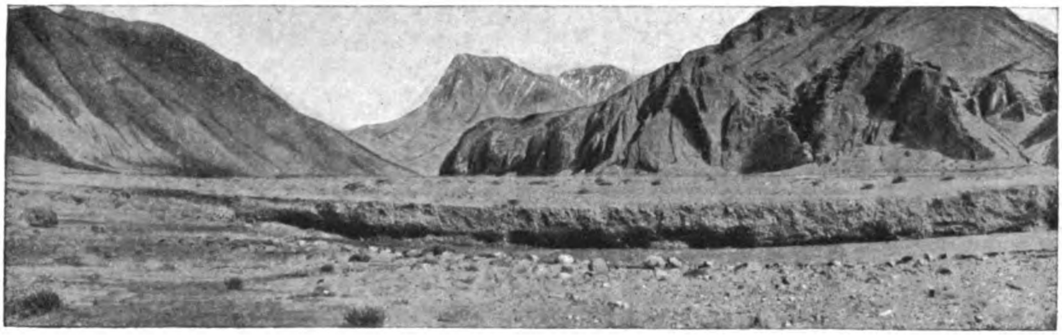


Fig. 463.—Terraces of Markan Su.

The canyon is now perhaps 500 feet in depth and cut half in the older series. Its depth increases to 1,000 feet and more while the older series rises, outcropping from the now much-dissected piedmont more often, until at length we find it as spurs projecting from border masses of ranges entirely composed of it (the older series), and its tilt has steadily increased. These mountains, thus composed of desert piedmont strata built as those now forming, were in Quaternary time the

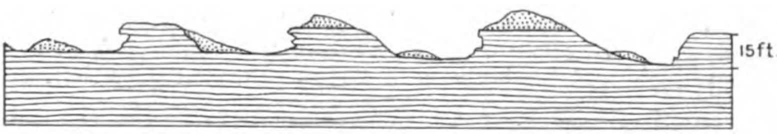


Fig. 464.—Deflated Silts and Residual Sand-dunes (Tarim).

source of the red silts and conglomerates composing the more recently dissected piedmont and are together with them the source of materials laid down on the oasis playas and piedmonts of to-day. Continuing the journey into the mountains there were seen remnants of a high-uplifted and much-dissected topography of mature form and doubtless corresponding to the dissected piedmont derived from them. This topography, none of which may be termed a peneplain, but which nevertheless conforms to that found on the border ranges of Pamir, is doubtless an equivalent of the mature stage found by Davis in the Tian Shan and Bailey Willis in Central China.

Such in general are the great features of Western Tarim. Yet one characteristic of importance should be considered. We have seen how a wide margin of the Tarim basin has been uptilted in Quaternary time, and it may be said that this tilt gradually increases mountainwards, so that a horizon nearly flat in its far-out extension is bent up to 10° or 15° and more near the mountains. Besides this general marginal tilt, there have been more local movements in the form of broad anticlinal arches nosed up, each with a transverse fault-scarp facing mountainwards and surmounted by its anticlinal surface sloping gently back into the plain. These "up-nosed" piedmont strata, bent behind and faulted out in front, some of them rising as high as 500 feet out of the plain, range about parallel to the bordering mountains and are found even as far out as Kashgar.

EVIDENCE OF RECENT CHANGE TO EXTRA DRY.

The last great change over the Tarim basin has been one of desiccation. Of this we have both physiographic and historic records, which tell that it became serious about a thousand years ago, when some hundreds of cities were overwhelmed by sand. Some of these ruins were excavated by Stein, and Mr. Pumpelly found mention of them in Chinese literature in the imperial archives of Pekin. It is also believed there were then expansive bodies of water of which Lob-nor and other shrunken lakes and brackish tarns are the withering survivals. During the time of greater precipitation much of the great area of dunes throughout Tarim was doubtless grassed over, and we may thus ascribe its burial of cities to sand set free when rainfall had so seriously decreased that grass failed and left the dunes bare and free to drift.

TENTATIVE RECONSTRUCTION OF THE PAST IN TARIM.

First cycle (Pliocene).

- The Tarim basin defined with high border ranges eroding to mature topography and building immense piedmonts of gravel, sand, and silt.

Second cycle (Quaternary).

- Uplift of border ranges, with deep gashing of old topography and sinking of plains, with upbending margins worn down by streams beveling their tilting strata, with an erosion plain and the building of a later piedmont over that.

Third cycle (Quaternary).

- Second uplift of border ranges, with terracing down of valleys partially alluviated ere the close of the second cycle, and marginal tilting up of plains with dissection of their second-cycle piedmonts? Shrinkage of alluviation at close of the glacial period and recession of silt zone over gravel zone.

Fourth cycle (Postglacial).

- Third uplift of border ranges with stream-channeling of valley flood-plains of glacial alluviation during the third cycle, and more sinking of plains with tilting and dissection of their third-cycle piedmonts.
- Recent decrease of precipitation, shrinking of rivers and lakes, and desolation of dune pastures, setting free the sand that buried the cities of Tarim a thousand years ago.

THE FERGANA BASIN.

ITS BROAD OUTLINES.

The Fergana basin lies north of the Pamirs as a deep embayment between the Alai Mountains and Tian Shan, or rather between two far-western members of the Tian Shan that branch out and nearly join again in the west to form a structural depression. Its plains, about 200 miles long and 50 miles wide, are thus nearly closed around by high mountains and connect with those of the Aralo-Caspian basin, of which it is a tributary, through a western gap only 15 miles wide, of which over 10 miles is blocked by half-buried mountains. Though it has doubtless accumulated most of its erosion products, an important portion must have escaped in the Syr Darya, through the outlet to be accumulated in the greater basin. With its border ranges the Fergana basin attains a maximum relief of 18,000 feet, while passes stand ordinarily about 13,000 feet above its lower plains of 1,000 feet elevation above sea. As an organic whole it approaches nearer the ideal type of basin than any other one considered by us. Its high mountains have responded to a varied series of glacial changes, and its nearly self-contained state has resulted in the differential crustal movements characteristic of such basins.

The Alai Mountains ranging along its southern border rise rather abruptly as seen from Marghelan. From there they appear as high snow-mantled pyramids and giant peaks with cliffs truncating broad sloping fields of crevassed snow and ice. This high crest ranges east and west behind a flanking mass of rather flat-backed mountains with but few projecting horns—a high, uplifted, outlying mass, once base-leveled, but now deeply gashed by gorges that end abruptly to open out in a fairly even line. It was shown in my report of 1903 that the Alai Range appears to have been thrice uplifted in Quaternary time.

ALAI EROSION CYCLES (BASED ON TALDIC PROFILE).

First cycle (Preglacial).
- Pliocene, Alai worn to low relief and half-buried in piedmont deposits with projecting monadnocks.

Second cycle (Quaternary).
- Uplifted about 1,500 feet and gashed with valleys that widened after uplift had ceased and partly refilled as the plains aggraded, raising their base-levels.

Third cycle (Quaternary).
- Uplift tilting the transverse horizontal till the dissected northern side was about 3,500 feet higher than the buried southern side; valleys then alluviated again as in the second cycle.

Fourth cycle (Postglacial).
- Uplift of about 100 feet with canyoning of third-cycle flood-plain still continued.

UPLIFT OF THE TIAN SHAN.

In the Bural-bas-tau of Tian Shan, northeast of the Fergana basin plains, Professor Davis found a key to the history of that side. He states:

> The evenness of the plateau-like highland, all snow-covered at an estimated height of at least 12,000 or 13,000 feet, was most remarkable. . . . It must have gained its present altitude with comparative rapidity, and in geologically modern time. . . . . When it still lay low, the lowland of which it was a part must have been much more extensive than the present highland; for lowlands can not be worn down on resistant crystalline rocks without the very general reduction of all neighboring and quiescent structures.

And, as he goes on to say, the fact that some of the Tian Shan ranges are now gashed into more alpine form means that "they were somewhat less worn-down in the previous cycle of erosion, or, like the Dongus-tau, already more consumed (owing to greater uplift or to weaker structure) in the present cycle of erosion or both."*

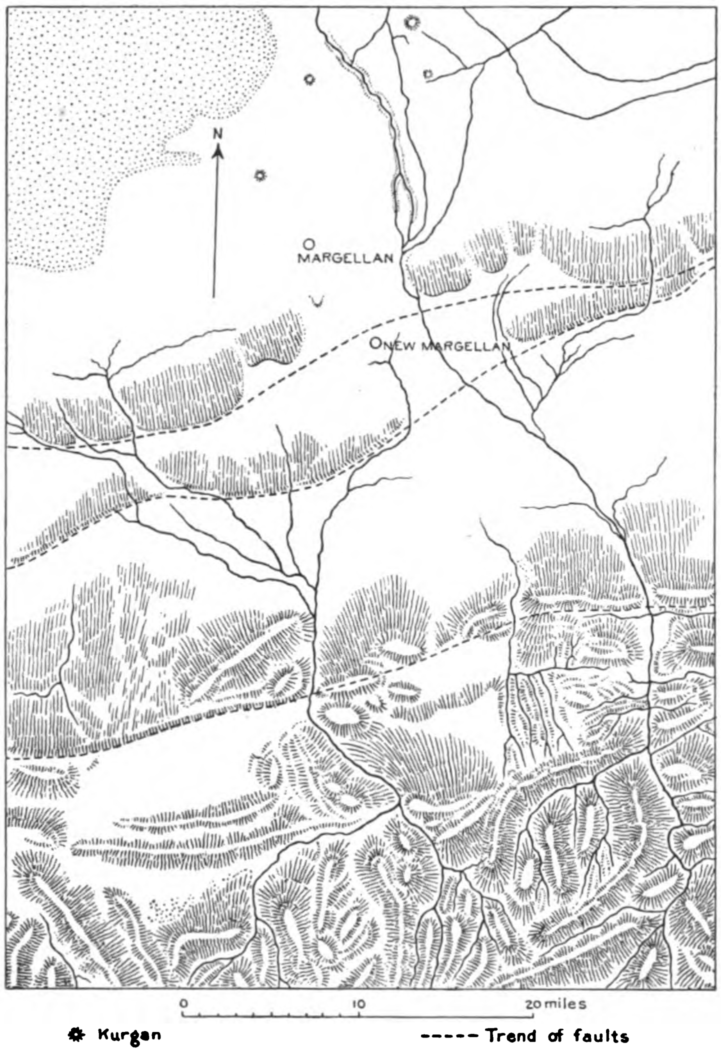


Fig. 465.—Uptilted Piedmonts of Marghelan.

In the Fergana basin we have, as already hinted, a remarkably good example of the differential earth-movements characteristic of a sinking deposition area with uplifting of eroding border ranges. And there, as in the Tarim basin, this movement has involved an encroachment of mountains on plains through uptilting of their margins. We have seen how, with the Alai Mountains, uplift was periodic with intervening times of quiescence, which with the Taldic gave rise to four erosion cycles, the first one closing in Central Asia's peneplain stage, and how

*Carnegie Institution of Washington Publication No. 26, Explorations in Turkestan, 1903, p. 73.

that low relief was dissected during the following three uplifts with their erosion cycles. It is gratifying to find corroboration of this threefold division of uplift in the structural deformations of plain-deposits derived therefrom. There are three rows of uptilted piedmonts ranging parallel to the Alai Mountains, as the three respective marginal deformations corresponding to the threefold uplift both in magnitude and degree of subsequent erosion. It is further interesting to find that these three belts of uplifted piedmont, which converge towards the mountains opposite Khokand, near the western or lower end of the basin, widen eastward to include a considerable area of the eastern end of the plains, where deposition has necessarily been much heavier, as that portion lies before a vast mass of high-uplifted mountains. Another feature affected by this process and characteristic of the Fergana plains, especially on their Alai side, is the threefold, and sometimes fourfold, division of distributary systems. Larger streams descending from the Alai cross all three belts of uptilted piedmont, having cut down as they were uplifted, and apportion their depositions over areas between them, some escaping beyond the last to spread towards the middle of the basin. Each stream, therefore, gives rise to from two to four successive groups of delta-oases, thus giving an interesting variation of type I*a* of my classification. In several instances a stream escapes from its first delta in two or more distributaries to form other deltas beyond, so that the intervening uplifted ridge of piedmont has been dissected by two or more channels separated by many miles (fig. 465).

The oldest belt of uptilted piedmonts bordering the Alai Mountains probably contains products of the first erosion cycle and was thus upheaved during the uplift which caused the breaking up of its peneplain stage. On the Terek trail between Osh and Gulcha it attains a height of over 3,000 feet above the present Gulcha River flood-plain. There it is a mass of loosely cemented conglomerates with confused dips, and of which the old surmounting piedmont topography has nearly disappeared. The later upheavals of plain-deposits rarely rise more than a few hundred feet above present deposition.

Where we approached the northern margin of the Fergana plains in the regions of Chust and Khojent, only one belt of uptilted piedmont was observed, probably because the mountains on that side are much lower and doubtless have been so in the past. This one belt, however, is of especial interest as it can be traced all the way from Namangan to Khojent, a distance of about 140 miles, and crosses the Syr Darya, which has cut down as it was uplifted.

From the standpoint of hydrography alone, the Fergana basin expresses the same series of cyclical events deduced from the topography and structure of its mountains and plains. In the mountains larger streams join at oblique angles and generally inherit the courses held before the first uplift of the low relief then drained by them. Their smaller tributaries contrast with this rule by joining the larger nearly at right angles and have come to be since that uplift. We have seen how streams descending from the Alai split into distributary systems in a manner determined by the marginal deformations of the plains and that feature may be recognized with a glance at the hydrography on a large-scale Russian map.

PRESENT OSCILLATION IN THE DEPOSITION ZONES.

Four out of the five zones of deposition characteristic of a desert basin are found in Fergana, namely, glacial, alluvial, flying sands, and loess, while the lacustrian is lacking. An area of about 500 square miles of the central portion of the basin forms its nucleus of flying sands, while two other smaller nuclei of dunes are found in its western half—one just west of Khokand, the other crossed by the Syr where this basin narrows near Khojent at its western end. Most of the alluvial zone is barren gravel steppe and only its small areas of silt give rise to oases. Loess is nearly confined to its bordering uplands, a portion of which is composed of uplifted piedmont structures. The nuclei of flying sands are now expanding, steadily encroaching on the alluvial zone as its perennially flooded areas decrease, a fact evidenced by Russian and native records as well as our own observations. A considerable part of the loess zone, its lower areas, is now dead and suffering erosion, while living grass-covered areas have shrunken to pastures ranging above 4,000 to 6,000 feet.

RECONSTRUCTION OF PAST EVENTS OF THE FERGANA BASIN.

First cycle (Pliocene).

Pliocene basin defined with high relief of border ranges eroding and building the plains of waste under desert conditions. Cycle closes with the low relief of Central Asia's peneplain stage.

Second cycle (Quaternary).

High block uplifting of border ranges with gashing of their mature first-cycle topography, and corresponding marginal upbendings of the piedmonts constructed by the first cycle. Closes with well-widened mountain gorges partially alluviated.

Third cycle (Quaternary).

Similar to second, but of less magnitude.

In the Alai Range, characterized by tilting of uplifted blocks raising that side next the plains. Nothing is yet known about it in the Tian Shan to the north. Its marginal deformations of piedmonts built by the second cycle were on new lines farther out on the plains than those upheaved by the second cycle.

Fourth cycle (Postglacial).

Similar to the second and third, but of much less magnitude and still in the uplifting stage.

Marginal deformations of third-cycle piedmonts on new lines still farther out on the plains. Climate in process of desiccation, flying sands expanding, alluvial activity shrinking, living loess areas shrinking to higher limits.

This reconstruction of the past is of course purely tentative and subject to subdivision with cycles of less intensity or duration.

THE ARALO-CASPIAN BASIN.

COMPLICATIONS AND FUNCTIONAL PECULIARITIES ARISING FROM SHAPE AND SIZE.

The broad definitions and most of the great features of the Aralo-Caspian basin have been so well set forth by Professor Pumpelly that little more than a description of its four deposition zones remains to be here undertaken. In the Tarim and Fergana basins we found that plains of deposition and their deformed margins express fully as much as their bordering mountains do, and perhaps even more, of the history of their basins. This is especially so of the Aralo-Caspian, where lacustrian zones become an important aid. Its peculiar shape and but half-isolated state, with naught but low divides north and west, have given it a history so involved and complicated with outside influences that we must be contented with explaining only a very few of its greater features and direct our attention to those concerning the archeology of its southern part.

An important part of its physiography has already entered this report in undertaking that of the Pamir, Alai valley and Kizil Su, Karategin and Hissar, Zerafshan, and Fergana basin, which taken together compose most of its high eastern drainage area. In considering the immense area of high mountains drained

Fig. 466.—Manish Valley Terraces (in the Kopet Dagh Mountains).

by the nine rivers—Ural, Chu, Syr, Zerafshan, Amu, Murg-ab, Tedjen, Atrek, and Kur—and the great flow of water brought in by the Volga, draining all of Eastern Russia, we must marvel at the degree of aridity signified by such a small area of water exceeding evaporation as that which survives in the Aral and Caspian—its two shrunken seas. Only half its larger rivers reach their seas at all, while the remainder with scores of other streams, by no means small, dwindle away on the plains, and others fail to reach even the plains, but die far up in the valleys they excavated when precipitation was heavier. Central-Asian hydrography is thus often the reverse of drainage systems in regions of ordinary rainfall familiar to most of us. Many of its rivers have the aspect of a drainage system reversed as they decrease in size downstream and finally split into distributaries resembling tributaries on the plain.

The evolution of a basin so large as the Aralo-Caspian can not be expected to have been through the cyclical uniformity followed by a small basin with a complete periphery of mountains. Indeed, it is so large that there is no surprise in finding that different portions entered from time to time into fairly independent series of changes, or developed in a way causally connected only in a broad sense.

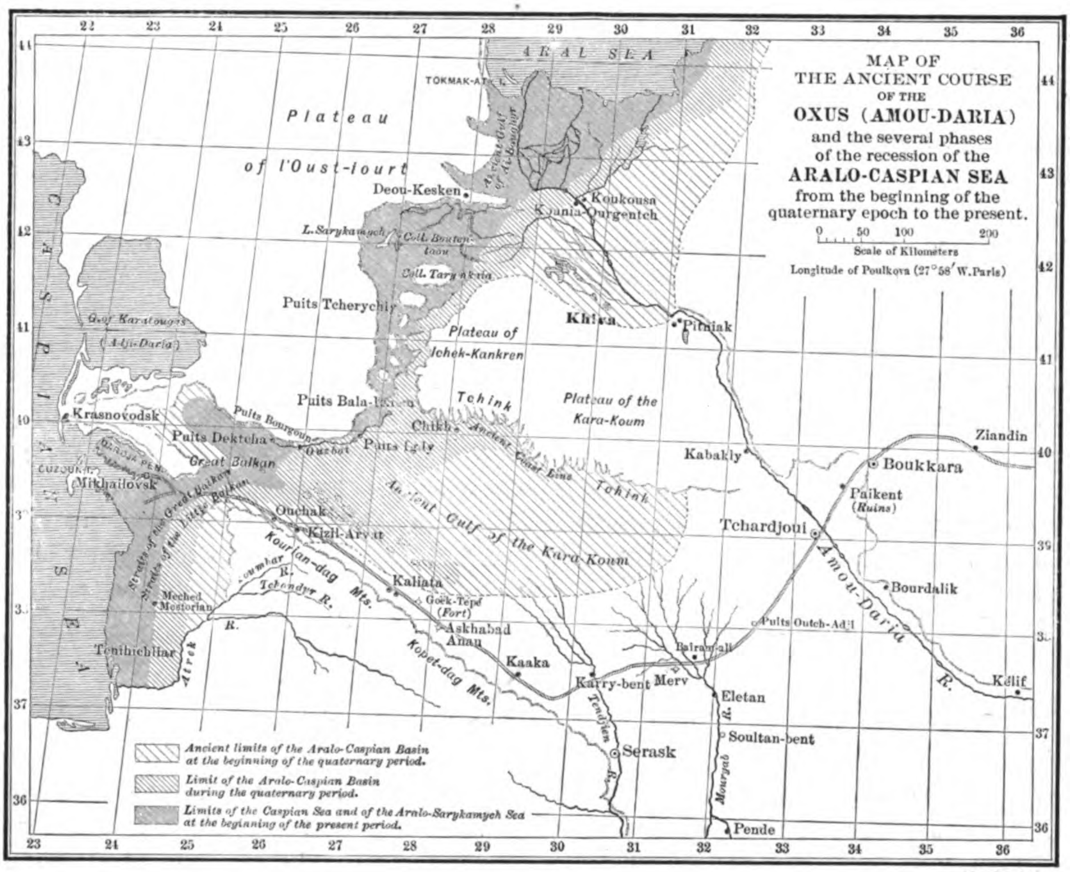
To begin with, the mountains directly bordering it have contributed but a small portion of the sediments spread before them. The Amu, for instance, brings most of its load from many hundred miles behind the border ranges, whereas these border ranges probably had the benefit of rising to give way for sinking of most of that load, if the differential movements of sinking plains of deposition and rising of worn-down mountains resulted from such a displacement. Another deviation from the ideal type is a serious difference in height of mountains from east, where they rise to over 20,000 feet, to west, where the Kopet Dagh attain a maximum of only 9,000 feet. And this difference appears to have been no less in Tertiary time, for no crystallines have yet risen to view in the Kopet Dagh, though the Pamir and Tian Shan have weathered to their granite cores. More sediments were, therefore, loaded onto the plains in the east, and we find that mountains there were uplifted higher and more often than the Kopet Dagh, where only one really great erosion cycle appears to have followed the peneplain stage, though the second and third uplifts are recorded on a small scale. Besides all this, the plains have been seriously warped, a fact evidenced by channels of the Oxus and Zerafshan and other streams, probably as a result of the great difference of deposition load over different areas.

Perhaps even more serious than these internal organic peculiarities must have been the climatic complications arising from external sea connections. A recent connection between the Caspian and Black Seas through the Manitch, north of the Caucasus, and a more remote overflow of an Aralo-Caspian Sea through Siberia to the Arctic, limit the possibility of climatic calculations based on determinations of sea-water areas. The moment an interior sea either overflows or receives an influx from some other basin or of tide-water, its surface area ceases to be a function of climate. And, on top of all this, the river Don, behaving in the uncertain manner of a large aggrading river, may have flowed alternately into the Caspian and Black Seas. It is, however, hoped that a more complete study of the past and present marine fauna and flora of the Aralo-Caspian Basin may decipher most of these remarkable hydrographic variations.

THE LACUSTRIAN ZONE (ARALO-CASPIAN SEA EXPANSIONS).

Its lacustrian or marine history, though involved, affects such a large area and throws so much light on its climate, especially during archeological time, that it becomes of first importance. Russian and other geologists have naturally directed special attention to this aspect of the basin, but their work has so far been lacking in quantitative results. After the early Tertiary upheavals of its peripheral mountain ranges, a Tertiary sea, perhaps at first connected with the Mediterranean and Arctic, appears to have shrunken till in late Tertiary time it washed the oldest shores indicated on Konshin's map (fig. 467). From that it withered into an Aral and Caspian with shores below those of to-day. This fact, recognized first by Davis, is demonstrated on both sides of the Caspian, where valleys dissecting its high-level Tertiary sediments are contoured up to 200 feet and higher by shore-lines of its later Quaternary expansions, but extend down under water or are drowned by the present level. This reasoning is enforced by Walthers's statement that in a well-boring on the Caspian shore, southeast of Krasnovodsk, dune-sand was penetrated to a depth of 35 meters below the sea-level.

Therefore, a long interval of subaerial erosion elapsed after the Caspian had shrunken from its great Pliocene Aralo-Caspian expanse to below its present level, and before it rose to its higher Quaternary shores. Assuming that it expanded from this low level, called early Quaternary by Davis, to unite again with the Aral and transgress the Kara Kum, we have an early Quaternary cycle of desiccation



After Konshin

Fig. 467.—Map of the Aralo-Caspian Expansions (Konshin).

as distinct from the Pliocene. During this it appears to have fallen to lower and lower shores till but a narrow connection existed between the Aral and Caspian through the Sari Kamish Basin. In the course of desiccation both seas shrank till this connection became an overflow of the Aral through the Usboi channel to the Caspian, which is probably an historic stage.

Davis's recognition that "the Quaternary sea resulted from an expansion of a smaller early-Quaternary sea, to which the waters had shrunk from their great Pliocene extension," becomes of importance in that it demonstrates a pre-glacial aridity more pronounced than that of to-day. And if we place the great

Pliocene sea contemporaneous with the peneplain stage of its peripheral mountains, and the very shrunken early-Quaternary sea with the following high-uplifted stage of those mountains, still preglacial, the phenomena fall into organic accord; for the surface area of a landlocked sea is a direct function of the climate of its basin—the climate of its basin varies with the general continental geography and all mundane climatic change. Of the geographical factor, most important is variation in the shape of the basin; and, as shown in preceding sections, this shape changed through a series of erosion cycles with uplifts giving its periphery alternately low and high reliefs.

Assuming, then, that the great Pliocene Aralo-Caspian Sea belonged to the peneplain stage at the end of our first erosion cycle, and that the early Quaternary, low Aral, and Caspian shrunken survivals of that sea belonged to the high-relief stage of its uplifted periphery of mature mountains dissected during our second erosion cycle, we are next confronted by the later wide-expanded Aralo-Caspian Sea. Knowing that during the third and fourth erosion cycles this basin suffered a great mundane change of climate in the glacial period, it is natural to correlate phases of its high Quaternary sea with assumed increases of precipitation belonging to the glacial epochs. Although we do not, as yet, know how many phases there were to the high Quaternary sea, it might roughly be called a glacial sea, leaving the epochs to future exploration. It may be that Konshin's next lower Aralo-Caspian shores, when the Gulf of Kara Kum had dried out and only a strait running south of Ust-Urt connected the Aral and Caspian, were postglacial. This brings us into the third erosion cycle of its high eastern drainage; and the following uplift, ushering in our fourth erosion cycle, might account, in part at least, for the last historic shrinkage, severing the Aral and Caspian from their recent Usboi overflow connection to the two low seas of to-day—withered survivals of a glacial mediterranean.

RECENT DEVELOPMENTS IN THE ALLUVIAL AND FLYING-SANDS ZONES.

Turning to the other three lowland zones of deposition, we find additional data, especially on the more recent developments of this great basin. Glancing at a large-scale map we see most of that area from the Caspian to the high eastern peripheral ranges covered by dune-sand. Russian geologists have ascribed that of the Kara Kum to deflation of its Quaternary sea deposits. But, as we have shown, vast nuclei of flying sands inevitably accumulate from wind-work over the silted flood-plains of a desert basin, and all areas of its plains in the neighborhood of alluviation, whether or not far removed from ancient sea deposits, are characterized by them. We, therefore, differ by attributing much, if not most, of the Kara Kum sands to wind-work over the flood-plains of late Quaternary time. Some of it was undoubtedly derived from deflation of marine deposits, but those deposits are much more resistant than fresh-dried alluvium, especially than the sandspits of its distributary channels. In either case all the sand is ultimately of alluvial origin.

The wide-expanded zone of flying sands we find surrounded by an alluvial zone, narrow between it and the southern peripheral ranges, but widening eastward over the Hunger Steppe and Fergana plains, *i. e.*, widening in proportion to the height of mountains drained. This alluvial zone, furthermore, extends into the great Sand, where it is penetrated by the rivers Tedjen, Murg-ab, and Zerafshan, and where it is divided by the rivers Syr and Amu crossing to the Aral Sea. Now, it is a fact of significance that all five of these large rivers, as well as many smaller ones that still reach, or have recently reached, well out onto the plains, have cut channels from 10 to 100 feet or more in depth to where they debouch over deltas. It is, moreover, characteristic of these channels that they vary in depth in such a way as to indicate a varied warping of the plains. And though most of them are still occupied by streams, there are many instances of channels now always dry, but so recently abandoned by the streams now ending many miles above in a shrunken condition that ground-water still survives, obtainable in shallow wells of the nomads. On our large-scale Russian maps there are remarkable fragments of such channels so far removed from present alluviation that it is difficult, sometimes impossible, to say what river they belonged to. Others appear to have been the work of distributaries cutting into the plains they had once overflowed. Where distributaries have been thus incised, we have definite proof of crustal movement. Our most striking examples of distributaries cut into a warped plain are afforded by the Zerafshan, while of those cut into the zone of uptilted piedmonts we find most remarkable examples along the southern border of the Fergana plains.

The vast alluvial zone of this basin was built by its rivers when they wandered freely. Now most of them are relatively fixed. That the Turkoman Trough was at one time the Amu's flood-plain, when that river flowed to the Caspian, building the immense deltas characterizing the coast south of Krasnovodsk, seems more than likely. That would be postglacial. Then it and doubtless most of the large rivers were unconfined and spread a large portion of their load on the plains, whereas silt of the Amu and Syr of to-day is mostly in transit to the Aral. This period of free-shifting rivers with unconstrained alluviation was followed by warping. Here we must remember the postglacial uplift of mountains, the peripheral uplift of our fourth erosion cycle. The warping of plains, uptilting of their margins, and uplift of their border ranges fall logically together into one cycle of a basin's differential movements. As a confirmation of this idea we have the corresponding increase of aridity, shrinkage of sea-water area, contraction of streams, shrinkage of living loess, and expansion of flying sands, and, finally, depopulation of oases.

RECENT CHANGES IN THE COURSE OF THE OXUS (AMU DARYA).

The archeologic and historic period of this basin is treated under "Physiography of Oases," chapter XV, this report, but there has been so much discussion about historic changes of river courses, especially of the Oxus, that a physiography of the basin must take up the problem. Élisée Reclus states:

The great changes that have taken place in the course of the Oxus within the historic period are amongst the most remarkable physiographic phenomena, comparable in recent times only to the periodic displacements of the Hoang Ho. . . . . In the days of Strabo the Oxus, "largest of all Asiatic rivers except those of India," flowed to the Caspian, and the trade between the Euxine and India followed this river, continuing the valley of the Kur eastwards of the Hyrcanian Sea. But in the time of the first Arab and Turkish writers, the Oxus, described by Edrisi as "superior in volume, depth, and breadth to all the rivers of the world," had been diverted northwards to the Aral. In the fourteenth century it had again resumed its course to the Caspian, towards which there is a relatively steep incline, for the bifurcation of the present and the old bed below Kunya-Urgentch is 140 feet above the level of the Aral, and 380 feet above that of the Caspian. The new channel was blocked for about 200 years; but towards the middle of the sixteenth century the Amu, for the second time during the historic epoch, shifted its course from the Caspian to the Aral.

If so, it has followed the present course for only about 350 years.

These facts, based on the writings of classical and medieval travelers, and ancient maps, make it appear as though the Oxus were normally an affluent of the Caspian. It was not until the last few decades that actual physiographic study of the region opened up another side to the question. Konshin, Mushketoff, Sievers, Hedroitz, Lessar, and Somkoff have made special study of the problem. The now dry Usboi channel, from just south of Krasnovodsk, skirting around southeast of the Ust-Urt northwards to the tarn of Sari Kamish, has thus been a great subject for controversy. Few geographical problems have become more familiar than the question as to its origin. At first it was naturally taken for the historic course of the Oxus. Élisée Reclus, in reviewing explorations up to the time of his great work, was sure that it was. Conshin, after exploring it for two years, decided that the Oxus had never flowed that way directly, but that it was an ancient channel through which the Aral overflowed to the Caspian.

The data now at hand are as follows: The Usboi is a channel in the unconsolidated sediments of the steppe, starting southwestward from the Sari Kamish basin and thence skirting around the Ust-Urt escarpments down into the Balkhan Gulf of the Caspian, a distance of over 200 miles, with a total fall of about 234 feet; it averages 60 to 70 feet in depth, about 3,000 feet in width, and resembles a river-bed with occasional islands and rapids, and in it still survives a series of brackish "*shores*" or pools. Three ancient distributaries of the Amu, channels now dry, run from the Amu's present delta into the Sari Kamish basin. Élisée Reclus states that during the inundations of 1878 the river discharged 31,500 cubic feet per second to the Sari Kamish. That it formerly flowed there regularly is evidenced by two epochs of ruined towns and cities along the abandoned courses. As there are no ruins along the Usboi, its water is supposed to have been brackish.

The Usboi is, therefore, supposed to have been an overflow channel from the Sari Kamish, into which both the Amu and Syr have emptied. As the divide between the Aral and Sari Kamish basins appears to be at least 60 feet above that between the Caspian and Sari Kamish, the Aral was doubtless dried up when both its rivers were thus diverted, and only a small lake at whatever time the Oxus alone flowed west. As a full Sari Kamish sea would be of much less surface area than the present Aral, or about 130 by 70 miles, the Usboi would still receive an overflow if both rivers were again diverted there. The Usboi, therefore, throws no light upon the climate of our basin. But the more ancient stage of a wider strait or continuity of level between the Aral and Caspian, that stage which

Konshin believes to have followed the high Quaternary sea, is another, more ancient, and indicative of a different climate.

Though thus forced to disbelieve that the Oxus ever flowed through the Usboi, we can not utterly discredit the writings of geographers and travelers so renowned as Ptolemy, Strabo, Pliny, and others. Assuming that during one or more periods of the past two millenniums water of the Oxus did flow to the Caspian, there are two alternatives: First, that the Usboi overflow, as a continuous waterway from the Caspian up the Oxus, might have been referred to as the Lower Oxus; second, that the Oxus may, in historic times, have flowed to the Caspian through some other channel. As both the Aral and Sari Kamish were through whole centuries omitted from writings and maps, it would seem that whatever waterway there was must have been far south of them or that they were dry. On the other hand, there appears to be little doubt that the Oxus recently flowed west from near Charjui through the Turkoman Trough and so into the Balkhan Gulf. This channel, the Kelif Usboi, or Ungus, indicated on Russian maps and known to the Turkoman, has not attracted government exploration as an engineering project, such as the Usboi of Ust-Urt, and must therefore remain only a possibility.

However often the Oxus may have shifted, or whatever course it may have followed in reaching the Caspian or in contributing overflows to that sea, the total surface area of sea-water in the Aralo-Caspian basin would have been but little, if at all, affected by such oscillations. The River Don problem is more serious from this point of view. The Don, converging with the Volga to a point about 350 miles north of the Caucasus, now bends sharply away from there and flows to the Black Sea. There appears a possibility that it was once a branch of the Volga. The change of course may have resulted from faulting across the channel, and the river's grade is very slight—only about 5 inches to the mile. But if it ever did flow to the Volga, the change to its present course was so long ago that time enough has elapsed to cut the present wide Don valley in consolidated rocks. Assuming that Don water flowed to the Caspian before earth-movements forced it westward and to cut a deep channel in the plains, the surface area of Aralo-Caspian sea-water would not have been so much increased as might first appear the case. It is much smaller than the Amu and yet the Amu and Syr together maintain a surface area of only 26,300 square miles—that of the Aral. If the Don were now diverted to the Caspian, it might raise it till its surface area increased by perhaps 10,000 square miles. But that would change its present outlines but little except over the low marshes of its northern end, while the Kara Kum would be transgressed by some few miles. The Don, therefore, can not have effected any of those great changes we are discussing.

TENTATIVE RECONSTRUCTION OF THE PAST IN THE ARALO-CASPIAN BASIN.

First cycle (Pliocene).

Opens with high relief of Pliocene mountains.

Closes with low relief of Central Asia's peneplain stage; great Pliocene Aralo-Caspian Sea; broad continuity of grass over the plains and gently rolling steppes of their worn-down peripheral mountains.

Second and third Cycles (Quaternary).

Preglacial: High uplift of peripheral mountains and general sinking of plains with upbending of their margins; change to high relief brings intense aridity and shrinkage of the great Pliocene sea till separated into an Aral* and Caspian as small if not smaller than the present. Most of what was water and grass in the first cycle is changed to barren desert.

Glacial: Toward the end of the second cycle there begins the first epoch of the glacial period with its increase of precipitation† effected by mundane change; expansion of valley glaciers and ice-domes in the mountains, and birth of the great Russian ice-cap; swelling of rivers and seas till all unite into one hydrography, an Asiatic mediterranean reached by all the rivers of its basin; broad continuity of grass steppes and moderate climate with vast accumulation of loess. Between the second and third cycles a second peripheral uplift takes place with a sinking of the plains and marginal deformations of the piedmonts. A long time lapses between the first and second glacial epochs and these are followed by a third and possibly a fourth epoch.

Postglacial: The glacial sea (survives a while longer?) supported by melting of the last epoch's ice, and maintains a moderate climate. As glacier ice vanishes, desiccation prevails under return to normal aridity and the sea withdraws to lower and lower shores till only the Usboi overflow connects the Aral and Caspian. It is a period of free alluviation over steppes abandoned by the sea; a period of incalculable wandering of large rivers, and vast accumulations of flying sands.

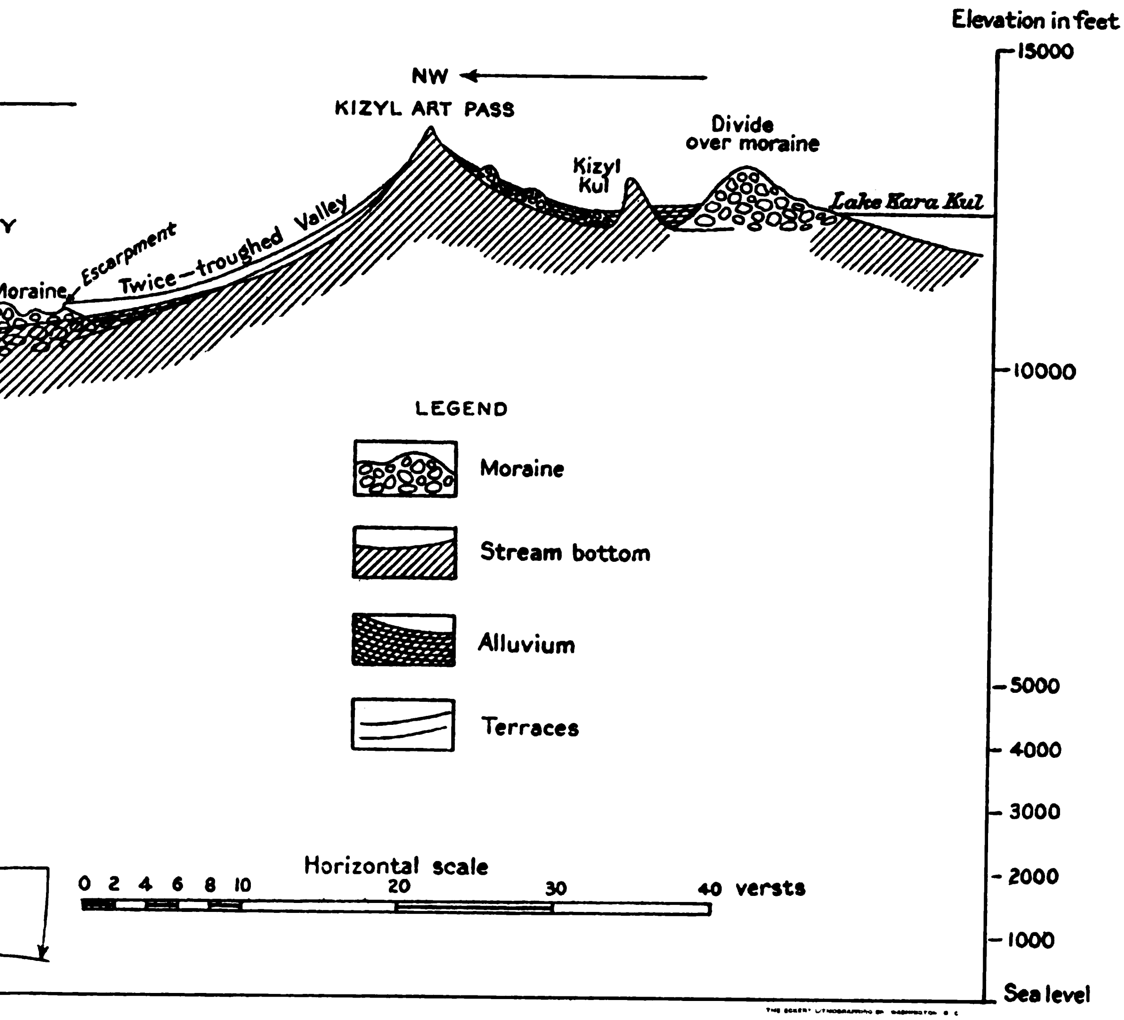
Fourth cycle (Archeologic).

Uplift of peripheral mountains (so far slight, but still in process), and sinking of plains with varied warpings and marginal deformations; consequent incision of water-courses on the plains constraining alluviation to limited areas (and deep dropping in of the Caspian Sea floor in its southern half?); shrinkage of sea-water area severing the Usboi overflow (uncertain shifting of the Amu and Syr between the Aral and Caspian, twice leaving the Aral—once before Christ and once 1550 A. D.—as a shrunken marsh or lakelet with little or no influx?); recent 200–300 feet recession of glaciers; contraction of streams, shrinkage of living loess, and expansion of flying sands; depopulation of withering oases.

---

*The Aral may have dried up entirely.

†It may have been colder, but we have no proof either way.


Elevation in feet
15000
10000
5000
4000
3000
2000
1000
Sea level
NW
KIZYL ART PASS
Divide
over moraine
Kizyl
Kul
Lake Kara Kul
Escarpment
Twice-troughed Valley
LEGEND
Moraine
Stream bottom
Alluvium
Terraces
Horizontal scale
0 2 4 6 8 10 20 30 40 versts

CHAPTER XV.—OASES.

THE OASIS AS A GEOLOGICAL PROBLEM.

MAN AS A GEOLOGIC FACTOR IN EXCAVATION, TRANSPORTATION, AND DEPOSITION, AND A DIRECTOR OF ALLUVIAL DEPOSITION.

How early man appeared in the region is a question that may never be solved, but the problem of the comparative antiquity of human records is more possible of solution. There are, geologically speaking, two kinds of human records—(1) cuttings, such as canals, trails, tunnels, wells, pictographs, rock inscriptions, etc.; (2) depositions, such as the débris of occupation, burials, and scattered remains. Those of the first kind, having been executed on the topography and bare rock of the land, remain where made until obliterated by erosion or burial. Those of the second kind are aggregations or single articles, of materials transported by man independent of the laws of natural transportation, and in defiance of all change beyond those of a single generation,* and are, therefore, especially subject to erosion and transportation in regions of erosion; and to erosion and burial direct, as well as redistribution and burial, in regions of aggradation. Besides all these natural changes, remains especially of the second kind may be modified or shifted by succeeding generations of man.

The immense accumulations of débris in cities and towns, accumulations brought together during long occupation, are of course by far the most important remains and belong to those of the second kind, deposition. It is of especial importance to analyze the structure of such an accumulation and have some understanding of the controlling factors in its growth. With the exception of a few public buildings of burnt brick in the larger cities, and a few cobblestone huts in the higher mountains, all houses in Central Asia are built of sun-dried mud. Without entering into the architecture, we may have a geologically sufficient understanding of them. The ordinary house has only one story, but a large proportion are of two, and inclose a courtyard with stables on one side. The walls vary from 1 to 2 feet thick, and each story from 7 to 9 feet high. There are three kinds of roofs: (1) those throughout the plains, nearly all flat, of mud 0.75 foot to 1.5 feet thick, laid over brush and split poles resting on beams; (2) those of the Persian or Afghan style, domes of mud without wood; and (3), those made entirely of wood and brush thatched with straw or reeds. Merv, Bokhara, Samarkand, Kokhand, and all the cities of Fergana are built with flat mud roofs, the smaller towns along the Persian frontier with mud domes, while some houses of Karategin and other places where the vegetation permits have sloping thatched roofs. Thirty years is said to be an ordinary lifetime for an adobe house with an

*Moving and shaping matter into unstable positions and shapes.

adobe roof. When the roof falls a house is abandoned or rebuilt, but most of the old débris is graded over and new material brought in for the new structure.

Fixing our eyes on Bokhara, perhaps the best example of a walled city of ancient style, we see long, heavy-laden caravans, some of camels, others of donkeys and horses, filing slowly into its crowded gates. Other caravans are issuing, and as many as go in, from day to day; but with this difference—though most of the camels come out laden anew, some of them issue bare. And so it is with the horses, and especially with the donkeys. Whole swarms of donkeys enter loaded with mud and wood or food, and then issue with nothing. No less significant are the dust-clouded flocks of sheep and goats driven slowly into the arched gates, for but few of them ever come out again. Within the city, houses are building of the mud, and some of the wood is entering their construction, as steel does with our concrete; while some of it is used in manufactures, and the rest for firewood. Of all the food, practically none comes out; almost all ultimately finds its way to refuse piles and holes. And of articles of merchandise, all that is used therein remains as a surplus of income over outflow of that class, and becomes a

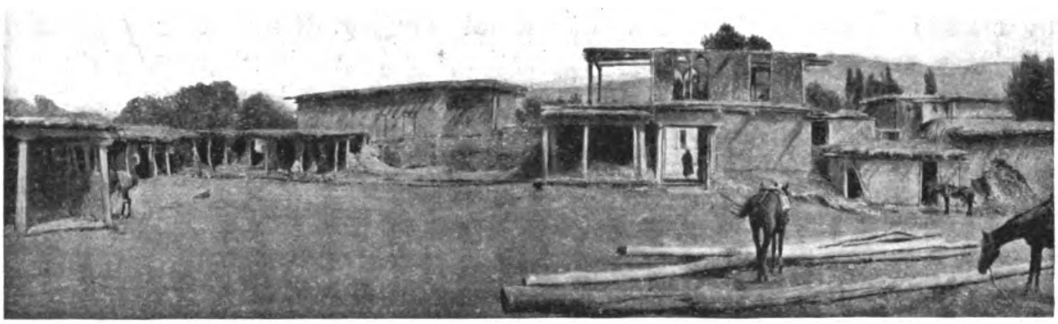


Fig. 468.—Construction of a House in the Hissar Valley.

deposition of rubbish. As long as the city lives, there is an inflowing supply of food for its occupants, and raw material to replenish the decay of their houses and supply their useful arts. The deposition of that inflow is spread more or less evenly throughout the city or whole walled area and must in time result in an appreciable growth. That such a growth does and did result is evidenced by plateaus of stratified débris that rise from out the plains where ancient cities were. From exposures in gullies and trenches, we have found that these are composed of horizontal layers of clay with pottery, bones, and charcoal, and here and there the basal remnant of a wall with part of an old floor.

Seen far out on the desert plains, where they most abound, these plateaus are unmistakable. And any one who has thought about topography can not fail to recognize them, even though the land be one of high relief. Even when much modified by erosion, as are the older ones, they still rise as contradictions to surrounding forms until obliterated by weathering or burial. It can not, however, be assumed that all artificial mounds are records of slow growth from occupation, even though left by man, for in the past he heaped mounds over the dead and, in more recent ages, deliberately built them for citadels. It is often possible to recognize in gully sections what kind of a mound one is dealing with.

In diverting rivers and streams to irrigate wide areas of cultivation, man has been a director of alluvial depositions.

In general, it was found that mound remnants of occupation are numerous over all areas, both of alluvial clays and of loess, that were accessible to running water; that is, the ancients made their cities and towns wherever there was water to drink and flat clay or loess ground to build on and of. On the other hand, all areas of stony steppe, where there was no clay for vegetation or building material, are barren of these remains.

Knowing that ancient oases are to be looked for and how their remains appear, the next two questions that rise are, first, where to look, and second, what chance is there of anything very ancient still remaining?

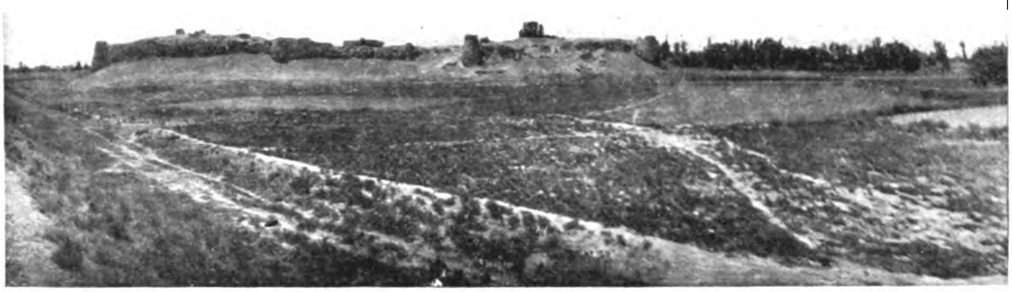


Fig. 469.—A Ruined Citadel on the Lower Zerafshan.

PHYSIOGRAPHIC CLASSIFICATION OF OASES.

Before answering these questions it is important to understand the present distribution of oases and cast them into a type classification based on natural forces and their products with man. Such a physiographic classification results in five types remarkably distinct in their reactions upon civilization.

(I) Delta Oases: (*a*) of rivers; (*b*) of small streams.
(II) River-bank and flood-plain oases.
(III) High-valley oases.
(IV) Spring and well oases.
(V) Lake-shore oases.

Examples of all five are still to be found in their full life. At the ends of the Murg-ab and Zerafshan lie Merv and Bokhara, our two best examples of type I*a*, while type I*b* is found all along the edge of Central Asia's desert plains, where small streams discharge from the border of its inclosing ranges. The important difference between I*a* and I*b* lies in the effect of climatic change. Oscillating degrees of precipitation over the catch-basins of larger rivers involve a corresponding oscillation of the distances to which they penetrate the desert, so that the positions of type I*a* were ever shifted out and back, whereas smaller streams, those supplying type I*b*, as long as they reached the plains, could effect no more than a corresponding oscillation in magnitude of population. Moreover, type I*a* was always far more in danger of being overwhelmed by sand.

Type II, river-bank and flood-plain oases occur along the courses of large streams, especially the Zerafshan. Type I is thus, to a certain degree, at the mercy of type II, in danger of losing part or all of its water-supply to pirating canals tapping the river above. Type II is relatively unaffected by climatic change till extreme contraction leaves it beside a dry channel. But warping of the earth's crust has in some instances, such as Samarkand, seriously affected type II. Both type I and type II are relatively exposed to invasion by hostile people.

Type III, or high-valley oases, are common throughout the mountains of Central Asia. Lying for the most part on the terraces of large valleys, they depend on small tributaries for water-supply. Their irrigable area being limited by the terraced nature of their topography, this type of oasis has in general commanded an excess of water-supply and probably supported a relatively constant population and in their isolated conditions must have produced marked individualities of culture in a civilization left to work itself out through a long series of unmolested generations.

Type IV.—Examples of both spring and well oases are still to be found far out on desert plains among the sand-dunes, as well as at rare intervals in the mountain wilderness. Few of them are more than nomadic camps or mere caravan stations on long trails of trade, and though real self-supporting centers of life in an otherwise lifeless region, some people would deny them the name of oasis. There is, however, a remarkable kind of spring oasis, really of artificial springs, that has been of great importance, especially in Persia and along the Persian frontier of the Turkoman Steppes. There it has been contrived to tap ground-water at the base of the mountains with a series of shafts connected by tunnels, leading it ever nearer the sloping surface of the plain until it is discharged at the oasis. The city of Askhabad, capital of Transcaspia, and many others along that belt, as well as farther east, are examples of such artificial spring oases. It is an old Persian method, doubtless introduced during the early Persian rule of this region, and is known as the Carice system.

Type V.—Mr. Huntington visited lake-shore oases in Persia. Theoretically it is a type of great interest. We hope that future exploration may disclose the mound remnants of oases on now dry shores of the ancient Aralo-Caspian Sea and vanished lakes that lay towards the Arctic. Modern science has developed a new kind of lake-shore oasis, that on salt-water shores. Baku and Krasnovodsk are extraordinary examples of this class. All their water is distilled from the Caspian and there is every reason to suppose that other cities will be founded on their plan along the coasts of interior seas of brackish water. To what extent the ancients irrigated fresh-water lake-shore oases, we know not as yet; but there is no reason to suppose that irrigation was not carried on by them over flat areas near water-level in the same way in which Egypt has for many thousand years watered the flood-plains of the Nile.

The five types of oases behave in different ways toward the questions as to their early distribution and what antiquity may be discovered. It is obvious that all streams, and even valleys now dry and their possible prolongations on the plains, should be explored for remains of types I, II, and III. The possible distribution of type IV is more indefinite. They may have existed on almost any steppe of clay or loess, even where now invaded by dunes. Obviously, type V should be explored for on all lake-shores, even where no lake exists to-day.

RELATIONS BETWEEN EROSION AND BURIAL IN THE OBLITERATION OF KURGANS (OASIS CULTURE DEPOSITS).

The chances of finding culture mounds more than a few thousand years old seem relatively slight. Under the arid conditions of most of Central Asia, mounds are bare of vegetation and stand windswept with no protection from the wear of sandstorms. They are no more than naked heaps of unresistant clay, of which the round-worn forms of those more ancient stand evidence of fast withering by wind. During our work at Ghiaur Kala there was a sandstorm of such strength that stones 2 inches across were bounded along and smaller ones driven through the air with a blast of fine stuff scoured off the mound. Fortunately such storms are rare, for if they came often all our older mounds would long since have disappeared. Every time a desert rain falls it wears the mound away to best advantage; and lastly but not least, anything upon aggrading ground must in time be buried out of sight. Obviously most of the important oases were on delta plains and flood-plains that were always aggrading through year after year of muddy floods and irrigation.

Any discussion, therefore, about ancient oases, abandoned or occupied, must balance the effect of erosion and natural burial upon their remains. Sometimes we can be sure that no growth of the plain around has taken place, and in some more rare instances we know there has been protection against erosion. The most important remains, however, have been subjected to both. The problem then arises, how to deal with a time-equation into which there enter three rates—growth of plain, growth of culture, and erosion. We believe that in a given region these have fairly constant values when expressed in terms of centuries. Without pretending to get ultimately accurate results, we can give at least a logical expression of the relations between these different rates through time. Indeed, without keeping the problem in logical proportions, we could never hope to understand either the relative rarity or distribution of really ancient remains.

Let t = number of centuries since a city was founded.
l = number of centuries it was occupied.
G = culture growth per century.
A = aggradation of plains per century.
E = erosion per century.
h = height above plain at any time.

If the mound is still occupied and has been from the beginning, its height will obviously be $h = lG - At$; and since in that case $l = t$, $h = t(G - A)$, or the number of centuries since it was founded, times the difference between its rate of accumulation and the rate of surrounding aggradation. If, as has been with many excepting those of type I, it was away from aggradation, its height would be simply $l\,G$.

Most of the oases that interest us have long since been abandoned and erosion enters the equation; then $h=l\,G-[E(t-l)+At]$, or total thickness of culture, minus erosion since abandonment and amount the plain has arisen around it. But obviously the plain will in time rise to bury the eroding top. Let t_b = time at which erosion will meet aggradation (time of total burial), then $h=0$ and $lG=E(t_b-l)+At_b$ and $t_b=\frac{l(G+E)}{(A+E)}$ and the first equation $h=lG-[E(t-l)+At]$ is true only when t is less than $l\,\frac{G+E}{A+E}$.

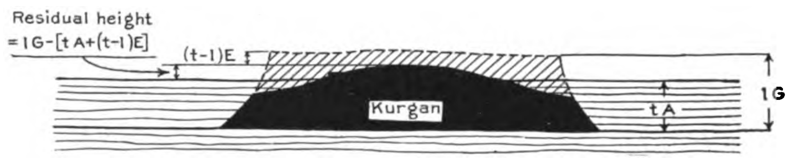


Fig. 470.—Diagram showing Relation between Erosion and Burial of Abandoned Kurgans. Cross-hatching represents wasted top of Kurgan.

(1) $$h=l\,G-[E(t-l)+At] \text{ when } t<l\frac{G+E}{A+E}$$

After that burial takes place, and the depth to which the top is buried at any time will be:

(2) $$d=A\left[t-l\frac{G+E}{A+E}\right] \text{ when } t>l\frac{G+E}{A+E}$$

or the rate of aggradation multiplied by the time since foundation minus the time that elapsed between then and the beginning of burial.

Changing the equation of obliteration somewhat in form, we get our third and most important equation.

(3) $$l=t\frac{A+E}{G+E} \text{ when } h=0$$

which means that on aggrading areas any town, not occupied more than the ratio $\frac{A+E}{G+E}$ times the number of centuries since it was founded, has vanished from sight beneath the aggrading plain. The depth to which the eroded top of its accumulation has been buried can be found from equation (2).

Assuming Professor Pumpelly's values obtained at Anau, we have $G=2$ and $A=0.8$, and since it is from erosion the growth of plains is supplied and since the areas of erosion and aggradation seem to correspond in a general way and our culture mounds probably erode as fast as anything, we may for experiment assume $E=A$ or $E=0.8$. Then $\frac{A+E}{G+E}=\frac{1.6}{2.8}=0.57$ as a conservative ratio of much less error than equation $E=A$, because E partly compensates itself by division.

It may, therefore, be said that the kurgan remains of most favored oases, those where water was easily led and found its way in flood, have been eroded and buried, wholly obliterated unless they were occupied over 0.57 of the time since their foundation. Or, any such city, founded 5,000 years ago and not occupied at least 3,000 years, has vanished. Such must have been the fate of those where the plains are always aggrading; but along the borders in the region of uptilting piedmonts, where oases of type I *b* and type IV abound, aggradation was apparently so counteracted by crustal movement that during dry periods some areas rose above it altogether. It is to that process we owe the preservation above ground of both kurgans at Anau. The piedmont on which they rest appears to have been uplifted so nearly as fast as the plain aggraded that during all of 10,000 years no more than 20 feet of sediments has risen around the North Kurgan, though during that time it seems likely that about 80 feet have been deposited farther out in the desert. As a check upon the logic of our equations, it is interesting to solve for occupation on the North Kurgan. Knowing the total remnant thickness of culture, 60 feet, and assuming Professor Pumpelly's estimate of time since foundation, 100 centuries, we have: taking the remnant height, $h = lG - E(t - l)$, $64 = l \times 2 - 0.8 (100 - l)$ or $2.8\, l = 144$ and $l = 51.5$ centuries. Then its original thickness, lG, would have been $2 \times 51.5 = 103$ feet, of which it has lost by erosion 43 feet. This, taken in view of the deformation testified by its profile, the upper part having withered to a rounded form leaving a base under ground of twice the diameter of that above ground, seems a conservative estimate. There is, however, no reason to suppose that it had ever attained a thickness of 103 feet at any one time. This accumulation may have resulted during several periods of occupation, between which it was abandoned to erosion. That part of its growth was during reoccupation of comparatively recent times is evidenced by quantities of late pottery and débris, deep-buried in the wash under its surrounding plain, having drifted down there from above, though now absent on top.

An examination of the surface and gully-sections of 20 or 30 kurgans on the zone of constant aggradation, revealed no indication of anything over 1,000 to 3,000 years old, and such was Mr. Huntington's experience in his study of 20 or more kurgans north of Merv. To one having a general idea about rates of erosion and aggradation in this region, it is no surprise that nearly all the kurgans of Central Asia seem to belong in the last 2,000 or 3,000 years. There can be very few as old as the North Kurgan at Anau still above ground.

But the very fact that Central Asia has been progressively drying up has helped prevent a universal burial of oases of type I *a*, those on far-out deltas, because streams and their canals contracted, leaving their oases beyond both water supply and sedimentation. Many kurgans, then, still rise above the desert for the very reason for which they were abandoned. Another set-back against burial has been warping. The region of Samarkand has been warped into a low dome about 40 miles across, through which the Zerafshan distributaries—many of them artificial—have cut their channels to a depth of 50 to 100 feet in the highest or middle part, some of them reuniting beyond. Now, it is only with canals many miles long that water can be led onto the old plateau and on such a gentle grade that scarcely any sediments are introduced, so that the surface there to-day is practically that of antiquity, the uplifted and dissected horizon of many thousand years ago.

Type III or high-valley oases, because of their position on terraces high above the river, have perhaps been most free from natural burial; and owing to isolation from hostile tribes and their excess of water-supply, were less often abandoned to erosion.

Favorable topography, crustal movement, and shrinkage of alluvially active areas have thus conspired against a universal burial, but we still face erosion. The question is, what is the reason why Nature's wind and water have not altogether obliterated whatever she left unburied? It can not be from absence of the agencies of erosion; they are universal. There must have been protection. We have seen in the equation $h = l\,G - [E(t-l) + A\,t]$ that as long as $t < l\frac{(G+E)}{(A+E)}$ there is still a discoverable remnant. If $l = t$, that is, if the kurgan is still occupied and never was abandoned, then the factor $E(t-l) = 0$. That is, no erosion has taken place. For several reasons, climatic and protective, it has always been advantageous to reoccupy old culture-mounds. In other words, the value of l was from time to time increased and so the time necessary for obliteration, $t_b = l\frac{(G+E)}{(A+E)}$, increased whether E alone was involved and $A = 0$, or when A alone was involved and $E = 0$, or when both together were involved.

In a grassy region the value of E is greatly diminished and vanishes altogether where loess is precipitated. Such a region is found in the wide Hissar valley, where kurgans are mantled with a foot or more of loess and the great citadel of Hissar itself, rising about 100 feet above the plain, stands as evidence of that protection. It is not unlikely that other kurgans, now bare, were once favored with grass. And there is one other protective agency that has played an important rôle in the preservation of ruins to discovery; and that is flying sands. In Chinese Turkestan many cities have been reexposed by the shifting dunes that swallowed them over a thousand years ago. Such must have been the fate of most of type I*a*, or far-out delta-oases.

But do not be too encouraged by this display of protections against obliteration. We still must face the fact that few remains of very great antiquity have as yet been found. Erosion and aggradation have done their work and, where time allowed, have successfully obliterated. Whatever may be their actual values in any given region, the agencies of Nature, where continuous, have completed the task in $t_b = l\frac{G+E}{A+E}$. And though flying sands have preserved, we must believe that most of what they have buried shall remain to us unseen. And high-valley oases, type III, though in other ways more favored, had to be on or near the edge of such steep slopes and receding canyon walls that many of them have been long since blown and washed away or caved into their valley torrents. On the highlands streams are ever and anon accelerated by mountain uplift and their valleys changed so fast that with them some topography, once inhabited, exists no more; while the plains, where habitable because of river water, must with that water receive its sediments, so that with them the horizons of antiquity lie buried.

Such are the problems to be faced in exploration for the oases of antiquity and interpretation of what remains of their culture depositions. And although so little of what once has been can still be found, there seem great chances in what is left, especially when one year's exploration has revealed thus much of the remote past.

If the caves of Central Asia were occupied by early man as in Europe, still more ancient records may be looked for in them.

THE ANCIENT ALAI VALLEY ROUTE FROM BACTRA TO KASHGAR.

After communication was established between oases, trade routes and their intersections must have had an influence so important that it becomes necessary to find out all we can about them. As a contribution, I may be able to give new light on one of the ancient ways between Bactria and China. This will be purely objective evidence from observations on a journey over that route from Hissar to Kashgar.

OBJECTIVE CRITERIA OF ANCIENT LONG-USED ROUTES.

The question arises, how is it to be decided which of several routes was the important one? Must it remain a purely theoretical discussion, based on maps, traditions and writings, or are there objective criteria by which the traveler may recognize an ancient, long-used route of trade? There is reason to believe that all important trails of antiquity were, where crossing mountains, well-engineered with bridges and embankments, long rock-cuttings in cliffs and declivities, and carefully drained fillings where intersected by gulches. We should expect that steep ascents were, if possible, avoided by zigzagging grades and otherwise eased by long flights of steps hewn in the rock, while certain passes and defiles as well as stopping-places were fortified. Moreover, any trail long used must have worn deep into loess steppes where they were crossed, and even into bare rock. Of all this there should remain a recognizable trace. It is hard for Nature to obliterate long trenches worn in her loess plateaus, and harder still to wear away hoof-worn paths in rock and long cuts hewn midway up high cliffs. Where crossing aggrading plains and deserts of sand, there would be no marks except for caravansaries or fortresses, clay structures that fast crumble to low mounds and are soon buried in drifting dunes or obliterated by the growth of plains. Fortunately the nature of Central Asia has been such that few important routes could have been wholly on aggrading ground or drifting dunes.

THE CONTROLLING FACTORS OF TRADE ROUTES.

Trade routes are determined by three controlling factors, (1) needs of trade, (2) natural conditions, and (3) attitude of intervening peoples; and not only were they determined by these three factors but they also depended on them for existence and shifted or died out at the hand of their change. Needs of exchange were always changing in degree and kind; new centers of trade were ever springing up and newly discovered routes opened in competition. Scores of miles of trail and sometimes whole routes were shifted by the work of rivers and avalanches, and others abandoned for lack of water and decrease of fodder during cycles of desiccation. And history and tradition and Oriental romance have emphasized how robber khans and nomad tribes made raid and others levied toll on passing caravans. It is easy to draw a line on the map, but quite another matter to follow it out in reality with pack-animals that can neither fly over canyons nor live without fodder and water, neither scale mountains nor swim bad rapids, nor pass unknown to watchful enemies; and it is hard enough to make such a risky enterprise profitable by having the right merchandise for the right market.

ADVANTAGES OF THE ALAI VALLEY ROUTE.

It is no surprise that within historic time there has been much shifting of the main trade-way between far East and West. Whether or not some of Bactria's early trade passed over the Southern Pamir by way of Tash Kurgan to China, it does not seem likely that the much-spoken-of Terek Davan route to the north was ever of great importance. On it there are eight passes to be crossed within a distance of 250 miles—eight passes, most of them involving a steep rise of over 2,000 feet, and to cross the Terek itself from the north, one must climb 6,000 feet in one day, all in less than 12 miles, 5 of which are up the bowlder-strewn bed of a torrent in which many a pack-horse has stumbled to drown. Of all the passes I crossed during 2,000 miles of travel through those mountains, the Terek Davan stands out as one of the two or three worst, not so much because of its height (13,500 feet, which is perhaps low for passes on those high ranges), but because of bad trail, or rather the utter lack of trail over many miles, especially on its northern side. Moreover, there is no indication of its ever having had a good trail or any trail at all.

Beyond Irkeshtam (going westward), where it branches from the Alai valley route, there is on the Terek trail no trace of what we should expect to find on an important pathway of antiquity, no resemblance to one's expectations of a one-time main way from Bactria to China. Beyond this junction there is no remnant stretch of graded way or cliff-cut, nor hoof-worn path in rock or loess, nor sign that ever caravansary or castle stood upon it. Though with their railroad built to Andijan and the military post at Irkeshtam, the Russians have had to better it as much as possible, it is still a decidedly bad trail. If such a route was used for Bactrian caravans instead of that through the Alai valley, over all its length contrasting in goodness, whole mountains must have heaved and gorges carved since then.

From Kashgar to Bactra, via the Alai valley and Hissar, is only 600 miles, all of it good trail, well-engineered, and over 300 miles shorter than via the Terek Davan and Iron Door—300 miles shorter, or but two-thirds of the distance by the other, and so good that, with a little improvement at a few points, light artillery could pass all the way. Moreover, there is no doubt about the Alai valley route having been one of long use. The ruins of its caravansaries and fortresses still remain beside its time-worn paths still followed by Afghan caravans and travelers. On it there are but three passes, none of them at all bad; and fully one-third the way lies over steppe, most of the rest along smooth, broad terraces such as those of the Kizil Su. Nowhere is there lack of water, and beyond the borders of Tarim, that all these routes must cross, it lies throughout in a region of remarkably good grazing. Lastly, it is perhaps the easiest route of all to police.

The worst stretch is from Kashgar to Irkeshtam, over which it is one with the Terek route that branches off at that point. Through these first five days it leads over a desert of low red mountains, sharply sculptured in a gently rising plateau, as with the Western Bad Lands of the United States. There, as farther on, were seen long hoof-worn trenches in hard sandstone and notches worn 6 and 8 feet deep into ledge ridges crossed by it. At Ming Yole and Ulugchat the traveler still puts up in fortified cereis and at Shur Bulak Pass must ride through the

Fig. 471.—A Fortress in the Alai Valley on the Ancient Route from Bactra to Kashgar.

battered gate and wall that crosses its defile beside a ruined castle. One day from Irkeshtam leads over the Taun Murun, its last and highest pass, but only 11,200 feet in elevation, easily crossed, and down into the Alai valley, famous for its pasture. From there on for 100 miles this valley opens out a restful stretch for the caravan. In it there is still a ruined fortress, the relatively modern structure at Daraut Kurgan, where a trail branches off into Fergana. Leaving the Alai valley, it continues along the Kizil Su through Karategin, as a well-engineered way where engineering was needed, but most of the way in this region is along broad, smooth terraces. The next ruined fortress is met with at Haui. Others may have been obliterated, but, as with the Alai valley, the valley of Karategin is so isolated, except for the route in question, that it is not likely they had to fortify its caravansaries. From there we enter the lands of ancient Bactria and find the trail worn sometimes 40 feet into loess steppes leading down to old Hissar. What kind of trail it is from Hissar to Bactra must be judged from maps, as I did not follow over that part. On a large-scale Russian map it follows south along the flat bottom of a valley to the Oxus, and beyond the ferry it lies in open country a few miles to the end.

There is, therefore, reason to believe that at one time the famous way from China to Bactria lay along the Alai valley and past Hissar, which city may have owed its importance to it. Moreover, there is a well-engineered trail from Hissar over the Mura Pass to Samarkand, and another one to Bokhara or Pai-kent, which would make at Hissar a point of intersection of three important routes. This would not interfere with the idea that direct communication between Bactra and Samarkand took place via the Iron Door. Perhaps it varied with the attitude of intervening people. And the Tash Kurgan route over the Southern Pamir may have been used for communication between Southern Bactria and China, while the more important trade of Bactra itself passed direct by way of the Alai valley.

Fig. 472.—Ruins of the Tomb of Bibi Khanum (Samarkand).

OASES OF THE ZERAFSHAN.

RIVER-BANK (TYPE II) OASES OF THE LOWER ZERAFSHAN.

Having been a river fed almost exclusively by glaciers for all archeological time, the Zerafshan has necessarily given a fairly constant supply of water—that is, its oases were never affected by the sudden droughts and minor oscillations of precipitation that ever and anon wrought famine to oases depending on streams fed by unconsolidated snow or rain.

Everywhere along its lower course and beyond the limits of its now living oases, rise the mound remnants of past civilization. From Paikent to Samarkand is a land no less favored than the long stretch of the Jaxartes where there was an unbroken belt of gardens, of whose houses it is said the roofs were so joined through continuous villages of covered-over lanes that a cat might find his way throughout and never come to ground. Even now, for 200 miles along the Zerafshan it is mostly oasis, though crept upon by intervening deserts, and still stands unparalleled in Central Asia. Such a gifted land was naturally preyed upon by the plundering hordes that ranged the steppes of Asia from Manchuria to the Caspian, and enters history as a goal of conquering armies. Even now the story-tellers of its bazaars recite the feats of Iskander (Alexander), Genghis Khan, and Timur; and from the foliage of Samarkand, once capital of that last world-conqueror, still rise glittering faience domes and towers, the earthquake-shattered ruins of his colleges and tombs.

AFROSIAB.

Just to the east of this old city of Timur and on a loess plateau about 70 feet above the big Obu Siob, bounding it north and east, lie the ruins of Afrosiab, still more ancient Samarkand. Tradition tells us this was founded by a Persian, Prince Afrosiab, while some believe it to have been the Maracanda of Alexander. Its great areas of ruins have crumbled to a barren surface of low mounds with several depressions connected by canals and moats, the remnants of a water-system. Water entered from the south and split into secondary canals, two of which ran just outside the inner walls, those south of its citadel, to supply various neighboring basins. The surplus of these two emptied into the Obu Siob on the north, at a level about 15 feet higher than the Obu Siob water of to-day, as though the canal had deepened 15 feet since these tributaries were abandoned. It was hoped

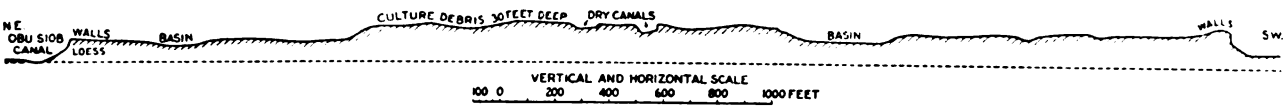


Fig. 473.—Profile of Afrosiab.

that some light on the antiquity, and especially on the introduction, of glazed ware might come from a study of gully sections through its culture remains. This work proved difficult, if not impossible, without excavation. In the gullies two habits have conspired against reliable sections; first, creeping down of muddy débris during wet weather; and second, refilling of narrow parts choked up in various ways, after which reexcavation leaves sections of washed-down débris in which all horizons of the culture-strata are mixed together. Some gullies, 30 feet in depth, are so narrow from top to bottom that when a wall caves in, refilling takes place behind. The large gully running to the Obu Siob canal opposite the mill widens and deepens downwards with several terraces, and has been artificially dammed across at regular intervals, thus refilling to form cross-terraces that are cultivated. Reexcavation of this valley would leave sections of most unreliable data. But though unreliable in general, there are a few gully sections in Afrosiab that give clean exposures of undisturbed strata. In two or three, through its central plateau of débris there appears to be a total depth of 30 to 35 feet of culture-strata resting on the original loess foundation. Through its northern wall along the Obu Siob cliff a tunneling gully shows the culture débris thinning out to but a few feet in thickness.

HIGH-VALLEY (TYPE III) OASES OF THE UPPER ZERAFSHAN.

So often conquered and swept by migrating hordes, the lowland oases of the Zerafshan now present a mixture of races, though according to the ethnologist there is still a predominance of Tadjik, excepting perhaps in Bokhara. And this mixture continues some way up into the mountain valley, where for about 16 miles from its entrance the traveler meets with Usbeg camps of felt kibitkas side by side the Tadjik villages. The last kibitka is passed below Iori, above which the type strengthens into a pure Tadjik; and, as my Tadjik caravan men testified,

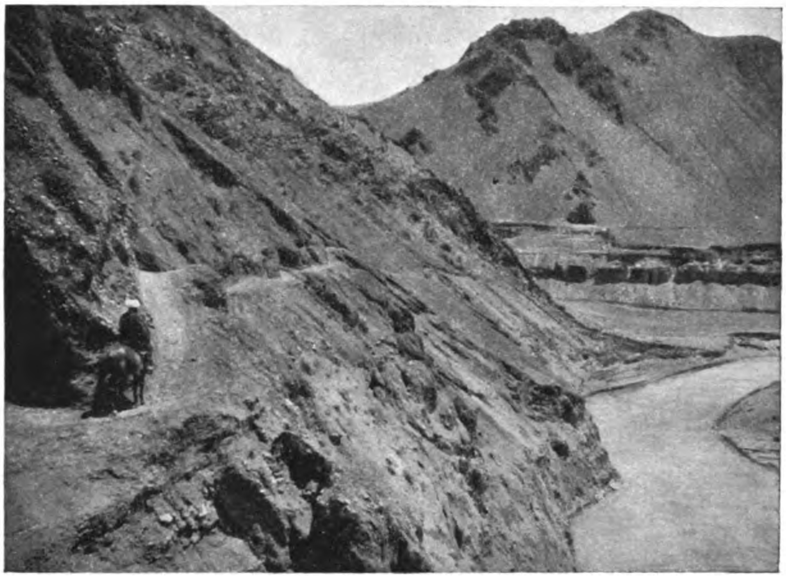


Fig. 474.—Cliff-trail up the Zerafshan Gorge.

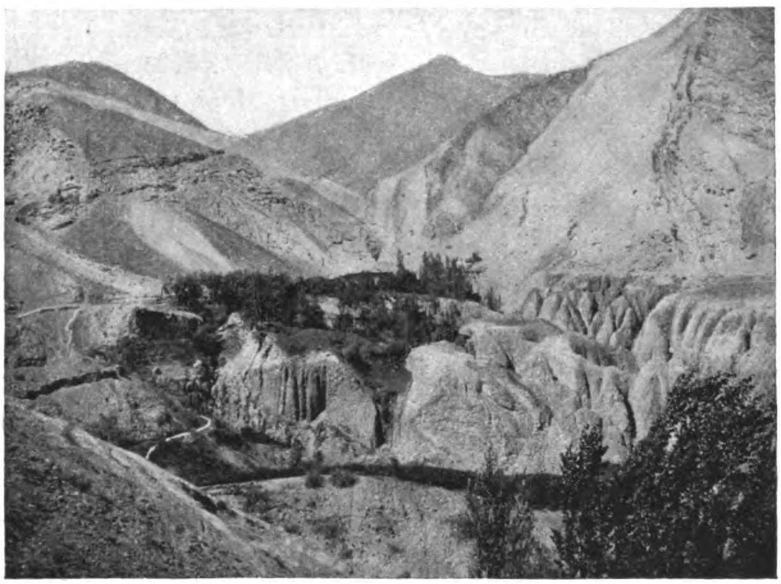


Fig. 475.—A High Valley Oasis of the Zerafshan Gorge.

all speak a good Galcha, a language said by philologists to be a pure remnant of Aryan. They are broad-shouldered, of medium stature, averaging something like 5 feet 9 inches, usually with black hair, bushy black beards, dark eyes, and clean-cut features of dark complexion, high foreheads, strong chins, and prominent noses. If it were not for their dark complexions, many of them would pass for Europeans. Some are lighter in complexion and some freckled, and one or two were seen with reddish hair and blue eyes. They live in houses grouped into village oases, the high-valley type, from 200 to 600 feet above the river, where the waters of tributary streams may be diverted for irrigation. Standing in contrast to the desolate slopes of barren rock that surround them, these oases with their gardens and apricot orchards and grain-fields are a welcome sight to the traveler who has struggled over miles of the rough trails that wind up their desert gorge. Lying as they do, surrounded by a wilderness of cliffs and bare declivities, each is isolated and self-supporting, separated from the next by miles of dangerous trail often cut as a half-tunnel in the canyon wall hundreds of feet above its river; and there are long rock-hewn flights of steps up which pack-animals must struggle. Sometimes the cliff-cuts were so narrow and low-roofed that our packs had to be taken off and carried by hand.

For about a hundred miles above Samarkand all houses are built of sunburnt brick. They are rectangular in plan and sometimes two-storied, with a courtyard for the horses and stalls on the ground floor; but most of them are

Fig. 476.—A Village built of Cobble-stones laid with Sun-dried Brick (Zerafshan Gorge).

smaller and only one-storied, about 8 feet high. All have flat roofs of ordinarily 8 inches of clay over brush laid on split saplings and hewn timbers. Proceeding upstream we find occasional courses of cobbles built into the house walls, and the proportion increases as we proceed till in the upper part of the valley we see houses built entirely of cobbles, cemented with clay, while even this cement is lacking in the last two or three villages near its glacier, where many of them are mere squalid huts with rounded corners and brush roofs, usually protected with felt.

An important fact about these people is that they have no tradition of arrival in the land, but boast of having been there from the beginning of man. All the old mullahs questioned insisted upon this, and it points to a very ancient Aryan civilization of the valley. For thousands on thousands of years they may have lived there, undisturbed and isolated from the rest of Asia, building up a simple civilization uninterrupted, hardly feeling an echo from the tumultuous struggles that so often destroyed all culture on the plains.

The mullahs say their forefathers were Christians, but were conquered by a great Mussulman general, Hodja Mussaii Ashari, who came over the Mura Pass from Hissar a thousand years ago.

There are comparatively few abandoned culture-mounds in the mountain valley, but many of its oases appear to lie on a considerable thickness of accumulated débris; in other words, most of the village sites of antiquity there are still occupied, whereas most of those on the plains have been abandoned. This difference is a good illustration of the characteristic distinctions of high-valley oases, type III, especially the difference of water-supply and degree of exposure to hostile people. Towns on the plains were from time to time abandoned for lack of water as their distributary streams contracted because of a general progressive desiccation of Central Asia, and others were destroyed by armies that plundered and passed on, leaving their ruins to the desert. Still others may have lost their water to pirating canals of other oases. Most of the oases of the high valley have always had an excess of water-supply, their size being limited by topography only, and their inaccessibility has always been a protection against invasion; one man can guard a trail in the Zerafshan.

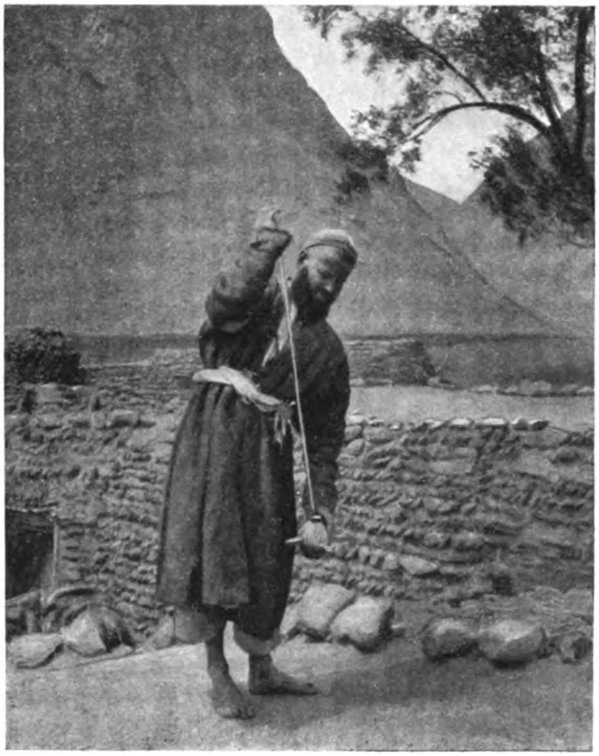
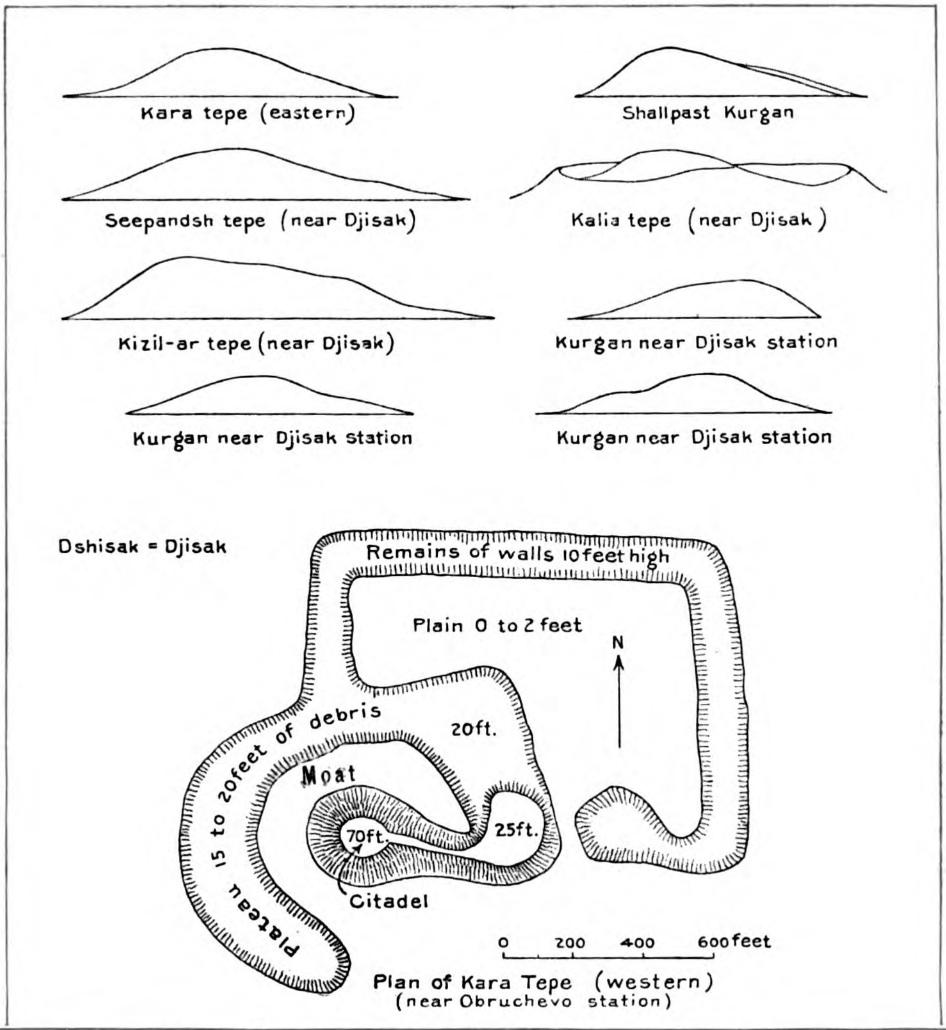


Fig. 477.—Zerafshan Galcha Spinning at Yarum.

In many of the towns débris of occupation has accumulated in the form of terraces, in successive steps from 4 to 6 feet high, down slopes of the old alluvial terraces and doubtless extending to a depth of several feet below. The thickness varies from town to town, according to the amount of sediments in the waters drawn upon for irrigation, the proportion of stone used in construction, and the time of occupation. The few abandoned sites observed are in positions relatively more exposed to neighboring oases and intersecting routes. Their positions were evidently chosen as the easiest to fortify in their neighborhoods, and, in some cases, seem to have been abandoned for other points nearby that are agriculturally more advantageous. Of abandoned villages there are three of especial interest: One at Iori, one at Urmitan, and one at Kadushar (figs. 481–483).

Iori Kurgan (fig. 481) is an old citadel, about 100 feet by 200 feet long, running north and south and resting on gypsum beds rising from the eastern edge of a



View of Eeman Tepe. Citadel of Kara Tepe (Western) taken from northwest.

Type-forms of Kurgans in Fergana.

tributary delta descending onto the Zerafshan's great lower terrace. It is a mass of remarkably rich culture remains, about 25 feet thick, and composed of sunburnt bricks, ashes, and bones, and very much pottery well exposed in pits dug out for fertilizer. Three kinds of pottery were found—two of fine red texture, wheel-turned, of which one was dull and the other polished, the third kind a large, coarse, brown jar. One piece of glass was found 5 feet below the top.

Urmitan Kurgan, though small, becomes of interest in its relations to Zerafshan terraces and the tributary Vaushan Darya. Standing in an easily fortified position on the southern side of the canyon, it rises somewhat above the level of terrace G, from which it appears to have been partly severed by erosion since it was abandoned (see fig. 482). A portion of the Vaushan Darya's flood-plain of a higher terrace age, belonging to the ultimate height of alluviation at the close of the Zerafshan's second cycle of erosion, has now been cut down on both sides,

Fig. 478.—Zerafshan Galchas near the Glacier.

leaving a remainder standing as a high inclined table at that tributary's valley mouth. There still remains a shallow channel, once occupied by Vaushan water, leading to the kurgan, but now the Vaushan debouches into the Zerafshan through a canyon in terrace G on the other side of the ancient table.

Kodishar Kurgan (fig. 483), or the ruins of ancient Kodishar, is physiographically by far the most interesting abandoned oasis of the valley. Lying on terrace G and just outside the present oasis, it is bounded on two sides by an impassable cliff of the meandering canyon, while round the other two it is bounded by a triple row of moats, ranged one within the other. Altogether its ruins cover about 100,000 square feet, with about 4 feet depth of culture remains, composed of clay-mixed cobbles rich in pottery, both glazed and not glazed, with some glass and iron fragments. Tradition places it over a thousand years old and mullahs say the Zerafshan flowed on a level with it, splitting through its moats then spanned by bridges. Besides stone implements other slabs were found to have Arabic inscriptions, but without dates, one of our men being able to read them with some difficulty.

Fig. 479.—Zerafshan Galchas (Gentlemen).

Its moats and the native tradition that the Zerafshan once flowed through them make Kodishar Kurgan of interest. If we grant truth to this tradition, there are two possibilities; water may have stood at this level because of a landslide across the canyon or because the river then had not cut down below terrace G. Although there are remains of landslides that appear to have wrought a comparable change in other portions of the valley, no such remains are found near Kodishar. Perhaps the chances are in favor of a landslide, but it seems barely possible that the Zerafshan, now so actively corrading, has cut down its narrow channel to a depth of 280 feet in say 2,000 years, but that would be 1.5 inches per year.

HISSAR.

In discussing the natural processes of obliteration, the remarkable height of the citadel of Old Hissar was attributed in part to a mantle of loess protecting it from erosion. It rises to a height of 100 feet or more, in the form of a crouching lion facing east. A part of its highest end (the eastern) is occupied by the palace of the viceroy (koshbegee), while the rest is bare except for his stables. Culture-strata of loess mixed with pottery, bones, and charcoal are exposed to a depth of 20 feet in a pit on its western half. It is possible that a portion of its 100-feet thickness above ground is composed of loess deposited during periods of abandonment,

Fig. 480.—Zerafshan Galcha with his Plow.

but that would not detract from the antiquity of its deep layers. The base of culture may be at a considerable depth beneath the plain. Hissar was probably a city of importance when Bactrian trade with China came past it via the Alai valley. Suitable presents to the viceroy would make it possible to dig there, and labor is only 35 cents a day (fig. 484).

There are many small kurgans and remains of ancient fortifications, canals, and dikes in the Hissar valley.

ABANDONED OASES OF FERGANA.

A rapid reconnaissance of chances for excavation in Fergana was made by stopping at intervals along the railroad in a private car, lent through the kindness of General Ussakovsky and General Ulianin.

Near Osh there are two small mounds with no surface indication of culture remains. No others were seen in that region and its natives say there are none. There is a kurgan at Marghelan, but west of there it is not until the railroad strikes

Fig. 481.—Iori Kurgan.

loess steppe near the kurgan Karaul Tepe, between Balyakandosc and Rojevat, that kurgans are seen from it. As Kavast junction with the Tashkent Railroad is approached they become numerous, and from there on to Samarkand abound, because the area is all loess. The following sketch outlines are typical ones selected from a larger number. As their forms are in general rounded, it would seem that few of these kurgans are not so recent as those for instance on the Murg-ab delta; and it seems possible, since it is a region of uptilted piedmonts, there may be examples of great antiquity among them, though only one (Kara Tepe, western) of those examined was free from glazed ware on the surface.

Four of these—Kara Tepe (western), Eemari Tepe, and two river-cut mounds at Millitinskaya—deserve special mention; the first two because of their great size, the second two (fig. 485) because of their physiography.

KARA TEPE (WESTERN).

Kara Tepe (western) lies a few hundred feet south of the railroad, a little over 1.5 miles west of Obruchevo Station. Its citadel rises over 70 feet above its northern base and about 65 feet above the general level of the plain, and stands in part surrounded by a broad moat between it and a crescent-shaped plateau of culture débris left open on the south. The long embankment, 10 feet high, appears to be the remains of a wall built late in the city's history when it had expanded to that extent. In size these ruins approach those of the Merv delta, while their older portions are much older in appearance. The only pottery found in small exploration pits to a depth of 2 or 3 feet on top of the citadel was wheel-turned, red, vesicular black, and light-gray, while similar pits on the plateau west exposed human skulls. Here may be a column of records down through the Græco-Bactrian age into horizons contemporary with Anau's South Kurgan culture.

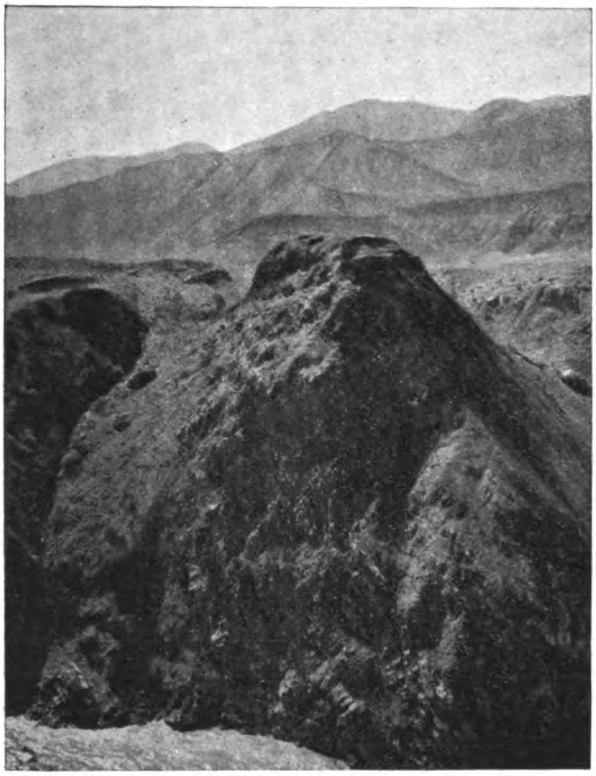


Fig. 482.—Urmitan Kurgan.

EEMAN TEPE.

Eeman Tepe, about half a mile southeast of Dshisak Station, stands 65 feet out of the plain as a citadel of special importance to us, for, though of an ancient round-worn form, it rises into glazed-ware time. Its culture was explored with a few shallow exploration pits on top and has been exposed in terraces, cut in near its base, where natives have taken débris, presumably for fertilizer. In these were found two or three specimens of glazed ware and glass and much red and gray wheel-turned pottery, some of it with incised designs. It is a mound of rich culture, abounding in bones, ashes, and hearths. Here may be a column through the period of which so little is known, that between Mohammedan and early Græco-Bactrian times, perhaps overlapping part of Kara Tepe (western).

RIVER-CUT MOUNDS OF MILLITINSKAYA.

The valley of Djillan-ooti Darya, otherwise known as Timur's Gate, is a remarkable example of the hydrographic complications brought about by uplift of mountains, whose round-worn, outlying, terminal spurs were well-nigh buried in waste. Before its uplift alluviation from the Zerafshan appears to have overflowed, or nearly overflowed, the worn-down Millitinskaya spur and possibly coalesced with the Syr Darya plains, so that the Djillan-ooti Darya found its way out to the Syr Darya. Uplift resulted in the Djillan-ooti excavation of Timur's Gate, widened during quiescence to a flood-plain about two-thirds of a mile wide. Even after this the ancients led Zerafshan water from Pendyakent through an old canal-way to the Djillan-ooti, and it is thought the Zerafshan might still be diverted north to join the Syr. If so, Bokhara lies at the mercy of the rulers of Samarkand. When the two now river-cut mounds were built the Djillan-ooti was alluviating its whole flood-plain with a sluggish flow of water carrying fine silt and spreading through a dense mass of rushes on either side of a gravel-strewn channel. Much

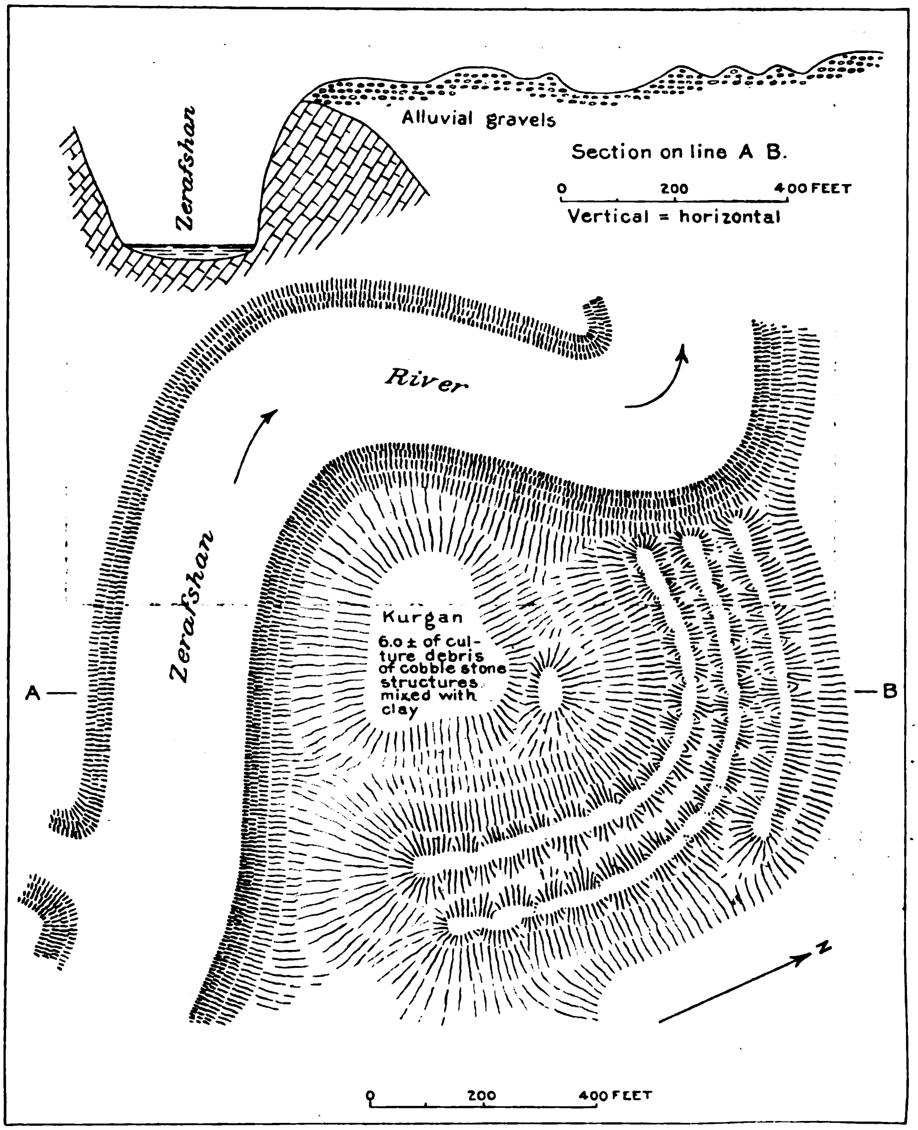


Fig. 483.—Map and Section of Kodishar Kurgan.

of the flood-plain must have been a marsh, as the layers exposed are matted with rushes now in part replaced by carbonate. The remarkable arching of layers was doubtless caused by a compression of organic constituents. Neither mound can be attributed to débris of occupation, as there are scarcely any culture remains, but they may have been graves. Our sections appear to indicate the following sequence of events:

(1) Uplift of spur and formation of Djillan-ooti valley.
(2) Alluviation of wide flood-plain of rush-marshes, loess, and alluvium.
(3) (*a*) Construction by man of a canal bringing in Zerafshan water with gravels; (*b*) building of mounds.
(4) Drying up of that canal and shrinkage of Djillan-ooti water, with formation of present channel and accumulation of 3 feet of loess on mounds.

Fig. 484.—The Citadel of Hissar.

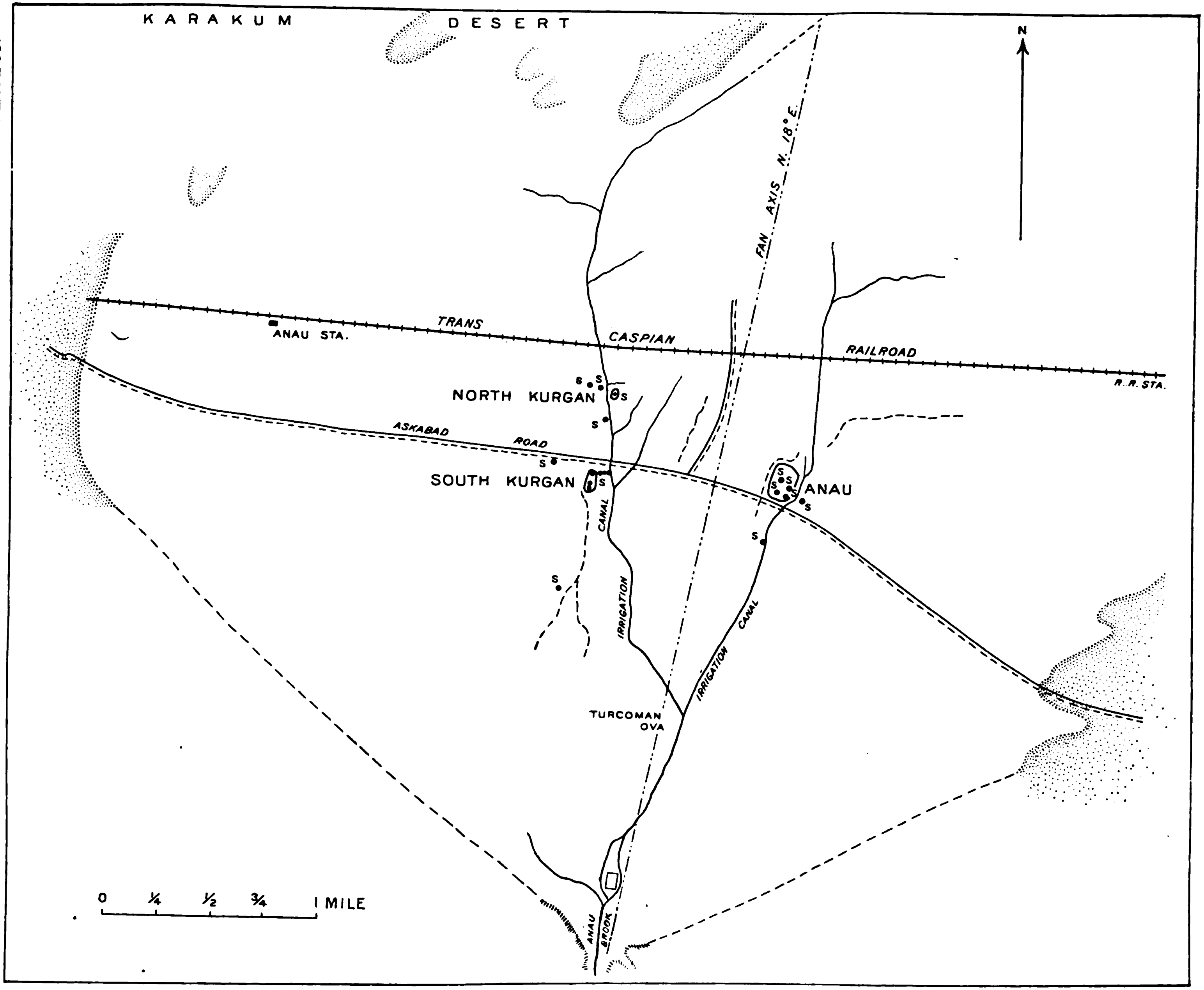
ANAU.

PECULIARITIES OF ANAU AS AN OASIS OF TYPE I *b*.

(Plate 65.)

To us it is of first importance to know what we can of the physiography of Anau, in whose ancient oases our shafts and excavations sank through no less than 10,000 years of man's stratified débris. And though its geographical position is fully set forth in the beginning of this volume, it remains to sketch a few of its type-peculiarities.

Anau is our best, or most familiar, example of an oasis of type I*b* (delta-oases of small streams). This type, it may be remembered, is characteristic of the border of the plains where small silt-laden streams discharge from the mountains and are to best advantage diverted for irrigation. It is a type less exposed to sandstorms and overwhelming dunes than type I*a*, like those of Merv, and yet more open to invasion by man, who may descend from the mountains or migrate along their base from oasis to oasis. It is, moreover, a type practically fixed in position, as contrasted with the inevitable shifting of type I*a* through long-continued change of climate or rearrangement of distributaries. The oasis of Anau has for some 10,000 years remained so fixed that cultivation is still carried on over fields that bury its most ancient ruins. The greater oasis of Merv has in 100 years changed place by 15 miles.



Map of the Anau Delta. By R. W. Pumpelly.

As a center of trade old Anau lay at the intersection of two important routes, the route from Meshed to Khiva crossing here with the great through way from Balkh via Merv round the Caspian's southern shore.

THE BUILDING OF A TILTING DELTA.

The Anau delta is one of a group of similar fan-like plains spread out, side by side, from the mountains, and merging together into a piedmont whose slope averages perhaps 1 in 100. Although the history of such an area is essentially one of a varied aggradation, there is a peculiar deviation from this rule towards the margins of a Central-Asian plain, a deviation which has especially complicated the part which of any delta, subaerial or subaqueous, is necessarily most complex in manner of growth. It is only well out on the area of deposition that only

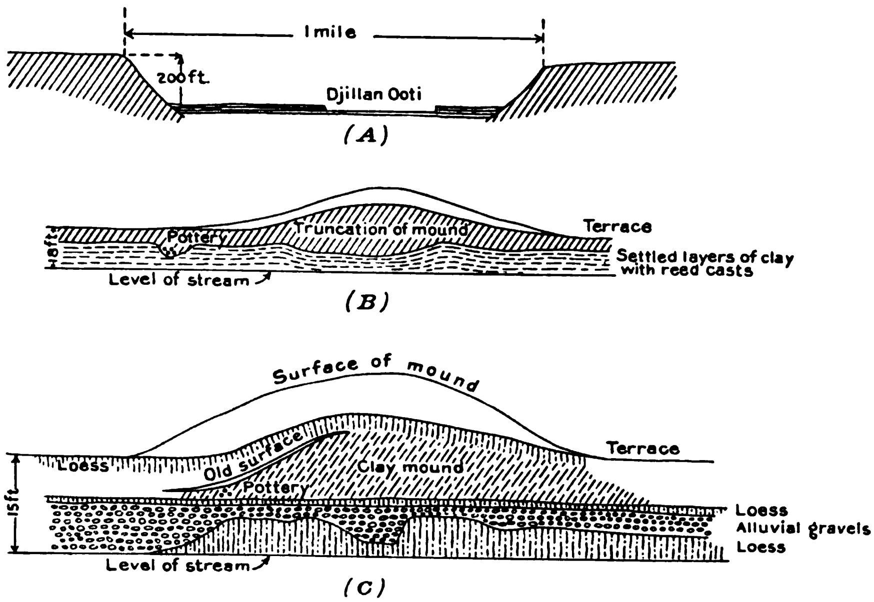


Fig. 485.—River-cut Mounds of Millitinskaya (Timur's Gate).

deposition takes place, for most of the layers formed near the apex of radiation afterwards suffer removal to a greater distance. No permanent growth of the apex itself can take place without either a corresponding aggradation of its debouching valley's flood-plain above, or a relative sinking of the plain below. Of such a sinking we have manifold evidence, and it is the way in which the plains of Central Asia sank that wrought their marginal peculiarities. This of course is the uptilting of narrow strips of piedmont beds forming low ridges with fault-scarps facing mountainwards and back of which the strata and conformable surface slope into the basin where they are buried by later waste. Whatever the cause of sinking, these uptilted piedmonts have resulted; and, with that part of the Anau delta where the oases were, tilting appears to have been one of the controlling factors of topography, not only of the present surface but also, as we shall see, of the surface of antiquity now buried by later waste.

EROSION CYCLES OF THE ANAU SU IN THE MOUNTAINS.

As the Kopet Dagh Mountains were simultaneously affected and their movements well recorded by erosion cycles, it is important to fix our attention upon them first. After their Tertiary rocks were laid down, a period of mountain-building activity resulted in deformation to synclines and anticlines with some overturned folding, most of which ran oblique to the general range axis. Then followed a lull in crustal movement, during which erosion progressed to maturity, leaving remnants of ancient crests as sharp talus-flanked peaks projecting from otherwise smoothly rounded ridges on either side of broad, shallow, longitudinal valleys. These valleys in general emptied into short trunk-streams discharging at right angles upon the plain, building immense deltas now partly exposed by the marginal tilt through which streams, descendants of the ancestral ones, have cut valleys to their present deltas just beyond.

This was the completion of what we may call the first erosion cycle, whereupon began, we suppose as a result of its shifting of load, a bodily sinking of the plains, with tilting of the border and cross-fracturing of mountains into huge blocks differentially uplifted. This cross-fracturing, evidenced by scarps both parallel and at right-angles to each other but oblique with the range axis, becomes of interest in connection with Woodworth's classification of rock-fractures. It seems to be a habit with Central-Asian ranges, even to the extent of oblique folding axes; indeed, the range structure is rarely parallel with its main axis and usually crosses at an angle of 30° to 45°. One block rose across the Anau trunk-stream, which, however, maintained its course, cutting down a gorge. The broad floors of longitudinal valleys were dissected by an extensive system of new tributaries developed from their main streams. Now there are commonly three terrace-levels: (1) the old first-cycle grade plains, (2) a narrow terrace about halfway between (1) and the present stream, (3) the broad flat of the valley bottom cut by the present narrow channel of the stream 10 to 25 feet deep with falls. This indicates division of crustal movement into a second and a third erosion cycle with relatively short lapses of quiet (as compared with the first cycle). In comparatively recent times there appears to have begun the third period of crustal movement. In the region of Manisht south of Anau dissection of the wide valley bottom (third-cycle flood-plain) had progressed till the fourth-cycle (present) channels were well incised. There but small portions of the old first-cycle floor remain as the flat tops of steep-sided hills rising several hundred feet above these channels. Streams were cutting back over small falls and rapids, and divides were shifting while pirating heads were capturing less active streams.

RECENT DECREASE OF SURFACE DRAINAGE.

A fourth erosion cycle had been well started and was actively progressing, when occurred a remarkably sudden decrease in surface drainage and most of these tributary channels have been left without running water to this day, and remain grown over with grass, the sod extending directly under the brinks of old falls. As this region is tributary to the Anau Su, it is important to explain its decrease in surface-water contributions. Most of the Anau valley system is developed in soluble rocks, limestones, and gypsiferous beds, with occasional deposits of pure gypsum. Caverns are rare as compared with a land that has always received much rainfall, but we must believe a good system of underground drainage has been developed—a system competent to lead off most of the present rainfall, which, though sufficient to nourish a varied and profuse vegetation on these mountains, is nearly absent from their surface streams.

The upper branches of the Gyourse valley, about 15 miles southeast of Anau, tell a similar story. Their sodded-over channels and falls join about 10 miles south of Gyourse, where the lower terrace broadens into a wide grass plain confronted by a bare rock wall running northwest, straight across and conformable to the 40° dip of the red sandstone beds of an uptilted block, bounded elsewhere with battered fault-scarps. Here the Gyourse trunk-stream enters the block at right angles to its rock face, having carved its way down as the block rose across it. All this represents a stream of erosive activity and rapid enough to leave a valley of the canyon class, but recently the stream has dwindled, till now its waters can barely creep over the slight grade established under its former large flow. The old rock floor is covered with an organic mud grown over with reeds, which still more retard its thin sheet of slowly moving water. After traversing this swampy bottom of the old canyon it passes through a narrow valley in the tilted piedmont and emerges upon the apex of its fan, where it is entirely consumed in irrigating a small area of Turkoman fields. Except in flood the water is clear, though vile from organic solutions. Formerly during its active time this stream was charged with silt and spread over a large delta.

This remarkable decrease of surface drainage was obviously so recent that it becomes of vital interest to the archeology of Anau. Our problem as a whole is peculiar and a new one to physiography. Here are mountains in whose soluble rocks there has been developed a system of underground drainage of capacity sufficient to consume most of the present precipitation, all of it in some valleys, but until recently there was such an excess over this capacity that surface streams were well supplied and actively eroding. Two explanations may be offered: Either the underground capacity has suddenly increased, or precipitation has decreased. It is improbable, if not impossible, that underground drainage of all this area simultaneously perfected to sudden monopoly. On the other hand, if we postulate a decrease in precipitation, it need only be general, not sudden. As long as the underground system remained saturated as it would be with an excess of supply, a slow and continuous decrease of precipitation would cause only a correspondingly slow decrease in surface drainage. But as soon as precipitation decreased to the value of underground capacity, surface drainage would vanish. Or, to put it mathematically, let

P = inches of precipitation t years ago.
G = capacity of underground drainage; a constant to be expressed in inches of precipitation.
S = surface drainage or excess over G.
p = rate of decrease in precipitation (inches per year).
t = time in years.

Then in t years from the time that a decrease in fall began, $S=P-G-pt$. If P in the beginning had been equal to $2G$, and thus evenly divided between surface and underground drainage, and p equal to say $\frac{P}{2000}=\frac{G}{1000}$,

$$S=G-\frac{G}{1000}t$$

and total fall $(S+G)=P-\frac{P}{2000}t$.

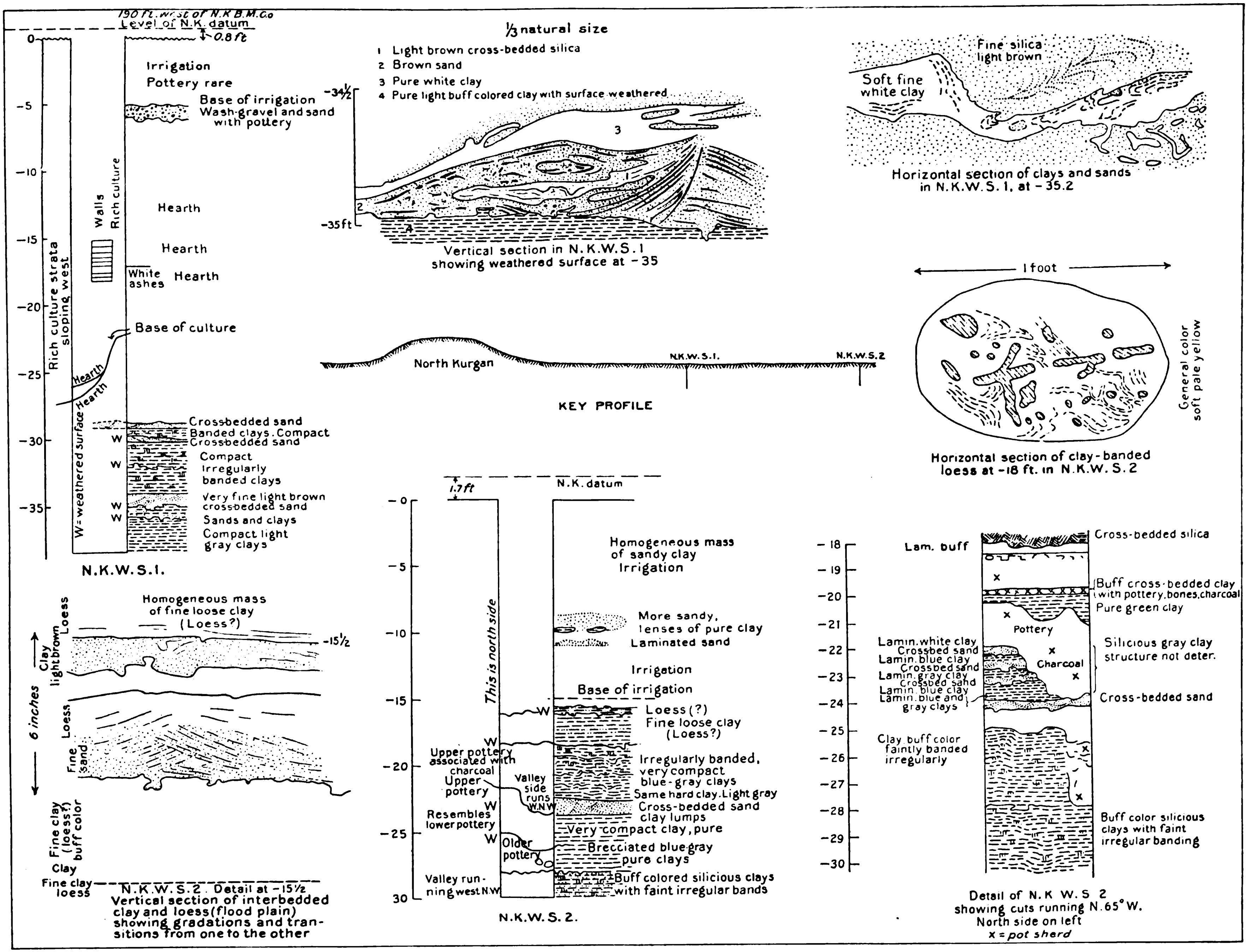
Plotting these sloping lines we see how a steady decrease in precipitation, as the underground value is approached, affects the surface drainage during the first century by only 10 per cent, during the sixth century by 20 per cent, during the ninth century by 50 per cent, and during the tenth century by 100 per cent; that is, a uniform decrease subtracts an increasing proportion of what is left till the surface excess vanishes, though there may still be a plentiful fall, which is thereafter consumed by underground drainage. Whatever record remained would thus have the appearance of sudden change towards the end.

We are thus driven to believe there has been a relatively recent decrease in the precipitation. The next question is: Where does the underground water drain to? A small proportion finds its way to the surface again, supplying most of the present flow in trunk-streams, a return through small cavernous springs, several of which were observed near Manisht. But the limited amount which now composes the Anau Su and Gyourse Su, even at high water, represents but a slight proportion of what falls over that high region. That it continues out under the plain is evidenced by water rising in native wells scattered far and wide over the Turkoman Trough. It seems barely possible that water drains through sand and gravel beds all the way from these mountains to the Caspian.

Turning to the delta again, we find it tells the same story in a recent shrinkage of water distribution. Wide areas of clay, some of which project 5 to 10 miles out among the dunes, are now dry during the highest floods, and not many centuries can have elapsed since their alluviation, for all would otherwise have been strewn with dunes. Some few hundred years ago water found its way to a small town near Ball Kuwi, about 6 miles north, whose ruins we explored.

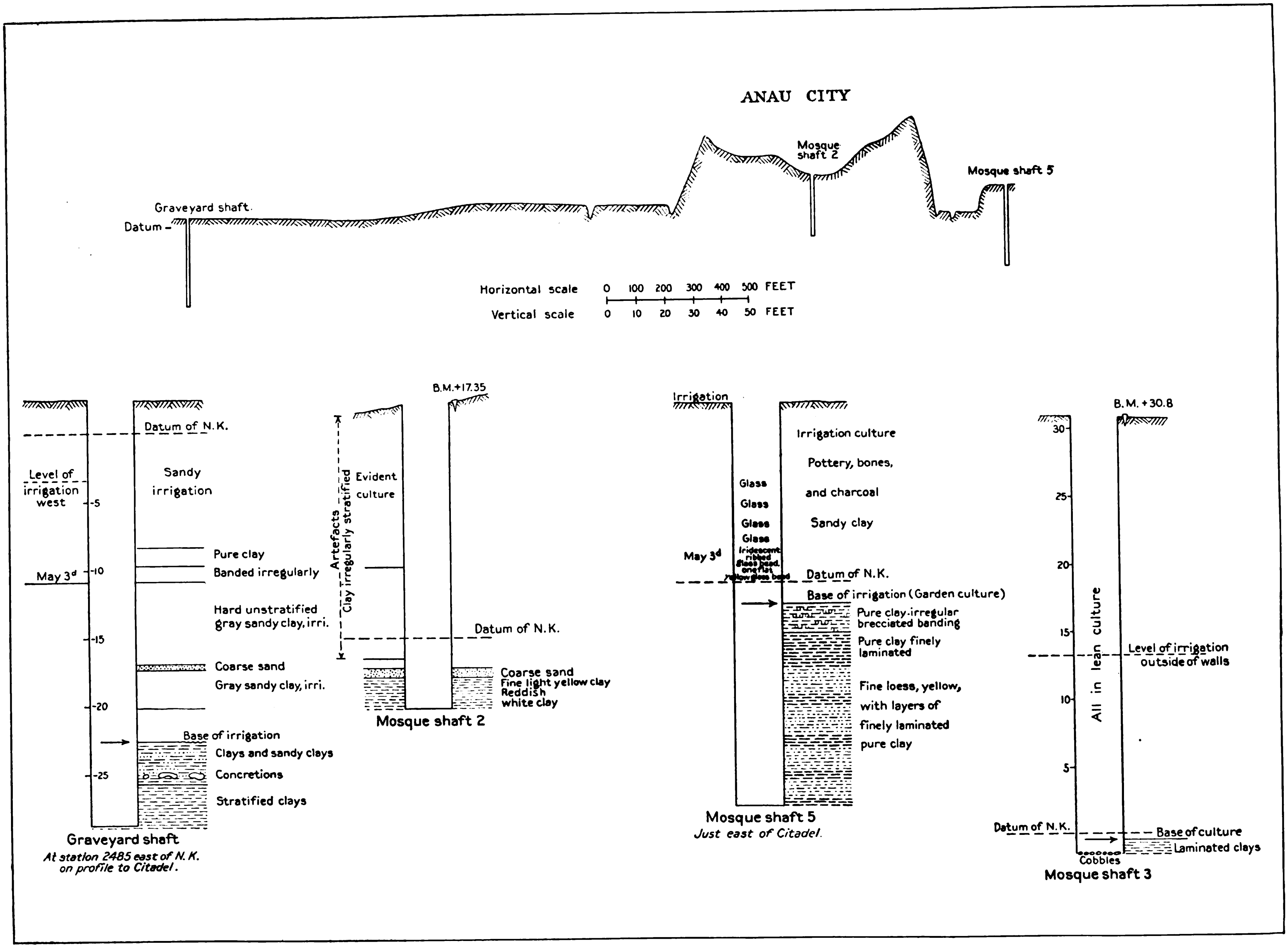
SHAPE OF THE ANAU DELTA AND IRREGULARITIES WROUGHT BY MAN'S DÉBRIS OF OCCUPATION AND HIS CONTROL OF ALLUVIAL DEPOSITIONS.

The Anau delta and its surroundings present a myriad of surface problems, of whose most general features a competent study would involve a large-scaled topographic map, constructed with the double eye of physiography and archeology; while far more light on both past and present may be revealed with the aid of a microscope and sensitive weighing balance. When for the first time one stands upon its clay surface, all the plain appears in simple flatness to the eye. Rising to the south is the Kopet Dagh Range of rather flat-backed mountains, notched by valley gaps, and from their base the plain slopes gently out into the northern semicircle of ocean-like horizon, broken only by sand waves tossed from the desert of Kara Kum. Toward the middle rise two kurgans and the last citadel of ruins with its outlying watch-towers, the three dead towns of Anau in whose stratified débris we dug.

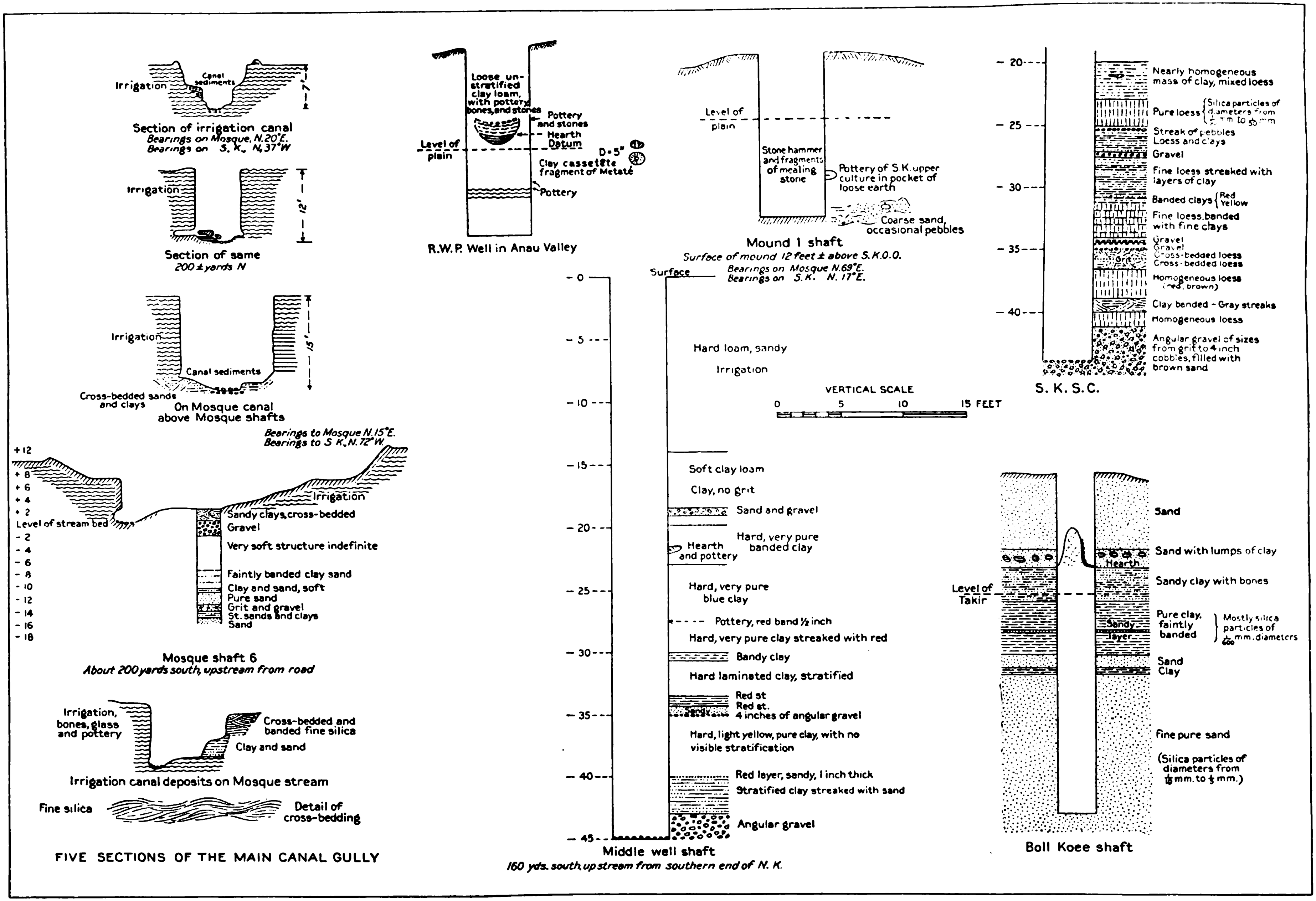


190 ft. west of N.K.B.M.Co
Level of N.K. datum
0.8 ft
Irrigation
Pottery rare
Base of irrigation
Wash-gravel and sand with pottery
Walls
Rich culture
Hearth
Hearth
White ashes
Hearth
Rich culture strata sloping west
Base of culture
Hearth
Hearth
W=weathered surface
Crossbedded sand
Banded clays. Compact
Crossbedded sand
Compact irregularly banded clays
Very fine light brown crossbedded sand
Sands and clays
Compact light gray clays
N.K.W.S.1.
1/3 natural size
1 Light brown cross-bedded silica
2 Brown sand
3 Pure white clay
4 Pure light buff colored clay with surface weathered
-34½
-35 ft
Vertical section in N.K.W.S.1 showing weathered surface at -35
Fine silica light brown
Soft fine white clay
Horizontal section of clays and sands in N.K.W.S.1, at -35.2
North Kurgan
N.K.W.S.1.
N.K.W.S.2
KEY PROFILE
1 foot
General color soft pale yellow
Horizontal section of clay-banded loess at -18 ft. in N.K.W.S.2
Homogeneous mass of fine loose clay (Loess?)
Loess
Clay light brown
-15½
6 inches
Loess
Fine sand
Fine clay (loess?) buff color
Clay
Fine clay loess
N.K.W.S.2. Detail at -15½
Vertical section of interbedded clay and loess (flood plain) showing gradations and transitions from one to the other
1.7 ft
N.K. datum
This is north side
Homogeneous mass of sandy clay
Irrigation
More sandy, lenses of pure clay
Laminated sand
Irrigation
Base of irrigation
Loess(?)
Fine loose clay (Loess?)
Upper pottery associated with charcoal
Upper pottery
Valley side runs W.N.W.
Resembles lower pottery
Older pottery
Valley running west N.W.
Irregularly banded, very compact blue-gray clays
Same hard clay. Light gray
Cross-bedded sand clay lumps
Very compact clay, pure
Brecciated blue-gray pure clays
Buff colored silicious clays with faint irregular bands
N.K.W.S.2.
Lam. buff
Cross-bedded silica
Buff cross-bedded clay with pottery, bones, charcoal
Pure green clay
Pottery
Charcoal
Lamin. white clay
Crossbed sand
Lamin. blue clay
Crossbed sand
Lamin. gray clay
Crossbed sand
Lamin. blue clay
Lamin. blue and gray clays
Silicious gray clay structure not deter.
Cross-bedded sand
Clay, buff color faintly banded irregularly
Buff color silicious clays with faint irregular banding
Detail of N.K.W.S.2 showing cuts running N.65°W.
North side on left
x = pot sherd

Anau Shafts.


ANAU CITY
Graveyard shaft.
Datum
Mosque shaft 2
Mosque shaft 5
Horizontal scale 0 100 200 300 400 500 FEET
Vertical scale 0 10 20 30 40 50 FEET
Datum of N.K.
Level of irrigation west
Sandy irrigation
May 3d
Pure clay
Banded irregularly
Hard unstratified gray sandy clay, irri.
Coarse sand
Gray sandy clay, irri.
Base of irrigation
Clays and sandy clays
Concretions
Stratified clays
Graveyard shaft
At station 2485 east of N.K. on profile to Citadel.
B.M.+17.35
Artefacts
Clay irregularly stratified
Evident culture
Datum of N.K.
Coarse sand
Fine light yellow clay
Reddish white clay
Mosque shaft 2
Irrigation
Irrigation culture
Pottery, bones,
and charcoal
Sandy clay
Glass
Glass
Glass
Glass
May 3d
Datum of N.K.
Base of irrigation (Garden culture)
Pure clay-irregular brecciated banding
Pure clay finely laminated
Fine loess, yellow, with layers of finely laminated pure clay
Mosque shaft 5
Just east of Citadel.
B.M. + 30.8
All in lean culture
Level of irrigation outside of walls
Datum of N.K.
Base of culture
Laminated clays
Cobbles
Mosque shaft 3

Anau Shafts.


Irrigation
Canal sediments
Section of irrigation canal
Bearings on Mosque. N.20°E.
Bearings on S. K. N.37°W
7'
Irrigation
12'
Section of same
200 ± yards N
Irrigation
Canal sediments
15'
Cross-bedded sands and clays
On Mosque canal above Mosque shafts
Bearings to Mosque N.15°E.
Bearings to S K. N.72°W.
+12
+8
+6
+4
+2
Level of stream bed
-2
-4
-6
-8
-10
-12
-14
-16
-18
Irrigation
Sandy clays, cross-bedded
Gravel
Very soft structure indefinite
Faintly banded clay sand
Clay and sand, soft
Pure sand
Grit and gravel
St. sands and clays
Sand
Mosque shaft 6
About 200 yards south, upstream from road
Irrigation, bones, glass and pottery
Cross-bedded and banded fine silica
Clay and sand
Irrigation canal deposits on Mosque stream
Fine silica
Detail of cross-bedding
FIVE SECTIONS OF THE MAIN CANAL GULLY
Loose unstratified clay loam, with pottery, bones, and stones
Pottery and stones
Hearth
Datum
Level of plain
D=5"
Clay cassette fragment of Metaté
Pottery
R.W.P. Well in Anau Valley
Level of plain
Stone hammer and fragments of mealing stone
Pottery of S.K. upper culture in pocket of loose earth
Coarse sand, occasional pebbles
Mound 1 shaft
Surface of mound 12 feet ± above S.K.O.O.
Bearings on Mosque N.69°E.
Bearings on S.K. N.17°E.
Surface
- 0
- 5
- 10
- 15
- 20
- 25
- 30
- 35
- 40
- 45
Hard loam, sandy
Irrigation
VERTICAL SCALE
0
5
10
15 FEET
Soft clay loam
Clay, no grit
Sand and gravel
Hard, very pure banded clay
Hearth and pottery
Hard, very pure blue clay
Pottery, red band ½ inch
Hard, very pure clay streaked with red
Bandy clay
Hard laminated clay, stratified
Red st
Red st.
4 inches of angular gravel
Hard, light yellow, pure clay, with no visible stratification
Red layer, sandy, 1 inch thick
Stratified clay streaked with sand
Angular gravel
Middle well shaft
160 yds. south, upstream from southern end of N. K.
- 20
- 25
- 30
- 35
- 40
Nearly homogeneous mass of clay, mixed loess
Pure loess
Streak of pebbles
Loess and clays
Gravel
Fine loess streaked with layers of clay
Banded clays {Red Yellow
Fine loess, banded with fine clays
Gravel
Gravel
Cross-bedded loess
Cross-bedded loess
Homogeneous loess (red, brown)
Clay banded - Gray streaks
Homogeneous loess
Angular gravel of sizes from grit to 4 inch cobbles, filled with brown sand
S. K. S. C.
Sand
Sand with lumps of clay
Hearth
Sandy clay with bones
Level of Takir
Pure clay, faintly banded
Sandy layer
Mostly silica particles of mm. diameters
Sand
Clay
Fine pure sand
(Silica particles of diameters from mm. to mm.)
Boll Koee shaft

Anau Shafts.

More careful observation shows the plain, at first so simple in appearance, to be of complex form. Its conical convexity, indicated on the map by radiation of distributaries, may be demonstrated by watching a rider who crosses its lines disappear as does a ship at sea, whereas one passing straight down the slope will slowly fade into the heat waves of mirage. Our map shows it to be a characteristic subaerial delta with the general outlines of a fan, encroached upon by dunes from the north. Except for about 2 miles from its apex, it is everywhere bounded by dunes, without which its radius would be over 10 miles, as prolongations of bare clay still reach that far into the desert. At present outlying sandhills stand 4 miles north of the apex, while its greatest width is but 5 miles. Careful study of the surface proves it by no means that of an even cone. It is everywhere broken with irregularities wrought by man; canals long since abandoned, mounds, and roadways, and most significant are its areas of many hundred acres several feet above the general surface, a difference caused by man's control of alluviation, concentrating the stream with its depositions into limited areas of cultivation. These areas of concentrated deposition are bounded on the lower side with long bluffs varying up to 4 feet in height and of irregular plan, as shown on the map (fig. 486 and plate 65).

For more complete explanation of these zones of concentrated deposition we may look to its present distribution. Except during exceptional flood, all the water of Anau Su is led into a system of canals irrigating fields with low dams on their down-slope sides. An irrigated area thus comprises a system of fields bounded round the lower side by an irregular, often more or less crescent-shaped, dam and merges above into the plain. This dam or dike may be only a foot or two in height, but it is always easier to rebuild or patch up the old one than to make it in a new place, so that a permanent barrier to deposition may exist for centuries on the lower border of irrigation; and since the whole stream is consumed in these areas, its depositions are concentrated therein and accumulate in the form of what we may term "irrigation terraces." All phases of this process may be observed in the Turkoman grain-fields of to-day. We thus have an ancient delta surface surmounted by irrigation sediments concentrated into terraces near its apex. If man, their controlling factor, for any reason abandons them to carry on his agriculture elsewhere, they show their instability with the first flood; water-gates burst and dikes are rent by the stream thus set free to rush over terraces, falling down bluffs and gullying back. In the course of a score or so of years this channel will be carved to base-level and the excavated terrace material lie spread over the delta beyond.

Pronounced irrigation terraces result only where a fixed area has been continuously irrigated for a long time, and so the outlying, more erratically cultivated areas, comprising a large portion of the Anau delta, have aggraded in a less differentiated or more uniform way. The non-observant might cross such a terraced plain with never a doubt as to its uniformity. A sloping and often round-worn bluff, only 2 or 3 feet high and irregular in course, running perhaps a half mile and fading at either end into the plain, does not ordinarily arrest the eye nor does such a slight difference of level between two wide adjacent areas. To the trained eye there are pronounced terraces and others which are distinguishable by careful sighting only. Some slight accumulations have resulted from Turkoman irrigation, while large areas formerly irrigated by the Anau-li and abandoned only 50 years ago are now dissected with gullies 15 feet deep and over that in width, and other areas of Anau-li fields are still growing under Turkoman irrigation. As a whole the irrigation deposits of our Anau delta lie within an area spread out from its apex to irregular limits near the railroad. In its central portion this accumulation, exposed by a gully down into its underlying floor of natural sediments, attains a thickness of 15 to 20 feet, but from there outwards terraces down over broad fields with 2-foot drops.

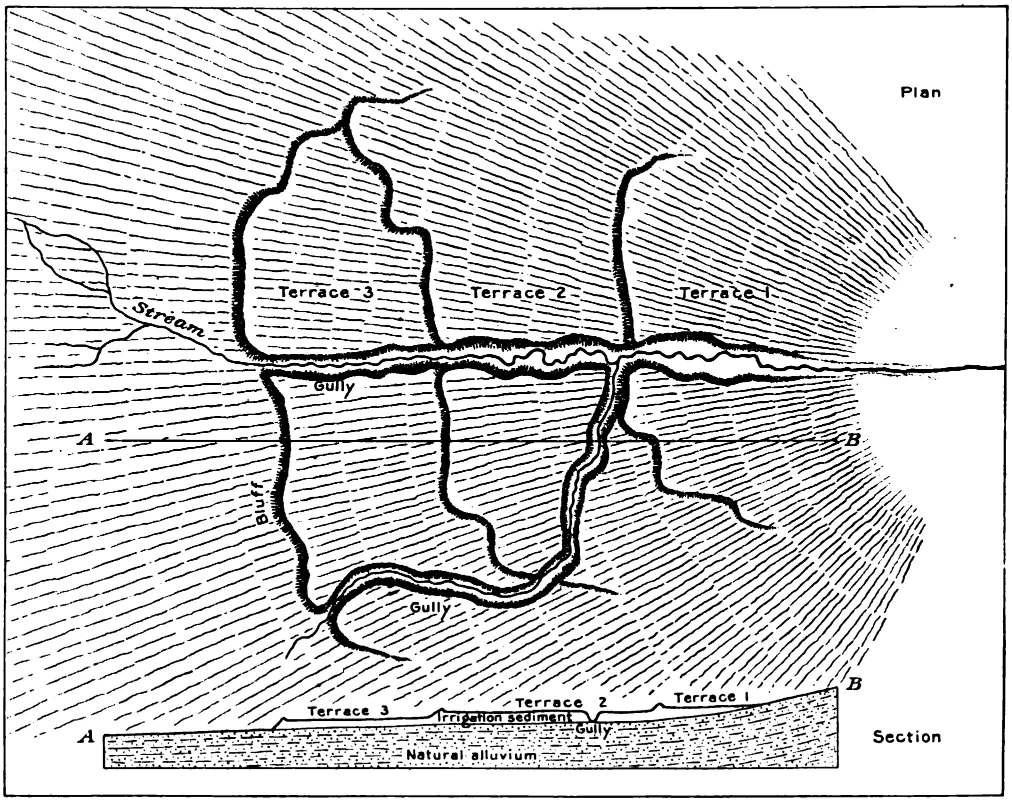


Fig. 486.—An Abandoned System of Irrigation Terraces.

The old through route of East and West crossed the middle of the delta and so determined the boundaries of Anau's ancient fields along it that a bluff from 1 to 4 feet high of irrigation limits follows much of the way along its southern side. Other irregularities are found in shallow rounded troughs, whose heading branches fade into the plain obliterated by more recent irrigation. These are old canalways, bounded once by fields aggrading on either side while they remained unsilted till abandoned, now slowly losing shape. Each kurgan and the citadel has split the irrigation stuff around it, thus in part protecting an area directly north or below from deposition and leaving it somewhat depressed. These are a few of the topographical variations wrought in time by human occupation of an aggrading delta.

THE ANCIENT AND THE MODERN DUNES OF KARA KUM AND INTERBEDDING OF THE DELTA MARGINS WITH THEM.

Riding north from Anau, one passes from bare clay on to gently rolling sand-hills, ancient dunes that have long since lost their barkhan shape and now appear to be of great antiquity. For a few days in spring these are green with grass, soon withered brown by the arid sun. So old are these now fossil dunes that their firm, cross-bedded sand stands wind-carved in vertical and overhanging bluffs, while all around are seen resistant holes deep-burrowed by desert turtles, lizards, and hyenas. Over them lie fresh barkhans of sand, now drifting from the ever-shifting waves of Kara Kum beyond. One might expect to meet with naught but dunes in such a wind-built desert land, but far out among them lie small areas of smooth

Fig. 487.—A Canal Gully in the Abandoned Irrigation Terraces of Anau.

flat clay, still bare—portions of the delta isolated from the rest at different times long past. And as they vary greatly in relation to each other, to the mother delta and to the dunes, these areas of bare clay become of interest. In some instances two plains separated by only a narrow ridge of dunes differ several feet in level. Thus we have preserved in open air the ancient delta surface, various horizons of antiquity escaped from burial.

How old these more ancient dunes around Anau are may be conjectured from a section exposed by our shaft sunk through the ruins of the sand-buried oasis near Ball Kuwi (see plate 69). There culture rests on hard, extremely fine, laminated clay, light brown, the contact being practically on a level with the takir plain just north and doubtless a continuation of its horizon. This clay bed is 4.5 feet thick and rests on 1 foot of dune-sand, below which lies another sheet of clay 0.5 foot thick. From there down our shaft continued in dune-sand, cross-bedded on a large scale and so loose that it was unsafe to go deeper, and how far it is to the next clay layer we know not, but imagine that for great depth the structure would be large masses of dune-sand interbedded with clay. What we did suffices to show that here was an area where an aggrading delta surface was from time to time encroached upon by dunes which it rose to bury. We have a value of 17 feet for the growth of the plain since it had risen to the level of the bottom of our shaft; a minimum value for the antiquity of the sand, because it is a long time since the last alluviation of this area. For at least many thousand years it must have been a region of outlying dunes.

ANALYSIS OF SHAFT SECTIONS OF THE DEPOSITS FROM MAN, WATER, AND WIND.

(See Plates 66–69.)

The moment that deeper layers are explored a host of problems arise. In our shafts, ranged on curved lines on plate 2, and on the profiles on plates 66–68, we penetrated four distinct kinds of growth, that of man's débris, that of his irrigation, that of natural alluvium, that of loess, and adding to them the flying sands of outlying dunes we find our plain is built of five divisions of deposition under the forces of man, water, and wind. It will be observed that there is a perfect gradation between the different divisions and subdivisions.

Man	Culture débris	Kurgan culture: Slow growth of clay débris rich in pottery, bones, and charcoal.
		Walled culture (that of fortified citadels): More rapid growth of clay débris less rich in pottery, bones, and charcoal.
Man / Water	Irrigation sediments	Garden culture: Growth of irrigated fields near a city; contains some artefacts.
		Undifferentiated sandy clay deposited under continuous irrigation of annually plowed fields.
Water	Natural sediments (alluvial)	Interbedded irrigation and natural sediments (the result of cultivating a naturally flooded area at rare intervals).
		Series 3: Laminated clays, sandy clays, sand and gravel.
		Series 2: Pure, hard, banded clays and beds of angular gravel with grit.
Water / Wind	Wind-swept flood-plain deposits	Series 1: Interbedded loess, blown sand, and alluvium. Soft, velvety clays, clay-banded loess, grit and gravel.
Wind	Dune-sand	Fresh dunes of pure loose sand (drifting).
		Dune-sand interbedded with the delta margins.
	Loess	Ancient dunes of firm sand mixed with loess particles (fixed).
		Loess mixed with wind-blown sand.
		Loess, pure homogeneous, of vertical cleavage, with small gypsum crystals.

Over 150 hours were spent underground in sketching the shaft sections here reproduced, and, in addition, fully half that amount of time was given to the study and comparison of samples taken out. Each shaft was scaled all the way down with levels scratched from a tape line, its layers cut clean by a long knife and studied with the light of an acetylene lamp, and characteristic samples taken out in solid blocks up to a foot high. Afterwards the material in these samples was studied under a microscope.

Culture remains are easily distinguished by their pottery, bones, charcoal, clay bricks, and various artefacts. In amount they vary from isolated artefacts found as fossils in wind and water deposits to the massive accumulations left by towns. It was found that such remains when *in situ* of original deposition were invariably associated with bits of charcoal, whereas those afterwards shifted by water or wind, or gravity alone, are nearly always utterly without charcoal; a truth explained by the fact that a material so light as charcoal is inevitably borne far beyond its heavier associates, such as potsherds or bones.

Irrigation sediments are of course far more widespread than culture, while between them there is a gradation which may be termed garden culture—sediments arising from the concentrated irrigation of gardens in and near a city and thus more rapid in growth than those of ordinary fields and containing many artefacts. These are all well exposed in gullies near the citadel of Anau. Irrigation stuff proper is at first hard to distinguish from natural alluvium, its stratigraphically differentiated equivalent, and even after long experience utmost care must be given to their separation. If all fields of cultivation had been continuously irrigated till abandoned, there would be no trouble, but this was not always so. In the graveyard shaft, we see how an area, after having aggraded 9 feet under irrigation, was abandoned to natural forces long enough for 2.5 feet of laminated clays to accumulate, after which it was again cultivated during the upper 11 feet of growth. It took about 10 hours' hard work to make sure how deep irrigation was in that shaft. No stratification can result on a cultivated area unless it be abandoned long enough for natural sediments to accumulate a greater thickness than is disturbed by subsequent hoeing or plowing, which is 4 inches and more. At its base irrigation stuff is often found containing fragments of natural sediment, below which are remnants of the original plow or hoe trenches. A characteristic mass of irrigation stuff contains all sediments utterly undifferentiated except for the gravel and coarser grit concentrated here and there in bottoms of canals from time to time abandoned and buried by irrigation through new canals. It is thus a homogeneous mass of sandy clay. The limits of such accumulations, both ancient and modern, have been described. Though varying in thickness from 10 to 25, the average appears to be 15 feet.

Natural alluvium directly underlies irrigation sediments. Of that penetrated by our shafts there appear to be three epochs of growth, differing in structure and kind and separated by two erosion intervals as indicated in sections of unconformity. During the first of these, our delta appears to have been a wind-swept flood-plain, which through inequalities of growth from time to time gave rise to shifting grassy areas left isolated from alluviation for so long that wind-blown material accumulated on them in various degree. Such appears to have been the first epoch state with its resulting interbedded gravels, grit and clays and homogeneous loess, which were penetrated with two shafts at the North Kurgan and two at the South. Some change took place and the delta was divided by a valley, how deep we do not know. Then began our second-epoch growth of pure, hard, laminated clays interstratified with beds of gravel. Probably ere the North Kurgan was founded this new epoch had aggraded its valley flood-plain and refilled its delta valley to within about 8 feet of the delta's old first-epoch surface, as traces of culture are found in all shafts down to this horizon, but nowhere below. This growth was of pure, hard clay, banded and finely laminated; blue when wet and yellowish when dry; it appears to bottom on a basal bed of semi-angular gravel, and to have ultimately risen nearly high enough to overflow the whole delta; that is, till the delta valley or channel was filled practically flush.

A second reexcavation of the valley was followed by its third-epoch growth filling the last channel, and this growth was in process when Anau city was founded and the stream was probably wholly used for irrigation, and so the growth has continued till now in the form of irrigation sediments, raising the delta plain around our kurgans to a height of 20 feet above its ancient first-epoch surface on which the two kurgan oases were founded. In it there is more sand than in any of the preceding epochs and it is likewise more rapid in appearance.

SUMMARY OF THE MORE IMPORTANT FACTS OF THE PAST PHYSIOGRAPHY OF ANAU.

First cycle.

- Pliocene, Kopet Dagh worn to low relief.
- Immense deltas built.

Second and third cycles (Quaternary).

- Two uplifts of Kopet Dagh and corresponding general sinking of plains, while the piedmont deltas of the first cycle are bent up along the base of the mountains.
- Valleys excavated and prolonged through old uptilted deltas to build new, smaller ones beyond.

Fourth cycle (Postglacial).

- Mountains continue rising again and the new delta at Anau continues tilting, but so slowly that with sufficient alluviation it grows.
- Reaction to dry and formation of delta valley.
- Reaction to wet and alluviation of delta valley. North Kurgan founded.
- During oscillations in precipitation over the mountains, alluviation twice again falls below rate of tilt and our buried delta valley thus twice again comes to be.
- Precipitation now scarcely in excess of underground drainage.
- Dunes desiccated of grass and set free to encroach on the delta plains.

OASES OF THE MURG-AB DELTA.

THE RIVER MURG-AB AND THE TYPE-PECULIARITIES OF THE MERV OASES, PAST AND PRESENT.

Rising in the mountains of Afghanistan and swollen by their melting snow and ice, the River Murg-ab issues north onto the plains of Transcaspia. There it splits over a large subaerial delta 100 miles from the mountains and inclosed by dunes of sand wind-sifted from its river silt. This far-expanded sea of drifting barkhans merges into the desert of Kara Kum, making the great delta a seat of oases extreme in desert isolation. At one time the Murg-ab may have joined the Oxus, and in still more remote antiquity may have flowed direct into an Aralo-Caspian Sea. Its chief oases may, therefore, in the past have changed through type V, type II, and finally into type I*a*; from lake shore to river bank, and at last the oases of an isolated delta. From the time when it failed to join either Oxus or Tedjend or reach a sea, the Murg-ab flowed to build an independent delta, and its oases were delta-oases, which, in the course of centuries, moved with the delta out and back, or perhaps always back if the river shortened with continuous desiccation. Here and there upon the clay surface, and beyond the limits now attained by water or even where the sand is drifting in, are seen mounds of clay and crumbled walls, the ruins of ancient towns and cities.

Prosperity of oases is wrought by two great factors, water-supply and geographical position. With the rivers of Central Asia, Murg-ab ranks fourth in volume and, unlike the Zerafshan, which feeds a myriad of oases along its course above ere nourishing the last, Murg-ab water flows to spread in full among the gardens of its delta. In it we find a river whose life-giving has been concentrated into one veined mass of gardens safely housed far out amid the dunes. The cities of Merv have thus long been favored with abundant water combined with sound protection by its wide surrounding desert. Alexander found it populous and full of wealth, and so did the Persians and afterwards the Arabs. And once

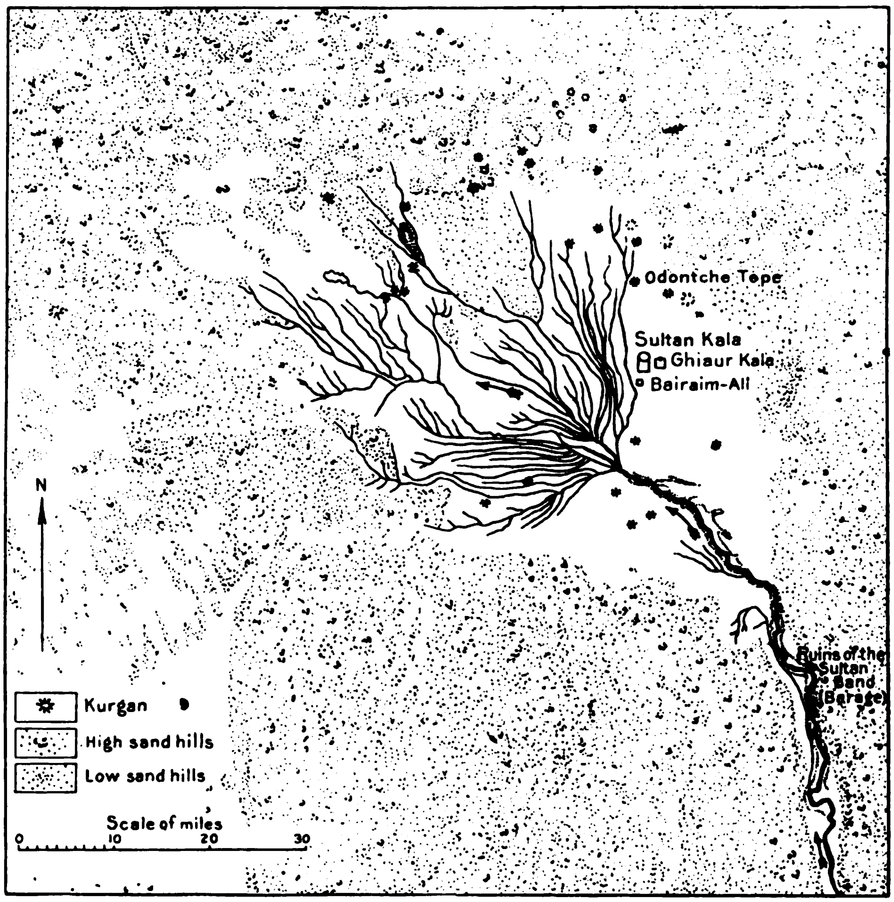


Fig. 488.—Map of the Murg-ab Delta. The Oasis of Merv.

the caravans had opened out their routes across the sand, Merv ranked as one of the world's great trade centers. Lying midway between the Caspian Sea and Roof of the World, it centers that whole region of ancient oases. By caravan from Meshed to Merv is less than 200 miles, from Khiva 300, from Paikent or Bokhara 190, from Samarkand 300, and from Balkh 275, measured along the route.

In their peculiar state as oases of type I*a*, those of Merv must have been especially sensitive to climatic change. To begin with, we must believe that a sufficient general increase of precipitation or even some change that would give rise to a larger proportion over the plains would make the desert into grass and thus break down the protective barrier. Also a large volume of water would penetrate farther out in the desert, a less volume less far, so that the delta with its oases, ever since there were any, must have varied in distance from the mountains, shifting out or back; responding to all greater cycles of climatic change. It is also evident that a river whose grade is for 100 miles that of a vast silt-made plain must have been extremely sensitive to any warping or tilting of its channel. But even greater must have been the changes wrought by floods, the ever-shifting of distributary systems or even bursting of the whole river out to build elsewhere anew. If we could look back through foreshortened geologic time, the Murg-ab would appear in course and kind fast changing, a river living through a marvelous variety; we might first see it flowing to the ancient Aralo-Caspian, and as that sea is cloven into shrinking remnants, and rivers wandering free-ended join, we see the Murg-ab now with the Tedjend, now with the Oxus, then shrunken alone and ever shifting, with meanders made to break into new straightness; a silt-laden flow that coils to burst and glide in some new wandering way; a river which with its season's flood may spread rare water in a wide sheet far out among the dunes and from that flood subside into new channels; for millenniums be led far to one side, leaving what was garden so by chance transformed to desert.

Thus were the oases of Merv controlled by Nature's ways and, though man could not prevent the effect of long-changed climate or much alter that of serious crustal movement, if it happened, the capricious behavior of delta distributaries used by him so stimulated his ingenuity that in time he got them under control. The Murg-ab with her silting distributaries proved a costly school, but graduated engineers whose works—canals, barrages, water-gates, and meters—were a marvel to antiquity.

An oasis so bountifully favored, and whose civilization was so stimulated by trade relations and the natural education forced upon its type, as well as the protective isolation of that type, bore a populous and wealthy growth with varied culture; a growth that always recuperated rapidly after falling to the power of such organized attacks as those of Alexander, Genghis Khan, and Timur.

The present outlines of bare clay upon the Murg-ab delta are irregularly pronged and have the aspect of a change or shrinkage of alluviating area, upon whose abandoned parts sand-dunes are drifting. In a general way it resembles a long leaf about 30 miles across, with two prongs—the left-hand one longest, and main axis pointing northwest to follow a general slope of the Turkoman Trough towards the Caspian. The convexity of alluviation is beautifully emphasized by its radiation of distributary veining and indicates a permanence of the present position of the delta for many centuries.

At present it is impossible to indicate the whereabouts of Murg-ab's most ancient oases. Knowing that for some thousand years all Central Asia has been undergoing desiccation, our first thought is to look north beyond the limits now attained by water. There is, however, no reason to doubt that a climate even more arid than the present may have existed in still earlier time; indeed, we have seen that throughout the Pamir and its border ranges glaciers had receded back of where they are now, apparently having been subjected to a reaction of extreme dryness after the glacial period came to an end. The Murg-ab delta was then very likely south of its present position; and although the delta is the most favored spot, it is possible that some town of importance may have been upstream. This, however, appears unlikely, for by tilt or warp its channel has long been cut beneath the plain and dunes have drifted to its banks where no water can be led now. It seems most likely that, if there were oases of importance to the south, they were of its delta there, and now cut through by its channel, since then prolonged. We have seen what a various existence the Murg-ab must have led through the long past, and shall therefore refrain from too much conjecturing as to the exact whereabouts of its more ancient oases.

IRREGULARITIES OF THE DELTA SURFACE WROUGHT BY MAN'S DEBRIS OF OCCUPATION AND HIS CONTROL OF ALLUVIAL DEPOSITIONS.

Turning to the ruins found upon the present delta and beyond, we find a field of great interest. Nowhere else in all Central Asia are ruins so abundant or so vast. In preservation they rank from Bairam Ali's state of brick-robbed walls and still-standing battlements, with gates and inner streets that may yet be ridden through, to the round-worn mounds of far more ancient cities. In size they rank from mounds that count square miles and rise as platforms of stratified débris, one to five score feet above the plain, to low clay heaps that mark the ruins of past monuments and tombs.

In all there are perhaps more than a hundred traceable towns and cities, some as much as 20 miles beyond the gardens of to-day; but for the most part they lie so far out on barren clay that only shepherd Turkomans know of them or wander among their heaps. Only Bairam Ali, Sultan Kala, and Ghiaur Kala are much visited or dug into by treasure hunters. They lie within the reach of cultivation, and through Ghiaur Kala's outer walls, now trenched, water is led to irrigate a wide depression, which may once have been a market-place. Round the ruins of these three cities and Iskendar Kala the native romance dwells.

Nearly a thousand square miles of the Murg-ab's delta are still bare of sand and ruins are seen over all this wide expanse of clay. It is a field so vast of surface problems, mounds, depressions, walls half buried, and canals long since abandoned, that years of study might be carried on without digging. One ride of a few miles leaves the rider at a loss for explanations; he finds areas that stand 5 to 10 feet higher than the plain in general, as though irrigation had been carried on a long time there with the rest around left barren; others in irregularity resembling the mere tops of silt-buried towns; and low areas somewhat irregular in surface with small holes where water has leaked down as though to fill the loose débris of buried ruins. Towards the delta margin he may come to a canal 5 to 10 feet deep and in the section thus exposed discover silt-buried dunes and find much sand has drifted, interlapping with alluvium. And the horizon round about him, flat and desolate, is broken here and there by distant towers, mounds, and citadels, that range far out into the faintly outlined forms which rise and vanish in mirage.

The most comprehensive point of survey is found on the Erke Tepe, a high knoll or crumbled tower of Ghiaur Kala's inner walls. This point stands central and 120 feet above the plain, with all the citadels of ancient Merv ranged round for 20 miles. Nearly all are flat-topped plateaus of varied height and length in profile; but sometimes, as the dust haze clears, far to the north more rounded forms are seen.

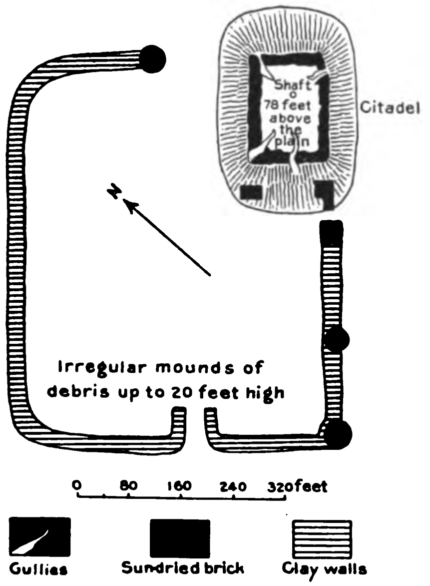


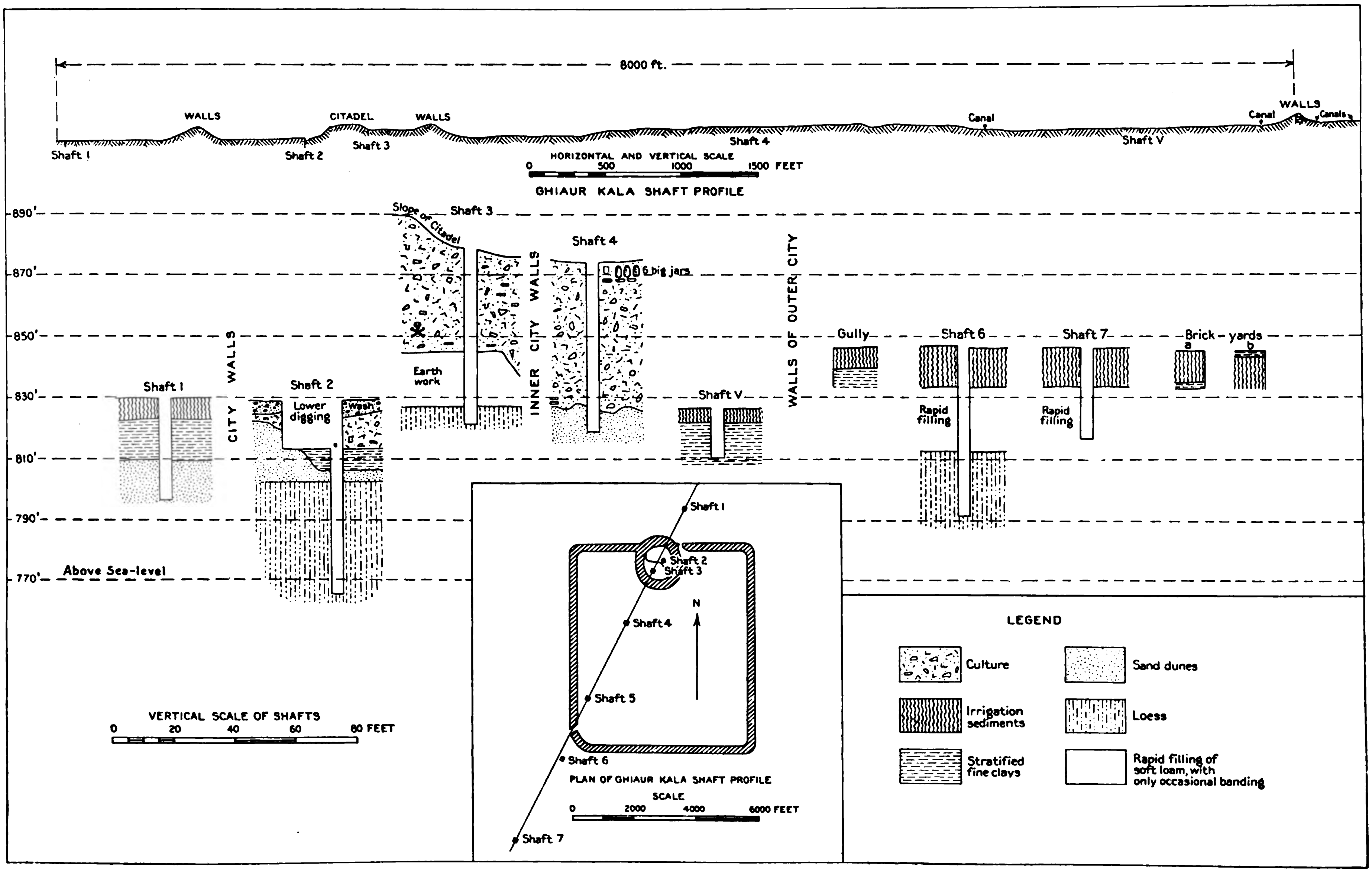
Fig. 489.—Sketch-map of Odontche Tepe (Merv).

Highest of all on the far horizon stands Odontche Tepe, nearly 8 miles due north. A superficial examination of this citadel revealed common wheel-turned pottery and glass, such as found on Ghiaur Kala, but its great height of 78 feet seemed promising of old layers towards the bottom. We attempted to explore it to the foundation with a shaft, but owing to its distance from water no men would stay there, though offered high wages, and our shaft was abandoned at a depth of only 44 feet. The débris proved lean of remains, evidently having been rapidly built up with walls as a point of fortification and not by slow accumulation of occupation. It seems probable, however, that in the construction of such a citadel advantage was taken of some preexisting mound, so that old débris might have been penetrated at a greater depth. It nevertheless proved a lesson in wind erosion. The adjacent area of culture mounds has been so rapidly worn down that a surface of erosion weathers pots and jars and cuts them clean off, flush with faintly outlined crumbling edges.

ANALYSIS OF SHAFTS AT GHIAUR KALA.—THE DEPOSITS FROM MAN, WATER, AND WIND.

As Ghiaur Kala was chosen for excavation it became important to concentrate physiographic shaft exploration upon that city and determine the relation between its growth and that of the plain through water and wind. For this work there was so little time that only a few shafts could be undertaken, and to assure the possibility of correlation it was necessary to have them fairly close together and in some simple relation to each other, to the main excavations, and to the oasis in general. With all these considerations in mind we located seven shafts on the profile line as shown on the map, three without and four within the city walls.

Here, as at Anau, we find that culture-strata, irrigation silt, natural sediments, and loess entered into the growth of the plain, but with the very important addition of large masses of flying sands, a fact to be expected with an oasis of



Ghiaur Kala Shaft Profile.

type I*a*. But the significant features in this section that may be comprehended at a glance are, first, the order of succession; second, the stratigraphic unconformity; and third, the relatively small thickness of water-laid deposits.

Beginning with culture-strata, we come face to face with several problems. Ghiaur Kala was a great city and one of fame. Its ruined walls inclose an area of more than 1.5 square miles, wherein there still remains a plateau of the débris of civilization rising to a height of over 50 feet above the surrounding desert, while the citadel itself attains a height of nearly 90 feet. Did occupation of this whole area begin on virgin ground, or was a part already occupied by some more ancient town when the greater city was laid out? Or, in either case, was the inner city founded at the same time as the whole? And after the whole city was laid out with its present outlines, was it occupied continuously till abandoned, or was it abandoned and reoccupied one or more times?

In the shafts, as in the main excavations, there was found no sharp transition showing change of culture, and no one of them passed from culture into irrigation. Moreover, if there had been a town there before, we should expect to find its pottery or some trace, such as charcoal or ashes, in the natural sediments under irrigation and culture-strata, as was invariably the way at Anau; but such is not the case. Though our evidence is in part merely negative, the city of Ghiaur Kala seems to have been founded on a desert surface of sand-invaded loess-steppe, partially buried in alluvium, and irrigation seems to have started simultaneously with it. And the fact that genuine culture-strata attains the same thickness above the citadel's foundation as it does in the plateau of the outer city is evidence pointing to a simultaneous occupation of both.

With irrigation deposits we find that 12 feet is apparently the average depth, surprisingly little when considering the antiquity attributed to Merv; 15 feet was the average at Anau and we had thought of Merv as an oasis of such ancient importance that it must have introduced irrigation long before, and, with the whole Murg-ab to draw upon, been able to maintain bountifully rather than sparsely watered gardens from the beginning. Then what is the explanation of its shallowness? Obviously we must choose between three possibilities—either the rate of growth was less, or irrigation was introduced later, or it was in no given area carried on so uninterruptedly here, as at Anau. Surely there is silt enough in the river to give a growth as rapid as the Anau, and Ghiaur Kala was founded earlier than irrigation is supposed to have been introduced there. We are driven to the conclusion that the gardens of Ghiaur Kala were of a wandering sort, shifting out and back and sideways around the city, according to complications in the canal system and conditions of soil. Large areas are in our days from time to time abandoned for fresh land on account of the efflorescence produced by prolonged irrigation with saline water.

Natural sediments fall next in the order of antiquity. They lie directly under culture and irrigation silt and over dunes and loess. Here, again, we are surprised by shallowness. Except for the interesting masses of obviously rapid formation that appear to fill depressions of the old loess topography in shafts 6 and 7, the natural sediments are nowhere over 10 or 15 feet thick. Their delicate laminations and extreme fineness of material differentially colored in thin bands of clay, for the most part buff and brown, are evidence of slow accumulation over a surface exposed to the oxidation of desert conditions. Although in a general way the growth of natural sediments came to an end with the beginning of irrigation and was superseded by that new kind of growth, we should expect to find layers similar to the natural at any horizon and interstratified with both culture and irrigation beds. From the time when one of the Murg-ab's distributaries which fed Ghiaur Kala came under the control of man for irrigation, it ceased to be natural, *i. e.*, became an artificial canal, and thenceforth any sediments deposited by its waters were other than natural. We have called those accumulating under the stratigraphically disturbing influences of cultivation irrigation sediments. Sediments formed in choked-up canals, reservoirs, and abandoned fields may be termed *canal sediments*. The irregularities produced by occupation and irrigation of a plain, with such a gentle slope as the one with which we are dealing, inevitably result in the formation of extensive shallow depressions where, sooner or later, canal sediments accumulate. It is, then, canal sediments that have risen by the west wall and that form a 2-foot capping to the irrigation stratum cut by brick-yards southeast of the walls of Bairam Ali.

Shafts I, II, and IV penetrated characteristic dune-sand, so loose that shafts I and IV had to be abandoned before the underlying loess was reached. But in shaft II we had just enough to give a key to the section and yet not enough to interfere with sinking, though the same mass attains a thickness of over 15 feet in the wall of the main excavation (lower digging), just to one side and a few feet above. Sand-dunes were evidently characteristic of the region before it was occupied and much of the city appears to overlie them. It is a significant fact that flying sands are found beneath both culture-strata and water-laid deposits, natural and artificial, and beneath it all is the loess. Every shaft that went deep enough found the great underlying mass of loess. Shaft II found it under dune-sand at −27 feet and sank 36 feet down into it, pure fine loess with vertical cleavage and calcareous concretions all the way down to where we stopped at water-level, 63 feet below the surface. How much deeper it goes may be guessed, but there is no reason to doubt that it might be many hundred feet.

THE STRATIGRAPHIC ORDER: (1) LOESS, (2) DUNE-SAND, (3) ALLUVIUM, EXPLAINED BY CLIMATIC CHANGE TO DRY, AND RECESSION OF THE DELTA.

Now we are in position to correlate. The direct neighborhood of Ghiaur Kala had long been a loess steppe with topographical relief amounting to at least 25 feet elevation between its summits and depressions. As a result of some change in conditions it was invaded by flying sands, after which began the alluvial flooding and depositions over its lower portions; and it was during this stage that the builders of Ghiaur Kala arrived to look upon a land of desert dunes and playas, with here and there a remnant of the old half-drowned loess topography. Upon one of these remnant loess masses rising about 16 feet above the flood-plain of a distributary canal, they built their citadel, piling it up with clods of clay to a height of 34 feet, and around it threw up the massive walls of the inner city, of whose colossal height more than 70 feet still remains. That the outer city with its walls was laid out at the same time we have shown to be likely. So they built their city and from that time the distributary stream they had chosen is for physiographic purposes to be regarded as an irrigation canal, and the sediments laid down upon its flood-plain, irrigation and canal sediments, according to whether the area considered was under cultivation or not. While the débris of occupation rose within, these sediments grew upon the plain without the walls and to a certain extent continued growing after the abandonment of Ghiaur Kala in the eleventh century; for it was then that a new Merv, whose ruins are now called Sultan Sanjar, was founded but a few hundred yards away and water still found its way into this region.

Loess, dune-sand, alluvium, and human débris is, therefore, the stratigraphic order of our physiography at Merv, the record of Nature and man, the effect for which we seek a cause. And of all time-sections it has been our fortune to study, this one is the most beautiful illustration of the organic changes that constitute the process of a great interior desert region effected by climatic change.

During the accumulation of loess there must have been a sufficient precipitation to nourish grass over this area, but it is now too arid. It was then doubtless a time of greater precipitation over the Murg-ab's catch-basin which would enable that river to penetrate farther into the desert giving it a delta north of the present. The flying sands derived from wind-work over the delta were probably accumulated into more or less stationary dunes around it, while most of the finer material settled as loess between it and the mountains. Then, I believe, a decrease in precipitation demolished the grass, set free the dunes to drift over all neighboring areas free from alluviation, while the river shrank with its delta, receding mountainwards to build over the dune-strown loess topography of Ghiaur Kala, and at this stage the city was founded.

PART VI.

ANIMAL REMAINS FROM THE EXCAVATIONS AT ANAU

AND

THE HORSE OF ANAU IN ITS RELATION TO THE RACES OF DOMESTIC HORSES.

By Dr. J. Ulrich Duerst.

Professor in the University of Bern.

[Chapters XVI–XX. Plates 71–91.]

CHAPTER XVI.—INTRODUCTION.

The rich material sent to me by Mr. Raphael Pumpelly for examination consisted of a very large quantity of small fragments of bones, the putting together of which was attended with great difficulties. Fortunately the collecting and the preserving of the bones had been conducted with extreme care. It was thus possible both to form a picture of the fauna which lived during the forming of the different culture-strata at Anau in Turkestan, and to complete the reconstruction of some skulls and extremities. The whole collection of bones can be best classified, according to derivation, into those which come: (1) from the North Kurgan; (2) from the South Kurgan; and (3) from the citadel of Anau.

The material from the North Kurgan is by far the most abundant. It is classified according to the system established at first by Messrs. Pumpelly and Hubert Schmidt, viz: Culture I, from 20 feet below the level of the plain to 15 feet below the same; Culture II, from 15 feet below the plain to 25 feet above the same (−15 to +25 feet); Culture III, from +25 to +40 feet, *i. e.*, to the summit of the kurgan. This classification has, in the light of my investigations, shown itself to be justified, although these gentlemen have since abandoned it for archeological reasons, in favor of the more simple subdivision into two cultures, viz: (I) Æneolithic, −20 to +25 feet; (II) Copper Culture, +25 to +40 feet. Notwithstanding this change, I believe that the original classification should be maintained to the extent of dividing culture I as follows: (I*a*) −20 to −10 feet; (I*b*) −10 to +25 feet.

With this general explanation I shall present a review of the varieties of animals represented among the bones found in the kurgan.

First of all, it is evident that these bones are wholly the remains from meals, this being shown not only by the manner in which they were broken, but also by the numerous traces of teeth and sharp instruments still to be seen on their surface. The bones of which I shall treat in the following pages are the best pieces only. All the indeterminable pieces and those of uncertain determination are wholly omitted. It would be difficult to give a trustworthy and convincing outline of the approximate number of individuals, since the pieces are often too poorly preserved to permit us to see whether or not they belong to one and the same individual. We can, therefore, only estimate them as follows:

Culture I*a* contains about 150 good pieces of bones, including *Equus* sp., 20 per cent; *Bos* sp., 27 per cent; *Ovis* sp., 22 per cent; *Antilope* sp., 20 per cent; *Canis* I sp., 11 per cent.

Of culture I*b* there are about 1,850 good bones. Here the representation of species is as follows: *Equus*, 28 per cent; *Bos*, 25 per cent; *Ovis*, 25 per cent; *Sus*, 12 per cent; *Antilope*, 7 per cent; *Cervus*, 1 per cent; *Vulpes*, 2 per cent.

Culture II, with 1,300 bones, shows the following relative distribution: *Equus*, 25 per cent; *Bos*, 20 per cent; *Ovis*, 20 per cent; *Sus*, 15 per cent; *Capra*, 10 per cent; *Camelus*, 5 per cent; *Canis* II, 2 per cent; *Antilope*, 2 per cent; various wild animals, 1 per cent.

The same relation as in culture II holds good also for the South Kurgan and the mosque-shafts of the citadel of Anau, except that here the sheep and goat are more prominent, while cattle and pigs are diminished in importance.

The number of bones determined and numbered by me amounts to about 3,500, of which unfortunately only a relatively small percentage, about 10 per cent, are skull bones, about 17 per cent lower jaws and teeth; about 5 per cent are vertebræ and rump pieces and 71 per cent are bones from the extremities.

As regards the preservation of the bones, we find here the same conditions as among the European occurrences. The greater part of the bones have a light yellow-brown color, though some from the very lowest layer, as for instance those of the wild ox, the gazelle, the wolf, and the horse, show a dark red-brown color. There also occur some burnt bones from the period I*b*, which are calcined and colored greenish-black. Some bones are distinguished further by a rich content of saltpeter, which causes them continually to extract water from the atmosphere and remain in a constantly moist condition. The old fractures, which show the same coloration as the surfaces of the bones, in contrast to the yellowish-white color of fresh fractures, enable us to make certain observations concerning the way in which the Anau-li broke bones. But we must first mention a peculiarity of all the light-colored bones—their high porosity and capillarity. If, for instance, one takes the metacarpal or metatarsal bone of a horse, even as heavy as 200 grams, or a piece of any other bone with much *substantia compacta*, and touches the tongue to a fresh fracture, the bone will hang on so firmly that it can be removed only with difficulty; and a place so small as to be touched only with the point of the tongue is able to support a weight of 200 grams or more. This is a peculiarity which I have found to exist to a similar extent only in the teeth of the fossilized Siberian mammoth, and it indicates a very great age for the bones of Anau.

The breaking of the bones was carried to a greater extent than among the neolithic Europeans; for while these last broke open only the tubular bones of the horse, ox, deer, sheep, and pig, to suck out the marrow, and rarely the plate bones, as the caps of the skulls, horn-cores, ribs, etc., this was always done by the prehistoric Anau-li. All bones were broken into several pieces and many still show the distinct traces of sharp cutting instruments as well as of crushing teeth. The phalanx bones of the horse, ox, sheep, and pig escaped this fate, as did the horn-cores of the *Gazella subgutturosa*, of which the structure is too hard and the texture too compact to offer any temptation to break them open for marrow.

Little is to be seen here of a definite method of breaking bones, such as described by Rütimeyer for the dwellers in the Swiss pile-dwellings, and by me for the Germans of the Schlossberg, as the tubular bones and plate bones, lower jaws, and other cranial pieces are of an entirely different shape. Of the tubular bones, chiefly the distal and proximal ends are found, and the shaft is broken in many pieces, which it is rarely possible to put together to complete the bone; so that it would seem that the bones were for the most part broken with a dull instrument. Only in culture periods I*b* and II do we find more frequent traces of scraping and cutting done with sharp instruments. In connection with the cranial pieces it is to be mentioned that all skulls were split through the middle. What I just said also applies here. In culture I*b* for the first time, and in period II, we find a sharp cut through the skulls of horses and of sheep. Skulls of period I*a* and the beginning of period I*b* were probably all broken with dull instruments; and for this reason we do not find any linear fractures, but merely jagged breaks, which in young animals follow the sutures.

Lastly, as regards the age of the animals of which we have the bones, it is to be noticed that really old animals do not occur, with the exception of some horses, an ox, and some pigs, sheep, and gazelles. The remaining animals are for the greater part adult, except that among the sheep and pigs there is a great quantity of bones of very young animals—small porklings and lambs. This is confirmed by the abundant occurrence of milk teeth and epiphyses of the extremity bones. It is particularly important to observe that more than 95 per cent of the bones of very young animals belong to uppermost layers of the period I*b* and period II; from which it would seem proper to draw the conclusion that this consumption of young animals indicates herds of considerable size. The contrast to the pile-dwellers of Europe and the Germans of Schlossberg is very evident, since among these Europeans the appearance of young animals on the table was relatively rare.

The investigation of these bones lasted from the autumn of 1904 to the spring of 1907, and was carried on according to the methods applied in former researches. For their comparison with recent bones I have used my own collection, as well as those of the museums in Bern, Vienna, London, and Berlin. Besides this, my friend, M. Paul Gervais, in Paris, very kindly made for me any necessary measurements on the skeletons in the collection of the Museum of Natural History in Paris. For comparison with subfossil bones I have, in addition to the results of my own previous investigations and the measurements given in the literature on the subject, the collection of the Museum Society in Teplitz, including bones from fifty localities in Bohemia, sent to me at the same time for determination and labeling.

It only remains for me to express publicly to Prof. Raphael Pumpelly my warmest thanks for the pleasure he has given me by intrusting to me the study of the bones from such an extremely interesting locality, as well as for the kindness with which he assumed the tedious task of correcting and translating this report, which I had written partly in English and partly in German.

I am also indebted to the directors and managers of the museums I have named, and especially to Professor Studer, director of the Museum für Naturkunde at Bern, for assistance in preparing this memoir.

CHAPTER XVII.

Ordo CARNIVORA.

CANIDÆ.

The Canidæ are abundantly represented among the bones from Anau; nevertheless their determination is not always easy. The animal of which we find the best-preserved bones, both complete skulls and bones of the trunk and of the extremities, is the fox.

Canis vulpes Linnæus, *Vulpes montana* (?) Pearson. (See plate 71, figs. 3–13.)

We find in the Anau kurgan two skulls in a very perfect state of preservation and 12 bones of the extremities as well as cervical vertebræ. Thus we can make an exact determination of this animal.

As the measurements of the following list will show, the foxes of Anau were not as large as those of Germany, but are closely similar to a recent fox from Tor on the Red Sea, whose skull is preserved in the Museum at Bern. The neolithic fox skull of the Swiss pile-dwellings of Schaffis is also smaller and nearly agrees with another skull from Sinai. The size of these fox skulls must not be taken as indicating a difference in species, however, for it is quite possibly attributable to a difference of age and sex.

Pearson,* in describing his *Vulpes montana*, which probably occurs also in Turkestan, was not able to show any osteological difference between it and the common fox; the only difference being in the skin. Thus we may assume, though without possibility of confirmation, that we have here also the mountain fox (*Vulpes montana* Pearson), which is surely only a variety of the common fox. The bones here shown are certainly not those of an interloper of modern times, as one might suppose from the perfect state of their preservation. They are, to judge from the structure of the bone material, as old as the other bones of the

Table of dimensions (in millimeters.)

Extremity bones.	Femora.		Tibia, −6 feet, No. 389.	Radius, +23 feet, No. 56*b*.
	−6 feet, No. 392.	+26 feet, No. 871.		
Length	112	126	123	113
Width of proximal end	21	24	19	14
Diameter of proximal end	7	8	21	20
Width of median part	6	7	5	6
Diameter of median part	5	6	6	7
Width of distal end	17	18	12	18
Diameter of distal end	18	21	8	13

*On the *Canis vulpes montana*, Bengal, Journal Asiat. Soc., IV, 1835, p. 324.

Table of dimensions (in millimeters).—Continued.

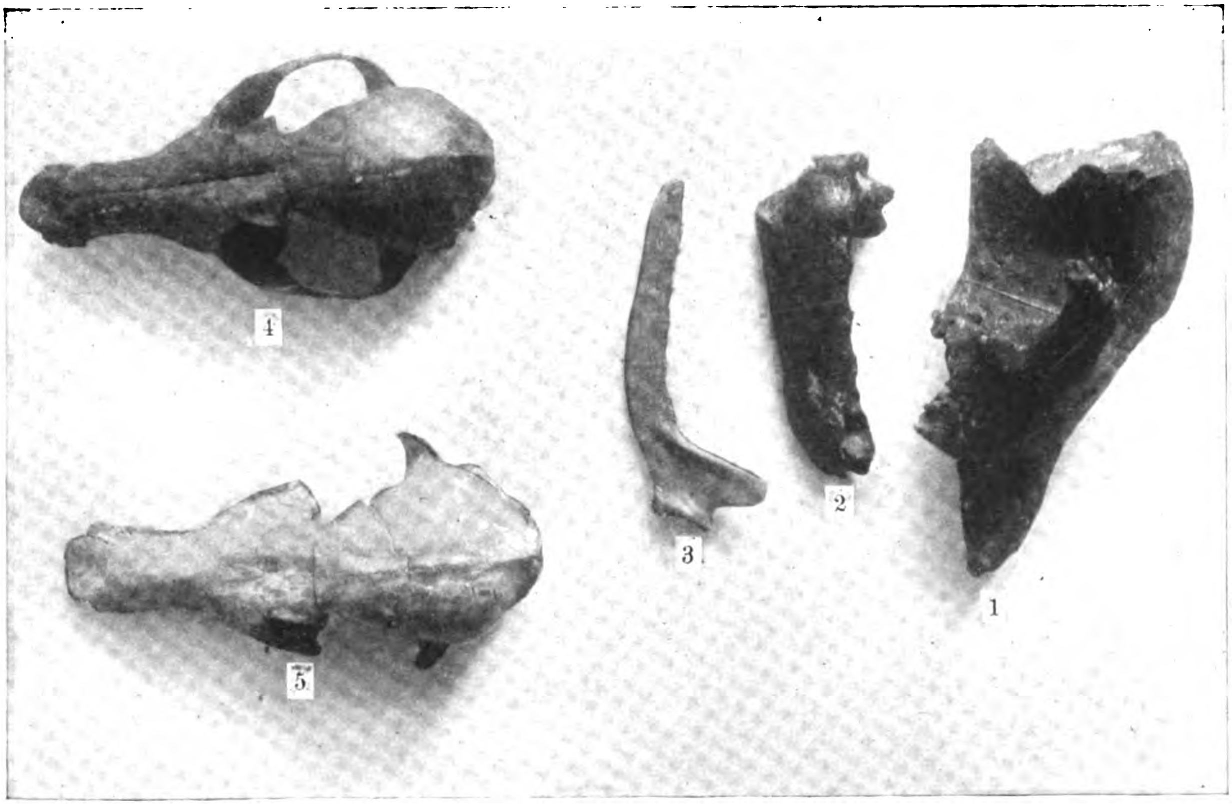
Skull.	North Kurgan, Anau, +17 ft. No. 95.	North Kurgan, Anau, +17 ft. No. 94.	Fox from Tor on the Red Sea (Mus. Bern).	Common fox (fem.) from Germany (coll. Duerst).	Fox from neolithic pile-dwelling Schaffis (Mus. Bern).	Fox from Sinai (Mus. Bern).
Basilar length	123	124	122	128	114	113
Basicranial axis	50	51	50	54	49	46
Basifacial axis	71	....	69	72	65	61
Length of nasalia	47	....	46	49	39	42
Width of nasalia	8	9	8	9	7	9
Length of palate	66	....	65	69	58	57
Width of palate behind premolar 4	22	22	21	23	20	21
Greatest width of skull	44	48	44	44	41	42
Width on meatus auditorius externus	42	45	42	45	42	42
Width on arcus zygomaticus	66	....	66	72	68	78
Least dimension of temporal	19	19	21	20	20	20
Width between proximal orbitals	29	28	30	32	30	31
Least dimension between the interior borders of orbits	23	23	22	27	24	21
Length of cavitas cerebralis	70	69	71	76	69	72
Length of face	62	64	63	67	....	62
Width of skull	39	42	40	42	....	35
Width of occiput	42	45	42	45	....	42
Length of lower jaw	97	....	....	....	....	91
Length of molars of lower jaw	57	....	....	....	....	48

layers in which they are found; but their perfect condition seems to indicate either that the ancient inhabitants did not care to crush these bones or that the foxes died while searching for food after the destruction of the dwellings of the layer in which they were found.

Canis lupus Linnæus (*Canis pallipes* Sykes [?]). (See plate 71, figs. 1 and 2.)

In the æneolithic culture-period we find at +8 feet three remains belonging apparently to the same animal. These are a half of a right upper jaw, a part of the right frontal bone, and the anterior part of the right branch of a lower jaw. The dark-brown color of these three bones seems to confirm the supposition that they belong to the same individual. The upper jaw is distinguished by a short row of teeth. In this again the premolars form a relatively short row and the carnassial tooth is relatively very large. If we make the dental row equal to 100, the length of the carnassial tooth is 30 per cent and that of the three premolars 44 per cent. Among wolves, both European, Indian, and American, Studer finds the first relation varying between 25 and 29 per cent; only in a *Canis hodophylax* from Japan is the relation 31.4 per cent. The relation of the three premolars to the whole row of back teeth amounts among wolves to from 43.5 to 49 per cent, and in *Canis hodophylax* 40 per cent. In our case, however, it is 44 per cent, in which the proportion falls into line with those of the wolves.

This Anau canine was without doubt a wolf whose muzzle is somewhat short, the premolars are small, while the carnassial tooth is large, although the anterior inner protuberance of the carnassial tooth is very slightly developed. Interstitial



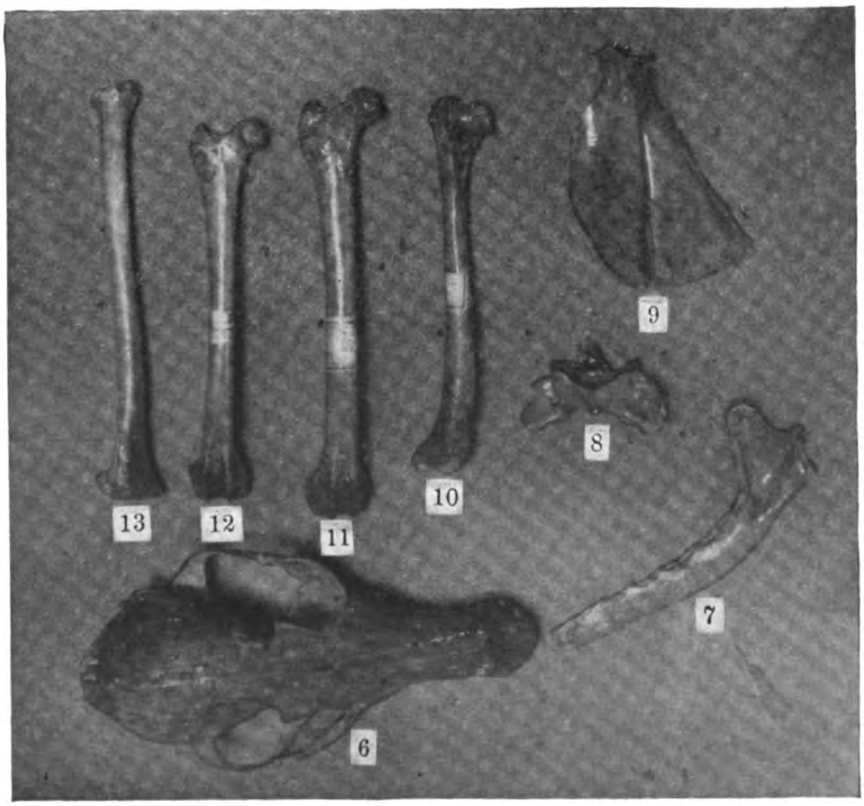


FIG. 1. Facial part of skull of wolf (*Canis lupus* Linn.).
2. Part of lower jaw of *Canis lupus*.
3. Lower jaw, left branch, of fox (*C. vulpes*).
4–6. Skulls of foxes (*C. vulpes* Linn.).
7. Left branch of lower jaw.
8. Atlas (first vertebra cervicalis).

FIG. 9. Scapula.
10. Humerus of young individual, posterior epiphysis wanting.
11. Femur of large individual.
12. Femur of smaller individual.
13. Tibia.

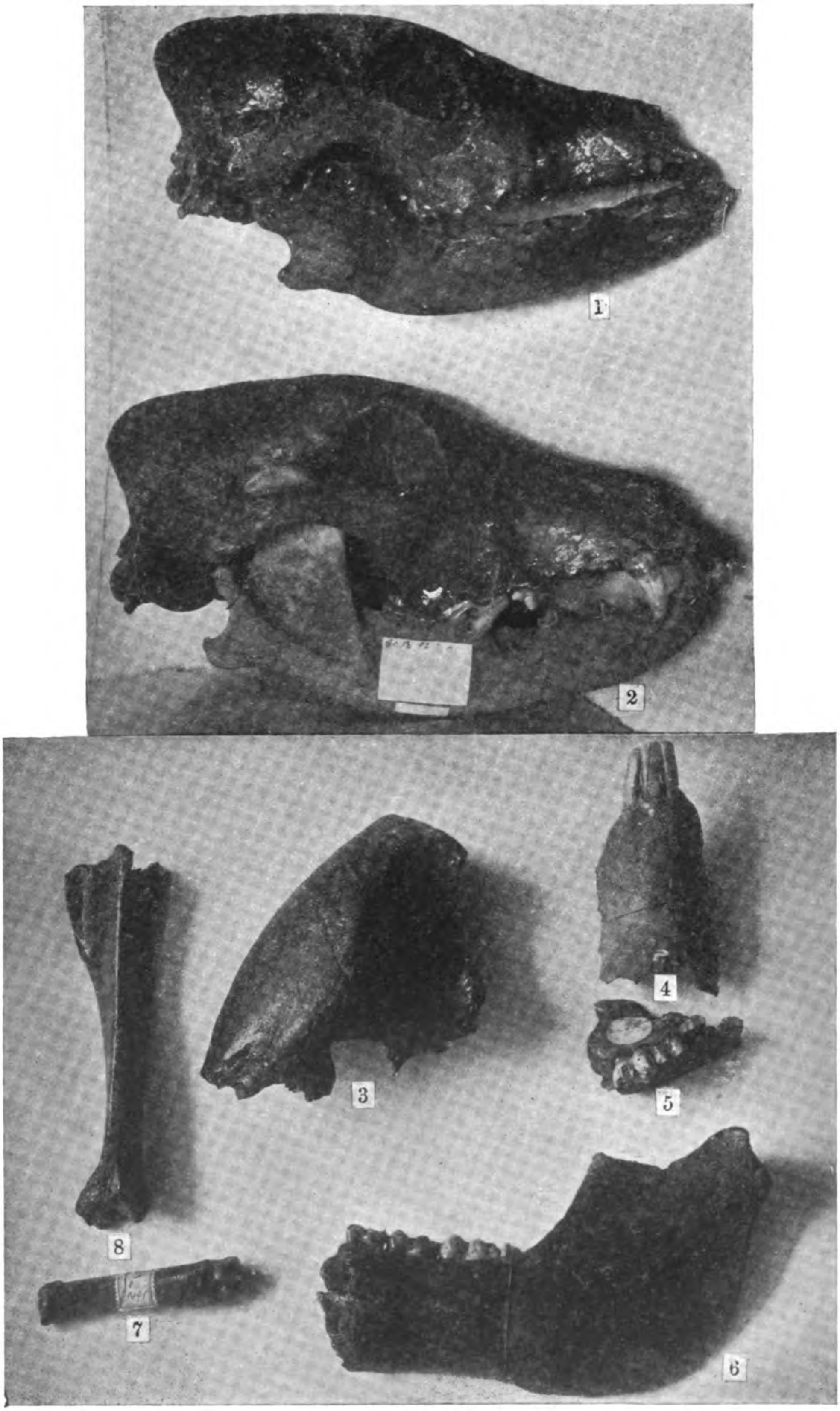


FIG. 1. *Canis matris optimæ* skull from Anau (restored).
2. *Canis matris optimæ* skull from Kutterschitz in Bohemia. Lower jaw from individual from Gross Czernosek a. Elbe. Bronze Period. Museum at Teplitz (Bohemia).
3. Brain skull of *Sus palustris*. (Compare with *Sus cristatus*, plate 80, fig. 1.)

FIG. 4. Corpus of lower jaw of *Sus*.
5. Rest of right part of upper maxilla.
6. Posterior part of left branch of lower jaw of *Sus*.
7. Tibia of *Sus* with mark of gnawing.
8. Right metatarsus medius of *Sus*.

spaces between the premolars are absolutely wanting, while they are very largely developed in the skull of a wolf from Peking. This character is derived from the greater shortness of the muzzle, whose length is that of *Canis pallipes*. The second molar is also strongly developed. Thus the remains of the upper jaw are characterized as belonging to a wolf. The lower jaw, however, contributes still more proof.

So far the bones might still possibly belong to *Cuon alpinus* Pallas, since the dimensions of the teeth are similar, especially as regards the carnassial tooth, which for the most part is 21 mm. long (21.2 to 21.5, according to Nehring). But the lower jaw decides clearly in favor of the wolf, since the talon of the first molar shows two very stout conical points. In the *Cuon* there is invariably only one conical point. The accompanying measurements explain these relations. The Anau wolf stands apparently nearest to the Indian wolf or *Canis pallipes* Sykes. Indeed, it is not at all unlikely that *Canis pallipes* formerly existed in the district of Anau and on the Kopet Dagh. In any event it is certain that the Indian

Table of dimensions (in millimeters).

Upper jaw.	Length of tooth range.	Length of carnassial tooth.	Width of carnassial tooth.	Length of molar 4.	Width of molar 4.	Length of molar 3.	Width of molar 3.
Anau, -6 feet	70	21	10	14	16	8	12
Canis lupus Linnæus, Russia (Mus. Bern)	71	20	11	13	17	7	12
Canis pallipes Sykes, India (Mus. London), after Studer	....	21	10	13	....	7	....
Cuon alpinus Pallas (after Studer)	67	21	....	15	15	7	10
Canis lupus Linnæus, killed near Peking (coll. Duerst)	81	21	11	17	18	8	12
Canis poutiatini (after Studer)	65	18	....	....	....	....	....
Canis inostranzewi (after Studer)	67	19.5	....	....	....	....	....

buffalo (*Bubalus arnee* Kerr) still existed in historical times in northern Persia and Mesopotamia; and if these, why may not *Canis pallipes* also have had a wide geographical range? According to the view of Th. Studer,* however, this is not at all necessary, for according to exact researches the different species of wolves present only local forms which are without profound differences. Therefore, we will characterize the wolf of Anau only in general terms as *Canis lupus* Linnæus. We will, however, emphasize the fact that it harmonizes best with *Canis pallipes* Sykes.

We have not, however, done with the bones of the Canidæ of the Anau kurgans. We find in the strata between +28 and +36 feet a perfectly preserved skull with the superior maxilla belonging to it, as well as two lower jaw branches, one right and one left, which possibly belong together. These bones differ in essentials from those of the wolf in numerous ways, for which reason they can not belong to the wild Canidæ; we have here to do with a tame animal, the domestic dog.

*The Prehistoric Dogs. Abhand. Schweiz. paleont. Gesell., p. 9. Zürich, 1901.

Canis familiaris matris optimæ Jeitteles. (See plate 72, figs. 1 and 2.)

I have with great care put together the remains of the skull found at +28 feet and thus reconstructed the whole skull as shown in plate 72, fig. 1. The length of the skull is 164 mm. Therefore, this dog belongs to the dogs of medium size. The skull is relatively low and approaches in this respect *Canis poutiatini* Studer, and the dingo. It is but little developed in width and is arched. Also, in the temporal region it is but slightly concave. The sagittal-muscle ridge is strongly developed. The tympanic cavities are relatively small, blistery, and without the usual keel-shaped ridge. The face shows a slight zygomatic arch and relatively broad, short palate. The relation of the dental arch of the upper jaw is as follows: The length of the carnassial tooth is 25 per cent of the whole row of back teeth, that of the three premolars is 42.5 per cent. We have, therefore, to do with the genuine dog. The carnassial tooth, however, has only an absolute length of 17 mm. and a width of 8 mm., which indicates a house-dog. The other cranial measurements are easily seen in the following table, in which the skull is compared with various others of similar size, of wild and domestic Canidæ.

Table of dimensions (in millimeters).

Skull.	*Canis*, North Kurgan, Anau, +28 ft.	Australian Dingo, after Studer (*op. cit.*)		Pariah dogs, after Studer.			Ireland, *Canis matris optimæ*, after Studer.	Switzerland, recent shepherd-dog of Bern (Studer).	Bohemia, *Canis matris optimæ*, Mus. Teplitz.		Siberia, *Canis inostranzewi*, after Studer.	Russia, *Canis poutiatini* Studer.	India, Salt Range, *Canis pallipes* (after Studer).
				Male.		Female.			Tschontschitz pile-dwellings.	Briesen La Tène.			
		No. 4.	No. 3.	India	Egypt	Egypt.							
Basilar length	164	166	165	161	167	157	165	164	168	164	164	169	208
Length of palate	88	91	92	90	94	84	91	91	94	91	90	..	115
Width of palate	50	49	52	47	50	47	46	50	49	49	50	..	53
Greatest width of skull	57	57	57	57	58	56	62	58	56	56	56	57	57.5
Width of meatus auditorius externus	57.5	56	57	52.5	55	50	60	52	59	60	60	58	75
Width on arcus zygomaticus	102	105	112	....	112	98	..	104	104	....	..	..	....
Least dimensions between inferior borders of orbits	37	34	35	....	42	39	32	35	34	36	..	38	....
Height of skull	54	52	51	51	59	53	56	58	55	57	58	50	59
Length of teeth	69	64	62	....	65	63	66	66	68	61	61	65	....
Length of carnassial tooth	17	18	17	....	17	18	18	18	18	15	18	18	21
Length of molars	18	18	17	....	18	19	20	20	17	15	18	..	20
Width of carnassial tooth	9	....	....	....	9	10	11	10	8	7	..	..	10
Basicranial axis	46	49	48	43	47	44	45	45	48	....	50	..	60
Basifacial axis	112	117	117	118	120	113	120	119	120	....	114	..	152

After long and careful consideration I give below certain conclusions which are based on these comparative measurements and on the direct comparison of the Anau skull with the collection of dog skulls in the museum at Bern, and also especially with the rich collection of subfossil Bohemian dog skulls, containing abundant material from 50 different Bohemian localities, which the Museum Society in Teplitz had the kindness to intrust to me for determination and publication.

As remarked by Prof. Th. Studer, to whom I gave simply the occipital bone and piece of skull of the still unreconstructed cranium for examination, this piece of the skull possesses in a high degree the peculiarity and character of the dingo or the pariah dog. However, after closer comparison made later with the completely reconstructed skull, I was able to decide that it has a very strongly marked resemblance to the European shepherd-dog, especially in the facial part. The only differences that this skull shows from the *Canis matris optimæ* of Jeitteles are that the upper jaw is less pointed and the palate a little broader than in the latter. This means that the muzzle of the Anau dog was somewhat shorter and broader than that of the prehistoric European shepherd-dog. As appears from the measurements, indeed, the skulls of the dingo and pariah dog agree very well with those of the Anau dog. Here, too, the muzzle is always a little longer and narrower, and the zygomatic arch a little wider than in our dog. Nevertheless, these differences are not great. They are even smaller than those produced by the difference in sex between two upper Egyptian pariah dogs published by Studer.

That the Anau dog belongs to the shepherd-dog or to the pariah dog, which resembles the shepherd-dog, will be made clear by the following relations of the basicranial axis to the basifacial axis.

Table showing relations between the basicranial axis and the basifacial axis expressed in proportions to 100.

European wolf.	Indian wolf.	Pariah dog.	Dingo.	Shepherd-dog.	Anau dog, North Kurgan.
36.5 36.8 37.7 38.7 39.1	36.3 38.3 38.7 39.4	36.5 Nepaul. 39.0 Egypt. 39.1 Egypt. 39.8 Bengal. 39.8 Sumatra. 40.8 Egypt.	38.1 41.3 41.9	40 Germany. 41.9 France. 41.9 *Canis matris optimæ* fossil.	41.8

Here again it is clear that the Anau dog can have nothing to do with the wolves or wolf-dogs, in which the basicranial axis is 36 to 39 per cent of the basifacial axis, or with the hound, in which this is 35 to 37 per cent.

What we deduced, from direct measurements as to the form and size of the skull, is thus clearly illustrated in these very constant ratios; and it appears that our dog, standing near to the dingo as well as to the small Russian fossil wild dog, (*Canis poutiatini*), must be assigned to the shepherd-dogs or to the pariah dogs which resemble them. This relation is very well shown further in the ratio between the cranial height and length, which is clearly expressed in the following table:

Table showing the cranial height expressed in percentages of the length.

Indian wolf.	Dingo.	Shepherd-dog.	Pariah dog.
27.2	30.9	32.7 *Canis matris optimæ*, fossil dog.	31.7 Nepaul.
27.8	31.1	32.9 Anau dog.	33.8 Egypt.
28	....	33.5 France.	35.0 Egypt.
30.2	....	34.5 Germany.	....

According to the table the skull from Anau ranks directly behind the subfossil cranium from Olmütz, the original skull of Jeitteles.

The domesticated dog of Anau belongs accordingly to the subspecies of Canis familiaris matris optimæ in a form which stands craniologically very near to the dingo and to Canis poutiatini Studer, but which is distinguished by a rather broad muzzle.

But how does *Canis matris optimæ* come to be among the inhabitants of the Anau kurgans? Judging from the very scant material thus far in hand, there can be no question that this dog did not originate at Anau during the first culture period. It is much more probable that it came to Anau with the people who brought thither the camel and the goat.

But how came the dog in the possession of that people, and whence came they? These questions can not be answered from the material in hand. One would have to know with certainty whether the pariah dog, the modern street dog of the East, which we know on the oldest monuments of Egypt, is directly related to the shepherd-dog.

Th. Studer* assumes merely a parallelism in development and derives the pariah dog direct from the dingo, which he considers to have been distributed in former times over all southern Asia, where it still occurred even in most recent times in the Tengger Mountains of Java. He believes, further, that in Eurasia in the diluvial period there existed a small wild dog which he has recently designated *Canis poutiatini*. This species is said to have shown itself to be more easily tamed than the wolf and from this he derives, on the one hand, *Canis palustris* and on the other the shepherd-dog. Jeitteles† himself thought that the *Canis matris optimæ* might have been derived from the Indian wolf (*Canis pallipes* Sykes), and assumes that the domestication of this animal took place in ancient Iran. Our finds in Anau might seem to lend a greater degree of probability to this idea, but the direct measurements and ratios given above show that the Indian wolf stands very far from the Anau dog. We must, therefore, waver between two opinions, namely, that the theory advanced by Studer,‡ in which he derives the shepherd-dog from a paleolithic dog of Russia (*Canis poutiatini*) is correct; or that the dingo, which we have represented as being similar to our dog from Anau, must have lived in southern Asia in some form, and that from it both the pariah dog and the shepherd-dog have descended.

Which view is correct we can not, as I have already said, decide with certainty from the Anau remains alone. Derivation from *Canis poutiatini* is favored not only by the similarity in the measurements but also by the fact that the dog was brought to Anau by a people who imported the camel and the goat. Considering the localities of fossil remains thus far found, and the present geographical distribution of these animals, it is possible that the camel came from the south or east, and the goat from the south or west, since its wild form now lives in Persia

*Ueber den deutschen Schaeferhund und einigen kynologischen Fragen. Mitteilungen Naturf. Gesell., p. 11. Bern, 1903.

†*Cf.* Jeitteles, Die vorgesch. Altert. d. Stadt Olmütz, pp. 56–80. Wien, 1872. Keller, Die Abstammung d. aeltesten Haustiere, p. 55. Zürich, 1902.

‡Zoolog. Anzeiger, Bd. XXIX, 1, pp. 27–30.

and the Caucasus. The dog, however, may have come either from the sphere of Indian culture or from Russia; although, according to Studer, a Siberian origin is possible.

On the other hand an Iranian or Indian domestication or an autochthonous origin of the house-dog, shown by the presence in the lowest neolithic layers of the Anau kurgan of *Canis pallipes* or a similar wolf, might support a very plausible hypothesis based on former philological or archeological researches. This would not apply especially to the domestication of *Canis pallipes*, but to that of the dingo or another wild dog of Turkestan as well. Perhaps later excavations by Mr. Pumpelly, possibly in strata of a still earlier period, will bring to light the bones of house-dogs; for the fact that none are known from the first period is no proof that they may not be found. It would, in fact, seem almost necessary that the Anau-li should have had, with their great herds of sheep and cattle in æneolithic time, a domestic dog that originated in the same neighborhood.

According to Hommel* the different peoples speaking the Turko-Tartaric languages must have had in common an autochthonous dog, which was designated by the radical word *kuc*. Budenz† also calls attention to the original character of this designation and concedes the hypothesis of an autochthonous domestication of the dog in the earliest times of the development of the Altaic culture. Vámbéry‡ also sees an evidence of the high age of Altaic domestication of the dog in the myth of the Kirghiz, who derive themselves from the dog through an unnatural connection with forty maidens.

Not only is the shepherd-dog thought by some to have originated in Iran, but H. Kraemer§ and C. Keller|| attempt to derive most of the European mastiffs —at least the *Canis molossus* of the ancients and the St. Bernard—from Tibet.

Albrecht,¶ however, shows from a large stock of philological data that the Tibetans were not responsible for this domestication but rather the people who lived to the west and south of Tibet; and that the name of the dog argues against a domestication in Tibet, for in the west it is ***kukurra***, while in Tibet it is ***khi***. Albrecht believes, therefore, in two domestications, one of which produced a large dog (***kukurra***), in the west, and a smaller one (***khi***), in Tibet, which were then exchanged and crossed among the respective peoples.

If, lastly, we would look for the shepherd-dog of the East, which might possibly have been derived from the dog of Anau, we must turn our eyes to where the earliest rays of the light of history penetrate the prehistoric darkness—to Babylon, Assyria, and Egypt.

The Assyrian monuments do not introduce us to more than two varieties of the dog—the large and powerful mastiff, used in the chase of great animals, and the grayhound, used in coursing the hare. Other breeds, however, were

* Die Namen d. Säugetiere bei den suedsemit. Voelkern, p. 441.

† Magyar-Ugor összehasonlito szotar, 1881, p. 74.

‡ Die prim. Kultur des turko-tatarischen Volkes, p. 197. Leipzig, 1879.

§ Die Haustierfunde von Vindonissa, Revue zoolog., tome 7, pp. 143–272; and Die Abstammung des Bernhardiner. Globus, pp. 171–188, 1904.

|| Die Abstammung der aeltesten Haustiere, p. 76. Zürich, 1902.

¶ Zur aeltesten Geschichte des Hundes, pp. 55–56. München, 1903.

doubtless known to the inhabitants of Assyria and Babylonia. In the bilingual lists which give all words in Accadian and Assyrian, we find the Assyrian word *na-adh-ru*, "the protecting dog," with the Accadian equivalent, *sega lik-ka-gab-a*, which probably means "the good mouth-opening dog;" then follows the Assyrian *cab-bi-luv*, from "to tie up" or "chain up;" represented by the same *lik-ka-gab-a*. Houghton,* who gives these translations, thinks that *na-adh-ru* and *cab-bi-luv* both stand for some strong dog, which was used both as a watch-dog to guard the house and as a shepherd-dog to guard the flocks. The idea embodied in the Assyrian and Accadian words *cab-bi-luv* and *lik-ka-gab-a*, "the chained-up mouth-opening dog," answers well to a house-dog; and the notion conveyed by the Assyrian and Accadian words, *na-adh-ru* and *sega*, "the good protecting dog," is quite descriptive of the same kind of dog when used as a shepherd-dog.

One of the best representations of "the good protecting dog" is on the cylinder seal of Bel-Bin (see tailpiece at end of chapter).† This dog seems to be of a large, powerful breed, with his tail rolled up and his ears drooping down. Another shepherd-dog is represented on a cylinder-seal of the Clercq collection.‡ The other dogs of the Babylonians and Assyrians were all intended for the chase, from the very large mastiff to the swift grayhound.

Even to-day one still finds in those regions, extending as far as Asia Minor, a large shepherd-dog of wolf-like appearance, used, as was the case among the Assyrians, to guard houses and protect the flocks from wild animals. One can form some idea of the size and savage character of this recent form from the report of Diest: "In Delilerkoi I had a fight with a dozen savage shepherd-dogs which were about as large as my little horse and almost pulled me from my saddle."

We may then assume that the Assyro-Babylonian culture did not derive the *Canis matris optimæ* from the later inhabitants of Anau; the size of the Assyro-Babylonian dog favoring rather Albrecht's opinion of the origin of both a large and a small dog in Central Asia, the large dog being that of the ancient Babylonians and Assyrians.

If we turn now to the Egyptian culture, thinking perhaps to find there traces of *Canis matris optimæ*, the monuments show us several types which correspond in size and shape to that animal. The real shepherd-dogs of Egypt as we find them, for instance, in painting and sculpture at Sakarah,|| and in the pyramids of Gizeh,¶ often represented with shepherds, seem to have belonged to the gray-hound form. On the other hand, there frequently occurs a somewhat larger, short-muzzled, smooth-haired dog which seems to correspond well with the Anau dog. Good pictures of this animal have been given by Rosellini, but the best representation is the statue executed in black marble in the museum of the Louvre in Paris, the dog represented here having erect ears and a rather short head (plate

---

*On the Mammalia of the Assyrian Sculptures, Trans. Bibl. Arch., 1877.
†Ménant, Rech. sur la Glyptique Orientale, partie I, p. 205, fig. 137.
‡Catalogue de Clercq, plate III, fig. 24; Description, p. 40.
§Petermann's Mitteilungen, Erg. Heft 94, p. 64.
||Perrot and Chipiez, "Bergers aux champs," Histoire de l'Art dans l'Antiquité, tome I, l'Egypte, p. 36.
¶Lepsius, Bd. VII, Abt. II, Blatt 9, Grab. 75, Ostwand.

79, fig. 1).* A mummied skull of the same animal is in the collection of the British Museum in London.

Aside from these facts I am able to give exact cranial comparison because among the skulls of Jeitteles's collection in the k. k. Hofmuseum in Vienna which

Table of dimensions (in millimeters).

Skulls.	North Kurgan, Anau, +28 ft.	Subfossil dogs (Mus. Vienna).*			Recent pariah dogs (Mus. Vienna).	
		Egypt.				
		From rock-tomb at Siût.†	From tomb at Thebes.‡	Greece.	Abydos.	Wadi-Halfa.
Basilar length	164	144	141	173	161	162
Superior length of skull	182	161	166	197	178	185
Length of frontal	....	55	57	61	53	55
Length of parietal	46	47	43	52	45	46
Length of nasal	....	59	66	72	66	71
Width of palate	50	48	46	53	46	47
Width of parietal	57	56	56	58	56	55
Width between proximal orbitals of frontal	....	54	52	55	47	47
Greatest width of nasals	....	17	18	18	16	17
Least width between inferior borders of orbits	37	38	38	37	31	31
Greatest height of occipital	46	46	47	50	47	51
Greatest width of occipital	60	62	62	67	60	63
Width on arcus zygomaticus	102	97	99	105 (?)	104	101
Width of muzzle before front premolar	41	35	35	41	36	38
Ratio of width of occipital triangle to height, expressed in proportions to 100.	77	74	76	75	78	79

Lower jaw.	Anau.					*Canis poutiatini.*§	Auvernier, *Canis matris optimæ.*‖	Wolf from Auvernier pile-dwellings.	Recent wolf.	Schlossberg, *Canis inostranzewi.*
	Wolf-dog.	*Canis matris optimæ.*								
Length from proximal angulare	....	145	140	..	..	139	152	....	197	145
Length from proximal articulare	....	147	144	..	..	140	62	....	....	. ..
Length of molars	....	72	73	79	..	....	84	....	100	78
Length of toothless space before premolar 1	5	4	6	1	..	....	....	....	....	5
Height of vertical branch	....	57 (?)	..	..	..	54	62	....	78	....
Height of horizontal branch behind molar	30	25	25	21	23	23	26.5	27	34	26
Length of molar	23	20	21	22	21	21.5	24	32.5	34	21
Length of symphysis	25	21	21	20	..	22	....	....	....	....

* Determined as *Canis matris optimæ* by Jeitteles himself. † Collected by Dr. Lauth. ‡ Collected by Schneider. § After Studer. ‖ After Jeitteles.

was open to me through the kindness of the Custos Kittl, there are several mummied skulls from Egypt which, according to the accompanying labels and written documents, were determined by Jeitteles himself as *Canis matris optimæ*. As a characteristic of these skulls, we may take the ratio of width to height of the

* Rosellini, I., Monumenti dell' Egitto, etc., Mon. Civile, plate XVII.

occipital triangle, which varies here between 1 : 0.74 to 1 : 0.78. In *Canis matris optimæ* this ratio, according to Studer, is generally 1 : 0.74 to 1 : 0.81 and in the wolf 1 : 0.91. That *Canis matris optimæ* occurred also in ancient Greece is shown by a skull in Jeitteles's collection, which is said to have come from a find in Greece (see table).

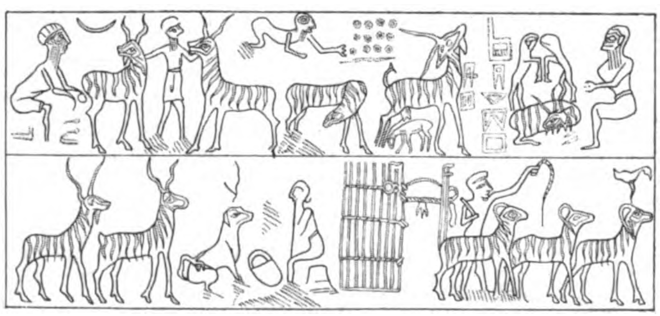
We have thus seen that the Assyro-Babylonian culture in all probability did not possess the dog of the metal period of the North Kurgan of Anau and therefore probably had no relation with the Anau people; but that, on the other hand, this dog is found in ancient Egypt—provided Jeitteles's original determinations are correct—and that we have here no such parallelism of forms as exists in the opinion of Studer already mentioned. It is, therefore, not improbable that the primitive Egyptians, who, in the opinion of most Egyptologists as well as myself (*cf.* Die Rinder von Babylonien, Assyrien und Aegypten, p. 73, Berlin, 1899), migrated from Central Asia via the Red Sea to Egypt, brought with them this dog as well as the long-horned cattle which originated in Central Asia. This is an attractive conjecture which follows logically upon what has been said. The appearance of *Canis matris optimæ* in Greece is not astonishing, but forms the connection of the Anau dog with Central European finds, which are especially abundant in Austria. Migrations of peoples and commercial intercourse had, therefore, at a remote time brought this dog from inner Asia into the heart of Europe.

Ordo RODENTIA.

MURIDA.

Arvicola sp.

As a recent interloper we have the lower jaw with all the teeth of a mouse.



CHAPTER XVIII.

Ordo ARTIODACTYLA.

SUINA.

Sus palustris Rütimeyer. (Plate 72, figs. 3-8, and plate 80.)

The remains of the pig are very common in the Anau kurgan. There are about 120 pieces, the greater part being remains of skulls. The hard frontal bones have shown themselves especially resistant. We have, therefore, parts of the frontalia of at least seven individuals, some older and some younger. In one of these pieces the bregma has a thickness of 2.5 cm., forming a real armor-plate over the brain, while this measurement in other individuals amounted only to 1.1 to 1.5 cm. This animal was probably a very old boar. Only one brain-skull has all the bones complete. Even then the skull was split in the middle along the suture so that a restoration was necessary. The skull is decidedly that of a small adult pig, whose front shows a slight convexity, which we usually find in the Indian *Sus cristatus* or *S. vittatus* Müller & Schlegel. We shall consider with Nehring (Katalog, 1886, p. 54) *Sus cristatus* as the continental variety of *Sus vittatus* and employ for the south Asiatic pig the general name of *S. vittatus*. In comparing with the parts of this skull the frontal, parietal, or occipital pieces of the other individuals mentioned, one recognizes that the other individuals can have been no larger than this. The relations of the skull to those of different other small Suidæ, as well as to two other small skulls from Anau, are shown clearly in the table on the following page.

This table shows that the skulls from Anau stand nearest to those of a wild *Sus vittatus* from Sumatra or to a tame Battak pig, not only in form but also in dimensions, and that they possess the greatest similarity to the skulls of the *Torfschwein* (turbary pig) of Schlossberg and La Tène, as appears from their general form. I think, therefore, that I shall not go amiss if I pronounce these skulls to be the oldest known remains of the *Torfschwein* or turbary pig.

According to the researches of Rütimeyer,* Rollestone,† Otto,‡ and others, *Sus palustris*, the turbary pig, which first appears in the Swiss pile-dwellings during the later neolithic period, is derived from *Sus vittatus*, which would agree very well with our finding.

Nehring,§ on the other hand, considers *Sus palustris* to have been autochthonous also in Germany and merely a starveling form (*Kümmerform*) of *Sus scrofa domesticus*. Which one of the opinions is correct can be determined with

*Rütimeyer, Einige weitere Beitraege, etc., Verhandlungen, Basel, 1876.
†Rollestone, On the Domestic Pig of Prehistoric Time in Britain, Trans. Linn. Soc., ser. 2, vol. 1.
‡Otto, F., Osteolog. Studien z. Geschichte d. Torfschweines, Revue Suisse de Zoologie, 1901.
§Nehring, Ueber das sog. Torfschwein (*Sus palustris*). Verhandl. Berl. anthrop. Gesell., pp. 181–187.

Table of dimensions (in millimeters).

Skull.	North Kurgan, Anau.			*Sus vittatus.* (Mus. Bern).		*Sus scrofa*, Tunis (wild boar).		*Sus scrofa palustris* (Mus. Bern).		Maori pig, New Zealand (coll. Duerst).	*Sus scrofa domesticus.* Tschontschitz. (Mus. Teplitz.)
	+6 ft.	−8 ft.	+20 ft.	Wild, Sumatra.	Tame, of the Bataks.	Mus Bern.	Coll. Duerst.	Schlossberg.	La Tène.		
Length from middle of occipital ridge to line of junction between anterior borders of orbits	116	125	....	120	118	113	127	....	....	99	116
Length from same point to coronal suture	51	54	55	55	53	46	56	36	38	35	40
Greatest width of frontal bone	82	96	101	86	92	85	102	84	86	81	102
Length of frontal bone to line of junction between anterior borders of orbits	61	....	....	76	75	67	73	....	....	57	64
Height of fossa temporalis	32	....	....	38	37	32	42	....	....	25	39
Greatest occipital height	92	....	....	98	99	....	106	....	....	60	102
Least occipital height	62(?)	....	....	....	....	....	82	60	65	55	79
Greatest occipital width	88	....	....	....	....	....	123	90	90	88	110
Least parietal width	32	....	....	33	34	26	17	24	24	23	29
Greatest parietal width	72	....	....	....	....	....	78	72	69	68	81
Width between anterior borders of orbits	58	58	66	54	58	53	74	....	....	60	74
Length from anterior to posterior border of orbit	31	....	....	34	33	35	38	32	36	30	31

Lower jaw.	Anau.					Schlossberg.		Vindonissa, Roman time.	Wild pig of pile-dwellings.*
	+12 to +15 ft. 1903.	+24 ft. Adult.	+19 ft. Adult.	+26 ft. Adult.	+26 ft.	No. 584.	No. 659.		
Length of symphysis	62	....	....	....	....	62	....	59	123–144
Width of corpus between exterior borders of alveoles of tusks	45	....	....	....	....	45	....	42	....
Width between inner borders of same	28	....	....	....	....	31	....	30	....
Transverse diameter before premolar 2	34	....	....	....	....	34	....	33	....
Height of horizontal branch before premolar 3	37	....	....	....	....	37	....	38	....
Height of horizontal branch behind molar 3	....	51	45	50	47	....	47	47	60
Length of molar 3	....	30	....	....	....	....	26	30–31	43–46
Width of ascending branch	....	78	65	70	69	....	70	67	....

* After Rütimeyer.

absolute certainty only by comparative experiments with living individuals of both of the respectively postulated ancestors. In the meantime we shall follow the recognized hypothesis of the majority of the authors, namely, that *Sus palustris* is derived from *Sus vittatus*, especially since this conception agrees with the requirements of our special case, and because, contrary to the requirements of Nehring's hypothesis, no remains of the large pig (presumably *Sus scrofa ferus*) are found in the lower strata. Notwithstanding the fact that the contemporary climatic conditions were favorable to the breeding of swine, they appear only at a later period. If, therefore, a degeneration and stunting of the wild *Sus scrofa* had occurred through a domesticated condition, we should have found transitional forms as well as among sheep and cattle.

The occurrence of *Sus palustris* among the remains of Anau is therefore no surprise, since it was logically easy to conclude, as had already been declared by C. Keller,* that the animal must exist in subfossil condition in Central Asia, since it came at so early a period from Asia into Europe. It is, however, important that the turbary pig does not seem to have been domesticated in Anau itself.

In spite of what has been said, however, there remains the possibility that the turbary breed of pigs, if not domesticated at Anau, may have been formed on some other oasis of Turkestan, since it occurs at such an early period (at —8 feet) at Anau. If we do not carry this hypothesis further, it is because in the first place we find no bones of swine in the lowest layers of the wild animal period, and secondly because an importation of the tame turbary pig from Iran or India remains among the possibilities. It is, however, certain that the turbary pig reached Central Europe with the builders of the pile-dwellings and contemporaneously with the turbary sheep that originated at Anau, since it occurs in the earliest pile-dwellings; and in this animal also we see proof of the influence that was exerted by the culture of Turkestan on that of Europe.

It is interesting also to compare the lower jaw with that of the European turbary pig (see table on p. 356). Studer, who explained the form of the turbary pig's skull as signifying a wild condition, owing to a freer life, thinks that the weakening of the lower jaw, which appears in the later bronze age in Switzerland, was due to a change in the manner of life to which the animals were subjected.

Our comparison, however, shows that the turbary pig of the Anau kurgan, down to that of the Germans of the Schlossberg and the Romans of Vindonissa, underwent no weakening process.

The measurements of the best of the extremity bones given in the following table need little further explanation. While the dimensions of the scapula, tibia, and ulna agree closely with those of the domestic pigs of the *Sus indicus* series, as for instance the China, Maori, and Siam pigs, the measurements of humerus, radius, and metatarsus correspond very well with those of the Eurasiatic *Sus scrofa* Linnæus or the wild *Sus vittatus* of southern Asia. The actual presence of the *Sus scrofa*, the Eurasiatic boar, in Turkestan is known; the larger bones of a wild boar appear only in the higher layers of the North Kurgan. It may also be possible that the Eurasiatic wild boar (*Sus scrofa*) reached Anau only after the south Asiatic wild boar (*Sus vittatus*) had disappeared. The exact relations, can not be determined in the absence of fuller data. The best conception would probably be that the neolithic or æneolithic Anau-li for a while killed and ate wild pigs. Nevertheless, the wild pig seems to have been very rare. Whether the region was too dry and the forests of the Kopet Dagh offered too little space, or whether the Anau-li found the chase of this animal too difficult, can not be stated, but it is certain that we find the bones of the wild pig only in later strata and very scarce among the enormous quantity of other bones.

*C. Keller, Die Abstammung der aeltesten Haustiere, 18, 102.

Table of dimensions (in millimeters).

(The measurements are taken in comparison with those published by Padelt [Padelt, M., Skelettmessungen am Schwein; Inaug. Diss., Leipzig, 1892] of specimens from China, Siam, Germany, England, and the Maori pig.)

	Length.	Proximal width.	Median width.	Distal width.	Lateral width.	Posterior width.	Depth.	Distal diameter.	Median circumference.	Circumference at collum.	Proximal circumference.	Distal circumference.
Scapula:												
North Kurgan, Anau, +20 ft.	..	..	90	33	..	..	..	22	..	68	..	..
North Kurgan, Anau, +26 ft.	..	..	75	28	..	..	..	22	..	52	..	..
North Kurgan, Anau, +33 ft.	138?	..	74	30	..	..	..	19	..	54	..	..
China, female	134	95	75	28	..	..	..	..	..	56	..	..
Maori pig, male	187	117	96	37	..	..	..	..	..	71	..	..
Siam, male	183	113	88	36	..	..	..	..	..	70	..	..
Germany, female	182	103	87	35	..	..	..	..	..	64	..	..
England, female	277	165	143	56	..	..	..	..	..	120	..	..
Wild pig, male	260	143	124	44	..	..	..	..	..	86	..	..
Humerus:												
North Kurgan, Anau, +20 ft.	..	..	..	36	..	..	..	29	..	..	..	..
North Kurgan, Anau, +28 ft.	..	..	..	37	..	..	..	28	..	..	..	..
North Kurgan, Anau, (?)	..	..	..	34	..	..	..	32	..	..	..	..
China, female	115	33	14	23	..	..	..	19	..	..	..	..
Maori pig, male	163	56	22	34	..	..	..	38	..	..	..	..
Siam, male	163	49	21	33	..	..	..	35	..	..	..	..
Germany, female	176	47	19	31	..	..	..	26	..	..	..	..
England, female	217	75	35	45	..	..	..	60	..	..	..	..
Wild pig, male	213	64	26	39	..	..	..	43	..	..	..	..
Radius:												
North Kurgan, Anau, +16 ft.	..	38	24	..	..	..	..	..	..	..	..	..
China, female	92	21	14	22	..	..	..	..	..	..	..	..
Maori pig, male	145	30	21	32	..	..	..	..	..	..	..	..
Siam, male	140	30	21	34	..	..	..	..	..	..	..	..
Germany, female	162	28	18	30	..	..	..	..	..	..	..	..
England, female	179	41	34	39	..	..	..	..	..	..	..	..
Wild pig	192	36	24	39	..	..	..	..	..	..	..	..
Wild pig	184	38	21	39	..	..	..	..	..	..	..	..
Wild pig	192	36	24	38	..	..	..	..	..	..	..	..
Ulna:												
North Kurgan, Anau, +16 ft.	..	..	12	..	20	22	12	..	52	..	..	..
China	128	..	9	..	12	16	8	..	46	..	..	..
Maori pig	198	..	16	..	17	23	12	..	54	..	..	..
Siam	191	..	11	..	19	21	11	..	..	..	..	..
Germany	211	..	13	..	13	20	9	..	50	..	..	..
England	258	..	27	..	31	41	25	..	102	..	..	..
Wild pig	266	..	18	..	18	26	13	..	..	..	..	..
Tibia:												
North Kurgan, Anau, +23 ft.	154	37	17	25	..	..	24	..	..	..	100	62
China	122	38	15	21	..	..	18	..	..	..	59?	44
Maori pig	183	52	23	31	..	..	32	..	..	..	104	62
Siam	167	49	19	27	..	..	26	..	..	..	94	58
Germany	202	49	20	29	..	..	29	..	..	..	100	59
England	244	70	32	42	..	..	38	..	..	..	150	97
Wild pig	236	56	27	38	..	..	35	..	..	..	99	73
Fourth Metatarsus:												
North Kurgan, Anau, +23 ft.	85	..	17	..	..	..	15	..	..	..	..	..
China	42	..	10	..	..	..	8	..	..	..	..	..
Maori pig	74	..	15	..	..	..	14	..	..	..	..	..
Siam	68	..	14	..	..	..	11	..	..	..	..	..
Germany	91	..	15	..	..	..	12	..	..	..	..	..
England	85	..	22	..	..	..	17	..	..	..	..	..
Wild pig	99	..	17	..	..	..	15	..	..	..	..	..

CAVICORNIA.

BOVINA.

(Plates 73 and 74; plate 78, figs. 1–4, and 7; plate 81, fig. 1; plate 83, fig. 1; plate 85; text-fig. 490.)

Bos namadicus Falconer & Cautley (*Bos macroceros* Duerst) or the Asiatic form of the urus (*Bos primigenius* Bojanus).

The remains of this bovid are also not very complete, but next to those of the sheep and the fox they are certainly the best of the bone fragments. They at least answer the requirements for the exact determination of the species present and are sufficient for the reconstruction of the skeletons. Among the 68 fragments of parts of the skull, trunk and extremity bones, the most remarkable pieces are two proximal ends of the radius with the corresponding olecranon of the ulna, Nos. 13 to 18. Both bones show old fractures, about 10 cm. below the articulations, and the ulna, No. 13, has distinct traces of gnawing, probably by human teeth. The dimensions of these bone fragments compared with the homogeneous bones of other animals are given (in millimeters) in the following table of dimensions:

	Radius.				Ulna.		
	Width of proximal end.	Diameter of proximal end.	Width of middle.	Diameter of middle.	Length of olecranon.	Least width of olecranon.	Height of sigmoid fossa.
North Kurgan, Anau – 24 feet	101	48	51	33	...	..	..
North Kurgan, Anau – 20 feet	96	49	52	33	140?	64	45
Bos primigenius after David*	99	..	..	..	146	77	50
Bos primigenius after Rütimeyer	103	..	..	..	152	84	53
Egyptian Apis, Paris Mus.	89	30	48	20	...	..	..
Bubalus arnee, No. 6707, Paris Mus.	78	28	40	22	...	..	..
Equus caballus (Clydesdale)	92	..	43	..	130	..	..

	Metacarpus.			
	Width of distal end.	Diameter of distal end.	Width of middle.	Diameter of middle.
North Kurgan, Anau, – 20 feet	70	36	37	26
Bos primigenius, after Tscherski	76.5	37	51	35
Egyptian Apis, Paris Mus.	70	37	38	27
Bubalus arnee, No. 6707, Paris Mus.	67	34	35	23
Bos taurus, Paris Mus.	68	42	46	32
Bubalus bainii, Ambolisatra	92	45	62	36

* David, A., Beiträge zur Kenntnis der Abstammung des Hausrinds. Landw. Jahrbuch der Schweiz, Bern, 1897, p. 134.

It is easy to observe that the dimensions of the subfossil bones from Anau greatly exceed those of the corresponding bones of one of the greatest modern horses and closely approach the bones of *Bos primigenius* of the ancient European culture-strata. It is not probable, considering the remains we find in the later periods of the kurgan, that the first inhabitants of Anau hunted a gigantic wild horse or had a horse of the size of a Clydesdale or a Percheron; and there can be no doubt that the bones mentioned belonged to a large bovine animal. Another extremity bone, a metacarpus medius, No. 121, confirms this conclusion. Marked by its special form as a bovine metacarpus, its dimensions are nearly the same as those of the Apis bull of the ancient Egyptian tombs of Sakkara, of which there is a skeleton in the Paris Museum, and are even greater than those of the recent Indian wild bulls.

It is, therefore, evident that the bone did not belong to a horse, but to a bovine animal, although it might be still doubtful whether it was of the "bubaline" or the "taurine" form.

Another confirmation of the correctness of this view is found in the determination of the bones collected by Professor Pumpelly from the Komorof trench in the North Kurgan,* during his previous visit to Anau in 1903. These were sent to Professor Zittel, in Munich, for determination; and among them Zittel determined a small and well-preserved bone as a right scaphoid of *Equus caballus domesticus* Linnæus. Mr. F. A. Lucas, an American zoologist, better versed in recent comparative osteology than was the great German paleontologist, writes on the bone another and more exact determination: "Not *Equus* but *Bos*, from a large animal. We have no skeleton of water buffalo (*Bos bubalus*), but it is probably this." It follows that we must first decide to which bovine form this animal belongs, whether to a *bubalus* or a *taurus* species. To do this we must first solve the question as to whether the bovid of the Anau kurgan was a wild or a tame animal.

More prudence is now shown than formerly in the application of the characteristics given by L. Rütimeyer in recognizing whether bones belong to a wild or a tame animal.

I judge the Anau bovid in question to have been wild for the following reasons: (1) because it was much larger than all the other domestic bovine animals, which were found in great quantities in the higher layers of the Anau North Kurgan; (2) because the structure of the bones is much heavier and harder than that of bovine animals in domestication, whose bones are spongy and lighter; (3) because the other species in the same layers belong undoubtedly to wild animals, and because this large bovid seems to be wholly wanting in the higher layers of the kurgan. These are my reasons, and I observe that in several recent publications on subfossil bones the authors have been contented with only one of these reasons in attributing bones to a wild or tame form of animal.

Assuming that this bovid was wild, we will inquire what wild bovids were living in Turkestan or Northern Persia in prehistoric times. The first indications are those furnished by the ancient Babylonians.

In earlier publications† I have established the fact that two wild bovine animals lived in Babylonia, and that the language and writing of the Sumero-Accadians, who are supposed to have immigrated from Iran or Northern Persia, before these people united with the Semitic race, have only one word for wild bull. The ideogram of bull was a two-horned bull's head, written  = *gud*, in

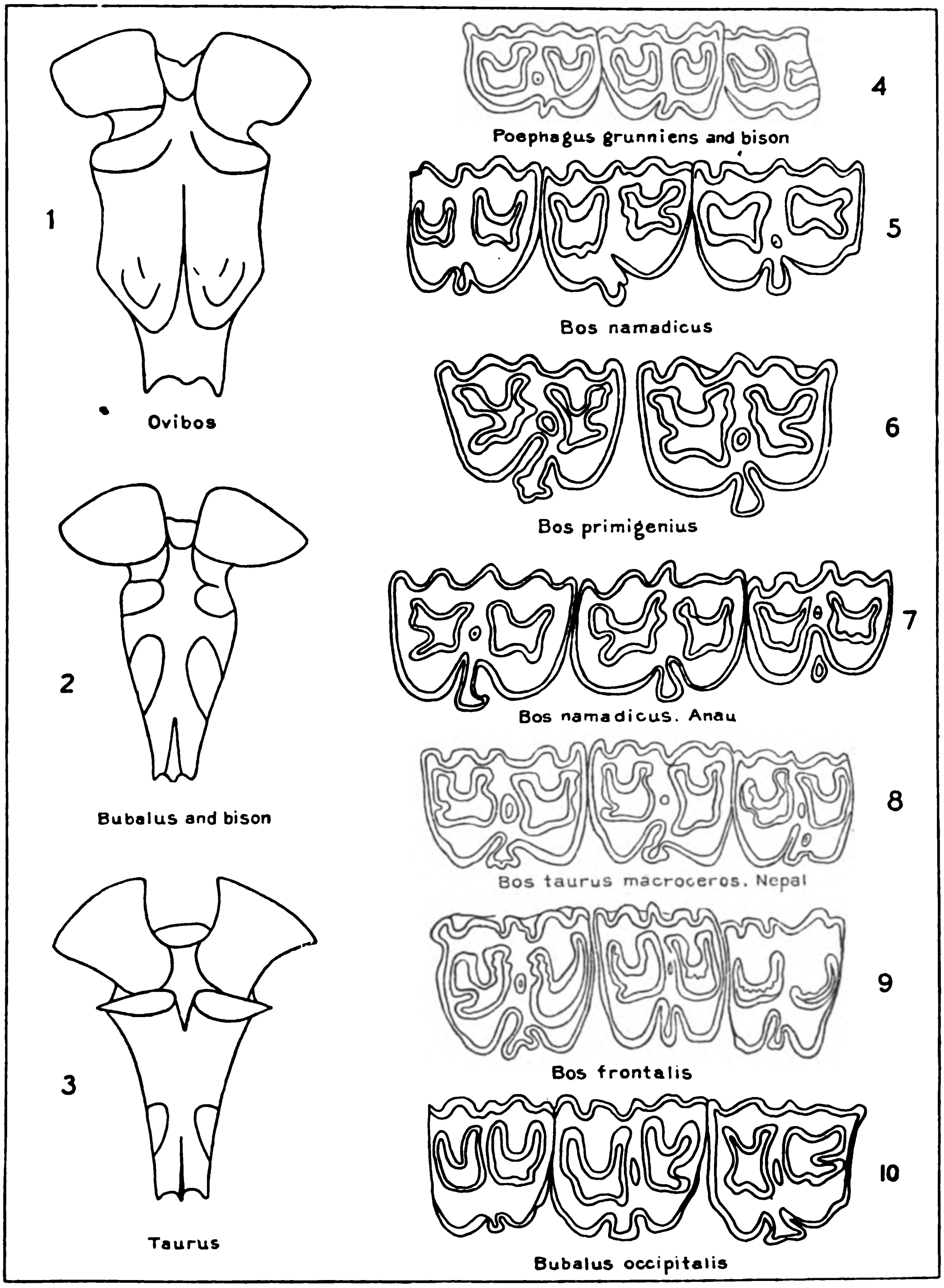
*Explorations in Turkestan, Expedition of 1903, Carnegie Institution of Washington Publication No. 26, p. 8. Washington, 1905.

† Duerst, Die Rinder von Babylonien, Assyrien und Aegypten, Berlin, 1899; Notes sur quelques bovides préhistoriques, l'Anthropologie, 1900, pp. 129–158.

PLATE 73.

FIG. 1. Right branch of lower jaw of *Bos brachyceros* of medium size from a turbary of Tschontschitz (Bohemia) Museum Teplitz.
2. Same bone (restored), *Bos namadicus*.
3. Metacarpus medius of large ox, breed of I*b* period.

FIG. 4. Metatarsus medius of small breed of II or metallic period.
5–7. Phalanx I, II, and III, of larger breed of I*a* period.
8–9. Phalanx I and II, smaller breed of II period.
10–11. Phalanges of camel.



FIGS. 1-3. Basioccipital bone in 1, Ovibos; 2, Bubalus; 3, Taurus.
4-10. Accessory columns in teeth of 4, Yak and Bison; 5, *Bos namadicus*, India; 6, *Bos primigenius;* 7, *Bos namadicus* (Anau); 8, *Bos taurus macroceros* (Nepal); 9, *Bos frontalis;* 10, *Bubalus occipitalis.*

Semitic = *alpu*; a wild bull was written [cuneiform sign] = *am*, Semitic = *rimu*, in Hebrew = *reem*. The difference between tame and wild bull is, therefore, in the ideogram, only the sign for mountain = [cuneiform sign]. A wild bull was in the ancient Sumero-Accadian language "a bull of the mountains."

Several ancient Babylonian sculptures or cylinder seals and many later Assyrian sculptures show very realistic pictures of a wild bovine, which I formerly identified with *Bos primigenius* Bojanus (plate 83, fig. 1).

My recent studies on fossil remains of the bovines of the Indian Pleistocene have shown me that the Indian (Narbada and Siwaliks) and China Taurina are the exact equivalent of the European urus (*Bos primigenius* Bojanus), excepting some very slight variations produced by different geographical and local influences; so that the *Bos namadicus* Falconer & Cautley would represent the European urus for the Asiatic continent, especially the North Indian mountains and their neighborhood (compare fig. 490 with plate 81).

Fig. 490.—Bos namadicus, after Lydekker. Indian Geological Survey.

The buffalo, the other wild bull hunted by the ancient inhabitants of Persia, Babylonia, and Assyria, is *Bubalus palæindicus* Falconer, or the recent form descending from that Pleistocene species, *Bubalus arnee* Kerr. It is already represented on the cylinder seals of the kings of Shipurla and of Ur. The best representation can be found on the cylinder seal of Sargon, King of Accad, who reigned B. C. 3800 to 3750. This seal in the collection of M. de Clercq, of Paris, bears the following inscription, "Sar-ga-ni-sar-luh sar Agaddeki Ib-ni-sar tup-sar aradsu" ("from Sargon, King of Accad, Ibnishar the scribe, his servant)."*

*See Clercq et Ménant, Antiquités Assyriennes, p. 79, fig. 46. Paris, 1888.

We know further that great numbers of these large animals were killed by the Assyrian king Ashur-nasir-pal, on the hunting grounds near the Euphrates. Aristotle mentions the occurrence of the buffalo with horns curved back to the neck, in Arachosia, the Persian province Khokand; and Chosroes II (591 to 628 A. D.) is represented on a silver plate in the National Library of Paris as hunting this animal.*

There can be no doubt that two large bovine animals lived in very ancient times in Northern Persia in proximity to the Anau kurgans. Which of these two animals furnished the bones we are discussing and was the one hunted by the ancient Anau-li? Fortunately there are among the bones from the deepest layers of the kurgan several which enable us to answer this question. These are fragments of a right branch of a lower jaw, which I have restored, a basioccipital bone, and a fragment of a horn-core.

Table of dimensions (in millimeters).

Lower jaw.	North Kurgan, Anau, - 20 ft.	*Bos namadicus* Narbada (Brit. Mus.).	*Bos primigenius* (Mus. Bern).	*Bubalus arnee* (Paris).
Length	438	443	....	455
Length of dentition	162	171	161	125
Length of molars	108	110	104	....
Length of premolars	76	80	56	....
Length of toothless part	117	115	....	154
Width of ascending branch	136	142	....	139
Height of horizontal branch at premolar 1	53	51	45	51
Width of incisive part	78	83	84	102

Basioccipital bone.	North Kurgan, Anau, − 17 ft.	*Bos primigenius*, Kirkendorightshire (Mus. London).	*Bos taurus*, Walthamstow.
Length of condyle	110	130	105
Width of foramen	43	43	....
Width above condyle	56	65	....
Width on upper protuberances	60	72	57
Width on tubercula pharyngeæ	37	37	26
Length from upper protuberances to tubercula pharyngeæ	44	46	....
Lateral length of basioccipital	92	94	76

Provenience of horn-core.	Circumference at base.	Vertical diameter.	Length of core.
Anau	about 400	120	....
Suen-Hua-Fu, China, *Bos namadicus* (Mus. Paris)	413	122	about 830
Ilford, Essex, England, Brit. Mus. (N. 25426) *Bos primigenius*	430	124	1000
Algeria, *Bos opistonomus* Pomel (Mus. Algeria)	340	90	800
Levallois-Perret (Paris), *Bos primigenius* (Mus. Paris)	415	110	725
Rhine, *Bos primigenius* (Mus. Darmstadt)	382	100	690

It is well known that one of the principal differences between the bubaline and the taurine form of the ox tribe consists in the slender form of the lower jaw and especially in the greater width of the incisive part (corpus) of the lower jaw in the buffalo, and the greater narrowness of the horizontal branch behind the

* Duerst, Quelques ruminants sur des œuvres d'art asiatiques. Revue archéolog., I, pp. 239–244.

incisive part. These qualities are easily recognizable in the table of dimensions above. It is clear enough that the present lower jaw belongs, not to a buffalo, but to a large taurine animal like the European urus.

The well-preserved basioccipital bone shows equally well a marked difference between buffalo and taurus (see plate 74, figs. 2–3). In the buffalo it approaches more the type of *Ovis*, is rather short, and the tubercula pharyngeæ predominate *vis-à-vis* the upper protuberances. In regard to size, the basioccipital of Anau corresponds very exactly with that of the skulls of *Bos primigenius* of the British Museum.

Lastly, the fragment of a horn-core (plate 78, fig. 2) denotes a round-horned animal and not a bovid with flat horns of quadrangular or triangular cross-section. This fragment represents the basal part of a left horn-core with some frontal pieces attached. Its surface is granulous, therefore it seems to have belonged to an adult individual. The core is at the base filled with some spongy bone substance, which gives the impression that it must have belonged to a gigantic individual with enormous horns, like those found by Abbé David in the Chinese loess near Suen-hua-fu. This is corroborated by the measurements compared with those of several other horn-cores of *Bos namadicus* and *Bos primigenius*, which are remarkable for their size.

It is, therefore, proved beyond doubt that a large taurine animal furnished the bones in question, and in the light of our researches concerning the wild bovine animals of these regions, it must certainly have been the *Bos namadicus* Falconer & Cautley, *i. e.*, the Asiatic urus.

Of the bovine group, there remain to be considered only the Taurina proper and the Protaurina, as well as the bison and yak. Here, too, the teeth offer an easy means of discrimination. According to Rütimeyer* (1): "Bison and yak have become so sharply characterized that their teeth can be distinguished from those of Taurus, Bubalus, and of the Bibovina (*Protaurus* mihi) through the weakest development of the accessory columns."

This difference is more clearly shown on plate 74. It will be seen from fig. 4 that in this specimen of *Pœphagus grunniens* from Nepal, male, about 6 years of age, the construction of the teeth is very simple. It is No. 611*a*; 5*ab* 28, No. 152, British Museum.

On the other hand, fig. 5, *Bos namadicus* (specimen 36672), called by Rütimeyer *Bos palæogaurus* (Paleontological Gallery, British Museum); fig. 6, *Bos primigenius* Bojanus, Pleistocene, Grays (Essex) (No. 21296, 21647, Paleont. Gal., British Museum); fig. 7, a molar series from Anau; fig. 8, *Bos taurus macroceros*, long-horned cattle brought from Nepal by Hodgson, 1848 (?) (British Museum) (skull, plate 82, fig. 1); fig. 9, *Bos frontalis* Evans, from Assam (British Museum); fig. 10, *Bubalus occipitalis* Falconer (*Probubalus triquetricornis* Rütimeyer, No. 16173, Paleont. Gal., British Museum) show more and different plications of the enamel-folds.

---

* Versuch einer Natürlichen Geschichte des Rindes, 1 Abteilung, p. 91.

Since all these molar series belong to individuals of about the same age, the variation can not be due to difference in age. The sex is also the same, at least in the recent specimens, although it is not certain whether fig. 8 is a male or a castrated male. This, however, should not produce a perceptible influence upon the dental markings.

Here, too, after an exact comparison, our Anau ox ranges itself between *Bos namadicus* and *Bos primigenius*; while the enamel plications are still more manifold than in *Bos taurus macroceros* of Nepal, which, in comparison with the early Egyptian long-horned cattle, has very numerous plications.

Bos taurus macroceros Duerst. (Plate 79, fig. 2; plate 81, fig. 2; plate 82, fig. 1; plate 83, fig. 3; map, plate 85.)

In the layers of the North Kurgan of Anau, beginning at −15 feet below the level of the plain and extending to the top of the hill, we find numerous bones of domestic cattle. These bones are found far more frequently than those of the other animals and are easily distinguishable by their lightness and highly porous character. In addition, the color of these bones is a light yellowish-brown, while that of the bones of the wild bull is a darker brown.

To determine the origin of the domestic cattle, we must try, first, to recognize the breed and size; second, to see whether there is any connection between them and the wild cattle of the strata below −15 feet; and third, to determine the probable distribution of these animals over the neighboring parts of Asia.

The Breed and Size of the Domestic Cattle of Anau.

In various earlier publications, I have several times expressed the opinion that the short-horned cattle of the turbary man of Europe (*Bos brachyceros* Rütimeyer), which seemed to have been imported from Asia, were the oldest cattle of the world, although descended from a long-horned wild species, the *Bos namadicus*. It seems, however, that the bones of Anau tend to contradict this opinion. The bones of the cattle in the layers from −15 feet to +25 feet show no concordance with those of *Bos brachyceros*. They are all distinctly larger in size and the few remains of horn-cores indicate a long-horned animal.

We will now first compare the dimensions of these bones with those of other prehistoric cattle, especially with those of the mummified skeletons of a sacred bull, Apis, of the old Egyptian tombs of Sakkarah, now in the Museum of Natural History at Paris, and with those of *Bos taurus brachyceros* Rütimeyer, from the excavations of Schlossberg, near Burg (Brandenburg), and several localities of Bohemia.

But we shall see that it is not possible that these marked differences were only those of sex or individuality. I begin with the extremity bones.

Several fragments of scapulæ were among the bones from the kurgan, but only two fragments of distal ends of this bone are sufficiently preserved to serve for measurements. The dimensions given in the table on pp. 366–368 show an exact concordance in size between the fragments from the +17-foot layer and the scapula of the Apis bull; the fragment from the +26-foot layer being smaller.

There is also a number of humeri, mostly fragments of the middle part without articulation. Only one proximal part and four distal parts are in good condition. The measurements indicate the same important rule—that the bones of the lower layers are much larger in size than those of the higher layers, and that those from +25 feet are approximately of the same size as those of *Bos brachyceros*.

The same rule is good for the radius, of which we have only four good pieces. We have the distal part, No. 1114, from the —15-foot layer, undoubtedly belonging to a younger specimen of the wild *Bos namadicus*, as is shown by the dimensions and the heavier and harder composition of the bones. As is proved by several other bones, such as phalanges, the wild animal appears from time to time in the layers near the level of the plain, but still decreasing proportionately in number, and seeming to disappear with the +20-foot layer.

All metacarpal bones were badly injured; only one has been restored and this shows a close concordance with the Apis of Paris, while another from the +20-foot layer approaches in size the *Bos brachyceros* of the Schlossberg.

I must here treat another question. It might seem probable that the smaller bones of the higher layers are those of younger animals of the same kind as the larger. This opinion is certainly true as regards the lower layers, as the smaller bones of these strata show very decided marks of youth; but this is not so with the smaller bones above +23 feet. All those which are mentioned in the measurement table are of adult animals. It seems very probable, therefore, that the higher layers contained a smaller breed of cattle which was formed there by the physiographical influence on the climate and on the production of food during the period of aridity at the end of culture period I, or which came into Anau at the same time as the camel, the goat, the hornless sheep, and the shepherd-dog.

But the long-horned larger bovid does not entirely disappear in the metal period* of the kurgan; several larger extremity bones show his presence among the smaller cattle. Among the phalanges there are in the lower strata several which in size correspond wholly to those of *Bos primigenius* and which are even considerably larger than those of the Apis of Paris.

The measurements of the femora from the North Kurgan, Anau, agree well, in the measurable dimensions, with those of *Bos brachyceros* and are considerably smaller than those of the Apis skeleton. The same applies to the tibiæ.

The metatarsi show also, in part, dimensions which indicate a somewhat more slender-limbed cattle than was the Egyptian long-horned cattle.

The measurements of the lower jaws of the first period correspond to those of the extremities and show the same dimensions as those of the family of the recent *Bos macroceros*, as is easily seen in the agreement of the few lower-jaw measurements with those of a mummy skull from Abadieh, and of the Hungarian bull of the Hofmuseum of Vienna (plate 81, fig. 2).

*Culture II.—R. P.

Table of dimensions (in millimeters).

	Length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal width.	Distal diameter.	Width of interior end of trochlea.	Width of exterior end of trochlea.	Least width at collum.	Width of articulation.	Diameter of articulation.
SCAPULA:												
North Kurgan, Anau:												
+17 feet	..	..	..	..	..	..	..	....	....	57	70	49
+26 feet	..	..	..	..	..	..	..	....	....	55	69	(?)39
Apis bull, *Bos taurus macroceros* (Paris)	..	..	..	..	..	..	..	....	....	57	70	50
Schlossberg, *Bos taurus brachyceros* (No. 27)	..	..	..	..	..	..	..	.. ..	....	48	50	41
HUMERUS:												
North Kurgan, Anau:												
No. 618, +2 feet	..	110	120	..	..	..	..	....	....	....	....	....
No. 747, +7 feet	..	..	..	..	..	94	..	51	....	....	....	....
No. 1081, +26 feet	..	..	..	..	..	69	..	46	37	....	....	....
No. 35, +26 feet	..	..	..	..	..	64	..	45	30	....	....	....
No. 1082, +26 feet	..	..	..	..	..	64	..	38	30	....	....	....
Apis, Paris	350	112	117	42	57	87	80	50	38	....	....	....
Schlossberg, No. 71	240	64	85	28	37	63	59	....	....	....	....	....
RADIUS:												
North Kurgan, Anau:												
No. 1114, −15 feet	..	..	..	60	35	91	58	....	....	....	....	....
No. 645, +7 feet	..	..	..	..	..	82	48	....	....	....	....	....
No. 772, +25 feet	..	88	39	..	..	..	..	....	....	....	....	....
No. 898, +25 feet	..	89	39	..	..	..	..	....	....	....	....	....
Apis, *Bos taurus macroceros* (Paris)	332	89	30	48	20	82	47	....	....	....	....	....
Schlossberg, *Bos taurus brachyceros* (No. 188)	174	54	33	30	21	56	27	....	....	....	....	....
METACARPUS:												
North Kurgan, Anau:												
No. 683, +7 feet	235	71	45	41	30	73	38	....	....	....	....	....
No. 781, +26 feet	..	..	..	..	..	72	35	....	....	....	....	....
No. 31, Komorof's trench	..	..	..	..	..	64	34	....	....	....	....	....
No. 272, +28 feet	..	71	48	38	28	..	..	....	....	....	....	....
No. 257, +28 feet	..	..	..	..	..	58	34	....	....	....	....	....
Apis, Paris	234	62	43	38	27	70	37	....	....	....	....	....
Schlossberg	190	53	32	28	18	56	30	....	....	....	....	....
FEMUR:												
North Kurgan, Anau:												
No. 1044, +28 feet	..	..	..	..	..	77	102	....	....	....	....	....
No. 521, +32 feet	..	..	..	..	..	80	100	....	....	....	....	....
+25 feet	..	..	..	..	..	83	112	....	....	....	....	....
Apis, Paris, *Bos taurus brachyceros*	..	..	..	..	..	104	134	....	....	....	....	....
TIBIA:												
North Kurgan, Anau:												
No. 899, +25 feet	..	..	..	..	..	62	43	....	....	....	....	....
+32 feet	307	75	73	38	32	65	43	....	....	....	....	....
Bos taurus brachyceros:												
Schaffis (after David)	..	..	..	..	..	62	43	....	....	....	....	....
Apis, Paris	403	107	90	47	54	70	51	....	....	....	....	....

Table of dimensions (in millimeters).—Continued.

	Length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal width.	Distal diameter.	Width.	Middle height.	Circumference.	Lateral height.
METATARSUS:											
North Kurgan, Anau:											
No. 650, +7 feet	..	..	..	..	..	67	38	....	....	....	....
No. 492, +20 feet	..	48	43	32	32	..	..	....	....	....	....
No. 495, +20 feet	..	..	..	..	..	62	30	....	....	....	....
No. 1149, +32 feet	..	..	..	..	..	56	35	....	....	....	....
No. 1579, +24 feet	221	41	40	23	25	50	28	....	....	....	....
Apis, Paris	..	58	50	32	32	65	37	....	....	....	....
PHALANX I:											
North Kurgan, Anau:											
No. 117, +2 feet	71	34	41	29	28	33	26	....	....	....	....
No. 22, Komorof's trench	67	35	38	28	26	31	23	....	....	....	....
No. 46, +21 feet	64	26	31	22	23	25	20	....	....	....	....
+23 feet	60	21	31	23	21	34	19	....	....	....	....
+24 feet	55	28	25	23	22	27	20	....	....	....	....
No. 797, +25 feet	65	28	34	22	24	28	21	....	....	....	....
No. 483, +26 feet	60	26	30	22	22	27	20	....	....	....	....
No. 762, +26 feet	60	29	35	25	24	27	20	....	....	....	....
No. 528, +28 feet	61	29	35	25	24	28	21	....	....	....	....
No. 903, +32 feet	63	30	33	26	25	28	22	....	....	....	....
Apis, Paris	63	35	36	30	26	35	24	....	....	....	....
Bos primigenius Bojanus:											
Unter-Grumbach, after Schoetensack	69	270	..	26	..	26	..	....	....	....	....
	70	395	..	37	..	39	..	....	....	....	....
Robenhausen, after Rütimeyer	66	36	..	35	..	..	..	....	....	....	....
	71	39	..	39	..	..	..	....	....	....	....
Bos brachyceros:											
Schlossberg, No. 234	58	30	33	23	22	18	20	....	....	....	....
Gross Czernosek, La Tène (Mus. Teplitz)	56	32	34	24	22	25	18	....	....	....	....
	58	30	33	26	23	28	20	....	....	....	....
PHALANX II:											
North Kurgan, Anau:											
No. 1008	43	33	37	27	26	29	33	....	....	....	....
No. 426	40	34	38	29	32	33	38	....	....	....	....
No. 525	42	30	32	..	..	26	28	....	....	....	....
No. 528	40	30	31	24	22	27	21	....	....	....	....
No. 647	41	31	34	25	24	25	31	....	....	....	....
No. 184, +14 feet	40	29	31	24	23	24	29	....	....	....	....
No. 916, +25 feet	40	33	36	27	27	31	35	....	....	....	....
No. 568, +26 feet	40	26	29	..	..	23	26	....	....	....	....
No. 91, +28 feet	37	33	36	27	28	28	35	....	....	....	....
No. 1317	38	30	26	20	21	23	26	....	....	....	....
Apis, Paris	46	32	39	26	26	29	35	....	....	....	....
Hostomitz (Mus. Teplitz)	44	34	37	27	25	30	35	....	....	....	....
Bos primigenius Robenhausen, after Rütimeyer	41	36	..	29	..	..	..	....	....	....	....
	44	38	..	31	..	..	..	....	....	....	....
PHALANX III:											
North Kurgan, Anau:											
No. 947	80	..	..	..	..	..	..	34	37	95	18
No. 801	77	..	..	..	..	..	..	29	38	90	17
No. 805	71	..	..	..	..	..	..	25	35	85	17
No. 40	67	..	..	..	..	..	..	26	35	78	18
No. 92	65	..	..	..	..	..	..	23	33	73	15
Apis, Paris	80	..	..	..	..	..	..	32	37	95	....

Table of dimensions (in millimeters).—Continued.

Lower jaw.	Length.	Length of dentition.	Length of toothless part.	Width of ascending branch.	Width of condylus of processus glenoidalis.
North Kurgan, Anau, No. 912, +8 feet	....	....	....	118	45
Mummied bull of Abadieh (Egypt), Mus. London	375	135	109	119	44
Bos brachyceros, Walthamstow, coll. Duerst	318	127	89	88	39
Bos taurus macroceros:					
Watussi, Mus. Berlin	340	123	104	114	....
Hungary, Mus. Vienna	395	136	86	118	44
Somâl, Mus. Berlin	325	114	93	111	....

Atlas.	Length of corpus.	Width of alæ.	Length of alæ.	Diameter of anterior articulation.	Diameter of aperture.	Diameter of posterior articulation.
North Kurgan, Anau, No. 1567, −6 feet	50	234	123	143	52	112
Bos primigenius Rütimeyer	56	255	147	150	....	115

The horn-cores of the tame bovid of Anau are represented only by fragments of the bases, and by several pieces from the inner curve of the cores. The one measurable horn-base is about 23 cm.; one of the longest fragments of the inner curve of the core has a length of 24.2 cm., which corresponds to an approximate length of horn-core of 32 cm. We find in some subfossil and recent *macroceros* bovids the following corresponding dimensions in millimeters, and the horn-cores from Anau would, therefore, correspond very well to the old Egyptian bovid:

	Circumference at base.	Length of horn-core.	Longitudinal diameter.	Transverse diameter.
Egyptian long-horns from Abadieh (Mus. London):				
No. 6	160	....	55	44
No. 5	190	270	64	56
Hungarian bull, Vienna	250	520	66	84
Apis skull of Halle	270	405	....	....

As in my memoir on the Fauna of the Schlossberg zu Burg a. d. Spree (pp. 254, 255) and the size of the domestic cattle found there, so in this case I shall calculate the height of the withers from the separate bones, in order to make clear the form and size of the Anau bovid.

For *Bos namadicus*, calculating the length of lower jaw, the length of skull along the base is 51 cm. and the height of the withers in the live animal is 149 cm.

For *Bos taurus macroceros* we obtain, according to comparative measurements, and basing our calculation on the metacarpus, which has a distance of 60 cm. from its distal end to the proximal end of the radius, a height of the withers in the living animal of 153 cm.

Some comparative withers heights are given below:

	cm.
Bos primigenius, skeleton at Berlin	168
Bos namadicus, Narbada Valley India, calculated from the length of the skull (50.8 cm.) in the British Museum	149
Bos namadicus, Anau	149
Apis skeleton (*Bos taurus macroceros*) Paris	154
Bos taurus macroceros, Anau	153
Hungarian cattle	150
Short-horn cattle	149–122
East Frisian cattle	149–137
Swiss Simmental cattle	145–137

It is probable that the measurement calculated from the lower jaw for *Bos namadicus* is rather small, because the lower jaw is perhaps that of a smaller or female individual. We have unfortunately no means of checking this, unless we calculate the height of the withers from the width of the metacarpus. This small measurement, however, leaves a very uncertain result. We obtain 158 cm. in our special case. In any event, the two calculated withers heights suffice perfectly to show that we have to do with large, stout bovids, in both wild and domesticated forms.

We can therefore recapitulate as follows concerning the results of our study of the bovids of Anau:

In the lower layers of the period I*a*, from −24 feet upward, there occur the remains of a wild *Bos namadicus* Falconer & Cautley. During period I*b* there originates from this wild form a domesticated bovid, large and stately, provided with long horns. Judging from the measurements of the preserved bones, this is absolutely the same ox that was possessed by the ancient Egyptians. In the period II the size of the animal seems to have somewhat diminished, unless possibly a smaller bovid may have reached Anau with the other newly imported domestic animals. It is, however, possible that this small form of cattle of the culture II originated in a decline of the cattle-breeding of the later Anau-li; as indeed the originally large, long-horned ox of the early Babylonians had already become small and short-horned in Assyrian times, and to-day, after a relatively shorter interval, shows a tendency to become hornless. The existence of the short-horned cattle in Western Central Asia is also shown by the discovery of a skull in a kurgan of bronze time in Bizino, near Tobolsk (plate 78, fig. 6).

We find the long-horned form of domestic cattle already in the time of the Babylonians about 4000 to 5000 B. C., in Mesopotamia, as appears on a cylinder seal of those times. We see on this seal the representation of two oxen, moving through a field of grain. Still better known and more available for comparison, because of the greater quantity of existing bone, whole skeletons, skulls, etc., is the occurrence of long-horned cattle dating from the earliest times in Egypt. I have previously discussed the connection of these bovids with the African and European forms. It follows clearly from the distributions of the long-horned cattle over Asia and Europe that the Anau bovids also had an influence in forming the European domestic cattle, as we shall endeavor to show later.

OVINA.

WILD SHEEP.

Ovis vignei arkal Lydekker. (See plate 75, fig. 1; plate 76, figs. 1–4 and 8; plate 82, fig. 2).

Among the bones which are assignable to the sheep there are several fragments of very large horn-cores, which could in part be put together, forming then the calvarium (plate 75, fig. 1). This comes from culture I *a* layers from a depth of −20 feet and, therefore, belonged to a contemporary of the oldest period.

In order to identify this fragment of a skull we must first learn whether we have to do with a wild or domesticated sheep. This question, thanks to the better bones, is easier to determine than it was in the case of the Anau bovids. There is no domestic sheep which shows horns corresponding even approximately to these horn-cores. We find them, however, among wild sheep.

Among the wild sheep that might come in question are those of the steppes, *Ovis orientalis* Gmelin (*Ovis arkal* Brandt) and those of the Kopet Dagh, which Lydekker calls *Ovis vignei arkal.*

It is now evident that, even according to Lydekker, there is no great difference between these two forms of sheep, and that it will not be possible to show any differences from the few bones, since the species and subspecies are based only on characters of skin and horn. I would remark here that in my preliminary report of last year to Professor Pumpelly, without then knowing of the occurrence of the urial in the Kopet Dagh, I wrote: "These large spongy horn-cores seem to belong to the forms of *Ovis orientalis* Gmelin, *seu O. arkal* Brandt, although they are but little different from *Ovis vignei* Blyth."

The Kopet Dagh sheep was named *Ovis arkal* in 1857 by Blasius and is evidently allied to the urial of the Punjab race, with which Lydekker has proposed to identify it.*

In a more recent treatise† Lydekker studies an adult skull of this animal and says:

It will be remembered that the Punjab race of the urial (*Ovis vignei cycloceros*), at any rate as exemplified by the specimens from Peshawer and Afghanistan in the British Museum, differs from the typical *Ovis vignei* of Astor and Ladak in the much greater prominence of the two front angles of the horns, which are often raised into nodose beads, between which the front surface of the horn is depressed and carries bold and widely separated transverse ridges. In the Kopet Dagh urial the prominence of the front angles of the horns is still more pronounced, though the beading is somewhat less conspicuous. Moreover, the front surface of the horn is unusually broad and flattened, with the transverse wrinkles very low and indistinct. The length of the horn is 33 inches along the inner front angle, with a basal circumference of 11 inches, a basal width of 3 inches and a basal depth of 4 inches.

The last two dimensions are considerably greater than in a skull of the urial, measured by Mr. Hume, in which the length along the curve is 35 inches.

The Kopet Dagh urial appears decidedly to be a distinct form connected with the typical *Ovis vignei* by the Punjab race of that species.

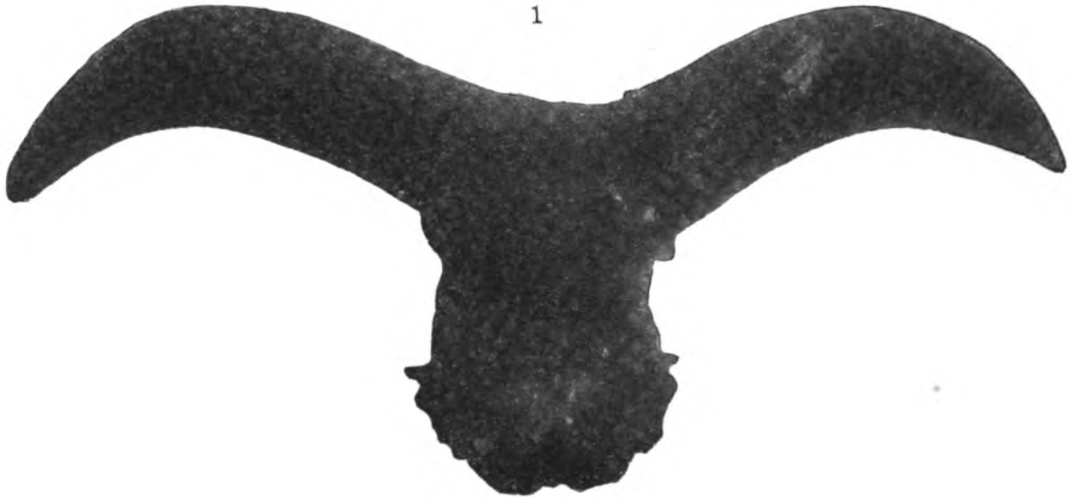
On these grounds I regard it as a local race, rather than a species; its name will accordingly be *Ovis vignei arkal* (or perhaps *arcal*).

---

* Lydekker, Wild Oxen, Sheep, and Goat, p. 173.

† Lydekker, Note on the Wild Sheep, of the Kopet Dagh, Proc. Zool. Soc., Feb. 3, 1903, pp. 102–3.

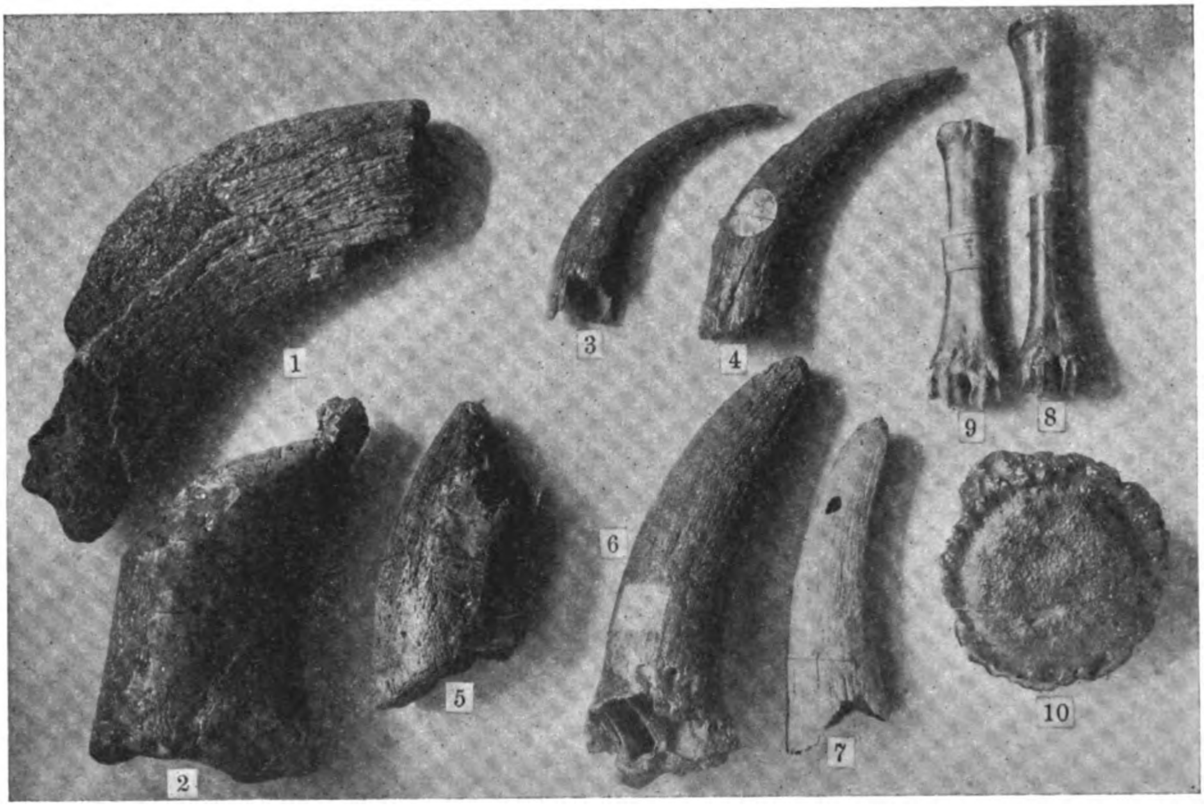
1



2

3

FIG. 1. Skull (posterior view) with incomplete horn-cores from *Ovis vignei arkal* of Anau, period I*a*.
2. Skull (posterior view) of *Ovis aries palustris*, Anau, period I. (Compare plate 83, fig. 2.)
3. Skull (lateral view) of hornless sheep of period II (restored).



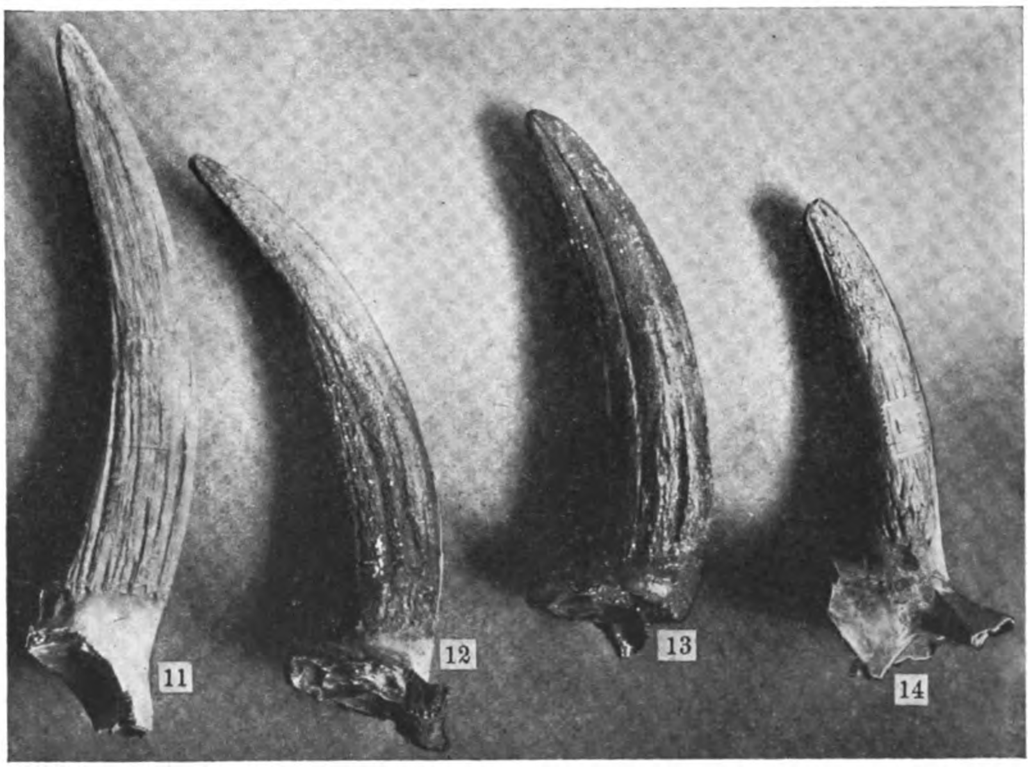


FIG. 1. Median part of carbonized horn-core of *Ovis vignei arkal*.
2. Basal part of another horn-core of same.
3–4. Horn-cores of female individuals of *Ovis vignei arkal*.
5–6. Horn-cores of large-horned breed of sheep.

FIG. 7. Horn-core of *Ovis palustris* form.
8. Metacarpus of *Ovis vignei arkal*.
9. Metacarpus of goat.
10. Basal part of antler of *Cervus*.
11–13. Horn-cores of antelope (*Gazella subgutturosa*).
14. Horn-core of goat.

Now, Anau lies just at the foot of the Kopet Dagh and within the area of distribution of *Ovis vignei arkal*; it is, therefore, most probable that we have to do with the remains of a mountain sheep still living in the Kopet Dagh and not with those of an inhabitant of the broad steppes of Persia and Asia Minor. We can, therefore, reasonably exclude the *Ovis orientalis*, *i. e.*, the steppe form of the wild sheep, from further consideration and say logically that we have before us *Ovis vignei arkal* Lydekker. As I am not able to give a direct comparison of our horn-cores with the original skulls of the Kopet Dagh sheep in the British Museum, I shall take for comparison two skulls of *Ovis vignei* that are preserved in Berlin and London, and shall contrast them with the measurements of the *Ovis ophion* of Cyprus and the Persian *Ovis arkal seu orientalis*. From these measurements it results that the agreement is closest with *Ovis vignei cycloceros* of the Punjab, and that the difference in dimensions of the two recent *Ovis vignei* skulls from Ladak and the Punjab is more noticeable than that between the skulls of Anau and all the others here brought into comparison with them.

Table of dimensions (in millimeters).

Skull.	North Kurgan, Anau.			Punjab. *Ovis vignei cycloceros*, Mus. Berlin.	Cyprus. *Ovis ophion*, Mus. London.	Ladak. *Ovis vignei*, No. 666, London.	Persia. *Ovis arkal*, Mus. Paris.
	− 21 feet.	− 15 feet.	+ 26 feet.				
Greatest width of frontal bones	125	....	....	127	125	145	134
Least width of same	95	....	....	94	93	111	98
Front line between base of horn-cores	23	....	....	17*	22*	18*	25*
Back line between base of same	73	....	....	89*	103*	133*	118*
Greatest width of occiput	83	....	....	78	79	96	88
Least width of same	55	....	....	51	60	62	58
Greatest height of same	54	....	....	56	64	64	54
Least height of same	43	....	....	42	47	52	46
Greatest width of parietals	91	....	....	82	80	89	83
Least width of same	57	....	....	51	54	60	55
Parietal height	30	....	....	33	33	30	37
Longitudinal diameter of horn-base	....	....	....	77	70	95	85
Longitudinal diameter of base of horn-core	62	70	67	52	54	63	58
Transverse diameter of base of horn	....	....	....	44	57	69	58
Transverse diameter of base of horn-core	45	53	43	32	42	44	41
Circumference of horn-base	....	....	....	195	205	200	200
Circumference of base of horn-core	180	200	170	175	180	180	180
Length of horn-core	250	....	....	220	....	....	....
Distance between joints	310	....	....	360	....	....	....

* Measurements taken on the *horns*, and not on the horn-cores.

It is clear that we have here a wild sheep that corresponds excellently well with the *Ovis vignei*. The horn measurements given by Lydekker for the *Ovis vignei* of the Kopet Dagh, if applied to the horn-cores in the manner followed with the skulls already mentioned, would correspond to a longitudinal diameter of about 70 mm. and a transverse diameter of about 54 mm., and would, therefore, agree very closely with the horn-cores of the Anau wild sheep from the culture period I*a* in the depth of − 15 feet.

A second category of horn-cores also belongs here. It is difficult to distinguish them in size from those which in the next section we shall indicate as belonging to *Ovis arkal palustris*, but upon taking these cores into the hand one recognizes, by the exceptional weight as well as by the remarkably hard structure of the core to which the exceptional weight is due, that we have here something different. In addition to this, the shape of the horn-core is somewhat different, becoming more sharply pointed towards the ends.

These characteristics suffice to assign these horn-cores to the females of the *Ovis vignei arkal*. A confirmation of this is found in a frontal piece, which, from the peculiar form of the superorbital part of the frontal bone, seems to have belonged to a female skull of *Ovis vignei*.

In the following table are given the dimensions of this bone in comparison with those of the adult female, *Ovis vignei* of the Salt Range, in the British Museum, and also the dimensions of the horn-cores.

Table of dimensions, female Ovis vignei (in millimeters).

	Frontal bone.			Horn-cores.			
	Greatest width between processus orbitalis.	Least width between bases of horn-cores.	Long diameter of orbita.	Length.	Circumference at base.	Longitudinal diameter at base.	Transverse diameter at base.
North Kurgan, Anau	10.3	72	35	....	....	....	....
−15 feet	....	....	....	150	83	30	17
+8 feet	....	....	....	144	80	28	18
Salt Range, India*	10.5	74	36	75	82	28	19

*Horn-cores No. 666 K, British Museum.

The peculiar form of these bones and the curvature of the horn-cores make it certain that they belong to a female *Ovis vignei*. Which bones of the trunk and extremities are to be assigned to the *Ovis vignei* it is naturally difficult to say. Only out of the difference in size, as contrasted with those of *Ovis palustris*, is it possible to draw some slight inferences. Therefore we will be right in assigning all the large extremity bones from the lower culture-strata to the wild sheep, while bringing them into the same tables with the domesticated sheep.

Domestic Sheep.

We now pass to the consideration of a series of horn-cores which are sharply distinguished, as I have already said, from those of the *Ovis vignei*. They are of almost similar aspect and form, but are shorter, somewhat more slender, and lighter and more porous in structure. This last characteristic seems particularly important; as except for it I might properly be confronted with the objection that these horn-cores perhaps belonged to younger or female individuals of the *Ovis vignei*. This objection, however, is contradicted by the more porous structure, the more extensive formation of sinus in the interior of the horn-core and their consequently thinner walls; for it is firmly established, that under domestication and its influences, the substantia compacta of the bones in all ruminants loses in hardness and weight, making the spongiosa more prominent. A further proof exists in the deep furrowing and roughness of the exterior of the cores, which is always an evidence of adult age.

In ascending through the culture-strata the horn-cores of the sheep become smaller and more slender and, in the larger forms, almost two-edged in cross-section. The conclusion is easy to draw that we have here the successive remains of the domesticated wild sheep, gradually altered in character through the process of domestication, which began with the taming of the ancestral form represented in the lower culture-strata.

Ovis aries palustris Rütimeyer. (See plate 75, fig. 2; plate 76, figs. 5–7; plate 83, fig. 2.)

The sheep represented in the fully preserved calvarium (No. 21) from +23 feet in the æneolithic culture-strata I*b* is, according to all the characteristics of the horn-cores, which are two-edged along almost their whole length, an *Ovis aries palustris*, a "turbary sheep" of Rütimeyer, in a form which closely resembles those found by Studer* and by Glur† in the Swiss lake-dwellings of Lake Bienne. It is a form with a little larger horn than those of this breed still living in Wales and Iceland and in small numbers in the mountains of the Grisons. But is it possible that a tame turbary sheep (Torfschaf) can have originated from a wild *Ovis vignei arkal* Lydekker?

In a former memoir Gaillard and I‡ undertook to show that C. Keller§ was wrong in his view that the turbary sheep was derived from the African Barbary sheep (*Ammotragus tragelaphus*). We reached the conclusion, then, that *Ovis vignei* must have been the ancestral form of the turbary sheep, and although we had at that time no direct proof to offer, it must be the case on account of the horns, which present the distinguishing, if not the only, characteristic of the turbary sheep.

The horns of the Barbary sheep develop, according to my investigations on more than twenty heads of young lambs of *Ammotragus tragelaphus*, in round and cone-shaped structures which retain the conical form till late old age. In the turbary sheep (at least that which C. Keller considers to be the so-called Nalpserschaf, from the Alp-Nalps in Canton Grisons) the young horn is pressed wholly flat and scabbard-like. I have confirmed this on individuals which C. Keller himself bought for the zoological park of Zürich, and which later came to me by purchase and are now in my experimental flock, where they are being studied with reference to the question of their derivation. Further, this peculiarity is clearly recognizable in the English turbary sheep of Wales and the Hebrides.

Now, the lamb and the female of *Ovis vignei* show the same form of horn-sheath, as will be seen in the picture; but since my researches on the origin and

*Studer, Th., Die Tierwelt in den Pfahlbauten des Bielersees. Mitteilungen Naturf. Gesell., Bern, 11 Heft, 1882.

†Glur, G., Beitraege zur Fauna der Pfahlbauten. Mitteilungen Naturf. Gesell., Bern, 1894.

‡Duerst & Gaillard, Studien ueber die Geschichte des aegyptischen Hausschafes. Receuil de travaux relatifs à la philologie et l'archéologie égyptiennes. vol. XXIV, pp. 44–76. Paris.

§C. Keller, Die Abstammung des Buendnerschafes und Torfschafes. Schweiz. Naturf. Versammlung, Chur, 1900.—Die Abstamm. d. ält. Haustiere. Zürich, 1902.

development of horns* have shown that it is the horn-sheath which causes the form of the horn, and since, on the other hand, a retardation of the development occurs under domestication in the sense that the growth of the horn remains fixed at the stage of an earlier youthful form, it is easy to understand that only a sheep which is flat-horned in its youth could have produced a sheep with compressed horns like the turbary sheep of Rütimeyer.

Table of dimensions (in millimeters).

Skull of *Ovis aries palustris* Rütimeyer.	North Kurgan, Anau, +28.5 ft.	Schaffis (Switzerland), neolithic, Mus. Bern.	Walthamstow, 15 ft. deep, coll. Corner, London.	Ireland, turbary, Mus. Paris.	Canning-town, neolithic, coll. Corner, London.	Iceland, recent, Paris.
Front line between base of horn-cores	45	43	65	43	47	45
Back line between base of same	73	78	81	81	82	76
Greatest width of occiput	73	....	67	69	67	69
Least width of same	42	....	50	39	48	42
Greatest height of same	49	....	49	50	49	51
Least height of same	32	....	34	32	30	34
Greatest width of parietals	62	....	68	73	68	69
Least width of same	41	....	40	39	41	41
Parietal height	31	....	28	29	22	30
Longitudinal diameter of horn-core	45	37	28	32	26	29
Transverse diameter of same	26	18	20	21	15	20
Circumference of core at base	115	100	79	95	75	87
Length of horn-core	195	78	150	110	80	110
Distance between points	248	....	267	....	169	....

Lower jaw of adult Ovis.	Entire length.	Length of dental series.	Length of toothless part.	Width of vertical part behind first molar.
North Kurgan, Anau:				
−15 feet	*180 (?)	75	45	*60 (?)
−15 feet	....	78	45	....
+6 feet	....	71	....	54
+20 feet	167	71	43	59
+23 feet	152	71	42	46
+24 feet	170	71	48	50
Ovis vignei, Ladak, Mus. London	190	81	47	56
Ovis aries palustris, from Ireland, Mus. Paris	173	71	42	51

* Measurements on incomplete pieces.

The appearance of the horn-cores of the turbary sheep and the goat-horned sheep mentioned in the æneolithic and copper-culture strata of Anau may, therefore, easily be considered the remains of an autochthonously derived domesticated form, especially because of the quantity of transitional forms to the large-horned sheep.

* Duerst, Versuch einer Entwicklungsgeschichte der Hoerner der Cavicornia, Frauenfeld, 1902. Sur le développement des cornes chez les Cavicornes. Bull. Mus. d'Hist. Nat., 1902, p. 197.

Table of dimensions (in millimeters).

Horn-cores.	Length.	Circum-ference at base.	Longi-tudinal diameter at base.	Transverse diameter at base.
North Kurgan, Anau:				
Ovis vignei arkal Lydekker:				
−10 feet	250	180	62	45
−15 feet	....	200	70	53
+26 feet	....	170	67	43
Probably domesticated, small-horned specimen, forming connection with the real *Ovis palustris:*				
+8 feet	....	150	57	40
	110	94	32	20
+20 feet	130	120	41	26
+25 feet	106	93	32	22
+26 feet	117	112	42	27
Ovis aries palustris Rütimeyer:	117	73	25	16
+26 feet	97	72	27	14
	114	73	25	14
+33 feet	75	72	25	14
Types of *Ovis aries palustris:*				
England:				
Lea Valley (coll. Corner)	85	70	24	14
Londonwall, Roman times (coll. Corner)	120	105	32	21
	105	85	36	16
Lea alluvium, The Mills, London	70	54	15	15
Germany:				
Naegelstedt neolithic, Prehistoric Museum,	130	100	37	22
Berlin	110	102	39	21
Schlossberg, La Tène	100	75	26	15
France:				
Grotte du Pontil, Nat. Hist. Mus.	120	100	40	20
Pile-dwellings of Paladru, Paris	75	80	23	16
Switzerland:				
Schaffis neolithic, Bern	78	100	37	18
Nalps, recent	80	75	22	19

It may be objected, however, that the turbary sheep might have been imported from elsewhere in the culture period II, and that the different large-horned domestic sheep were only the products of crossing with the wild sheep or with some other large-horned domestic sheep, such being found in the pile-dwellings of the Lake of Bienne, as *Ovis aries studeri*, or as products of the crossing of the wild Mediterranean mouflon on *Ovis palustris*. The decision between these two possibilities would not be fully possible had not Professor Pumpelly conducted the excavation of the bones with the greatest care throughout. It is of the greatest importance to us that we know exactly the depth from which each fragment of bone was taken; and it follows that we are able to make the following statement concerning the position in the stratified series, and consequently the relative time of appearance:

Ovis vignei arkal Lydekker occurs practically throughout all the strata; the best-preserved piece comes from the lowest layer at −20 feet, the second at −15 feet, other small pieces of horn-cores at +18 feet, +21 feet, and a good piece again at +26 feet. Therefore, this animal was hunted and eaten by the inhabitants of the North Kurgan down to the copper period.

At +8 feet we find for the first time a well-preserved core of a domesticated sheep, which belongs to the already mentioned large-horned form. It is the same as the *Ovis vignei* horn-cores, but a little smaller. But in the same layer there occurs a second core, which is not derived from the same animal, as it is notably smaller, more slender and also of two-edged form. Further core-pieces occur frequently in all the following layers, the best-preserved of these cores being found at +20, +25, and +26 feet. These cores disappear then entirely and from there on we meet only with the very slender cores of *Ovis aries palustris*, horn-core bases, with both attached frontal pieces and middle pieces, being very common.

The cores of *Ovis aries palustris* begin to appear, however, before the +28-foot layer, *i. e.*, during the occurrence of remains of the large-horned form. The calvarium already mentioned, shown in plate 75, fig. 2, comes from this layer. Its horns, which are still rather stout, indicate that the now-developing turbary-sheep form is yet in the process of evolution. The turbary-sheep form continues until the uppermost layers of the kurgan are reached. It becomes considerably rarer, however, above +33 feet and about that time there enters a hornless sheep, which we shall presently consider. Thanks to Professor Pumpelly's care these closely accurate stratigraphic relations afford us weighty evidence that the *Ovis palustris* is autochthonous in this part of Turkestan and was bred from the *Ovis vignei* of the Kopet Dagh; for it is clear that here a few feet of culture-strata represent centuries during which a very great transformation could take place in the Anau sheep.

In the tables on pp. 374–375, I have brought together the measurements of the horn-cores and the cranial remains from the layer +28 feet, in comparison with such specimens from European culture-strata. It is easily seen that the measurements agree with each other, serving merely to strengthen the impression made by the agreement in form.

The Hornless Sheep of the Copper Period.

(See plate 75, fig. 3.)

In the former section it was shown that at about the +33 to +34-foot culture-layer the horned *palustris* sheep was crowded into the background by a hornless sheep, which suddenly appears in numerous individuals. As is well known, it is difficult to find among the hornless sheep such differences in cranial structure as to permit a determination of the breed. The skulls of hornless sheep and of goats are distinguishable from each other with difficulty when the sutures of the parietal bone are no longer recognizable. It is, therefore, impossible to determine the exact relationship of the hornless sheep of the II or copper-culture period. The dimensions of the skulls of different hornless sheep, brought together in the following table, show a perfect agreement with the hornless sheep skull from a turbary at Abbeville in France, preserved in the Museum of Natural History at Paris; but, on the other hand, the agreement of the measurements with those of the skull of an *Ovis platyura bucharica* ewe is very strong.

Table of dimensions (in millimeters).

Skull.	Anau, + 34 ft.	*Ovis aries*, neolithic (without horns), turbary of Abbeville, Mus. Paris.	*Ovis platyura bucharica* Fitz (fem.), Mus. Paris.	*Ovis platyura ægyptiæ* Fitz (fem.), Mus. Paris.	*Ovis aries*, recent specimen. Gascogne.	*Ovis aries*, recent specimen. Ireland.
Greatest length of base, *ca.*	185	....	190	214	212	197
Lateral length of frontal (bregma to orbita)	57	....	63	80	74	75
Length of molars of upper maxilla	35	39	45	48	43	44
Length of premolars	26	21	21	25	19	19
Sagittal length of frontal bones	82	76	80	92	92	82
Parietal height	30	....	27	35	32	32
Parietal width	59	52	61	71	53	65
Greatest height of skull	87	....	86	104	72	78
Greatest height of occiput	52	....	52	59	48	48
Least height of same	37	....	38	43	33	29
Greatest width of occiput	65	....	66	76	67	67
Least width of same	42	....	43	55	44	41
Least width of front	65	....	66	68	63	69
Greatest width of same	104	108	109	119	117	119
Distance between orbitals	....	75	71	77	76	77
Width of palate behind molar 1	48	39	45	58	50	52
Width of palate in front of premolar 1	29	27	23	26	32	23

This apparent resemblance does not, however, permit us to assume a relationship to one of these forms, for it is readily seen from my former investigations into the influence of horns upon the shaping* of the skull, that the absence of horns produces uniform characteristics and that while considerable variance may exist in the absolute craniological dimensions, the relative dimensions always remain the same. Now, what can this hornless sheep form be, and whence can it have come? The bone remains give us no information on these points; and we must, therefore, resort to deduction and inference.

Let us first examine the recent races of sheep of Turkestan. The Central Asiatic steppes harbor only two races of sheep, which are generally designated:

(*a*) The fat-buttocked sheep (*Ovis aries steatopyga* Fitz); (*b*) the fat-tailed sheep (*Ovis aries platyura* Fitz).

Ovis aries steatopyga is characterized by a posterior overloaded with fat, which on the buttocks projects upward in the form of a fatty protuberance which is split in the middle. The ram of this breed has horns of medium length which are thick and strong at the root and grow narrower towards the blunt point. The horns, without rising above the crown of the head, form, in winding, a double snail-shaped revolution back, down, and forwards. In the ewes and the wethers the horns are smaller and weaker, and curved only backwards and forwards. There occur at times four-horned and even five-horned rams in this race of sheep; and, on the other hand, we find here and there hornless females.

*Experimentelle Studien ueber die Morphogenie des Schaedels der Cavicornia. Vierteljahresschrift d. Naturf. Gesell. Zürich, Jahrg. 1903, p. 360.

The second race is the fat-tailed sheep (*Ovis aries platyura*), whose long, limply hanging tail, reaching to the heel joint, is surrounded by a mass of fat, which has, however, no great size. The rams of this race are horned; the ewes for the most part are hornless. The horns of the rams are not very long, nor particularly thick; they are three-sided, with rounded edges, of which the inner one is always sharper. They rise slightly above the crown of the head and wind sideways and backwards from the root, forming then a simple helical turn down, forwards, and upwards, while the points turn somewhat inwards.

In the neighborhood of Anau the Afghan Maimene breed predominates. It is a sheep of excellent flesh of large growth. The wool is long and coarse, and the tail long. The animals are in part horned and in part unhorned. In the other parts of Transcaspia the fat-buttocked sheep (Kurdjak breed) predominates.

If now we visualize these forms of sheep, we can express the following ideas concerning the derivation of the hornless sheep of the culture-strata of the copper period of the North Kurgan, though these ideas can be but speculations.

The hornless sheep may be: (*a*) a female of the previously occurring form, which we have designated *Ovis palustris* and whose horns had reduced in size; or, (*b*) a hornless race introduced from somewhere else with the camel and the goat. The sudden appearance of several hornless frontal pieces argues for the last hypothesis. As we shall see, there appeared another domestic animal at about this time or in the +32-foot layer—the *camel*, of which no trace was found in all the earlier layers which have been so carefully searched. At the same time we meet another domestic animal, the goat (*Capra hircus rütimeyeri* Duerst).

The camel, the hornless sheep and the goat are, however, the animals found in the later South Kurgan, where there are few traces of other sheep.

Table of dimensions (in millimeters).

	Length.	Superior width.	Width at collum.	Length of articulation.	Diameter of articulation.
SCAPULA:					
North Kurgan, Anau:					
−8 feet	....	....	21	35	23
−8 feet	....	....	19	32	21
−8 feet	....	....	17	27	19
−7 feet	....	....	17	27	19
−7 feet	....	....	19	30	20
+17 feet	....	....	18	38	20
+19 feet	....	....	20	33	19
+22.5 feet	....	....	23	32	22
+23 feet	....	....	21	32	20
+26 feet	....	....	16	21	22
+26 feet	....	....	17	28	20
+28.5 feet	....	....	21	35	23
+32 feet	171	110	20	35	22
+32 feet	....	....	18	33	21
+32 feet	....	....	24	34	24
+32 feet	....	....	20	31	19
+32 feet	....	....	22	33	25
+32 feet	....	....	17	28	18
+32 feet	....	....	18	29	20
+32 feet	....	....	17	27	20
Ovis aries palustris, Nalps, coll. Duerst	172	115	20	29	21

Table of dimensions (in millimeters).—Continued.

	Length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal idth.	Distal diameter.	Width of interior trochlea.	Width of exterior trochlea.
HUMERUS:									
North Kurgan, Anau:									
No. 1286, −8 feet	138	38	43	18	20	30	....	17	13
No. 1304, −8 feet	....	....	....	....	....	26	....	17	14
No. 1005, +22.5 feet	....	....	....	....	....	30	....	19	14
No. 929, +22.5 feet	....	....	....	....	....	27	....	17	14
No. 1487, +23 feet	....	....	....	....	....	27	....	17	13
No. 554, +24 feet	....	....	....	....	....	32	....	20	15
No. 1032, +26 feet	....	....	....	....	....	32	....	20	13
No. 1100, +26 feet	....	....	....	....	....	30	....	18	14
No. 1072, +26 feet	....	....	....	....	....	30	....	17	14
Turbary sheep, Schlossberg	....	....	....	....	....	28	....	18	14
Recent sheep, Germany	135	40	45	20	21	32	....	25	18
RADIUS:									
North Kurgan, Anau:									
No. 1298, −8 feet	....	35	17	....	....	....	....	....	....
No. 1290, −8 feet	....	39	17	....	....	....	....	....	....
No. 539, +18 feet	140	27	19	14	8	29	14	....	....
No. 761, +25 feet	156	30	14	16	9	31	20	....	....
No. 1039, +26 feet	160	30	14	14	9	28	19	....	....
No. 1071, +26 feet	....	....	....	....	....	25	18	....	....
No. 255, +28 feet	....	33	14	15	9	....	....	....	....
No. 965, +32 feet	....	30	14	14	9	....	....	....	....
No. 943, +32 feet, old animal	....	....	....	17	9	30	20	....	....
South Kurgan, Anau:									
+23 feet	157	32	15	16	8	30	19	....	....
Londonwall, *Ovis aries palustris*, Dr. Corner, London	142	33	15	16	9	26	17	....	....
	157	30	14	17	9	29	19	....	....
METACARPUS:									
North Kurgan, Anau:									
No. 1202, −15 feet	....	26	18	15	12	....	....	....	....
No. 1202*b*, +15 feet	....	25	18	....	....	....	....	....	....
No. 113, +28 feet	....	....	....	....	....	22	16	....	....
No. 946, +32 feet	....	25	17	....	....	....	....	....	....
No. 922, +32 feet	....	20	15	....	....	....	....	....	....
No. 943, +32 feet	....	....	....	....	....	22	14	....	....
Walthamstow, *Ovis aries palustris*	111	19	14	11	8	21	13	...	....
	115	20	13	11	8	21	13	....	....
Ovis aries studeri, Lea alluvium	135	26	18	17	11	30	16	....	....
	161	29	20	17	12	31	18	....	....
FEMUR:									
North Kurgan, Anau:									
No. 1106, +26 feet	....	43*	19	....	....	....	....	....	....
No. 1098, +26 feet	....	....	....	....	....	37	45	....	....
No. 662, +27 feet	....	48*	22	....	....	....	....	....	....
No. 950, +32 feet	....	45*	20	19	16	....	....	....	....
No. 932, +32 feet	....	....	....	....	....	35	43	....	....
Ovis aries, German breed	212	62*	31	20	18	48	54	....	....
Ovis aries palustris, Nalps, coll. Duerst	185	49*	22	18	15	36	44	....	....
TIBIA:									
North Kurgan, Anau:									
No. 1276, −8 feet	....	....	....	....	....	25	17	....	....
No. 1484, +23 feet	....	....	....	....	....	36	21	....	....
No. 1043, +26 feet	....	44	45	....	....	....	....	....	....
No. 1034, +26 feet	....	....	....	....	....	23	18	....	....
No. 688, +27 feet	....	....	....	....	....	21	17	....	....
South Kurgan, Anau:									
No. 1580	....	34	38	....	....	....	....	....	....
Ovis aries palustris Nalps, coll. Duerst	220	38	41	....	....	26	19	....	....

*Proximal width on the caput femoris.

The latter alternative does not appear to me to be sufficiently justified, and I incline rather to the first idea, for the following reasons.

We find in the layer at +30 feet the frontal piece of an adult animal with a little horn-core of 3.5 cm. length and a circumference of 7.3 cm. This cranial piece must represent a transitional form to *Ovis palustris*, especially as no mistake as to the age of this animal is possible, because of the presence of a parietal piece which is connected with the frontal by the sutura coronalis. If this cranial piece had belonged to a young animal it would have broken open along the sutures when the skull was crushed, while in the old individual as a matter of fact the suture is still so firm that the bones would break before the sutures would open. Thus it seems that the long-tailed *Ovis palustris* form may have given rise to the long-tailed sheep (Maimene breed) which is still living in those regions, provided always that the formation of the fat tail, which was probably pathological, did not originate until after the distribution of the turbary sheep to Europe, which possibly happened towards the end of the æneolithic period of Anau. The occurrence to-day of hornless female animals among the fat-tailed sheep and turbary sheep renders this explanation more probable. However, this view rests only upon speculation, for direct proofs are not to be had and probably never will be.

In the tables on pp. 378–379, the extremity bones of the sheep of the Anau kurgan are brought together and compared with some accurately determined extremity bones of subfossil or recent sheep. In these one can see that the larger wild sheep or its direct descendants occurred in the lower layers, while in the middle and upper layers the small *palustris* sheep predominated.

Capra hircus rütimeyeri Duerst. (See plate 76, figs. 9 and 14.)

The goat, of which we find the horn-cores and extremity bones among the bone remains from Anau, belongs, as already stated, in the uppermost layers of the North Kurgan. Really typical and well-preserved remains are very scarce. Of these there are some horn-core pieces and two perfectly preserved metacarpi, as well as the fragment of another. In these we can recognize a small short-horned goat, such as lives still, in a slightly differentiated form, in Central, Eastern, and Southern Asia, as well as in the Malayan Archipelago. One of the most primitive forms is without doubt the so-called wild goat of Crete, which is probably only a reversion from the domesticated to a wild state, very similar to *Capra ægagrus*, and in which is embodied the exact type of the goat of the pile-dwellings. M. Evans has published from his excavations at Cnosse (Crete) of the second palace (about 1500 B. C.) a very perfectly preserved relief in faience representing a she-goat with her young.* The horns of this animal are much longer than those of the recent goat from Crete, figured in plate 78, fig. 5.

The horn-cores differ from those of the sheep in the greater height to which the inner cavity extends, which leaves room for only a little dense substance at the point of the horn-core.

---

*Salomon Reinach, La Crète avant l'Histoire, l'Anthropologie, 1904, p. 265, fig. 7.

In their dimensions they are similar to those of the *palustris* sheep. A horn-core, unfortunately preserved only with the basal part, belonging to an old individual, and marked as an old he-goat by distinct frontal bumps, is the only one that shows any larger measurements.

Table of dimensions (in millimeters).

	Length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal width.	Distal diameter.	Longitudinal diameter.	Transverse diameter.	Circumference at base.
HORN-CORES:										
Anau:										
Female	105	....	....	....	....	....	....	26	14	73
Female	110	....	....	....	....	....	....	31	19	85
Male	....	....	....	....	....	....	....	40	28	*ca.* 120
Capra hircus, male, Turkestan, Mus. Paris	250	....	....	....	....	....	....	54	39	150
Capra hircus, Malay Archipelago, coll. by Hombrone and Jacqueminot	100	....	....	....	....	....	....	26	15	74
Capra cretensis Brisson, Crete, Mus. Paris.	120	....	....	....	....	....	....	22	13	65
METACARPUS:										
Anau:										
Adult	102	23	16	15	9	27	16	....	....	....
Adult	98	20	14	14	8	23	13	....	....	....
Anau City, M. S. IV, –16 to –17 feet, recent	....	....	....	14	9	25	15	....	....	....
Gross Czernosek, Bohemia, Mus. Teplitz	99	20	14	12	8	24	14	....	....	....
Stockholm, Kungsträdgarden (King's Gardens):										
Subfossil goats*	102	23	....	16	....	23	....	....	....	....
Subfossil sheep after Kinberg, p. 373*	107	22.5	....	15	....	27	....	....	....	....
	98	22	....	14	....	24	....	....	....	....
	102	18	....	10	....	20	....	....	....	....
Schlossberg, *Ovis aries palustris*	103	18	12	8	7	9	8	....	....	....
Sardegna, *Ovis musimon*, coll. Duerst	135	23	21	14	12	25	17	....	....	....

*Kinberg, T. G., "Ossa metacarpi et metatarsi, Ovis et Capræ." Ofversigt Kongl. Vetenskaps-Akadem. Forhandlinger, 1869, pp. 359–433.

Although Rütimeyer* states that only the hoof phalanges and joint-surfaces of the bones are useful in deciding between the goats and the sheep and that the goat shows a deerlike delicacy of the bones, later investigations† have shown that the metacarpalia and tarsalia are good characteristics for a diagnosis, since, contrary to the general view as well as to Rütimeyer's assertion, these bones are much broader and shorter in the goat than in the sheep.

This appears clearly in the above dimensions, since the distal width of an equally long metacarpus of a goat and a *palustris* sheep is three times as great in the former as in the latter (27 mm.: 9 mm).

* Fauna der Pfahlbauten, p. 127.

† Cornevin et Lesbre, Caractères ostéologiques differentiels de la chèvre et du mouton. Bull. Soc. Anthrop., Lyon, 1891. Kriz, Martin, Die Hoehlen in den maehrischen Devon-Kalken, etc. Jahrbuch der k. k. geolog. Reichsanstalt, Wien, pp. 443–570.

ANTELOPINÆ.

Gazella subgutturosa Gueldenstedt. (See plate 76, figs. 11–13 and plate 84.)

Several of the best-preserved bones of all the layers belong to the *Gazella subgutturosa* Gueldenstedt, the small but beautiful antelope that still lives in Persia and Turkestan. There are both horn-cores and teeth, parts of lower jaws and extremity bones, which make the presence of the animal very evident. It occurs frequently from the lowest layers below the level of the plain to the summit of the kurgan.

It is clear that this swift game was successfully hunted by the inhabitants of culture period I of the kurgan. Assuming with Mucke,* that the wild animals of such an early period would show no great fear of man, it nevertheless seems strange that they could be killed without the aid of the dog, and it is probable that a dog, if not the same as the one we find in the higher layers, existed also at the earlier period, although no bones were discovered.

The great hardness and the absence of cavities in the horn-cores have served well to protect the remains of this animal from destruction by tooth and time. The color of the horn-cores is different from that of the inclosing earth, ranging from dark-red to light-yellow. In the following table are given the dimensions of some of these in the order of their position in the kurgan and in comparison with the measurements of the head of a modern individual. These animals are also represented in the sculptures of the ancient Assyrians (plate 84).

Table of dimensions (in millimeters).

Horn-cores.	Length.	Diameter anterior to posterior.	Lateral diameter	Circumference on base.	Width of frontal between horn-cores.	Length. of horny sheet.	Circumference of horn-base.
North Kurgan, Anau:							
−21 feet	160	30	22	89	14	....	....
−17 feet	155	30	22	90	....	....	....
−9 feet	175	31	21	90	....	....	....
+8.5 feet	145	38	27	105	....	....	....
+15 feet	165	34	24	100	....	....	....
+18.7 feet	165	32	24	92	....	....	....
+27 feet	210	33	23	90	....	....	....
+30 feet	170	34	24	94	....	....	....
Gazella subgutturosa, stuffed male adult specimen, Mus. Bern	....	34	25	....	15	280	95

CERVIDÆ.

The Stag of Persia.

Cervus sp. [*maral* Ogilby†(?)]. (See plate 76, fig. 10.)

This great deer is represented by the remains of an antler. The main branch has been knocked off with a sharp instrument and only the crown or burr remains. The circumference is 25 cm. In the European stag from the Schlossberg I found 24.5 cm. in eighteen antlers and 19 cm. in twelve. It is probably *C. maral* Ogilby, but for lack of material this can not be proved.

*Mucke, Urgeschichte des Ackerbaues und der Viehzucht. Greifswald, 1898.
†Gray, *Cervus wallichii.* Proc. Zool. Soc., 1850, p. 228, 1840, p. 11.

CAMELIDÆ.

Camelus sp. [*bactrianus* Erxel (?)]. (See plate 73, figs. 10 and 11; plate 77, figs. 10–12.)

Bones of the camel are found only in the highest layers of culture II or the copper period of the North Kurgan. The phalanx secunda, No. 615, came from between +26 to +31 feet, and the fourth vertebra cervicalis, No. 1062, from +32 feet. No remains of the camel were found below these layers, though we naturally find them again in the shafts of the much later Anau citadel, where they can be but a few centuries old. It is therefore very probable that the camel was imported as a domestic animal at a much later time than the age of the lower strata of the North Kurgan. However, even the complete absence of bones of a wild camel in the layers of culture I is no reason to conclude positively that this animal was not then living in a wild state in this region, for Przewalski found it still in a wild state near Lob-Nor, south of the Tian Shan.

Table of dimensions (in millimeters).

	Length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal width.	Distal diameter.	Length of corpus vertebræ.	Width of corpus vertebræ.	Width of anterior alæ.	Width of anterior processus.	Width of posterior processus.	Median height.
PHALANX I:													
Anau City mosque shafts −9 to −11 feet.	104	44	34	21	22	37	28	....	....	....	....	....	....
Camelus bactrianus, adult (Mus. Bern)...	91	40	32	20	19	33	24	....	....	....	....	....	....
PHALANX II:													
North Kurgan, Anau, +31 to +26 feet....	74	35	30	27	18	41	19	....	....	....	....	....	....
Camelus bactrianus, adult (Mus. Bern)....	56	28	21	21	14	30	11	....	....	....	....	....	....
FOURTH VERTEBRA CERVICALIS:													
Anau, No. 1062.......	..	..	..	..	..	..	..	138	58	108	77	69	62
Camelus bactrianus Erxel. (Mus. Bern)..	..	..	..	..	..	..	..	120	50	100	69	68	60

It is impossible to determine exactly the species to which the Anau camel may have belonged; but historical reasons and considerations of geographical distribution make it seem probable that it was of the Bactrian race of camel, and therefore two-humped. This is only our opinion, however, for the differences between the skeleton of the one-humped dromedary and the two-humped Bactrian camel are very slight and not perceptible in the well-preserved bones of the kurgan. The Anau camel was certainly a large animal, as will be seen from the preceding table of dimensions, where it is compared with the skeleton of a camel preserved in the Museum of Bern.

Fossil remains of the camel have been found in the Siwalik Hills of Northern India and in later Pleistocene deposits in Lutschka, near Sarepta, on the Volga, north of the Caspian, the latter having been published by Nehring under the name of *Camelus knoblochi*. Stefanesku discovered in Roumania the bones of a camel which he describes under the name of *Camelus alutensis*. Pomel describes *Camelus thomasi* from the Pleistocene of Algeria. Hence it seems to be highly probable, as was first pointed out by Nehring, that the one-humped and the two-humped camels were developed in different countries; and that while all descended from the ancestral form of the Siwalik Hills, one branch, reaching Western Asia and Eastern Europe, formed *Camelus knoblochi* and the *Camelus alutensis*, and probably also the domestic race of the camel found at Anau. This branch was two-humped; while the other branch, passing like the Indian buffalo (*Bubalus palæindicus*) into Africa, has formed the one-humped variety of Northern Africa and Arabia.

That the camel was domesticated in very early times is proved by the representations and sculptures of the Assyrians and Persians. In the later Persian monuments of Persepolis and those of the Assyrians of Khorsabad and Nimrud, we frequently see one-humped dromedaries; but it is only on the black obelisk of Nimrud, which is inscribed with an account of the campaigns of Shalmaneser II, King of Assyria from 860 B. C. to 825 B. C., that we see two-humped Bactrian camels, where several of them are represented under title of payment of tribute of the land of Musri. The land of Musri, which belonged to King Asu of Gurzan, or Gilgani, was situated north of Lake Urmia, in the neighborhood of the Kara Dagh and Mount Ararat. Since our results seem to show that at the time of the oldest culture-strata of Anau the wild camel did not exist in this part of Turkestan, it is possible that the domesticated animal was imported with the goat from Bactriana or from the Iranian plateau.

Ordo PERISSODACTYLA.

EQUIDÆ.

Equus caballus Linnæus. (See plate 77, figs. 1–9.)

One of the animals of which we find the greatest quantity of well-preserved bones is a relative of the horse tribe. From the deepest layers, −24 feet, of the oldest period to the superficial remains of the latest habitations of the North Kurgan, we find great quantities of these bones in all the strata that have been opened. Therefore the equine animals must have been very abundant throughout the life of the kurgan. Notwithstanding this great quantity, it is not easy to form a picture of the equids to which these osseous remains belonged. We have only very few data concerning the bones of the Post-Tertiary and subfossil horses of China, Mongolia, and Central Asia,* which have been only slightly increased by Tscherski† for the Siberian horses.

Nevertheless, despite the defective knowledge concerning the prehistoric horses, Central Asia is looked upon by many authors as the cradle of the European domestic horse, as well as that of the human race in general.

Nehring‡ has, it is true, proved that a domestic horse was formed out of the diluvial horse of Europe on European ground, which took part in the creation

*Gaudry, Journal de Zoologie, Gervais, 1872, t. I, pp. 300–302; M. Wilckens, Nova Acta, Leop.-Carol. deutsch. Akad. d. Naturf., 1888, Bd. LII, No. 5, p. 59.

†Tscherski, Mémoires Acad. Imp. St.-Petersburg, VII série, tome XL, pp. 257–383, 1893.

‡Nehring, Fossile Pferde deutschen Diluvial Ablagerungen. Landwirtsch. Jahrbuch, Bd. XIII, 1884.

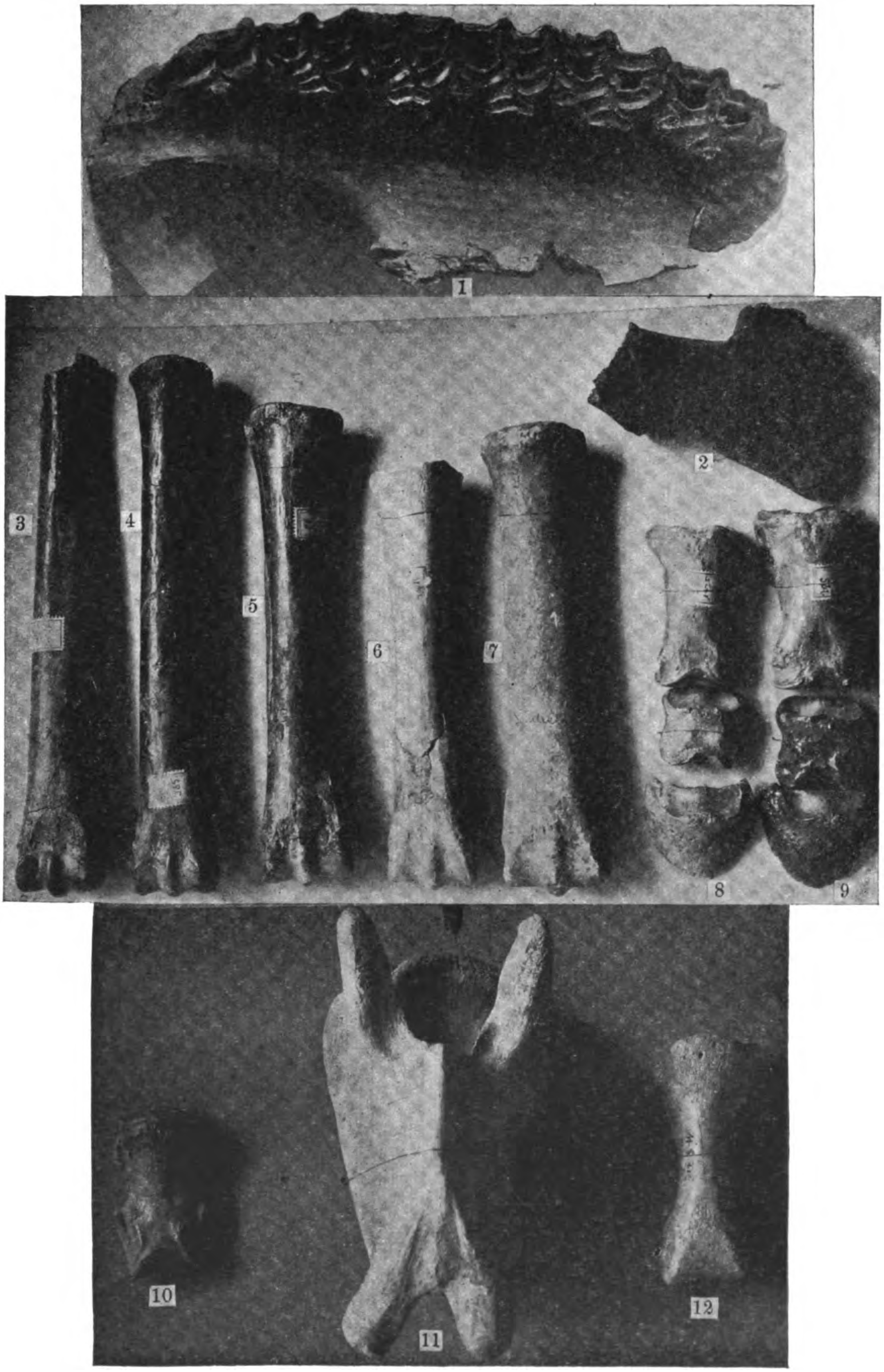


FIG. 1. Right part of upper maxilla, *Eq. caballus pumpellii.*
2. Anterior part of left branch of lower jaw of same.
3. Metatarsus of horse of II period.
4. Metatarsus of horse of I*b* period.
5. Metacarpus of wild (?) horse of I*a* period.
6. Metacarpus of horse of II period.

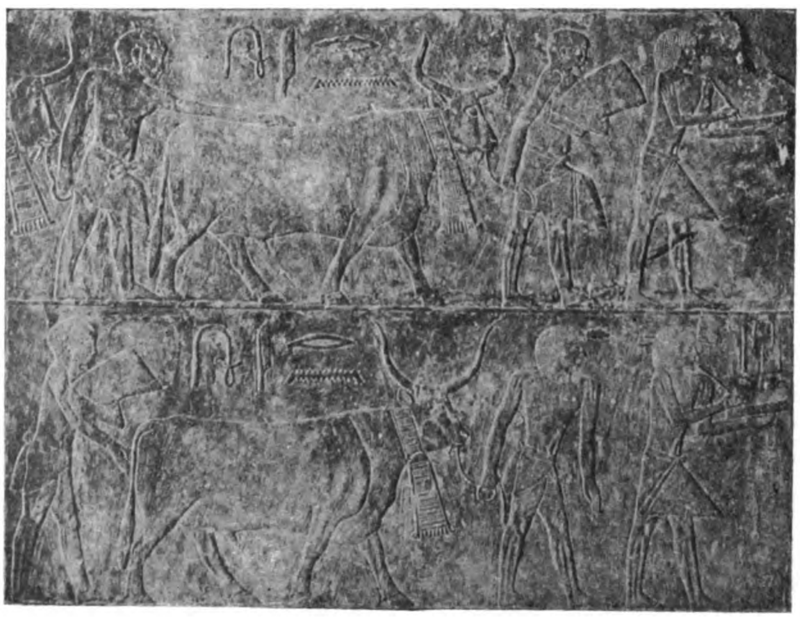
FIG. 7. Metacarpus of wild horse from Solutré.
8. Phalanges I–III of horse of I*b* period.
9. Phalanges I–III of horse of II period.
10. Phalanx II of camel.
11. Vertebra cervicalis of camel.
12. Phalanx I of camel.

FIG. 1. Basioccipital bone of *Bos namadicus* Falconer and Cautley.
2. Remains of a long and large round horn-core of *Bos taurus macroceros*.
3. Proximal part of radius with ulna of *Bos namadicus*.
4. Distal part of radius.

FIG. 5. Skull of a female wild goat from crete. (Mus. Paris.)
6. Short-horned cattle. Skull of a specimen from the kurgan of Bizino, near Tobolşk (western Siberia) (Mus. Paris).
7. Remains of basal part of long and large round horn-core of *Bos namadicus*.

(Figs. 1–4 and 7 from period I*a*.).

1



2

FIG. 1. Egyptian dog, marble, Mus. Louvre, Paris.
2. Egyptian long-horned cattle, Tomb of Manofer, 2600 B. C., Mus. Berlin.

of the heavy draft-horse of Europe; and now Kraemer* comes to the conclusion that the horses of classical Rome and Greece represent a cross between the heavy European horse and the Asiatic type. Notwithstanding the very plausible fact of the domestication of the European wild horse, however, it can not be contradicted that this wild horse itself could have come from Asia.

In considering the horse of the Anau kurgan, it is primarily worthy of note (1) That the horse from the lowest to the uppermost layers is represented by a great quantity of bones, to an extent which in the lower layers is only equaled by those of the bovid; (2) that in these bones we can recognize only one variety of horse, which thus occurs in the lowest layers with wild animals only and in the higher strata with the other domesticated animals; (3) that the percentage of the bones of the horse, as compared with those of other domesticated animals, also increases in period I*b*. This last fact permits the conclusion that the horse came to the table of the inhabitants more often in the later than in the earliest period of the development of the kurgan civilization, from which we might next conclude that the horse was then easier to catch and had, therefore, become tamed or domesticated.

It is not possible to assert with logical certainty the correctness of our conclusion that we have here, at least in the upper strata, a domesticated horse, as we were able to do in the cases of the bovid and sheep through a study of the skeletal remains. I hold that no one is able to determine with certainty, from the study of a few bones of a fossil or a subfossil horse, whether the individual was wild or domesticated.

There are wanting in the case of the horse precisely the criteria which we have in the bovids, where in consequence of stabling or of restriction of freedom of movement, the substantia compacta of the bones is thrown into the background in favor of the spongiosa. Again, we are not able to base a distinction between the domesticated and the wild animal on a change in the skull, as we do in the sheep. On the contrary, the mode of life of the horse, especially among inhabitants of the steppes, remains the same as in the wild condition. Harnessing, and the use of the organs as in the wild condition, insures the stability of the bodily form and of the skeleton; and the influence of the weight of the rider carried by the animal is not further perceptible in the bones. Consequently, in the horse of a primitive people, such as were the inhabitants of the Anau kurgan in the neolithic age, the quality of tameness is wholly psychological and is therefore not perceptible in an anatomical investigation.

The determinable remains of the horse from the kurgan number about 1,250. There are, however, but 120 well-preserved pieces, which repay an exact measurement and study. Beginning with the examination of the cranial remains, we find the best among them to be a right upper-jaw with the whole dental row and half of the bone palate. A comparison of the measurements of these pieces with other horse skulls shows a good agreement with a subfossil skull from Western

* Die Rassen der Pferde in der klassischen Staaten nach litterarischen und bildlichen Quellen. Deutsche Landw. Tierzucht, No. 37, pp. 433–437.

Siberia, from the Warwarinskischen "Yourts," on the River Tobol, and with the djiggetai (*Equus hemionus*). We must, therefore, first settle the question whether these cranial remains really belong to a horse or to a half-ass, like the djiggetai, or to a kiang.

Investigation into the relation of the teeth of the horse to those of the djiggetai and ass has been carried out most thoroughly by L. Rütimeyer,* R. Owen,† J. C. Forsyth Major,‡ A. Nehring,§ T. Frank,|| and M. Wilckens.¶

In consequence of these studies the following distinctive characteristics between the Western and the Oriental horse groups and the asses are available.

Oriental Horse Group (Broad-fronted Horses).

The premolars of the upper and lower jaws have a larger or equally large transverse diameter of the grinding surface with the longitudinal diameter. The plications of the enamel pattern are here considerably smaller than in western horses and the interior pillars of the anterior island appear rounded.

Occidental Horse Group (Narrow-fronted Horses).

The premolars are here more drawn out in the length; hence the depth of the grinding surface is greater than in the transverse diameter. The enamel plications of the islands are considerably more folded, and the ant-external horn of the posterior island surpasses the post-external horn of the anterior island, projecting further outward, even on the molars, on which in oriental horses they stand almost even. In the same way the stronger plication of the enamel margin on the internal lobe causes in the Occidental horse the striking bifurcation of the internal lobule and the stronger development of the spur** in the ant-oblique valley.

Asses and Half-asses.

In the asses and half-asses the longitudinal diameter of the crown is still shorter in comparison with the transverse diameter than in the oriental horse, the enamel plications are less prominent, and the spur is wholly wanting in the ant-oblique valley.

Tscherski†† gives a method by which he says the relationship to one of the groups mentioned can be expressed in figures. This is the determination of the index of projection of the anterior lobule of the interior pillar. If we take the distance from the posterior margin of the crown to the next point of the bottom

---

*Beitraege z. Kenntniss d. fossilen Pferde u. z. vergleich. Odontographie d. Huftiere ueberhaupt. Verh. Nat. Ges. Basel, 1863, p. 538.

†Description of the Cavern of Bruniquel. Phil. Trans. 1869, p. 517.

‡Beitraege z. Gesch. d. Fossilen Pferde. Schweiz. paleont. Gesell., 1877.

§Fossile Pferde aus deutsch. Diluvial Ablagerungen. Landw. Jahrbuecher, 1844.

||Beitraege z. Rassenkunde unserer Pferde. Landw. Jahrb., 1875.

¶Beitraege z. Kentniss des Pferdegebisses. Nova Acta, Leop.-Carol. deutsch. Akad. d. Naturf., 1888, p. 257.

**The "spur" of the German authors is the small enamel fold entering from the ant-oblique valley into the ant-oblique lobe (Owen's terminology).

††*Op. cit.*, p. 320.

Dimensions in millimeters of teeth of upper maxilla.

	North Kurgan, Anau.			*Equus caballus.*				*Equus hemionus* var. *kiang*, after Tscherski.	*Equus hemionus.*	*Equus onager.*	*Equus przewalskii*, Mus. Bern.
	Komorof trench.	−24 feet.	+15 feet.	Yana, after Tscherski.	Altai cave, after Tscherski.	Western Siberia, after Tscherski.	Tarpan.				
Premolar 2:											
Length of crown	38	31	....	42	....	34.5	37	36.7	35.7	36	40
Width of crown	26	26	....	30	....	21	22.5	24	20.7	25	21
Length of interior pillar from front to back	9	6	....	10.3	....	8.5	8.5	8	7.5	8	..
Length, posterior end of crown to next point of bottom of anterior-interior enamel creek	19	16	....	22	....	18.5	20	19	17.7	20	..
Same measure to end of anterior lobus of interior pillar	21	17	....	23	....	19	21	18.7	19	20.5	..
Premolar 3:											
Length of crown	32	....	....	31.5	27.5	27	29	26.5	26	28.5	27
Width of crown	28	....	....	33	27.5	25.5	27	27.5	25	26.5	23
Length of interior pillar from front to back	12	....	....	17.5	12.5	12.5	10	10.5	10.7	11	..
Length, posterior end of crown to next point of bottom of anterior-interior enamel creek	19	....	....	22.8	....	17	20	18.7	18	19.3	..
Same measure to end of anterior lobus of interior pillar	23	....	....	29	....	21	21.8	20.3	21	22	..
Premolar 4:											
Length of crown	28	27	27	30	27	26	26.3	25	26	26.7	..
Width of crown	27	26	25	33	29	25.5	26.3	27.5	27	26	..
Length of interior pillar from front to back	14	13	13	17	13	11.7	11	11.5	12	12	..
Length, posterior end of crown to next point of bottom of anterior-interior enamel creek	18	17	19	22	....	17	18.5	17	17.5	19.5	..
Same measure to end of anterior lobus of interior pillar	23	22	22	27	....	21	21	20	21.3	23	..
Molar 1:											
Length of crown	25	26	....	26.3	23.7	23	23	23	22	25	..
Width of crown	26	26	....	31	27.5	23	24.5	25	25	25	..
Length of interior pillar from front to back	12	13	....	15	12.5	13	10	10.5	12	11.3	..
Length, posterior end of crown to next point of bottom of anterior-interior enamel creek	16	15.5	....	20.5	....	17.5	17	16	16	17	..
Same measure to end of anterior lobus of interior pillar	19	20	....	24.5	....	21.3	19	19	19.3	19.5	..
Molar 2:											
Length of crown	27	25	23	28	25	22.5	23.3	22.5	23.3	25.5	..
Width of crown	24	25	24	30	27	24.5	24	24	25	24.8	..
Length of interior pillar from front to back	12	14	10	17	14.5	13.5	10.7	11	12	12.3	..
Length, posterior end of crown to next point of bottom of anterior-interior enamel creek	16	15	16	21.8	....	16.5	17	16	17	17	..
Same measure to end of anterior lobus of interior pillar	20	19.5	19	27	....	20.5	19	19	21	21	..
Molar 3:											
Length of crown	25	24	....	32	....	25.5	29	25	27.5	24	..
Width of crown	21	20	....	27 (?)	....	22.5	22	21	23	19.3	..
Length of interior pillar from front to back	....	10	....	17.3	....	13.8	11	13	13.5	13	..
Length, posterior end of crown to next point of bottom of anterior-interior enamel creek	....	19	....	24.5	....	17	22.3	18	20.5	15	..
Same measure to end of anterior lobus of interior pillar	....	22	....	29.5	....	20.7	25.5	22	24.5	19	..

of the ant-oblique valley (Owen) = 100, and call this = a, and call the distance from the same point on the crown to the end of the anterior pillar = b, then $a : 100 = b :$ index.

By means of the data furnished by Frank and Wilckens, and this added method of Tscherski, we are able to compile the following illustrative table, based on the dimensions of the teeth of the upper jaw.

Table of dental indices (in percentages).

Provenience of dental series.	Premolar 2.		Premolar 3.		Premolar 4.		Molar 1.		Molar 2.		Molar 3.	
	Index length to width.	Index of projection of anterior lobe.	Index length to width.	Index of projection of anterior lobe.	Index length to width.	Index of projection of anterior lobe.	Index length to width.	Index of projection of anterior lobe.	Index length to width.	Index of projection of anterior lobe.	Index length to width.	Index of projection of anterior lobe.
Anau, Komorof tr'h	78.8	110.5	87.5	121.0	96.5	128	104	119	88.8	125	83.3	....
" – 24 feet...	83.9	106.3	....	....	96.4	129	100	125	100	127	84.0	115
" – 15 feet...	....	....	....	....	92.6	116	....	....	....	....	....	....
Yana River......	71.2	104.5	106	126.1	110	122.2	119	120	107	122	84.4	120
Western Siberia..	60.9	105.8	94.4	123.5	100	123	100	123	109	125	88.8	123
Tarpan, after Tscherski......	60.8	105.0	93.1	109.	100	113	104	111	104	112	75.8	114
Equus hemionus...	57.5	107.2	96.2	103	104.4	112	108	119	93	123	83.0	120
Equus przewalskii.	50.2	....	85 2	....	....	....	....	....	....	....	....	....
Equus onager.....	69.8	100	93	115	96.4	115	100	119	96	123	82.5	132

It appears from the above table, as regards the length and width relation of the crown of the molars, which according to Frank and Wilckens is so characteristic, that in all the compared horse teeth the length exceeds the width in premolars 2 and 3, and molars 3 and 2, and only equals the width in premolar 4 and molar 1, or is shorter. Only on a skull from Yana River in Siberia do I find somewhat shorter teeth, in which the width is therefore relatively greater. This would be an indication that the horse of the Anau kurgan belonged to the Western race.

If, now, we compare the relations under Tscherski's method and their results, we find that the highest value for the projecting of the internal lobule belongs to the Anau horse, the Siberian horse, *Equus onager* and *Equus hemionus*.

We have here in the especially demonstrative premolar 3 = 121, premolar 4 = 128 and 129, molar 1 = 119 and 125, molar 2 = 125 and 127.

Tscherski* calls the measurements belonging to the Tarpan "high," which in the sense of Frank's method would assign this animal to the Oriental horse group. He mentions, however, that in an Arabian horse these measurements are 115.7, 116.6, 117.6, 121.2, and 118.3; and in a horse from Dongola 116.6, 122.7, 122.5, 125, and 125, which correspond excellently with those of the Anau horse. Tscherski says further that the maximum figures for this projection are found in the broad-fronted races of fossils and recent Siberian horses. In the ass Tscherski found strong variations, and in the half-ass a series of proportions which also were similar

*Op. cit., p. 307.

to that of the Anau horse; thus premolar 3 = 103.2, 116.6; premolar 4 = 112.5, 121.7; molar 1 = 144.7, 120.4; molar 2 = 117.3, 129.6.

However, if we now consider the teeth in connection with the appearance of their form, as well as that of their patterns and enamel plications, we shall recognize at once the extremely slight plication of the enamel layers. The internal lobule of the anterior island is further distinctly drawn apart into two horns and flattened. The "spur" (of the German authors) occurs only on the premolars. This eliminates the possibility that we have here an animal belonging to the group of asses or half-asses.

This is further evidenced by the lateral expansion of premolar 2, which in the Anau specimen is 78.8 and 83.9, in the Siberian horse 71.2, and but 60.9 in the asses and half-asses; especially in the djiggetai, *Equus hemionus*, which otherwise, on account of the size of the extremity bones, would here come very much into question, where it sinks to 50 to 57 per cent. This, according to Tscherski, is a very typical occurrence.

In general the premolars of the half-asses show a narrow isthmus and a strongly widened capitulum, which does not happen at all in the Anau horse. We can, therefore, assume with certainty that we have here, not a half-ass or an ass, but a genuine horse.

It remains now only for us to determine to what variety this horse belongs. The shape and conformation of the enameled crown, as well as the projection of the lobes, indicate a horse belonging to the Oriental group, but the form of the anterior island and the relations of length and breadth of the teeth point to the Occidental races. We have no frontal bone pieces, which would easily enlighten us on this point, and must, therefore, seek some other method.

If we compare fig. 4 on Tscherski's plate II with the molar series of Anau (plate 77, fig. 1, and text-fig. 491, *a* and *e*, p. 413), we shall see that beyond question a similar form of teeth is represented in both. The dental system of the fossil as well as of the known recent Siberian horses is peculiar in that, notwithstanding the characteristics of the skull, which place it in the group of the Oriental (medium-browed) horses, it shows a character which is peculiar to the heavy, narrow-browed West-European races, and in addition reaches the highest degree of the development of this type, especially as regards the considerable anterior projection of the internal lobule in the teeth of the upper jaw. If we should judge only by the form and the before-mentioned dimensional proportions of the teeth our Anau horse would belong to this Siberian group.

The Lower Jaw.

The remains of lower jaws which we have from the kurgan, although four in number, consist of very fragmentary pieces, in only one of which are the branches sufficiently preserved to permit a determination of the length of the diastemas. From the dimensions, however, we can easily recognize that only a horse of medium or small size is indicated. What has been said with regard to the peculiarities of the teeth of the upper jaw applies fully to those of the lower jaw.

Table of dimensions (in millimeters).

Upper jaw.	North Kurgan, Anau, +12 feet.	Subfossil La Tène horse, from Hostomitz, Mus. Teplitz.	Subfossil West Siberian Tartaria horse, after Tscherski.	East Siberian fossil horse, after Tscherski.	Przewalski horse, after Tscherski.	Turkestan horse, after Tscherski.	Indian horse.	Kalmukian horse.	Kiang, Tibet.	Djiggetai.
Width of face at orbita maxillaris.	168	162	169	179	193.5	182	173	175	176	170.5
Width of face at diastema between premolar 4 and molar 1...	118	112	118	124	113	....	....	119	118	112
Width of face before premolar 2.	58	64	59	69	68	....	....	61	70	64
Width of face between molars 1 and 2..........	119	108	118	120	....	....	....	....	116	121
Length of dental series of upper jaw from premolar 2 to molar 3.	174	169	164	172.5	....	167	159	183	165	165.5

Lower jaw and dental series.	Anau.		*Equus caballus.*			*Equus hemionus* var. *kiang*.	*Equus hemionus.*	*Equus onager.*
			Ljachow.	Ireland.	Tarpan.			
Width of lower jaw between alveoli of premolar 2....................	36	....	38.3	38	41	44	40.5	41
Length of diastema..................	90 (?)	....	97	97	80	86	87	73.5
Smallest part before premolar 2.......	37	....	47	39.5	39	44	37	44
Premolar 2 length................	32	....	33	30	30.5	31.5	30	23
Premolar 2 width..................	15	....	15.5	16	15	16.5	16	13
Premolar 3 length................	27	26	30	28	27.3	28	28	27.5
Premolar 3 width.................	17.5	20	18	16	17.7	18	18	16.5
Premolar 4 length................	....	25	28.5	27	26	27	26.5	26
Premolar 4 width.................	....	14	18	17	18	17.5	18	17
Molar 1 length....................	....	23	25.5	24	24.3	24	24	25
Molar 1 width.....................	....	16	17.5	15.5	18	16	16	15 3
Molar 2 length....................	....	24	27.8	25	25.5	23	25	26.5
Molar 2 width.....................	....	14	17	15	16	16	15	15

Scapula.

The one almost perfectly preserved specimen of the scapula belongs also, as is shown by the comparative dimensions, to a horse of medium size. The slenderness of the bones, a characteristic especially typical of the Anau horse, is here very perceptible. No further peculiarities are noticeable in the structure of the bones.

Humerus.

None of the bones permit a full measurement of the length of the humerus. Generally speaking, they were only distal pieces, the measurements of seven of which we have given in the table on p. 392. The few measurements of width here given approach nearest to those of *Equus przewalskii* and *Equus hemionus*.

RADIUS.

This bone is represented among the Anau finds in a somewhat better state of preservation than were those we have considered. The relatively slight lateral expansion of this shows already that the Anau horse belongs to the thin-footed type, as will appear clearly from the consideration of the well-preserved metacarpalia and metatarsalia.

METACARPUS TERTIUS.

One of the four measurable metacarpal remains from Anau is very well preserved; and from this it is recognizable that the Anau horse belongs to the narrow-footed horses, since it possesses long and slender metacarpi. The index of width of the Anau animal gives the following results in comparison with other fossil and subfossil as well as recent horses.

For the djiggetai (*Equus hemionus*)..........................11.8
For the onager (*Equus onager*)..............................12.0
For the kiang (*Equus kiang*)................................12.2
For the Anau horse...12.3
For the La Tène horse..13.0
For the Leitmeritz horse.....................................13.9
For the small German horse of Schlossberg....................14.0
For the large Schlossberg horse..............................15.3
For the German diluvial horse................................17.5

According to Tscherski, of the Siberian horses 10 per cent are narrow-footed, *i. e.*, have an index of width of 15 or under 15; 45 per cent are medium-footed, *i. e.*, have an index of 15 to 17; and 45 per cent are broad-footed, *i. e.*, have an index of 17 to 18.6.

The Anau horse is, therefore, uncommonly narrow-footed, in which particular it stands near to the half-asses and asses and is only rivaled to a certain extent by the European La Tène horse.

VERTEBRÆ.

There are several pieces of neck and sacral vertebræ, of which, however, the measurements can give us no information of importance.

Table of dimensions (in millimeters).

	Greatest length.	Distal width.	Superior width.	Width at collum.	Width of articulation.	Diameter of articulation.
SCAPULA:						
North Kurgan, Anau:						
+18 feet	310	64	120 (?)	57	48	..
+23 feet	...	77	...	56	47	39
Lena, after Tscherski	343(?)	90	178	61	56	51
Tarpan	316	85.5	163	59	53	47
Equus hemionus, Mus. Paris	250	..	124	44	43	35
Equus przewalskii, Mus. Bern	242	51	141	47	..	41
Schlossberg	282	..	147	64	45	..
Turkestan horse	321	..	162	60	48	..
European diluvial horse:						
From Kesslerloch (Thayngen), after Studer	320	90	...	..	52	45
Quedlinburg, after Nehring	...	99	...	..	58	51

Table of dimensions (in millimeters)—Continued.

	Greatest length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal width.	Distal diameter.	Diameter of interior trochlea.	Diameter of exterior trochlea.
HUMERUS:									
North Kurgan, Anau:									
No. 1203, −15 feet	....	....	....	30	33	67	....	45	37
No. 32, +20 feet	....	....	....	....	....	65	....	43	36
No. 33, +20 feet	....	....	....	....	....	63	....	40	33
No. 34, +20 feet	....	....	....	....	....	65	....	42	35
No. 485, +26 feet	....	....	....	....	....	64	....	41	34
No. 876, +25 feet	....	....	....	....	....	65	....	43	36
No. 896, +25 feet	....	....	....	....	....	68	....	42	37
European diluvial horse:									
Kesslerloch, after Hescheler*	....	....	....	....	....	83–85	....	77–78	....
Westeregeln, after Nehring	....	....	....	....	....	90	....	83	....
Equus przewalskii, Mus. Bern	230	74	80	28	35	67	....	45	37
Tarpan, after Tscherski	264	96	....	35	....	79	....	48	35
La Tène, Mus. Bern	231	71	72	23	29	60	62	....	....
Turkestan horse, after Nehring	284	88	94	33	....	64	....	....	....
Equus hemionus, Mus. Bern	223	70	76	27	34	67	....	....	35
RADIUS:									
North Kurgan, Anau:									
No. 1108, −15 feet	....	70	37	....	....	....	....	....	....
No. 1113, −15 feet	....	68	40	34	20	....	....	....	....
No. 1189	....	65	38	32	22	....	....	....	....
No. 1206	....	65	36	....	....	....	....	....	....
No. 1323, +20 feet	....	....	....	....	....	56	36	....	....
No. 1489, +23 feet	....	....	....	....	....	60	38	....	....
Equus hemionus	282	65	30	30	23	60	37	....	....
Equus przewalskii, Mus. Bern	276	70	37	31	21	67	37	....	....
Tarpan, after Tscherski	308	74	....	36.5	....	59	....	....	....
Yana, after Tscherski	308	83	....	42	....	75	....	....	....
Schlossberg	229	74	58	36	....	58	....	....	....
La Tène, Mus. Bern	300	67	37	....	29	63	38	....	....
	314	73	37	35	22	67	35	....	....
European diluvial horse:									
Kesslerloch, after Hescheler	....	79–82	....	....	....	....	....	....	....
Westeregeln, after Nehring	....	91–92	....	....	....	....	....	....	....
OSSA METACARPI:									
Anau, −21 feet	228	47	31	29	22	42	32	....	....
−15 feet	....	....	....	....	....	41	30	....	....
+8 feet	....	....	....	31	24	44	32	....	....
+28 feet	....	....	....	27	21	39	30	....	....
+33 feet	220	44	30	27	23	40	28	....	....
Subfossil Asiatic horse:									
Yana River, after Tscherski	226	51(?)	....	36	....	49.5	....	....	....
Same	208	48	....	34	....	48.5	....	....	....
Recent Asiatic horses:									
Turkestan, after Nehring	202	46	....	33	....	47	....	....	....
Kiang (*Asinus kiang*) †	229	46	....	28	....	42	....	....	....
Kulan (*Equus onager*) †	232	44	....	28	....	41	....	....	....
Tarpan	197.7	49	....	33	....	47.3	....	....	....
Equus hemionus, Mus. Paris	212	48	30	25	20	40	25	....	....
Subfossil European horses:									
Solutré, coll. Duerst	207	47	28	34	25	45	31	....	....
Santenay, Mus. Paris	....	44	30	....	....	....	....	....	....
Madelaine, same	....	....	....	....	....	46	33	....	....
Lourdes, same	....	....	....	....	....	48	39	....	....
Couvres, same	214	54	35	34	29	50	38	....	....
Curchy, same	216	48	32	39	27	50	32	....	....
Louverné, same	217	50	32	38	28	50	28	....	....
Cindré (paleolithic)	219	60	37	42	29	50	32	....	....
Caverne Fouvent	217	52	32	40	27	50	32	....	....
Santenay	....	....	....	....	....	54	44	....	....
Wohontsch	220	50	33	31	23	47	35	....	....
Leitmeritz	223	44	30	31	22	47	32	....	....
Schlossberg	222	49	33	34	27	49	33	....	....
Schlossberg	201	47	29	28	20	47	32	....	....
La Tène	214	40	32	23	28	40	31	....	....
Kesslerloch, after Hescheler*	....	....	....	....	....	48–55	....	....	....

*A written communication from the author, received with many thanks. †After Tscherski.

PLATE 80.

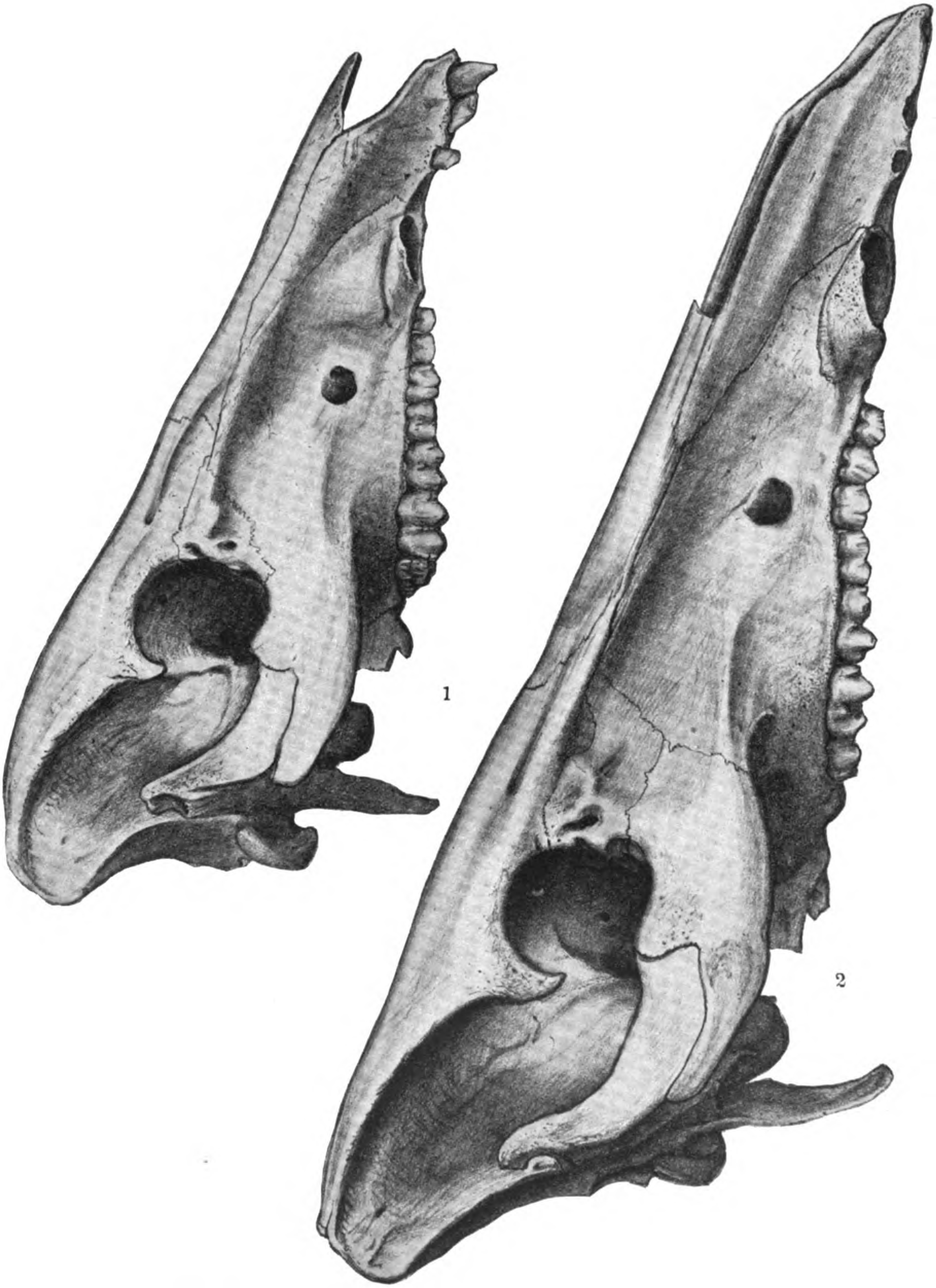
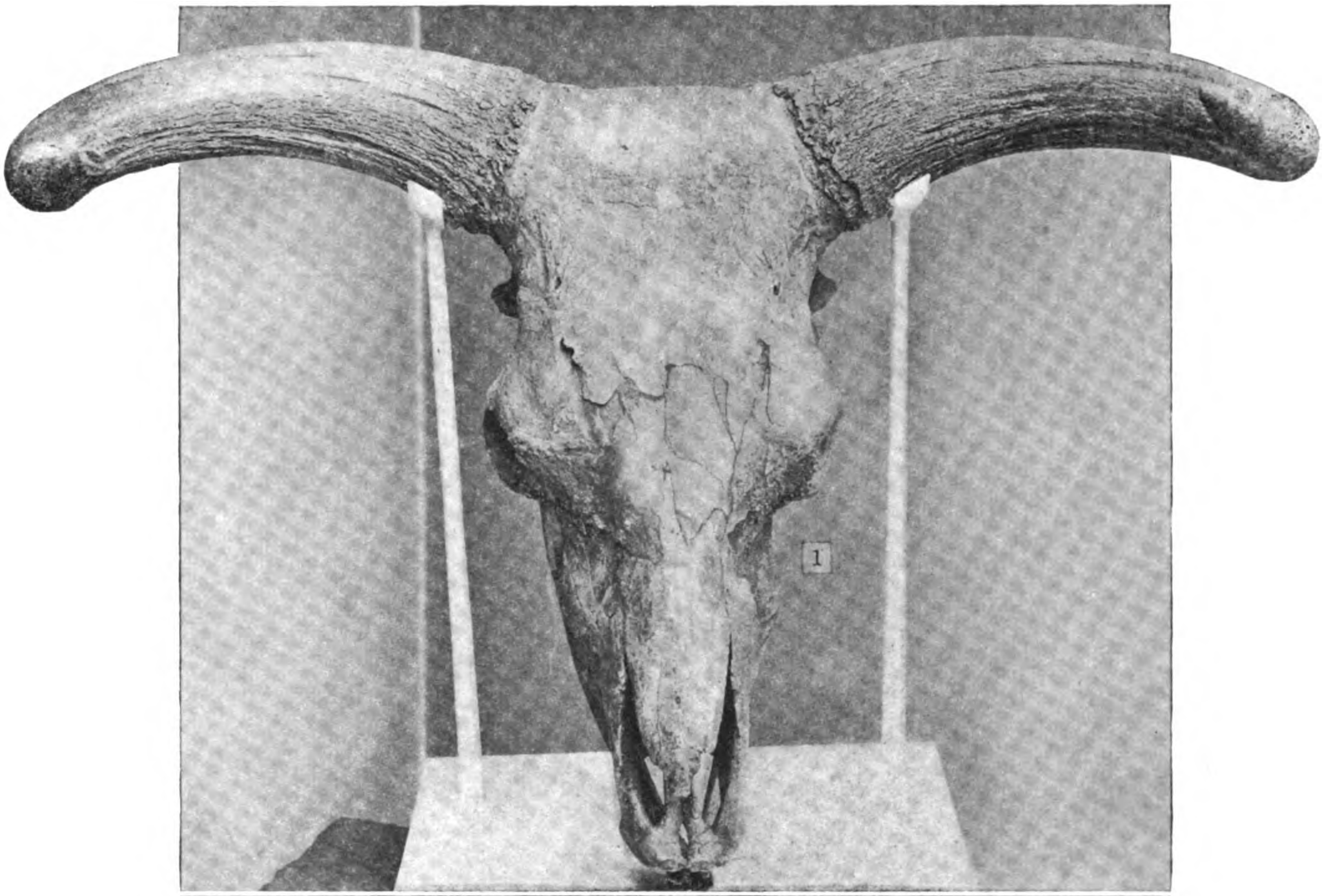


FIG. 1. *Sus cristatus* (or *vittatus*), after Rolleston, Trans. Linn. Soc., Ser. 2, Zool., vol. 1, plate 42.
2. *Sus scrofa* var. *ferus*, Germany.



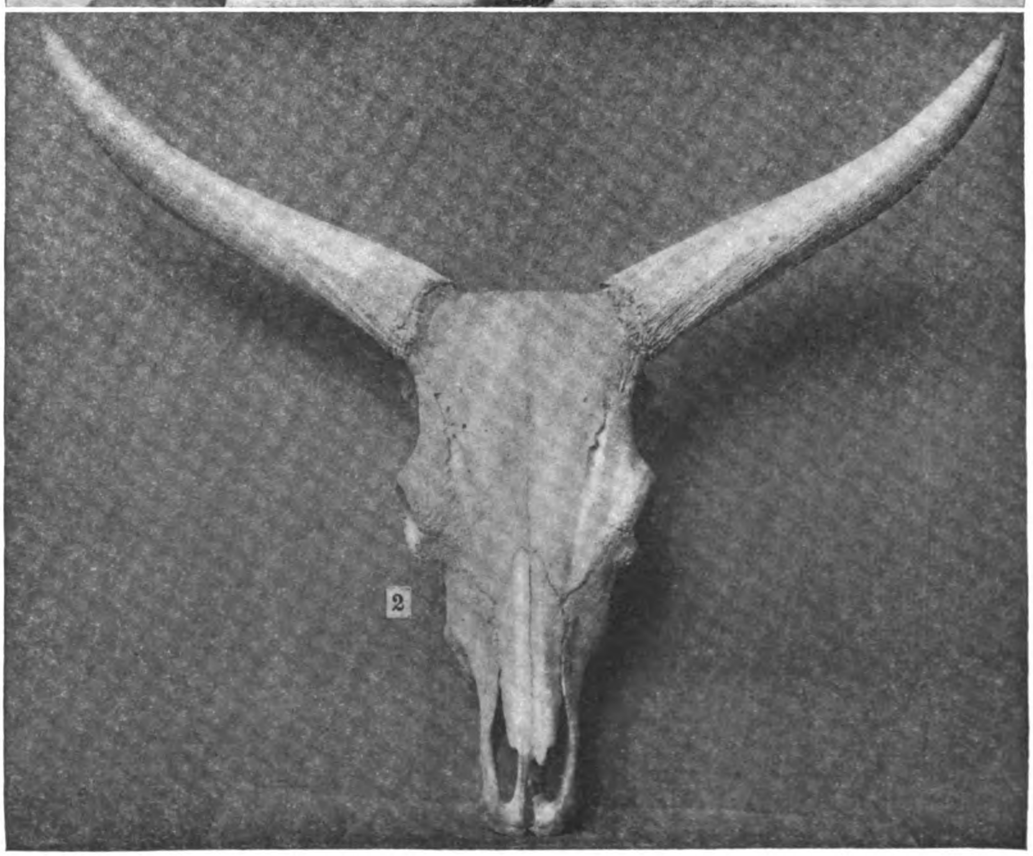
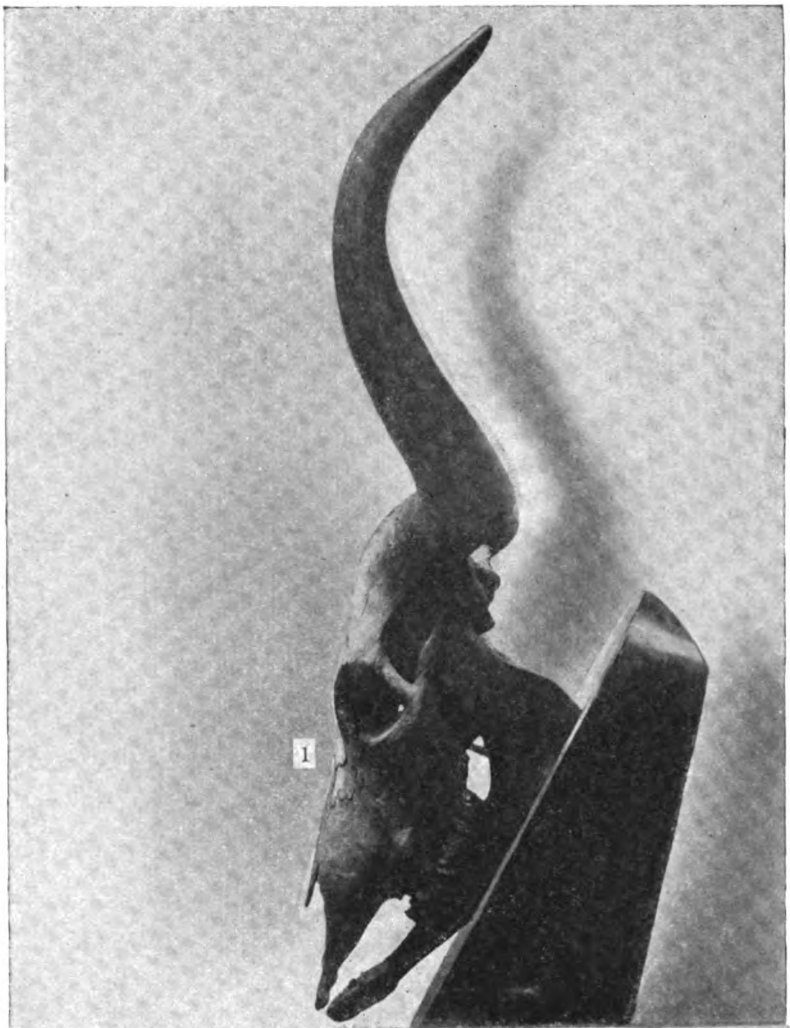


FIG. 1. *Bos primigenius* Bojanus; skull of European urus in British Museum.
2. *Bos taurus macroceros;* Hungarian bull skull, Museum Vienna.



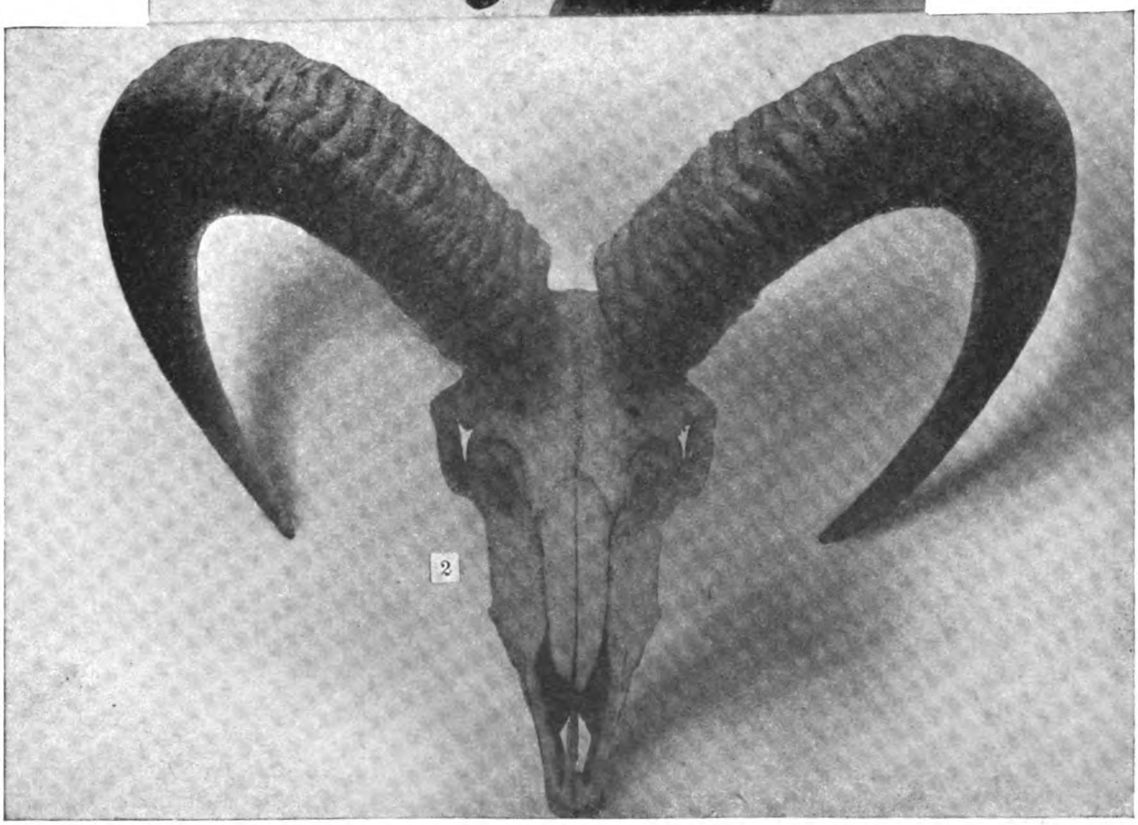


FIG. 1. Long-horned ox from Nepal, India; skull in British Museum.
2. *Ovis vignei* from Ladak, skull.

Femur.

Of the femora not one shows itself sufficiently intact to permit an exact measurement. Only the width and thickness can be determined, these confirming the narrow-footed peculiarity of the Anau horse.

Tibia.

Of the tibia, on the contrary, we have a perfect specimen, which permits of very exact measurement. This, too, shows that we have to do with a narrow-footed horse. The indices of width are:

Anau horse	25.8
Small Schlossberg horse	24.7
La Tène horse	22.7
Equus hemionus	28.0
Diluvial horse of Siberia	30.0
Equus przewalskii	33.0

Table of dimensions (in millimeters).

	Greatest length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal width.	Distal diameter.	Lateral length.
FEMUR:								
North Kurgan, Anau:								
+26 feet	....	....	....	....	....	76	98	....
+26 feet	....	....	....	44	39	83	85(?)	....
Equus przewalskii, Mus. Bern	286	87	67	39	29	80	102	....
Equus hemionus, Mus. Bern	290	90	....	50	30	80	93	....
Tarpan, after Tscherski	375	109	....	50	37	89	108	....
Equus caballus, Kalmukian horse, after Tscherski	442	127	....	55	42	102	133	....
Lena, after Tscherski	376	115	....	48	34	90	115	....
TIBIA:								
North Kurgan, Anau:								
+15 feet	305	78	72	40	32	63	43	301
No. 1190, +22 feet	....	....	....	....	....	58	41	....
No. 521, +26 feet	....	83	75	44	39	....	....	....
Yana River, after Tscherski	328	96	....	43	....	74.5	....	296
Kesslerloch, after Hescheler	....	....	....	....	....	79	63	....
Vindonissa Circus	....	....	....	....	....	70	48	....
Equus przewalskii, Mus. Bern	294	86	65	34	23	63	40	277
Tarpan, after Tscherski	340	89	....	38	....	70	....	307
Equus hemionus, Mus. Paris	287	80	52	32	30	60	40	....

Table of dimensions (in millimeters)—Continued.

	Greatest length.	Proximal width.	Proximal diameter.	Median width.	Median diameter.	Distal width.	Distal diameter.
OSSA METATARSI:							
North Kurgan, Anau:							
−10 feet	256	40	37	27	27	38	30
+26 feet	264	....	....	25	25	38	31
South Kurgan, Anau	....	....	....	....	....	38	30
+33 feet	....	43	30	27	21	41	30
Subfossil Asiatic horse:							
Yana River, after Tscherski	256	51.3	....	34	....	50.7	....
Lena, after Tscherski	256	48	....	30.5	....	51.5	....
Yana	254	44.5	....	31	....	46	....
Ljachow Island, after Tscherski	251	47	....	32	....	47.5	....
Recent Asiatic horse:							
Equus przewalskii, Mus. Bern	257	47	32	26	23	46	34
Kulan (*Equus onager*)	274	40	....	26	....	40	....
Kalmyk horse	299	54	....	34	....	54	....
Equus hemionus, Mus. Bern	250	40	31	25	22	35	30
European subfossil horse:							
Vindonissa	242	47	42	31	26	46	34
PHALANX I:							
North Kurgan, Anau:							
No. 20, −20 feet	87	45	33	28	22	40	20
No. 1205, −15 feet	81	42	31	27	19	37	18
No. 1228, −15 feet	79	42	31	25	21	35	18
No. 1170, −10 feet	78	44	33	25	23	34	20
No. 1382, −8 feet	72	41	31	25	21	35	19
No. 1475, +6 feet	78	42	31	27	21	35	20
No. 721, +21.5 feet	80	39	29	20	20	35	20
No. 988, +22.5 feet	79	42	31	26	22	38	19
No. 971, +22.5 feet	78	35	30	26	22	34	20
No. 1551, +23 feet	72	42	24	25	22	32	18
No. 269, +26 feet	73	46	33	28	22	38	21
No. 589, +30 feet (old individual)	83	46	35	28	25	39	20
No. 168, Komorof trench	81	40	31	26	20	38	21
No. 169, Komorof trench	72	40	31	25	22	36	20
Equus hemionus, Mus. Paris	63	43	33	23	20	33	17
Tarpan, after Tscherski:							
Anterior	71.5	54	....	34	....	45	23
Posterior	75	52	....	33	....	44.5	23
Yana	94.5	64.5	....	38.5	....	51	27.5
Equus przewalskii, Mus. Bern	75	47	31	28	20	39	21
European diluvial horse:							
From Kesslerloch:							
After Studer	70	56	....	....	....	47	....
After Hescheler	70–80	49–60	....	....	....	43–51.5	....
After Nehring	85–95	56–64	....	....	....	48–53	....
PHALANX II:							
North Kurgan, Anau:							
No. 101, −24 feet	40	40	26	37	19	38	19
No. 1183, −10 feet	44	41	27	34	18	37	23
No. 1175, −10 feet	39	39	27	34	18	35	22
No. 1000	44	43	28	37	20	41	23
No. 822	38	38	27	33	17	34	21
No. 1158	39	45	27	39	20	40	22
No. 1163	40	42	27	37	18	40	22
No. 677	40	40	27	40	19	38	22
No. 557	40	40	27	34	19	35	22
No. 657	37	36	24	31	18	34	20
No. 218	42	43	26	34	20	38	21
Equus hemionus	35	35	24	30	15	31	20
Equus przewalskii	33	45	26	39	19	46	21
European diluvial horse:							
From Kesslerloch:							
After Studer	29–46	49–59	....	....	....	46–55	....
After Hescheler	41.5–48	50–59	....	....	....	46–54	....
After Nehring	47–53	56–60	....	....	....	49–57	....

Table of dimensions (in millimeters)—Continued.

Phalanx III.	Posterior extremities. Length.	Width.	Height.	Lateral height.	Circumference.	Anterior extremities. Length.	Width.	Height.	Lateral height.	Circumference.
North Kurgan, Anau:										
−8 feet	43	57	29	11	120	..	..	..	....	....
+5 feet	48	54	33	16	130	..	..	..	....	....
+36 feet	48	57	33	15	135	..	..	..	....	....
+23 feet	..	..	..	....	....	55	59	32	15	120
+28 feet	..	..	..	....	....	56	60	35	18	140
+33 feet	..	..	..	....	....	48	59	32	13	125
Equus przewalskii, Mus. Bern	..	52	34	17	110	..	52	34	17	110
Equus hemionus, Mus. Paris	..	54	37	....	115	..	54	37	....	115
European diluvial horse, after Nehring	..	85	58	....	....	..	90	56	....	....

Astragalus.	Width of distal articulation.	Length of interior trochlea.	Length of exterior trochlea.
North Kurgan, Anau:			
−10 feet	44	52	48
+8 feet	41	53	49
+20 feet	48	59	54
+23 feet	44	52	48
+26 feet	48	55	51
+33 feet	47	56	49
Equus przewalskii, Mus. Bern	51	55	51
European diluvial horses:			
After Hescheler, Kesslerloch	51–54	74–78	....
After Nehring, Westeregeln	57–60	83–84	....
Vindonissa, Roman horses	50–59	60–63	....

ASTRAGALUS.

In all we have seven well-preserved astragali, three right and four left. Their size corresponds throughout to those of the horses already mentioned.

As is known, Forsyth Major points out that in the fossil horse the length of a segment of the inner end of the navicular surface of the astragalus, counted from its intersection by an imaginary line representing the continuation of the outer surface of the inner condylus, is considerably shorter than in recent horses, and he illustrates this in a table, from which we have extracted some points giving the relation of the length of the inner segment of the navicular surface referred to its full length, which is taken as 100.

Relation of length of inner segment of navicular surface of astragalus to its full length (expressed in percentages).

	Minimum.	Mean.	Maximum.
Hipparion	29.2	29.2	29.2
Equus stenonis	24.7	32.5	35.3
Siberian horses, Yana River	27.9	32.0	33.9
Roman horses, from Vindonissa	30.2	32.2	34.3
Horses of Solutré	31.7	33.2	34.5
Horses from Cardamone	33.8	34.6	35.4
Equus caballus, recent	36.0	37.8	40.4

The Anau horses range themselves quite in the beginning of this table, with minimum of 22.0, mean of 26.0, and maximum of 35.0, and show themselves, therefore, to stand nearest to *Equus stenonis*, here again inclining to the half-asses and asses. According to Tscherski, however, *Equus stenonis* is nothing else than the Siberian fossil horse which he describes.

METATARSUS TERTIUS.

Of metatarsal bones we have two completely preserved specimens, from which we can determine easily the index of width, which further confirms, in the most striking manner, the thin-footed character of the Anau horse.

Index to width.

Equus onager	9.0
Anau horse, culture I, −21 feet	9.5
Equus hemionus	10.0
Equus przewalskii	10.1
Small German bronze-age horse of Spandau	10.6
Anau horse, culture I, +15 feet	10.5
Small German horse of the Schlossberg	11.9
Large Schlossberg horse	12.0
Siberian fossil horse of the Yana River	13.3
German diluvial horse of Westeregeln	13.9

This table is particularly instructive, since in it so great a variation is shown between two metatarsi of the Anau horse that the Spandau horse of the bronze age is seen to be still more narrow-footed than the Anau horse I.

PHALANGES.

The phalanges also confirm what has been said, since their measurements agree only with the smallest breeds and species of horses. The larger of these phalanges from culture I, No. 20, −20 feet, and from No. 1205, −15 feet, as well as No. 168 from the Komorof trench, must be considered as the phalanges of the posterior extremities, and the others as belonging to the anterior extremities.

ON THE TYPE AND THE RELATIONS OF THE HORSES FROM ANAU.

We have now come to the close of our discussion of the remains of the horse of Anau, and it remains only to give a short recapitulation of the results and to draw some inferences.

In order to deal clearly with this subject, however, we must first try to determine arithmetically the approximate size of this horse in the manner formerly used by me,* the results of which I give below:

Height of withers (in centimeters).

Calculated from the scapula	132.7
Calculated from the tibia	132.9
Calculated from the metacarpus	146.5
Calculated from the metatarsus	136.4
Mean height	137

*Die Tierwelt der Ansiedelungen an Schlossberge zu Burg an der Spree, pp. 18, 276, 277.

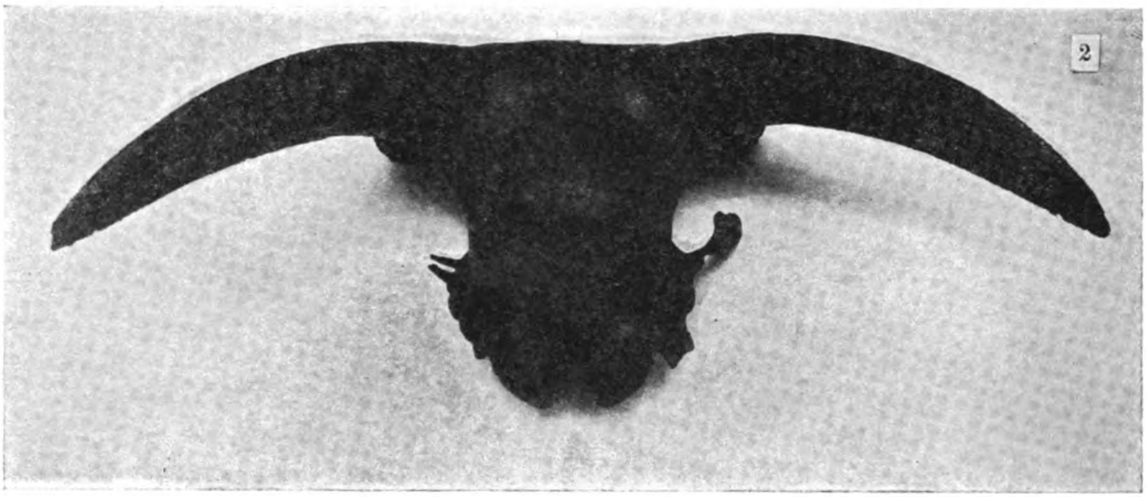


FIG. 1. *Bos namadicus* Falconer. The Assyrian king Ashur-nasirapal hunting the Asiatic wild bull, B. C. 885–860, Nimrud Gallery, British Museum.
2. *Ovis aries palustris*, horn-cores and skull from the turbaries of Walthamstow (England).
3. Babylonian cylinder-seal, with representation of an ox of the long-horned breed.

Gazella subgutturosa. Flock of Gazelles. Nineveh, Palace of Ashur-bani-pal, B. C. 686–626.

If we compare these heights of the withers with those of some known subfossil and fossil horses, we obtain the following picture:

	cm.
Diluvial horse:	
Westeregeln, after Nehring	155
Remagen, after Nehring	151
Siberia, Yana River, after Tscherski	146
Solutré, after Gaillard*	125
Subfossil horse:	
Ligerz (bronze age)	149
Schlossberg (iron age)	146
Petersinsel (bronze age)	142
La Tène (iron age)	141
Auvernier (bronze age)	138
Anau (neolithic age)	137
Zielkanal (bronze-iron age)	136
Schlossberg	118

The horse of Anau belongs, therefore, to the smallest of the prehistoric domestic horses and also, as we have already seen, to the most narrow-footed. It shows in this respect a most remarkable agreement with the so-called Helveto-Gallic horses, or the iron-age horses of Europe.

We can now summarize the characteristics of the Anau horse in the following terms: While its dental system shows certain characters, leaning closely to those of the fossil Siberian horse—characters which according to certain authors belong only to the group of Occidental horses—it shows, on the other hand, characters which belong to the purely Oriental horse group. In the characteristics of the extremities, also, in common with a small percentage of the fossil Siberian horses, it ranges itself wholly on the side of the group distinguished as Oriental horses.

We can, therefore, consider the Anau domestic horse as an altogether Oriental horse resembling the Siberian equine only in the structure of the teeth. The Anau horse is, therefore, the oldest domestic Oriental horse. I designate it, in distinction from other forms of subfossil horses, by the race or subspecies name *Equus caballus pumpellii* mihi. It is, however, difficult to say to what extent this subfossil horse resembles the equine from Maragha which Wilckens† from the data of a few incisors and molars, has named "*Equus fossilis persicus.*" The material at Wilckens's disposition does not suffice for a careful comparison. Further, such careful manifold enamel plications as recur in *Equus fossilis persicus* are not observable on the 60 or more molars examined by me in *Equus caballus pumpellii.*

As has already been stated by Tscherski (p. 356), the study of a large number of teeth of similar Siberian horses shows a wide range of variation in respect to enamel plications, the extremest types seeming to stand so far apart that, if one were to use only the enamel plications as a basis, two or three different species might be established.

Is it not possible that Wilckens has given too little value to the variation in *Hipparion*, which is chiefly represented in his material? I can, therefore, regard the existence of *Equus fossilis persicus* Wilckens only as very problematical! As

*Written communication.
†*Op. cit.*, p. 280.

regards *Equus przewalskii*, which it has been recently attempted to raise absolutely to the position of ancestor of the Occidental and Oriental horses,* considering it to be a survival of *Equus caballus germanicus* Nehring, we must remark that according to Matschie† there are three types or subspecies of the Przewalski horse which differ in size and form according to locality and environment. Among them *Equus hagenbeckii* Matschie appears to stand nearest to the Anau horse. The pieces measured by me from *Equus przewalskii*, which, however, did not belong to this subspecies, do not agree as well with the Anau horse as with the more stout-boned Siberian horses. In the construction of the teeth *Equus przewalskii* appears rather to be a survival of the Siberian diluvial horse and to represent the small horse of the Germans as we meet it in *Equus caballus nehringi*, but we can not decide this with certainty and so long as we can depend merely upon the existing materials we can only stand by the expression of the possibilities we have mentioned. It is to be hoped that later excavations by Professor Pumpelly will produce more complete material and more far-reaching conclusions.

Meanwhile, I may express my opinion as to the cause of the characteristic differences between the Occidental horse and the Oriental breed, although, as has been said above, both are assumed to be derived from the same ancestral form. It is only a supposition, a hypothesis, which has presented itself to me during the thorough study of the remains already described.

As is well known, *Equus przewalskii* still roams in the Djungarian Gobi and the neighboring tracts of the Tian Shan region. But that part especially of the Gobi—near the lakes—where alone, according to Przewalski, *Equus przewalskii* lives, has the character of a steppe with boundless pastures of reed-grasses and salt plants. Still more exuberant is the plant growth of the Tian Shan districts.

In strong contrast with these stands the Kara Kum—the Black Sands—the most forbidding desert of the whole world. Sand, for the most part shifting dunes, covers the immense surface; only in those places where the sand is to a certain extent arrested in its movement is it possible for the saxaul (*Haloxylon ammodendron*) and some desert grasses to grow and furnish a very scant nourishment to the few animals of the desert.

It was, as now, the "flying sand" that forced animals as well as man onto the shrinking oases, and caused concentration of family groups to battle against this enemy, with the aid, first of natural, and later of regulated irrigation. The horse, which, like the wild ox, still roamed wild in the Kara Kum when the North Kurgan was founded at Anau, was no longer an animal of the grassy steppes, but had become a denizen of the desert.

The Kara Kum, as a desert, could never have nourished the horse without the aid of man—man who raised the necessary fodder in his oases along the foot of the Kopet Dagh. But it does not follow that the horse did not remain an animal

*Th. Studer, Die Knochenreste aus d. Hoehle z. Kesslerloch bei Thayngen. Denksch. d. Schweizer Naturf. Gesell., Bd. XXIX, 1904.—H. Kraemer, Zur Aelteste Geschichte d. Pferde. Jahrb. Pflanzen u. Tierzüchtung, von Müller, 1905.

† P. Matschie, Giebt es in Mittelasien mehrere Arten von echten Wildpferden? Naturw. Wochensch., Bd. 18, pp. 581–583, 1903.

of the desert, as is to-day the horse of the Arabs and Berbers. The excellent observations of H. Kraemer* on the strength of the metacarpalia in the horse, taken together with well-known observations of the peculiar build of all animals of the desert, enable us to understand how there could occur a differentiation into slender-footed, slender-limbed, so-called Oriental horses on the one hand, and thick-footed, heavy, Occidental horses on the other hand. The differences in physiographic conditions were, in my opinion, the cause of the formation of both of the main groups of our horses.

The wild ancestral form was the same for both; it was the Diluvial horse of the ancient world, which roamed as far as the loess steppes and tundra plains extended; and which, surviving in separate groups the disappearance of the tundras, was transformed, according to the newly developing regional physiographic influences, into the *desert*-type (***Equus caballus pumpellii***), the *steppe*-type (***Equus caballus germanicus seu robustus***), and the *forest*-type (***Equus caballus nehringi***).

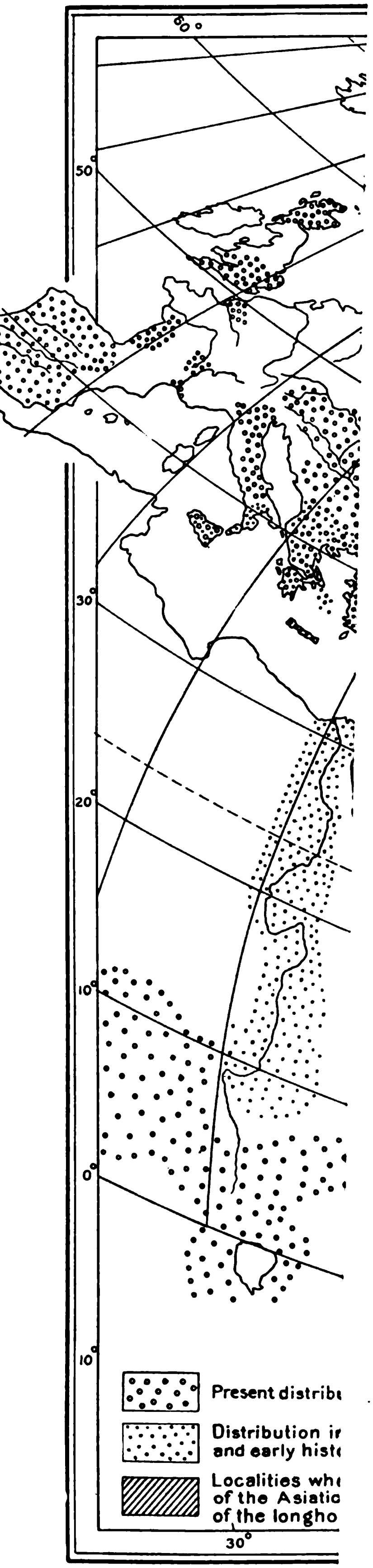
The same history is true of most of the domestic animals; and I do not hesitate to express the opinion that the change to slenderness in the hollow bones of the ox, together with the diminution of bodily size, as well as a general stunting (hindered development) in an early youthful stage of the normal form, developed gradually under the same influences, for it is evident that under conditions of insufficient food, early pairing and inbreeding—as to-day in Turkestan—the cattle were used for riding and driving, but not for milk and fattening.

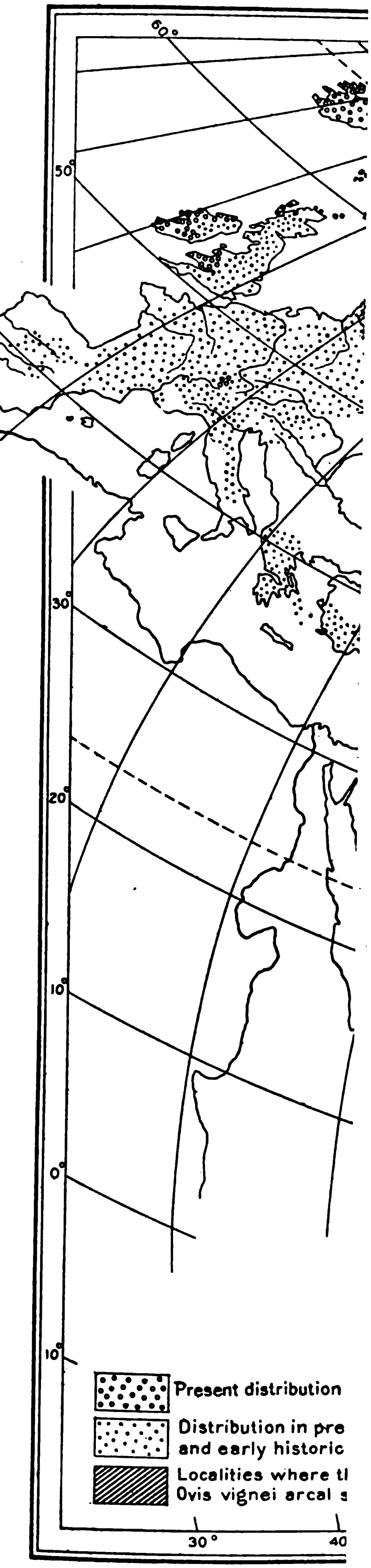
TORTOISE.

Testudo horsfieldii Gray.

Remains of the tortoise, consisting of dorsal and ventral plates, occur among the bones collected in Komorof's trench. They are, therefore, of an indeterminable age, but the form of these well-preserved plate bones permits an exact determination of the species, *Testudo horsfieldii* Gray.

*Zur Frage der Knochenstaerke der Pferde. Deutsch. landw. Tierzucht, 1904, Nos. 28 and 31.


60°
50°
30°
20°
10°
0°
10°
30°
Present distrib
Distribution ir
and early hist
Localities wh
of the Asiatic
of the longho



60°
50°
30°
20°
10°
0°
10°
Present distribution
Distribution in pre
and early historic
Localities where tl
Ovis vignei arcal s
30°
40

CHAPTER XIX.

THE HORSE OF ANAU IN ITS RELATION TO HISTORY AND THE RACES OF DOMESTIC HORSES.

(Plates 87–91.)

Having, in chapter XVIII, endeavored to prove that the equid of the North Kurgan of Anau is a horse and not an ass, and to show its relation to other Asiatic Equidæ, and further to picture the changes it underwent during the life of the civilizations of that kurgan, I shall now consider the relation in which the Anau horse (*Equus caballus pumpellii* mihi) stands to the subfossil horse and to some historical domestic breeds, as well as to the *Equus przewalskii* Polyakoff.

As is commonly known, the domestic horses are generally classed in two groups: the *Oriental* and the *Occidental.* Frank* calls the first of these groups also *Equus parvus*, and the second *Equus robustus*, and discusses at some length the points of difference between the two types. In this connection I will state briefly some points which have not been sufficiently touched upon in the previous chapter.

In the *Oriental horse*, especially in the Arabian, the brain-skull is, relatively, very strongly developed; the face less so. These horses are called broad-headed, because the width of the forehead is large in comparison with the length of the skull. We have already spoken of the teeth; regarding these we may here refer especially to the anterior and posterior crescentic islands (Owen's terminology), in which the enamel-margin is not so wavy; the internal lobe is placed just in the middle of the grinding surface, and its division into two is not very clearly marked. The hollow bones are remarkable for their graceful shape and solid, hard texture; the metacarpal bones are relatively narrow. In many points, therefore, this group of horses resembles the ass.

On the other hand, these same points distinguish the Occidental from the Oriental horse. In the *Occidental horse* the facial part of the skull predominates at the expense of the brain-skull, the skull appears long and narrow, the forehead is narrower, the rim of the eye-socket is but slightly prominent. The enamel-margin of the crescentic islands is very wavy, and the internal lobule is divided into two very distinct horns and flattened. The bones of the extremities are heavy and massive, while their texture is less dense and hard than in the Oriental horse. The tarsal bones are generally broader than in the latter group. Again, Sanson,† applying Broca's anthropological method, has proposed another classification of horses based on *dolichocephaly* and *brachycephaly*, dividing them into four dolichocephalic and four brachycephalic races; but it has not been possible to maintain this division in practice, as it is too schematic. We can not consider here other attempts at classification.

---

*Frank, Ein Beitrag z. Rassenkunde unserer Pferde. (Vortrag) Landw. Jahrbücher, IV, 1875, pp. 33–52.

†A. Sanson, Nouvelle détermination des espèces chevalines du genre Equus. Comptes Rendus de l'Académie d. Sciences, t. LXIX, pp. 1204–1207.

What concerns us before all else is the question: *In what relation does the horse of Anau stand to the domestic horses of to-day, and especially to their direct ancestors, the subfossil horses?* After the foregoing special investigation and the subsequent general comparisons, I have no hesitation in asserting that *we must see in the horse of Anau the first representative of the Oriental race of horses.*

FOSSIL AND SUBFOSSIL HORSES AND THEIR CHARACTERISTICS.*

I will not attempt here to trace the connection of the Equidæ of the later and middle Tertiary period, although since the wonderful results of Henry F. Osborn (in the American Tertiary) this would be a pleasant and profitable subject; nor can I here institute a comparison with the other diluvial Equidæ—the *Equus stenoni* Cocchi, *Equus quaggoides* F. Major, *Equus spelæus* Owen, *Equus mauritanicus* Pomel, etc. In this place I will attempt only to establish the relationship of the horse of Anau, especially to the remains of those horses which, with more or less right, have been regarded as the ancestors of our domestic horse, and whose direct conversion to the domestic state has been assumed to be certain. We will here notice the principal types in question.

THE HORSE OF THE QUATERNARY PERIOD OF EUROPE.

During the glacial period the forested area became greatly restricted, grasses, herbaceous plants, shrubs, succeeded trees as the predominant vegetation. These steppe-like regions became the home of numerous herds of wild horses, together with scirtetes, jerboas (alactaga), spermophili, bobacs, lagomys, arvicolæ, and other characteristic inhabitants of the loess steppes of to-day beyond the Volga.†

The horse that then lived in the northeastern part of Central Europe was, as shown by the remains found at Remagen, Westeregeln, and in other places, a medium-sized, stocky animal with thick bones and a large head. It may, therefore, from this bodily shape be taken to have ranked very near the present *Equus przewalskii*, which according to Grum-Grshimailo has a withers-height of 153 centimeters.‡ In the southern part of this region there seems to have lived besides this horse, either at the same time or somewhat later, a smaller form of the same variety. This is not surprising when we consider that Matschie recognizes a larger and smaller variety of the Przewalski horse. By this I do not mean the form of *Equus caballus fossilis*, which Woldrich has called "minor" and which Nehring, objecting, held should rather be called "major," since the horse of Nussdorf, with its 555 mm. basal length of skull, must be counted among the largest horses.

No; it was the horse of Solutré, Cindré, and other points in France, that represents the small, broad-boned European wild horse. We do not know whether the paleolithic horse of Solutré was domesticated, as Toussaint asserts. Nehring also assumes that the horse was already domesticated in the glacial period, and I,

* Dr. Duerst designates as "fossil" all occurrences of paleolithic age or earlier, and as "subfossil" all of later age.—R. P.

† A. Nehring Fossile Pferde aus deutschen Diluvialablagerungen, etc. Landw. Jahrbücher, XIII, 1884, p. 148.

‡ Compare p. 426.

too, influenced by many reasons, have expressed my belief in the probability of a very early domestication of the horse, probably in the paleolithic age of Europe.

But this has here no bearing. The essential fact is, and remains, that the horse of Solutré—which may have been the same that was hunted and pictured by the cave-dwellers of Dordogne—was smaller than the steppe horse of Central Europe, and had a withers-height of about 125 cm. if one may judge from the skeleton of a Solutré horse preserved in Lyons. To what is the smallness of this horse due? In giving my conclusions I shall attempt an explanation; here I will remark only that the climatic and physiographic conditions under which the Solutré horse of the paleolithic age lived were probably essentially different from those surrounding the steppe horses of the northern lowlands and coastal lands of Europe.

THE HORSE OF PREHISTORIC (LATER QUATERNARY) TIMES.

(a) *The Neolithic Age.*—Remains of horses of the neolithic age are rare; nevertheless, finds from Wohontsch on the Biela, Leitmeritz, Fouvent, and Louverné are evidence that at least in Bohemia and Gaul the horse had not disappeared in neolithic time.

More complete remains of the horse than merely a few bones of the extremities seem to have been found at Schussenried, of which Fraas* has unfortunately given a very imperfect account, and it was not possible to determine its geologic age. Here belong, however, still other finds: Boucher de Perthes found in 1833 at the bottom of a turbary in the Department of the Somme in France, 5 to 6 meters below the water-level, two skulls of horses associated with late neolithic pottery and with flint implements. These were deposited in the Museum in Paris; and one of the skulls was later examined by Sanson himself and determined as "*Asinus africanus* or the *African ass.*"

Sanson remarks concerning it on page 133, t. III, of his "Zootechnie": "En le donnant comme étant celui d'un cheval, Boucher de Perthes s'était donc trompé, erreur bien excusable d'ailleurs, de la part d'un très-habile archéologue tout à fait étranger à l'anatomie zoologique. Ce qu'importe, c'est que la présence de ce crâne dans le nord des Gaules, à l'époque de la pierre polie, atteste que sa race y avait été amenée dès lors par des migrations de population humaine."

Sanson considered this an isolated case, but a no less eminent authority than Ludwig Rütimeyer described an equid skull from a pile-dwelling at Auvernier on Lake Bienne, which he ascribed to an ass.†

Since, through the kindness of Professor E. Ray Lancaster and Oldfield Thomas, I was able to compare this African ass, so early an inhabitant of Europe, with its contemporary from the ruins of Abadieh near Kenia in Egypt, dating according to Professor Flinders Petrie from the IV dynasty, I came to doubt the correctness of the determination of the two authorities—Rütimeyer and Sanson.

Rütimeyer (p. 53), as well as Sanson, was led to its determination as *Equus asinus*, or the half-ass, on account of the small absolute size of the skull. But the greater extent of the diastema or toothless ridge of the jaws than is usual

---

*O. Fraas, Beiträge zur Kulturgeschichte, etc. Arch. f. Anthrop., v, 1872.

†Rütimeyer. Schädel von Esel u. von Rind aus den Pfahlbauten von Auvernier u. Sutz Pfahlbauten. VII. Bericht. Mitt. d. antiq. Gesellsch. Zürich, Bd. XIX, pp. 50–56, 1876.

among asses distinguishes this animal from those. The transverse diameter of the skull and the form of the nasal bones conditioned thereby are like those in the horse, as is also the eye-socket. The perfectly preserved teeth show that the length of the upper jaw is 34 per cent of the length of the skull. Rütimeyer finds for the horse, elsewhere, 32 to 35.6; for the ass 35 to 38.5 per cent. Thus it should be a horse. Also, the relation of the premolar row of the lower jaw to the dental row, which in the horse is 51 to 53 per cent and 49 in the ass, is 52 per cent in the skull from the lake-dwelling, thus again as in the horse. Only the occiput, says Rütimeyer, looks like that of an ass. And he closes his observations: "Notwithstanding all the uncertainties which seem to attach to these measurements, not only on the teeth but on the skull as well, certainly derived from nature, there remains in my mind no doubt that the skull from the lake belonged to an ass."

The kindness of Doctor Lehmann, Director of the Swiss Landesmuseum in Zürich, enabled me to make a direct comparison of the skull from Auvernier with the mummified skull from Abadieh and with the skulls from the Somme which I studied in the Museum of Natural History in Paris.

During this investigation there arose again the question which I had asked myself before, during the study of the craniology of the ruminants: *What are the really decisive criteria of species, and what the incidental characteristics brought into existence by causes acting during individual life?* At last I came to the realization that a conclusive method of discrimination did not exist; that all those in use might be said to be wholly empirical, in part, indeed, dependent on the personal perception and feeling of the individual student, and therefore not scientifically established. Nor have I succeeded—through lack of material, fresh heads and numerous skulls of asses—in adding much that is new; but I believe that I have thrown some light upon the causality of some of these relations, and have tried to incite to a more scientific treatment of the question.

CRANIOLOGICAL DIFFERENCES BETWEEN THE ASS AND THE HORSE.

The older authors, as De Blainville in his Ostéographie, and Cuvier, do not supply what is really needful for the comparison in question. L. Rütimeyer has opened the way here, too, as in many other branches of paleontology. His "Beiträge zur Kenntniss der fossilen Pferde," etc.,* was the first work worthy of note on the fossil remains of the genus *Equus*, but he did not treat of the differences between the horse and ass till in his second treatise "The Horses of the Quarternary epoch"† in the same year as the studies of Frank mentioned above. In the meantime this relation had been discussed by R. Owen in his "Description of the Cavern of Bruniquel and its Contents,"‡ in which are beautiful plates representing the teeth characteristics of the horse and ass.

*Rütimeyer, Beiträge zur Kenntniss der fossilen Pferde u. zur vergleichenden Odontographie der Huftiere ueberhaupt. Verh. Naturf. Gesellsch., Basel, Bd. III, 4, 1863.

†Rütimeyer, Weitere Beiträge z. Beurtheilung d. Pferde d. Quaternär Epoche. Abhandl. d. Schweiz. paleontol. Gesellsch., II, 1875.

‡Owen, Philosoph. Transactions, vol. 159, 1869, pp. 517–557.

Later J. C. Forsyth Major,* Mme. Pavlow,† Nehring,‡ Kowalewski,§ and Woldrich‖ touched more or less at length upon the relation of the skulls of the ass and horse. Still later some of the French investigators discussed these very different and partly contradictory criteria, thus Duges,¶ Monfalet,** and before all X. Lesbre,†† the veterinary anatomist of Lyons.

I will here state briefly those characteristics on which these authors lay the most stress:

According to Owen, in the upper series of grinders the degree of oblique attrition of premolar 2 causes its working surface to appear more produced and acute anteriorly than in less worn and more evenly worn specimens. Besides the general inferiority of size of teeth, molar 3 is relatively less than in *Equus caballus* and is not bilobed behind: the outer channels are more evenly curved or concave; and as the same character prevails in the inner enamel-wall of the lobes these are more regularly crescentic in shape. The longitudinal ridge is relatively narrower. A slight excess of fore-and-aft over transverse diameter of grinding surface is recognizable in the ass—such excess not being seen in the permanent grinders, premolar 3 to molar 2, of the horse.

Rütimeyer regards as a constant characteristic for the teeth of the ass, as compared with the horse, the relatively slight length of the foremost as well as of the hindmost molar in both the upper and lower jaws. Also he considers the premolars and molars in the ass to be shorter than in the horse; the foremost premolar tooth is strikingly short. Rütimeyer declares irrelevant the circumstance mentioned by Owen that molar 3 superior is less bilobed in its posterior circumference than in the horse. He ascribes to the ass, at least in the teeth of the upper jaw, more oblique enamel plications than occur in the horse, but he remarks that one can not disregard the fact that all these characteristics, in so far as they concern construction of the teeth, recur in very old horse teeth; therefore, in the earlier stages of abrasion, the teeth of the ass show the characteristics which correspond to the deeper parts of the tooth lying nearer to the root. In addition to this is the relatively small extent of the toothless part between premolars and canines, as well as the slight width of the incisor crown. Thus, in the ass the whole construction is more compact and crowded.

---

* J. C. Forsyth Major, Beiträge z. Geschichte d. fossilen Pferdes, insbesondere Italiens. Abhandl. Schweiz. paleontol. Gesellsch., VI and VII, 1880.

† Marie Pavlow, Étude sur l'histoire paléontologique des Ongulés. Bull. Soc. Imp. d. Naturalistes, Moscow, 1889.

‡ Alfred Nehring, Fossile Pferde aus deutschen Diluvialablagerungen, Landw. Jahrb. 1884, Bd. 13, pp. 149 *et seq.*

§ Waldemar Kowalewski, Monographie der Gattung Anthracotherium Cuv. u. Versuch einer natürlichen Klassification d. fossilen Huftiere. (Paleontographica, N. F. II, 3, XXII.) Sur l'Anchiterium Aurelianense Cuv. et sur l'histoire paléontologique des Chevaux. Mém. de l'Académie Imp. d. Sciences, St.-Pétersbourg, VII Série, t. XX, p. 5, 1873.

‖ J. N. Woldrich, Beiträge z. Fauna der Breccien und anderer diluv. Gebilde Oesterreichs. Jahrb. k. k. Geol. Reichsanstalt, Bd. XXXIII, Heft 4. Wien, 1882.

¶ A. Dugès, Paralelo de los craneos de caballo i de asino. Guanojuato, 1898. Actes Soc. Scient. d. Chili, t. VIII, pp. 77, 78.

** D. Monfalet, Note complémentaire sur la communication de M. Dugès. *Ibidem*, pp. 79, 80.

†† X. Lesbre, Observations sur la mâchoire et les dents des Solipèdes. Bull. Soc. d'Anthropologie de Lyon, t. XI, 1892, pp. 49 *et seq.*

Frank states chiefly that the plication of the enamel-margin in the upper molars of the ass is less complex than in the Oriental horse, and that the so-called spur is here wholly wanting. He considers the best characteristic to be the fact that the distance from the anterior margin of the foramen occipitale to the median point of the vomer incision is shorter in the ass than the distance from the same point on the vomer to the end of the palatine suture. In the horse this dimension is much greater.

Nehring also agrees with Frank as to the great value of this characteristic.

Dugès calls attention to the greater convexity of the forehead of the ass. According to him the face is shorter in comparison with the horse, and the orbits triangular. A perpendicular to the plane of support falls far behind the condyli of the occiput. The free part of the nasalia reaches to the posterior edge of the corpus maxillare and is therefore very long in the ass; then the spur is wanting on the teeth. In the horse, on the other hand, according to him, the forehead is flat, the orbits round and the occipital line touches the condyli. The free part of the nasalia does not reach to the middle of the incisive edge. The "spur" is characteristic of the teeth.

Monfalet gives nothing on the characteristics of the face, but only on those of the brain-skull.

The most accurate work, especially as regards dentition, is that of X. Lesbre. He is the first to distinguish between the teeth of the adult animal and of the young. He finds (p. 60) that in the horse, at the age of ten months, the "spur," which he calls "pli cabalin," is already clearly developed. In the young ass this is always wanting.

Lesbre confirms a shortening of the teeth of the adult ass through a kind of atrophy of the posterior pillar, but he considers the disposition of the enamel plications more important. (1) In the upper molars the internal lobule is less developed in the ass than in the horse, all proportions remaining the same; it is, in the first place, shorter towards the rear, so that its base stands median or almost median, and not, as in the horse, on the forward part of the tooth. In the first molar the plication is round in both animals, only in the ass it is less obliquely inclined toward the back than in the horse. (2) The exterior sides of the tooth seen from the grinding surface are narrow and simple in the ass, broad and compressed in the middle in the horse, especially the premolars. (3) The "spur" or *pli cabalin* is wanting in the ass at all ages, or is very inconspicuous, while in the horse it is often double, and disappears only at an advanced age, and earlier in the molars than in the premolars. (4) The crescentic islands are simpler in the ass than in the horse, less plicated and complex, but they often vary. (5) The outer channels are not so deep in the ass as in the horse. On the molars of the lower jaw Lesbre finds that the 8 formed by plications 1 and 2, has both of its loops generally *round* in the ass, and usually somewhat *flattened* and *angular* in the horse. In the ass both the loops of the 8 are equally large; in the horse the forward one is longer than the posterior, and they are separated by a sharp angle instead of by a curve. An exception is the first premolar, in which the posterior loop is often greater than the forward one. The external channel is much less deep in the ass than in the horse.

To discriminate among whole skulls, Lesbre finds by comparison, empirically, the method of drawing a connecting line between the *tuber molaris* and the *fossa articularis ossis zygomatici*; if the prolongation of this line strikes the crista occipitalis, or *anterior* to this cuts the facial plane, the animal is an *ass*; if this line passes *posterior* to the crista occipitalis it is a *horse*.

Tscherski* places much dependence on the construction of the nasal bones and on the form of the suture between the lacrimal and the nasal bone. This, he says, is in the ass always curved outward in bow shape, but is straight in the horse. I find that this relation is very dependent on the breadth of the forehead. The *foramina infra-orbitalia* stand nearer (to the naso-maxillar suture) in the ass than in the horse. He says, further, that in the horse the processus zygomatici ossis frontalis is three-cornered, but in the ass oval and compressed.

Salenski† asserts that Tscherski's criteria are valuable and to the point, especially the form of the suture between the lacrimal and the nasal bone, but that a difference in the cross-section of the processus zygomatici ossis frontalis can not be verified in the ass and horse. On the other hand, Salenski proposes another method, which he considers extremely constant: the lower edge of the lower jaw is in the ass curved and furnished with protuberances, while in the horse it is smooth and straight. Unfortunately I can not agree with Salenski, as I consider this criterion of the lower jaw very variable, eminently dependent on the age of the individual; one has only to compare the lower jaw-bone of the horse of Auvernier with the one of exactly similar shape in the ass from Abadieh (plate 87, figs. 1 and 2).

So far the authors. It is now time to investigate the *conditioning factors* that influence the shaping of the skull of the ass and of the horse. Starting with the law, which I have proved elsewhere,‡ that the skull is a flexible product of the influence of skin and muscle, the longer ear and its generally different position seems to be decisive for the head of the ass. The greater burden imposed by the external ear must have had as a consequence a change in the musculature of the ear, which in turn, as is shown by Anthony§ and Toldt‖ exerts its influence on the bones. Indeed the whole ear-musculature is different in the ass, as I was able to observe in agreement with Kirsten,¶ on the only fresh head that I could obtain.

* J. D. Tscherski, Wissensch. Resultate d. Neusiberischen Expedition. Mém. Acad. Imp. St. Pétersbourg, t. XL, 1893.

† W. Salenski, *Equus przewalski* Polyakof. Wissensch. Resultate d. von Przewalski nach Central Asien unternommenen Reisen. Zoolog. Teil, Bd. 1, Abt. 2, Lief 1, pp. 27–47, St. Petersburg, 1902.

‡ Experimentelle Studien ueber die Morphogenie des Schaedels der Cavicornia. Vierteljahrschr. Naturf. Gesellsch. Zürich, 1903, pp. 360–374.

§ R. Anthony, Études experimentales sur la morphogénie des os. Modification crâniennes consecutives à l'oblation d'un crotaphyte chez le chien. Journal de Physiologie et de Pathologie Gén., No. 2, Mars, 1903.

‖ R. Toldt, Asymetrische Ausbildung der Schlaefenmuskeln bei einem Fuchs infolge einseitiger Kautätigkeit. Zoolog. Anzeiger, 1905, Bd. XXIX, No. 6.

¶ F. Kirsten, Untersuchung ueber die Ohrmuskulatur verschiedener Säugetiere. Inaug. Diss., Bonn, 1902.

Not to go into anatomical details, this difference is shown, before all, in the significant enlargement and bipartition of the *musculus retrahens auris brevis,* which Kirsten aptly calls *musculus abductor auris brevis.* Strikingly enlarged, too, in the ass are the *musculus abductor* (*retrahens*) *auris longus; musculus adductor* (*scutulo auricularis*) *auris inferior; musculi levatores auris longi, medius, et brevis,* and others. In consequence of the insertion, direct or indirect, of these muscles on the occipital *crista* and the *linea nuchalis* of the occiput, it is clear that in the ass a stronger pull is exerted on the occipital surface and the lever-arm which is formed by the *crista.* Through this action there must necessarily follow an inequality in the back part of the brain-skull.

Variations may of course be caused by the size of the ears, as also by the manner of carrying them, as the flap-ears of the Sudanese domestic ass, in contrast with the Asiatic. In my opinion, therefore, the most important characteristic in the bony head for determining the specific difference between the ass and horse is the position of the occiput. This can be recognized by three different methods which are, however, of unequal uniformity and exactness in practice. (1) Lesbre's method of the *cheek-crista line,* for the clearer expression of which I would make a suggestion later. (2) The Frank-Nehring method—distance from *foramen occipitale* to *vomer palatinum.* (3) The *inclination of the occipital plane* mentioned by Dugès, for the determination of which I would also propose a new method.

Besides this there are other, mostly less regularly marked, features which can be traced to the action of the ear-musculature; the lateral edges of the *occipitalia lateralia* are drawn more strongly towards the *meatus auditorius externus;* the funnel of the *meatus auditorius externus* is more erect, etc. But, as was said before, there is here much room for the play of individual variation.

It may occur in practice that one has only a skull of an equid without cheek-bones or *maxillæ;* in this case, to determine the inclination of the occiput, use a tangent, B, on the *facies-surface* of the *frontales* and *nasales.* If, on the other hand, the *maxillary* is present, draw first Lesbre's line; on this (A) or on the facial tangent (B) erect a perpendicular which touches the highest or most aboral point of the *crista occipitalis,* and draw a tangent from this same point, first, on the upper edge of the *foramen magnum,* and second, on the most aboral point of the condyli; we find, according to my measurements of these angles to date, on thirty-two skulls:

	A 1.	A 2.	B 1.	B 2.
Horses	14–25°	10–24°	15–30°	10–25°
Asses	35–50°	30–35°	35–50°	30–45°

As is clear in this table, as great as is the difference between the ass and horse, the difference between the two relations A and B is small, and we can therefore use either the line A or B, according to the state of preservation of the material. I call this angle *ear-load index* (*Ohrbelastungsindex*) to indicate its dependence on the ear-musculature.

In order to express the Lesbre line numerically in an index I have applied the following method: draw the Lesbre line and then a connecting line between the *crista occipitalis* and the intersection of the Lesbre line with the *articular* *fossa* of the lower jaw. The angle formed by the two lines is the positive or negative *parietal-crest-curvature* index (*Scheitelkruemmungsindex*); the angle being positive (+) when the crista lies below the Lesbre line, and negative (−) when the crista lies above the Lesbre line. According to this, *horses* should almost always have a *negative*, and *asses* a *positive* index.

Since the "Lesbre line" leaves at times something to be wished for, I have chosen a *second-control index* which expresses the size of the acute angle formed between the prolongation of the facial tangent and that of a tangent on the brain part of the frontal and of the parietalia. In the ass this angle is about 40°, and in the horse 20° to 30°.

As regards the bones of the facies, it is to be noted that the observations of the length of the free part of the nasal bones have absolutely no value, since this is wholly individual, or possibly also subject to racial variations. Also I do not find the shape of the sutures of the nasalia with the frontal and the lacrimal to be always characteristic; if they are *useful*, as stated by Salenski and Tscherski, they are too dependent on the width of the frontal to be *decisive*. Not more so is the shape of the lacrimal on which Rütimeyer seemed to place great reliance; nor can the triangular form of the orbital be used as a characteristic of species.

Lastly, as regards the *teeth* characteristics, the occurrence of the "spur" must be used, notwithstanding Lesbre's assurances, with some caution; I agree with Rütimeyer, Tscherski, and Owen, when I assign a higher value to the position of the internal lobule and its form, as also to the size of premolar 2 and molar 3. In this connection I have made some very instructive experiments by grinding on teeth of asses and horses, and have thereby arrived at the conviction that, as regards the "spur," by grinding to a sufficient depth, one may make out of every horse tooth an ass tooth, and sometimes from an ass tooth a horse tooth, without taking into account that in the first teeth of the ass ever published (Owen, plate LVIII, fig. 1) the spur shows on all the teeth and even double on one. Such cases are, however, extremely rare, and the "spur" is nevertheless to be regarded as a *useful* characteristic.

After this review of the criteria in question we can pass now to a comparison of the ancient Egyptian mummified ass with the horse of Auvernier. The brain-skull of the ass of Abadieh shows the following relations: the ear-load index (Ohrbelastungsindex) is 42° with the foramen tangent, 35° with the condylus tangent; the same index on the skull of the Auvernier horse is 28° with the foramen tangent (B 1); the condylus tangent (B 2) is not measurable, as the condyli are broken off. The parietal curvature index (Scheitelkruemmungsindex) is +22° on the ass of Abadieh, and −7° on the horse of Auvernier. Rütimeyer remarked that there was something asslike in the shortness of head and width of forehead of the equid of Auvernier.

Teeth.—I have already discussed the teeth characteristics as described by Rütimeyer, and have repeatedly drawn the conclusion that the equid of Auvernier is a horse. The teeth are indeed very short and close-set. But we see clearly the horselike shape of the internal lobule which is very widely drawn out in two horns, while in the ass of Abadieh it is round and placed median. Then, too, in the ass the "spur" is wanting on all the teeth, while the equid of Auvernier has it on all the premolars and on the third molar. It is noteworthy, though without value in distinguishing between species, that the ass of Abadieh has the first premolar, which is not frequent at this age. I find no differences in the incisors, which are fully present in both skulls. The incisive part of the Auvernier equid is, with a width of 62 mm., somewhat wider than that of the ass, which measures only 52 mm. The equid of Auvernier had during life a broader muzzle than the ass, again recalling the horse, which, especially in the diluvial horse, had a very broad muzzle, broader than is shown in recent horses (83 to 88 mm., Nehring, *op. cit.*, p. 90).

The equid of Auvernier is thus shown to differ in its principal points from the ass of Abadieh and must, therefore, be regarded as a *horse* and no longer as an *ass*. We may see confirmatory evidence that it is a horse that was used by the people of Auvernier, in the size of a bronze bit from the pile-dwelling of Möhringen on the same Lake of Bienne; this measures 9 cm., while the maxilla where the snaffle lies measures 5.1 cm. Moreover, Marek* has published a series of skulls from stations of the same age, as well as later (among them a plaster cast of the Auvernier horse), which are classed by him as Helveto-Gallic horses.

If it has been shown that Rütimeyer erred in his determination of the Auvernier skull, it is now easy to prove the same in the case of Sanson. Two skulls in the Galerie de Paléontologie of the Museum in Paris belong, in dimensions and in form, to the same variety of horse as that of Auvernier, and their special characteristics will now be considered.

We can take up the thread of our argument at the point where we left it (p. 403) in order to identify these two skulls, which, if they had been African asses, would have been of fundamental importance as to the distribution of domestic animals in prehistoric times.

(*b*) *The copper time of the bronze age* brought to Europe the small, slender-limbed horses whose domesticated condition is for the first time certain; and which is proved also to have existed in:

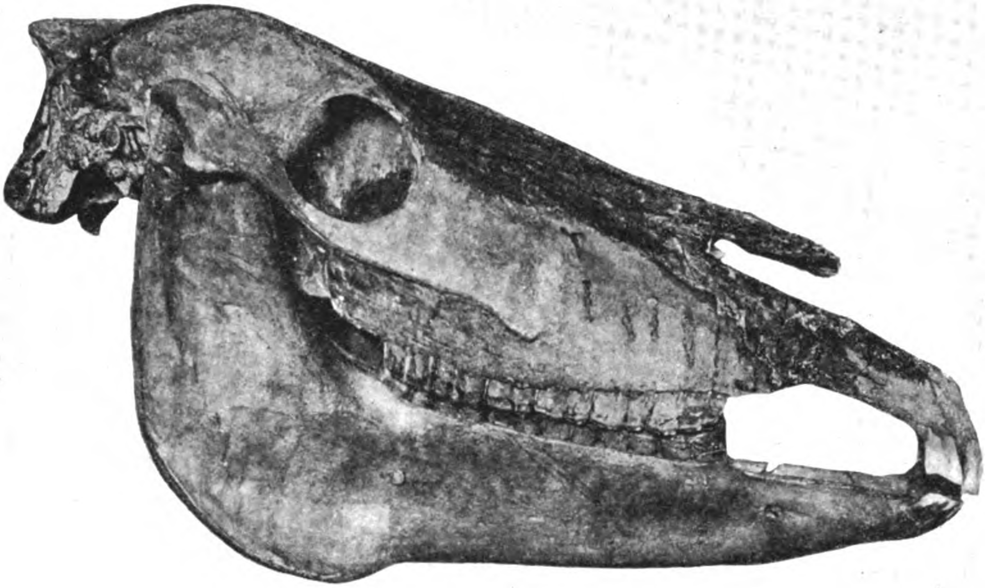
(*c*) *The La Tène Period* (iron) and which have been already treated by Studer,† Marek,‡ Kraemer,§ and others.

(*d*) *The Hallstatt Period* seems, probably on account of the heavier armor of the cavalry of that time, to bring us already the heavy type of horse that we find in Roman times at Vindonissa; at least the skull from Schuettarschen, which will soon be treated of, differs in several respects from those of the bronze and La Tène periods. Unfortunately we have from Schuettarschen no bones of the extremities to aid in more exact discrimination.

(*e*) *The Roman Times* bring us better, more abundant material, as we shall see in the finds from Vindonissa.

---

*T. Marek, Das Helvetisch-Gallische Pferd, etc. Abhandl. Schweiz. paleont. Gesellsch., Zürich, 1898.
†Th. Studer, Die Tierwelt in den Pfahlbauten des Bielersees. Mith. Berner naturf. Gesellsch., 1883.
‡J. Marek, Das Helvetisch-Gallische Pferd. Abhandl. d. Schweiz. pal. Gesellsch., xxv, 1898.
§Kraemer, Haustierfunde von Vindonissa. Revue Suisse de Zoologie, t. 7, 1899, pp. 143 *et seq.*

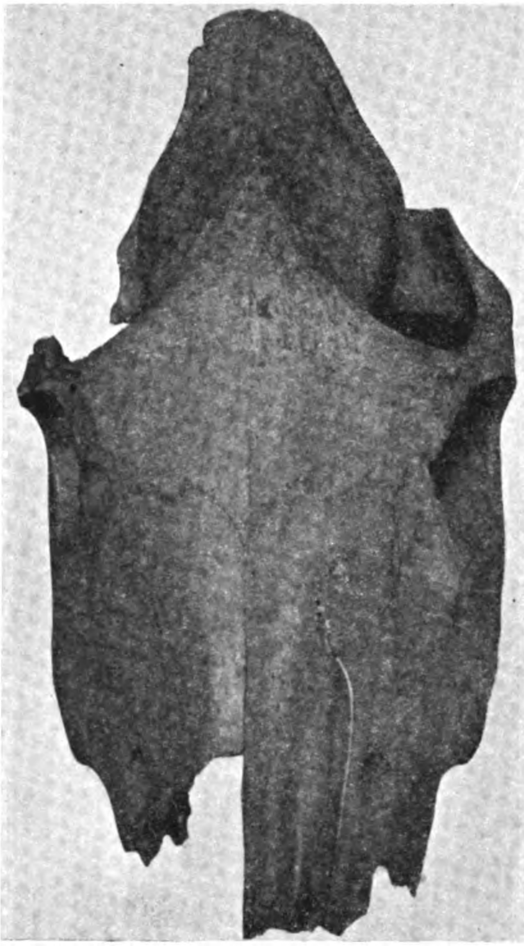


1

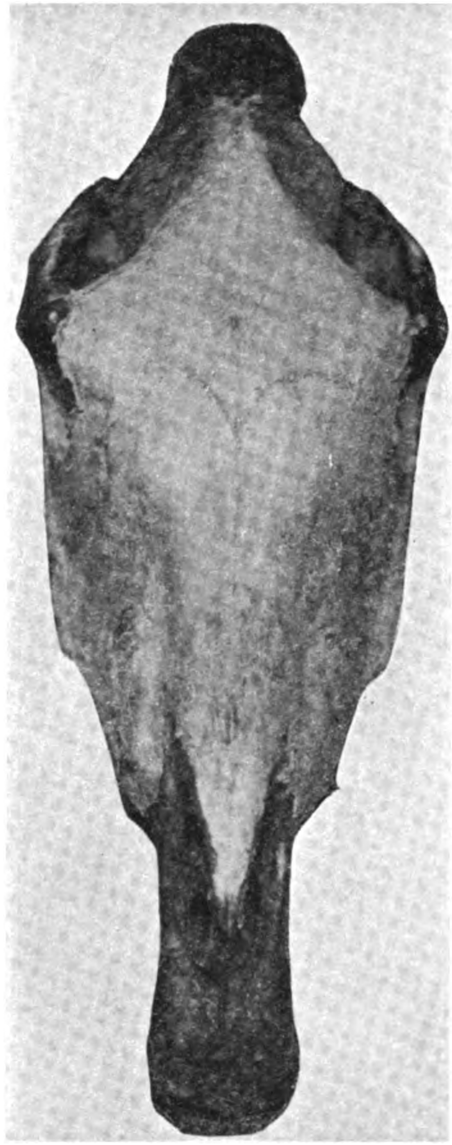
2

FIG. 1. Norma lateralis of skull (restored) of the horse (*Equus caballus pumpellii*) from pile-dwellings at Auvernier (Switzerland). Swiss National Museum, Zürich.

2. Norma lateralis of skull of the ass of Abadieh, IV dynasty, Egypt; coll. by Flinders Petrie; British Museum, Natural History.



1



2

3

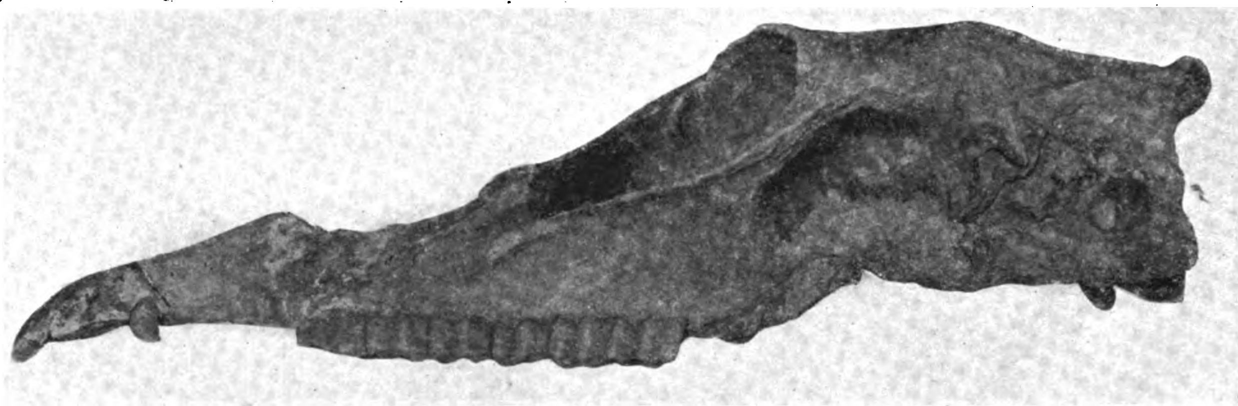
4

FIG. 1. Norma verticalis of skull of a great horse (*Eq. caballus robustus* Nehring) of Hallstadt time. Schüttarschen (Bohemia), Museum Teplitz.

2. Norma verticalis of skull of *Eq. przewalskii* Pol. 5-year-old stallion. Photograph by Professor Noack.

FIG. 3. Norma verticalis of skull of an old *Eq. caballus pumpellii* from the turbary of Kutterschitz (Bohemia), Museum of Teplitz.

4. Norma verticalis of skull of a young animal from a turbary at Sobrusan (Bohemia).



1

2

3

FIG. 1. Norma lateralis of skull of horse from Alemannic tomb at Königsfelden (Switzerland).
2. Norma lateralis of skull of *Equus przewalskii* Polyakoff. Photograph by Prof. Noack.
3. Norma lateralis of skull of young Sobrusan horse.

The horse of the La Tene period remains, however, till still later times, as is shown by a skull from an Alemannic grave at Königsfelden near Vindonissa. After this review of the most important finds at our disposal of remains of horses, dating from different periods, we may attempt to compare these finds with each other and with the Anau horse, which, with the horses of the Quaternary epoch and that of the paleolithic age at Solutré, ranks oldest among the horses we have considered.

THE SKULL OF THE PREHISTORIC HORSES.

THE TEETH.

The incisors of both jaws are abundantly represented in the collection before me. Still, notwithstanding the opinion of Wilckens,* I do not believe that their characteristics will be of value in classifying races and species; the phenomena of their growth and abrasion are sufficiently well-known and are widely used in determining age.

Although Salenski† says that *Equus przewalskii* has larger teeth than any other horse, this may be inconclusive, since this characteristic is essentially dependent on the age of the animal. Moreover, I have not been able to find out whether Salenski had in mind the whole length of a tooth or measured only the chewing surface. Indeed, it seems from the size of the dimensions that by length Salenski meant the projection of the tooth out of the alveola and called the length of the chewing surface "width." The value of such measurements is naturally problematic, since with age the incisors can project from 1 to 7 cm., and especially since we do not know from Salenski exactly how old (according to the teeth) were the animals in question.

More important than the size of the teeth is the width of the intermaxillary, which gives the means of determining the width of muzzle of the living animal.

From Anau, however, we have some specimens in which the intermaxillary can not be measured because the teeth are broken off. I will use here, for comparison with those from other localities, better preserved specimens of lower jaws.

Dimensions of corpus of lower jaw (in millimeters).

	Greatest width.	Width at foramen mentale.	Height of corpus.	Diastema from incisors to canines.
Anau horse	....	40	32	....
	....	35	28	....
Diluvial horse after Nehring, upper jaw	84	....	....	18
Diluvial or paleolithic, Schellenken, upper jaw, male, 12 years	67	....	....	18
Hostomitz, male, 9 years	62	35	24	10
Gross Czernosek, male, 8 years	62	43	25	5
Liebshausen (La Tène), male, 14 years	64	40	29	9
Gross Czernosek (Rasch), 10 years	56	37	23	....
Lignitz, neolithic	....	38	27	....
Auvernier	60	....	....	....
Alemannic horse, Koenigsfelden	61	....	....	....

*M. Wilckens, Beiträge f. Kenntniss des Pferdegebiss, etc. Halle, 1888. Nova Acta, K. Leop.-Carol. deutsch. Akad. d. Naturf.

†*Op. cit.*, p. 48.

The molars both of the Anau horse and of the other subfossil horses are represented by hundreds, but a detailed study of them can be of use only when we possess sets of teeth which surely belong together, as we fortunately have in a complete half of a palate from Anau.

After what has been said in reviewing the specific characteristics of ass and horse, it is superfluous to follow the course of each enamel plication. Here we will notice the principal differences; as regards the masticating surface the accompanying drawings (fig. 491) will speak for themselves. Nehring and later Salenski affirm that the relations assumed by Frank, for the Oriental and Occidental horses, between length and breadth of masticating surface (teeth broader than long in the Oriental, and longer than broad in the Occidental horse) are not decisive; indeed this relation is greatly influenced by the age of the animal, since through progressive grinding off of the teeth these become smaller towards the roots, and the row of teeth shortens. Nevertheless a comparative tabulation of the size-relations of the whole row of teeth is probably worth making.

Table of dimensions (in millimeters).

Grinding surface of upper molars.	Length of series.	Length from premolar 2 to molar 2.	Length of premolars.	Premolar 2.		Premolar 3.		Premolar 4.		Molar 1.		Molar 2.		Molar 3.	
				Length.	Width.	Length.	Width.	Length.	Width.	Length.	Width.	Length.	Width.	Length.	Width.
Anau (*Equus caballus pumpellii*) 5-year-old specimen	176	152	100	38	26	32	28	28	27	25	26	27	24	24	20
Same, −24 feet	..	..	..	31	26	..	..	27	26	26	26	25	26	25	21
Kesslerloch diluvial horse, 8 years	..	150	96	37	24	31	25	26	25	24	24	24	23	..	..
Auvernier domestic horse, bronze age, 6 years	153	127	81	33	22	24	23	23	24	21	24	21	24	25	20
Königsfelden, Alemannic time, 7 years	162	136	91	37	22	25	23	24	25	21	25	21	24	24	21
Hostomitz, 4 years	170	144	89	35	23	27	25	22	23	26	23	26	23	23	17
Remagen, diluvial horse, after Nehring, 10 years	169	..	..	37	24	29	29	27	29	25	29	26	29	27	26
Remagen diluvial horse, after Schwarze	..	..	..	38	24	30	30	28	28	28	28	28	26	22	22
Thiede diluvial horse, after Nehring, 6 years	..	..	..	38	26	31	29	..	..	26	27	26	26	26	23
Westeregeln diluvial horse, after Nehring, old	..	..	..	(?)	(?)	29	29	28	30	26	27	26	27	26	25
Equus przewalskii, after Salenski	170–185	..	..	37	25	29	29	27	29	21	23	21	22	30	23
Equus przewalskii, Mus. Bern	..	..	..	40	21	27	23	..	..	..	..	..	..	..	..
Indian horse, after Nehring, 7 years, Mus. Berlin	154	..	..	37	23	26	26	23	25	22	25	23	25	25	23
Arabian horse, after Nehring, 7 years	168	..	..	38	26	29	27	27	27	24	27	25	27	26	24
Grisonian horse, after Nehring, 8 years	174	..	..	38	25	28	27	27	27	26	27	26	26	27	25
Pinzgau (Tyrol) horse, after Nehring, 10 years	181	..	..	38	25	30	28	29	28	27	27	27	26	30	25
Holstein horse, after Nehring, 10 years	169	..	..	38	25	29	27	28	28	26	27	25	27	28	24
Dutch horse, after Nehring, 30 years old	174	..	..	37	23	28	26	27	27	23	27	26	27	34	25

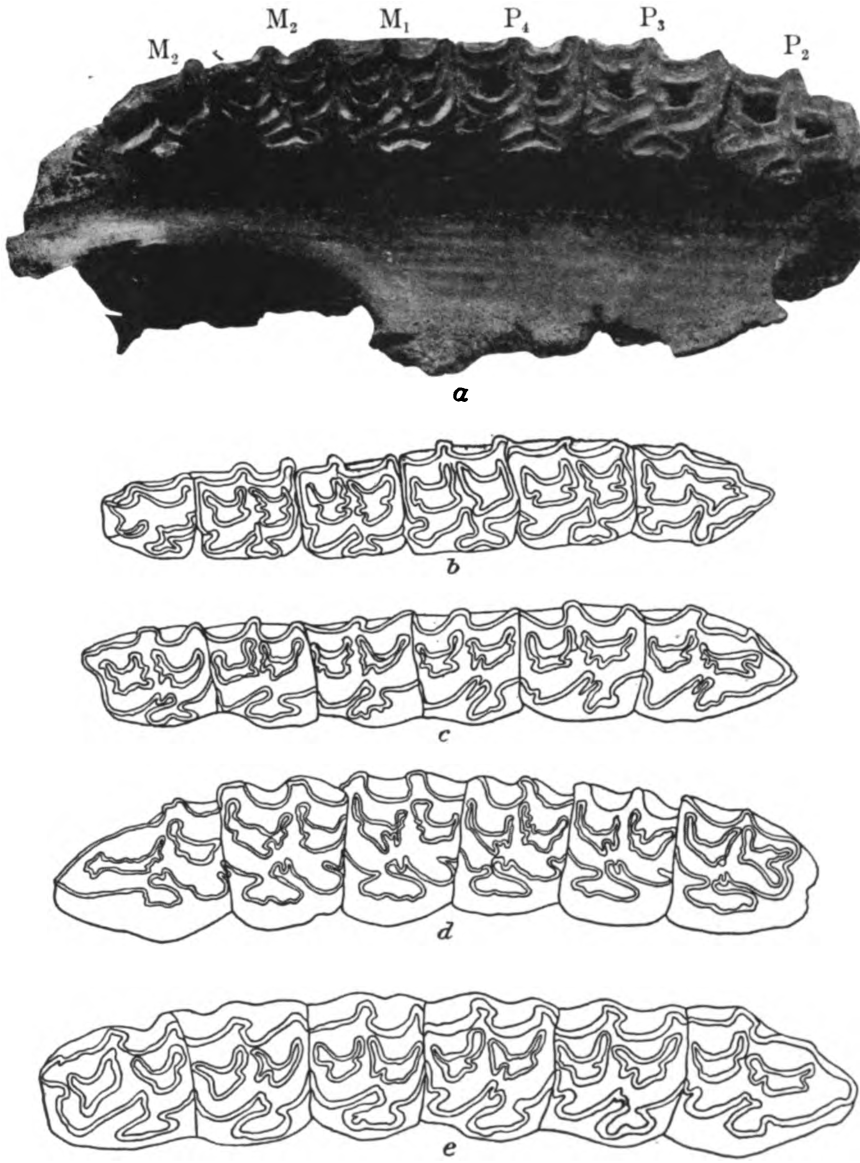


Fig. 491 (a) Teeth of Equus caballus pumpellii. Right part of upper maxilla.
(b) Teeth of Ass, from the Mummy from Abadieh, Egypt.
(c) Teeth of Horse, Pile-dwelling of Auvernier (Bronze Age).
(d) Teeth of Equus przewalskii.
(e) Teeth of Tscherski's Siberian Horse.

The form of the enamel of the teeth deserves further consideration, but since in horses the enamel is more wavy in younger than in older animals, while in the ass the reverse is the case, only specimens of similar age must be compared. Frank asserts that in the Oriental horse the enamel plication is less than in the Occidental. The most marked enamel plication of the interior borders of the anterior islands is shown in the diluvial horses; among these especially in the horses of Westeregeln and Thiede. The horse of Remagen has also slighter rippling, and I find it still less in the horse of Kesslerloch and Solutré. The plication of the enamel of the Anau horse stands midway between the Siberian horse of Tscherski and the diluvial horses of Rutimeyer, on the one hand, and on the other hand, the subfossil horses now before me from Hostomitz, Auvernier, Schuettarschen, and Königsfelden, which have a much simpler enamel plication than animals of the modern heavy Occidental races of exactly equal age.

THE SKULL AND ITS PROPORTIONS.

In beginning the study of a horse's skull one asks instinctively: was the skull large or small? Indeed the length of the skull gives a very good rule for determining the withers-height, and thereby also a provisional classification of the horse. It is accepted that heavy horses have the largest heads, and that light Oriental horses and ponies have the smallest skulls. I shall not speak here of the methods of taking the measurements, and will only refer for these to the rule drawn up by me in association with Professor Kraemer at the request of the Deutsche Gesellschaft für Zuechtungskunde, which will soon appear.

Since it is possible to calculate with approximate accuracy the length of the skull from any of its measures of length (the longest measure possible being preferable), I have calculated this for all the incomplete subfossil skulls before me, from the proportions obtained from 50 skulls that the molar row stands to the basilar length as 10 : 28, and to the anterior length as 10 : 31.

Length of skulls (in millimeters).

	Length on base.	Length of anterior face.
Clydesdale horse, after Nehring	574	623
Horse from Boulogne, coll. Duerst	543	618
Diluvial horse from Nussdorf, after Woldrich	555	....
Diluvial horse from Remagen, after Nehring	528	562
Schuettarschen, horse of the iron time (Hallstatt)	506	560
Arabian horse, after Nehring	500	540
Thoroughbred British race horse, coll. Duerst	496	538
Anau horse, calculated, 5 years old	492	545
Equus przewalskii, after Salenski:		
No. 5213	485	542
No. 5216	495	547
No. 5214	484	538
Equus przewalskii, after Salenski:		
No. 5218	481	543
No. 5212	472	528
Neolithic horse, Kutterschitz	487	543
Alemannic horse, Königsfelden	490	536
La Tène horse, Hostomitz	476	527
Arabian horse, from Abassii, after Nehring	476	520
Indian horse, after Nehring	438	492
Auvernier, bronze time horse	436	485
Subfossil horse from Gera, after Nehring	416	...
Exmoor pony, 15 years, after Nehring	390	424
Neolithic horse, turbary, Somme (France)	396	427
Ass from Abadieh	389	449
Ass from Aden, British Museum	376	431

It follows from this comparison that the Anau horse had a skull of about the same size as *Equus przewalskii* and that the other Bohemian subfossil horses, like the Alemannic horse of Königsfelden, stand very near the Anau horse and Przewalski horse in size of skull. In contrast, it appears that the horse of the bronze age from Auvernier has a very notably smaller skull, but still smaller is that of the subfossil horse of Gera and Spandau mentioned by Nehring. And smallest of all is the skull of the neolithic horse from a turbary of the Somme in France, being smaller than that of the smallest Exmoor pony in the Berlin collection;

and yet this little animal seems fully adult; in this we may see an explanation of the errors of Sanson and Rütimeyer.

The next question relating to the skull of a horse must concern the indices of ear-load (Ohrbelastung) and of parietal curvature (Scheitelkruemmung). Unfortunately I am not able to produce here a very comprehensive tabulation of these indices on prehistoric horses, since I am able to verify them only on the skulls actually before me *in natura*.

Table of indices.

	Ear-load index.				Parietal crest curvature index.	
	Facies tangent.		Lesbre.			
	A 1.	A 2.	B 1.	B 2.	C 1.	C 2.
Equus przewalskii, male, 3 years	18	15	25	23	−7	....
Kutterschitz	....	....	....	....	....	27
Sobrusan, juv	20	17	22	19	....	30
Schuettarschen	20	17	22	18	−7	23
Auvernier	23	....	28	....	−7	25
Moosseedorf, Mus. Bern	20	15	24	20	−7	22
La Tène, Mus. Bern	21	15	25	19	−7	22
Luescherz	14	4	22	11	−6	22
Ziel Canal	21	10	25	14	−5	18

Still more important in discriminating between different races of horses is the relation of breadth of forehead to length of skull. We know that, as Sanson has shown, the ass and the Oriental horse as well as the ponies are broad-fronted, while the heavy Occidental horses are usually narrow-fronted, as are also the quaggas and zebras. The following table, based on Nehring's method of determining this relation, exhibits the order of the skulls of the different races, when arranged according to size. I must remark that, in inserting the frontal width of the Anau horse I have calculated this approximately from the palatal width, which is determinable. The palatal width is to the frontal width as 10 : 21, which I obtained from a series of 20 Oriental and 10 Occidental skulls; at the same time I ascertained that this ratio is always greater in the Oriental race than in the Occidental.

Ratio of basal length to width of frontal bone.

	P. ct.
Ass from *Abadieh* (Egypt) mummified skull, 5 years, male	210
Ass from Aden (Arabia), 5 years, female	222
Horse from Iceland, after Nehring, old, male	221.7
Horse from a turbary of Tribsee, after Nehring	223
Horse from a turbary of the Somme (France)	230
Horse from Iceland, after Nehring, 9 years, male	230
Horse from Arabia, after Nehring, 5 years, male	230.7
Horse from *Anau*, 5 years	232
Horse from Gulbrandsdal (Skania), after Nehring	232.7
Equus przewalskii, after Salenski	232–244
Horse from Kalmukia, after Nehring, 4 to 5 years, male	239
Horse from *Auvernier*, Switzerland, bronze time, 6 years, female	240
Horse from Grisons (Switzerland), after Nehring, 8 years, male	241 4
Horse from Schuettarschen (Bohemia), Hallstatt iron time, old	241
Horse from Kutterschitz (Bohemia), 12 m. deep in earth, neolithic	243
Horse from Pinzgau (Tyrol), after Nehring, 10 years, male	242
Horse from diluvium of Remagen (Rhenania), after Nehring	249
Horse from Hostomitz (Bohemia), La Tène, 4 years	253
Horse from Pinzgau (Tyrol), after Frank, 9 years, male	254.6
Horse from Grisons (Switzerland), after Nehring, old, female	255

We see here that the skulls from the Somme, with a ratio of 230, stand in the same class with those of the Iceland ponies and the Anau horse, together with the Arabian horse and the smallest specimens of *Equus przewalskii*. Here, too, comes the Auvernier horse of the bronze age, and it agrees well with a Kalmuk horse of Nehring's series; but the Bohemian horses all belong to the narrow frontal class.

Nehring, in his table of this ratio finds the smallest index, on a real horse, on a Turkestan mare brought from Bushed by von Schlagenweit; her index was only 212. He calls broad-fronted all horses with indices up to 240, and narrow-fronted all above this.

Tscherski, as we have seen already in the general discussion, distinguishes also medium-fronted horses, among which he includes all with indices between 226 and 240. If we would avoid the expressions broad and narrow-fronted, it would be better, as Eichbaum has mentioned, to use the terms "dolichoprosopic" and "brachyprosopic" than "dolichocephalic" and "brachycephalic," since it is not the brain-cap but the face that varies.

The diluvial horses of Germany appear at once to have been narrow-fronted, while those of Siberia, of Tscherski, and the *Equus przewalskii* of Salenski were the medium-fronted. With these we must rank the horse of Anau, and there remains only the question as to where the horses of Solutré and Kesslerloch belong. Sanson wished to count them among the "dolichocephali;" he is, however, opposed by Fraas, who ranks them with the Würtemberg fossil horses as short-headed.

The studies of Studer* and Heschelerf† also, as regards the Swiss horses, have supplied no valuable data concerning the shape of head.

BASILAR AND PALATAL REGION.

I can not leave the discussion of the skull without touching upon Frank's proportion of the basilar-palatal region, although this dimension can neither be directly measured on the remains from Anau, nor calculated with approximate accuracy. I have determined the value of this index (which is also influenced by the ear-musculature) in discriminating between ass and horse, and I remark that Salenski as well as Nehring considers it of the greatest value; yet Nehring asserts that a real ass, *Equus tæniopus*, resembles in this respect a horse. But since this index is a weakened repetition of the ear-load and parietal-curvature indices, it is better to use the more delicate method; however this may be, a brief review of this index in our horses is given in the following table:

	From foramen magnum to vomer.		From vomer to sutura palatina.
Equus asinus from Sarepta, 5 years, after Nehring	88	:	95
Equus caballus, Exmoor pony, 15 years, after Nehring	95	:	91
Equus asinus, East Africa, after Nehring	101	:	88
Equus caballus Auvernier	102	:	100
Equus caballus Kutterschitz	103	:	94
Equus caballus Turkestan, 10 years, after Nehring	115	:	96
Equus caballus Schuettarschen, Hallstatt time	130	:	100
Diluvial horse, Remagen, after Nehring	139	:	111

*Studer, Die Tierreste aus den Pleistocaenen Ablagerungen des Schweizerbildes bei Schaffhausen. Neue Denkschriften Schweiz. Naturf., 1902. Die Knochenreste aus der Höhle zum Kesslerloch bei Thayngen, ibid., 1904.

†Hescheler. A written communication from the author from a study not yet published, received with many thanks.

Table of dimensions (in millimeters).

Skull.	*Equus asinus*, Abadieh IV Dyn., Egypt.	*Equus caballus pumpellii.*							*Equus przewalskii* Pol. No. 5212, after Salenski.	*Equus caballus robustus* Hallstatt time of Schuettarschen.
		Turbary of the Somme, France.		Pile-dwelling of Auvernier (Switzerland).	Turbary of Kutterschitz (Bohemia).	Bronze time of Hostomitz, Bohemia	Turbary of Sobrusan (Bohemia).	Alemann tomb of Königsfelden (Switzerland).		
Greatest length	449	407	....	477	543*	....	....	497*	528	560*
Basilar length	389	396	....	436	487*	....	....	453*	472	506*
Lateral length of frontal bone	....	151	170	169	185	....	157	191	....	198
Length of molars	62	59	....	67	84	79	....	72	....	81
Length of premolars	80	....	....	81	89	89	....	91	....	....
Length of diastema	54	60	....	89	....	....	....	97	....	....
Length of palate	200	189	....	233	....	....	....	267	....	....
Length of dental series of lower jaw	141	....	....	159	....	....	....	....	178	....
Length of diastema of lower jaw	58	....	....	81	....	....	....	....	74	....
Width of ascending branch of lower jaw	106	....	....	107	....	....	....	....	....	....
Greatest length of lower jaw	334	....	....	352	....	....	....	....	421	....
Length of frontal	102	173	....	197	244	210	189	225*	250	245
Greatest height of skull	118	....	....	120	....	....	116	115	246	119
Greatest height of occipital	89	85	82	85	....	....	74	89	111	110
Least height of occipital	62	60	55	57	....	....	47	52	....	62
Greatest width of occipital	106	99	102	94	....	....	89	109	114	108
Least width of occipital	60	....	....	54	....	....	49	60	....	67
Least width of frontal	71	64	70	81	84	80	74	72*	88	90
Greatest width of frontal	185	167	174	182	200	188	168	184*	202	209
Distance between interior corners of orbits	113	113	114	113	134	132	113	114*	....	143
Width of brain-skull between tempora	....	99	89	100	110	110	99	....	110	110
Width between oral ends of crista molaris	138	133	132	148	162	150	148	....	....	165
Width of corpus premaxillare	52	48	....	62	....	....	....	....	74	....
Greatest width of nasalia	90	84	....	....	110	....	90	....	....	112
Width of palate between molar 3	93	71	73	98	87	91	73	....	....	95
Width of palate before premolar 2	44	47	....	61	58	....	....	....	....	....

* Not exactly measurable.

THE BONES OF THE EXTREMITIES.

Referring to my comparative treatment of the bones of the extremities, in chapter XVIII, I will, to avoid repetition, lay stress only on such characteristics and dimensions of these bones as are of importance to our discussion; besides, I will add the tarsal and femoral bones, which were omitted in the earlier discussion. We have already noticed the marked slenderness of the *scapula* of *Equus pumpellii*, a feature which Frank* has already pointed out as a characteristic of the Arabian-Oriental horse. Particularly noteworthy in comparison with the scapulæ of the diluvial horse of Kesslerloch is the slight convexity of the contours of the bone at the collum; the edge of the articulation and the tuberculum supraglenoidale on the one hand and the squama on the other hand project very little over the straight line; this helps to produce the general impression of great slenderness. From this it is clear that the Roman horse of Vindonissa was almost as large as a recent horse of Pinzgau.

*Frank, Anatomie der Haustiere, 2 Aufl., p. 210.

Table of dimensions (in millimeters).

	Scapula.			Humerus.		Radius.		
	Length.	Width of superior part.	Width of distal part.	Length.	Distal width.	Length.	Proximal width.	Distal width.
Anau	310	120 (?)	64	....	60–68	....	65–70	56–60
Schlossberg	282	142	....	....	....	....	....	....
Kreisgruben* (after Nehring)	280	142	70	238	60	295	68	59
Fallow pony (after Nehring)	....	....	....	261	67	....	....	....
Vindonissa	360	....	95	294	81	....	....	....
Pinzgau (after Nehring)	365	189	104	....	....	....	....	....
Przewalski horse (after Salenski)	....	....	....	261	74	316	80	73
Przewalski horse (Bern)	....	....	....	....	....	276	70	67
Equus stenonis (after Major)	....	....	....	281	69–75	340	85.5	81
Westeregeln (after Nehring)	....	....	....	313	83	....	....	....
Cardamone (after Major)	....	....	....	305	84	333	91.5	81.5
La Tène	....	....	....	....	....	303	68	65
Stankowitz	....	....	....	....	....	292	70	65
Hostomitz	....	....	....	....	....	283	72	64
	....	....	....	....	....	323	74	66
Desenzano (after Major)	....	....	....	....	....	330	80	....

*Circular pits at Oldenburg, Germany, explored by Nehring.

Humerus.—Although the Anau humerus does not admit of complete measurement, it is possible to obtain from the dimensions of the distal part a certain comparison with the humeri as these are known to us from diluvial and prehistoric localities in Europe.

These figures show that the humeri of Anau, together with those of the Oldenburg-Kreisgruben and the Fallow pony often mentioned by Nehring, hold the record for smallness, while *Equus przewalskii* has, according to Salenski's measurements, a somewhat coarser humerus. *Equus stenonis* appears to agree well with *Equus przewalskii*, and the Roman horse of Vindonissa is notably larger than the Anau horse and comes nearest to the horses of Westeregeln and of Cardamone.

Radius.—As stated before, there exists no complete radius from Anau, but the quantity of perfect radii from the Bohemian localities and from Vindonissa permit us to make a very instructive comparison. Here again we see clearly that *Equus caballus pumpellii*, the horses of the Kreisgruben, the La Tène horse, and those from Stankowitz and Hostomitz are the smallest horses of the whole series, the Anau horse being probably the most slender-limbed. The second horse of Hostomitz seems to be somewhat larger, and also, according to the skull, to be a product of crossing with the large type of horse, as are also, probably, the horses of Cardamone and Desenzano and the Roman horses of Vindonissa. The *Equus przewalskii* has a radius approximately of the size of that of Anau, but stouter.

Carpus.—Of the carpal bones we have from Anau three ossa magna and one from Vindonissa. This last surpasses very significantly in size those from Anau. On the other hand, the ratio of width to length is throughout the same.

Metacarpus.—Ever since the exterior of the horse has occupied attention, a deep-reaching importance as regards value and race has been ascribed to the metacarpus and metatarsus (*os du canon* of French authors). But Kraemer was the first to explain, in a manner as plausible as it was scientific and accurate, the cause of the difference of form of these bones. According to him, the slenderness or thickness of this bone is traceable back to *mechanical* effects of use, aided naturally by nourishment and climate.* According to the view we have already developed in our special instance of the Anau horse the increasing slenderness of the bones, as the culture-strata grow in height, must be traced back to the increase of desert conditions and the use of the animal for rapid work. It is encouraging and confirmatory of our separate conceptions that our conclusions so agree, although so differently deduced.

On account of the special importance of this bone I repeat here all its dimensions in comparison with a series of other horses of European localities.

Table of dimensions.

Ossa metacarpi medii.	Length.		Width.			Diameter.			Index.
	Greatest.	Exterior side.	Proximal part.	Median.	Distal.	Proximal.	Median.	Distal.	
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	
Anau:									
−21 ft	228	220	47	29	42	31	22	32	12.8
−15 ft	....	....	....	....	41	....	....	30	....
+ 8 ft	....	....	....	31	44	....	24	32	....
+33 ft	220	....	44	27	40	30	....	28	12.3
Gross Czernosek (La Tène)	198	192	44	27	42	30	21	31	13.6
Hostomitz (bronze time)	200	191	46	29	45	30	28	34	14.5
Stankowitz (La Tène)	216	206	46	30	46	29	21	34	14.0
Couvres (?)	214	....	54	34	50	35	29	38	15 8
Curchy (?)	216	....	48	39	50	32	27	32	18.0
Louverné neolithic (?)	217	....	50	38	50	32	28	28	17.7
Cindré (paleolithic)	219	....	60	42	50	37	29	32	19.2
Fouvent (neolithic)	217	....	52	40	50	32	27	32	18.4
Equus przewalskii Salenski	215	206	48	32	44	....	....	....	14.8
Equus przewalskii juv. Bern, Kraemer	204	....	....	29	....	....	....	....	14.2
Solutré, Bern	218	211	49	35	48	33	25	36	16.0
Wohontsch a. Biela (neolithic)	220	213	49	31	46	31	21	33	14.0
Leitmeritz, A. (neolithic)	223	213	44	31	47	30	22	32	13.9
Solutré, Bern {	220	210	50	36	48	33	25	37	16.3
	224	214	50	35	47	32	23	33	15 6
Schlossberg (iron age)	222	213	49	34	49	33	27	33	15.3
Vindonissa:									
Amphitheater	226	218	47	30	43	31	21	31	13.2
Amphitheater	227	219	49	32	47	31	23	35	14.0
Castrum	228	217	50	32	47	33	23	35	14.0
Castrum	230	220	49	30	48	36	22	34	13.4
Castrum	230	220	52	32	49	33	23	35	13.4
Castrum	230	221	48	32	49	32	22	35	13.4
Westeregeln, Nehring (diluvial)	235	225	57	41	55	....	....	....	17.4
Rixdorf, Nehring (diluvial)	249	....	59	44	56	....	....	....	17.6

This comparative table shows distinctly the relation already noticed in the bones of the other extremities, that the horse of Anau agrees remarkably well with those of the European bronze age and of the later La Tene phase of the iron age. It shows, however, further, that among the horses of Solutré there occur adult

*H. Kraemer, Zur Frage der Knochenstärke der Pferde. Deutsche Landw. Tierzucht, 1904, VIII, Nos. 28 and 31.

remains (most likely young individuals like *Equus przewalskii* of Bern) which permit us to suppose a smaller size of this horse than is shown by the other bones; still, according to the index these bones are considerably larger than those of Anau and of the La Tène time. The horses of Vindonissa are notably larger than any of those mentioned, and approach throughout the heavy diluvial horse of Nehring. But *Equus przewalskii* stands, in respect to its metacarpi, in the middle, among the La Tène horses of Bohemia.

The other French subfossil horses resemble the smaller forms of the Solutré horse and *Equus caballus nehringi* of the Schlossberg as well as the Bohemian horses of neolithic age.

Femur.—For the sake of completeness we will add a brief comparison of some dimensions of the femora, although we have from Anau only distal ends of these bones, and in the specimens from Vindonissa the epiphyses are injured.

Table of dimensions (in millimeters).

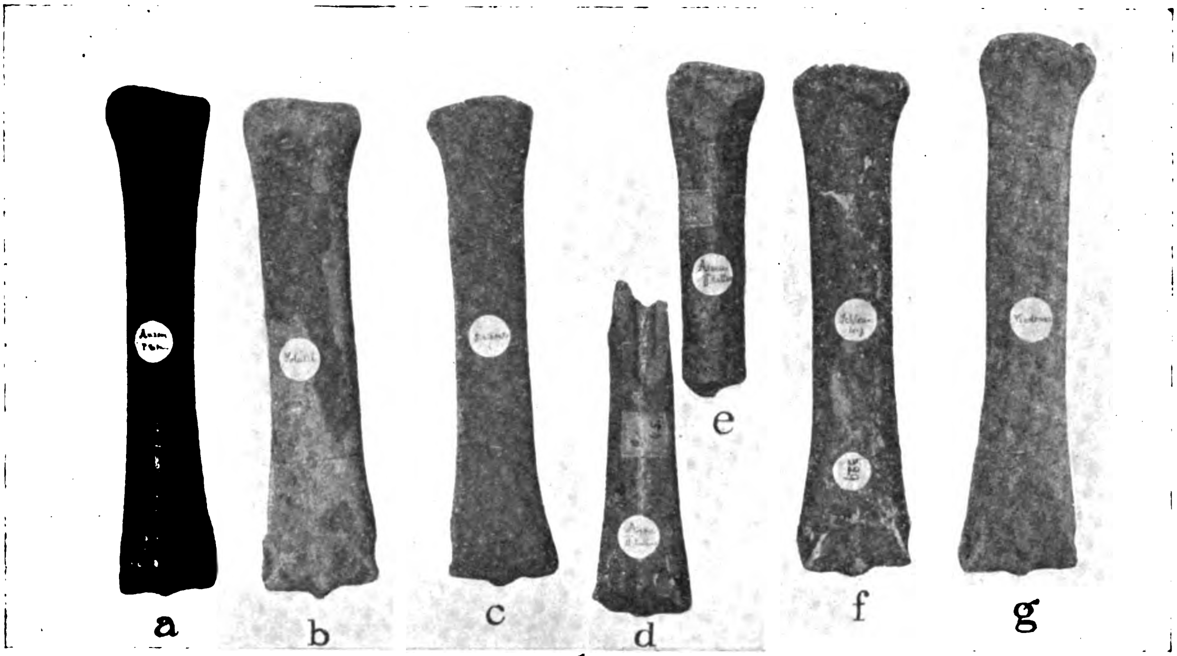
	Femur.			Tibia.		
	Distal width.	Diameter on interior condyle, after Major.	Diameter on interior condyle, after Nehring.	Length.	Proximal width.	Distal width.
Anau	76 81 77 83	43 50 46 46	102 110 105 114	305	78	63
Przewalski, Salenski {adult {young	81 80	....	118 102	325	92	65
Spandau	75	....	100	311	80	60
Equus stenonis	83	48.5	....	366 350	105 99	73 74
Cardamone	101	60	....	370	106	82
Vindonissa	85	51	112	367 372	 84	62 70
Westeregeln	108	....	112	340	103	85
Tschontschitz (turbary)*	....	....	....	282 285	70 64	50 47
Hostomitz	....	....	....	334	80	54

* Epiphysis broken off.

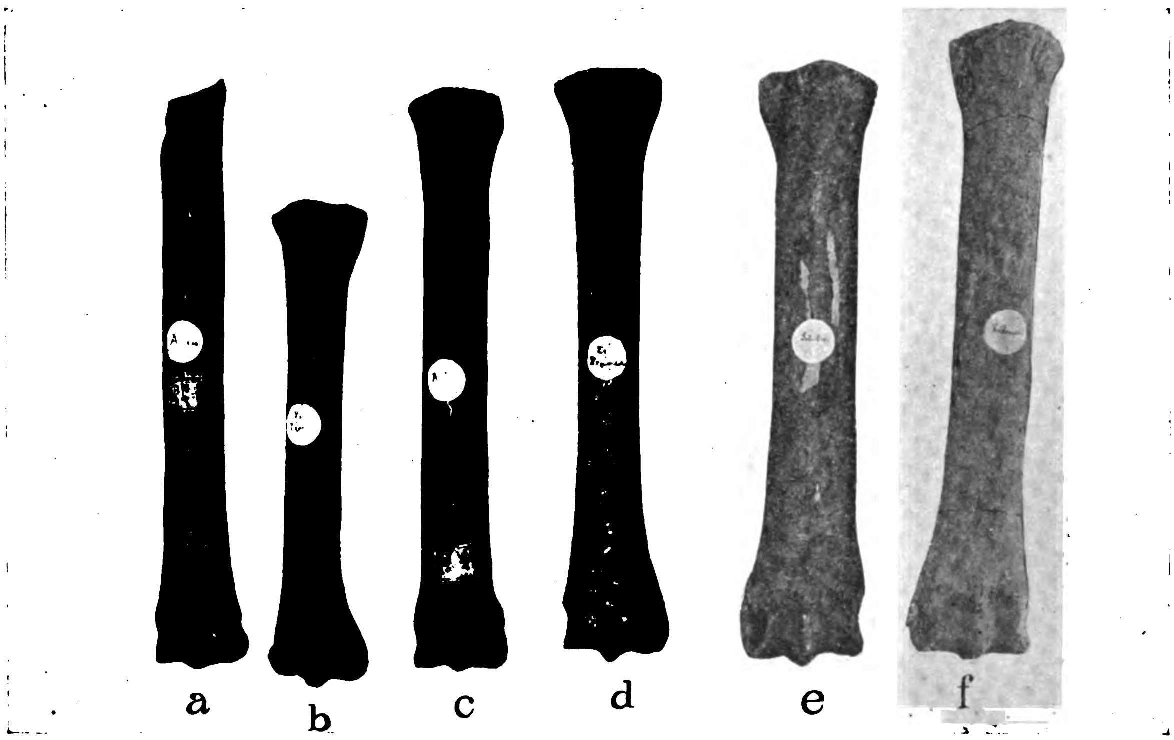
We see here, too, the above-mentioned relation of the Anau horse to the bronze-age horse and to *Equus przewalskii;* and of the Vindonissa horse to the diluvial horse. At the same time, since we have here to do with articulation, it is clear that, as stated by Kraemer,* the joints of the slender-limbed horses are relatively stouter and broader than those of other horses. This relation appears just here, since the lengths of the femora from Anau hardly exceed 300 mm. while those from Vindonissa measure 350, those from Westeregeln were about as large,† and those from Cardamone as much, indeed, as 414 mm.

We must also make some remarks in regard to the *tibiæ*, although these were considered at length in the first part of my report. The smallest of all here appear to be the tibiæ from Tschontschitz, which the turbary find seems to date from a relatively late time, probably in the bronze age. Those from Anau and Spandau

* D. Landw. Tierzucht, VIII Jahrgang, No. 28, p. 327. † Nehring, *op. cit.*, p. 134, note 3.



1



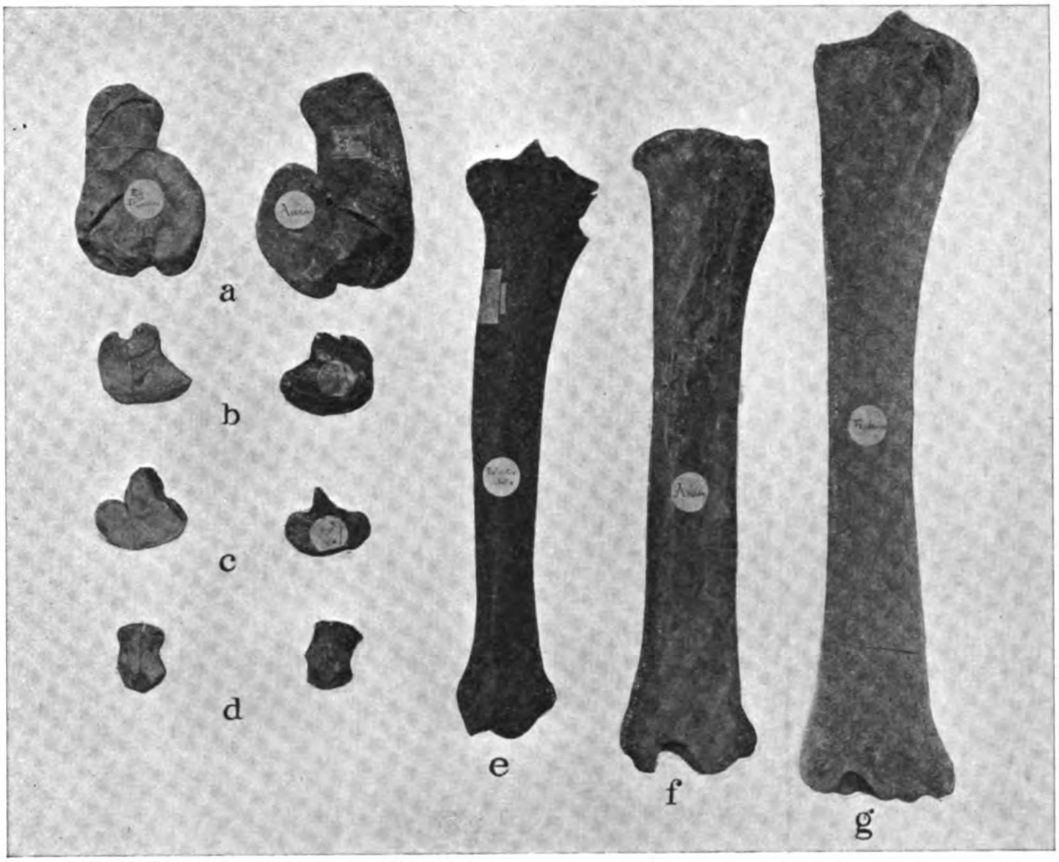
2

Comparisons of Metacarpi Medii and Metatarsi Medii, Showing Gracility and Slenderness of Anau Horse.

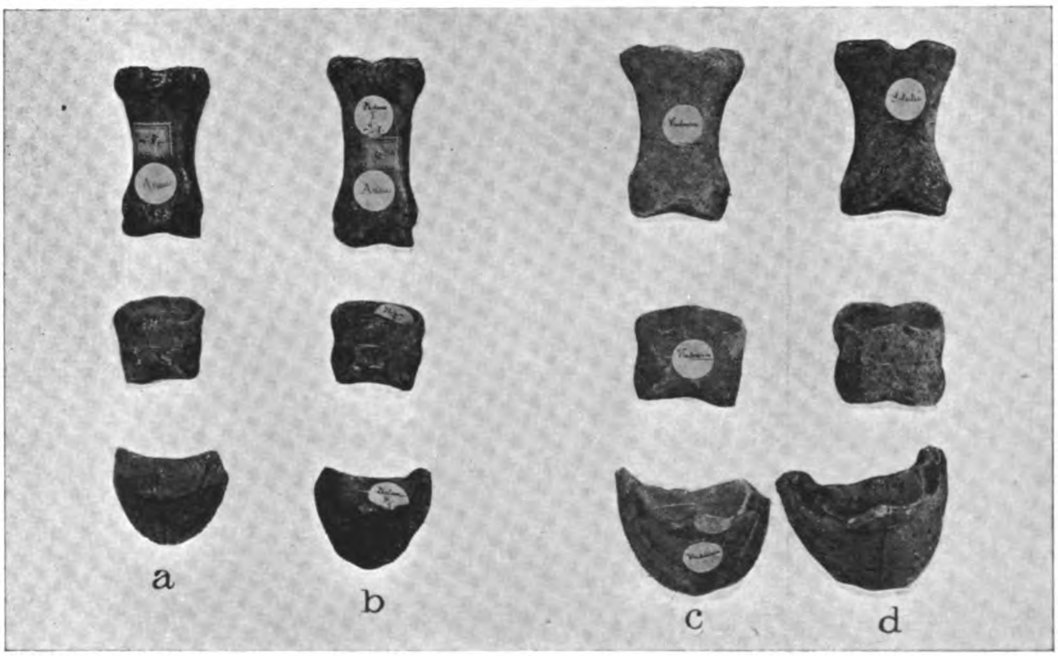
Fig. 1. *a.* **Metacarpus from first culture at Anau, showing when compared with European fossil horse on right from Solutré only a little more slenderness.**
b. **Metacarpus from Solutré.**
c. **Metacarpus of La Tène horse from Stankowitz (Bohemia).**
d **and** *e.* **Proximal and distal parts of metacarpi of Anau horse from top of North Kurgan, showing greater slenderness of bones developed during civilization of the kurgan.**
f. **Metacarpus of German pony (*Eq. caballus nehringi*) Schlossberg.**

Fig. 1. *g.* **Metacarpus of a Roman horse of the castrum of Vindonissa (Switzerland), showing much greater size of that animal.**

Fig. 2. *a.* **Metatarsus medius of higher strata of second culture at Anau, showing great slenderness.**
b. **Very small metatarsus from La Tène (Switzerland).**
c. **Larger metatarsus from first culture of Anau.**
d. **Metatarsus of *Eq. przewalskii.***
e. **Metatarsus from Solutré.**
f. **Metatarsus from Vindonissa.**



1



2

Comparisons of Extremity Bones, Showing Gracility and Slenderness of Anau Horse.

FIG. 1. *a*. Calcaneus and astragalus from *Eq. przewalskii* juv., in comparison with the same bones from Anau.
b. Os naviculare tarsi; *c*, os cuneiforme; *d*, os cuboideum, of *Eq. przewalskii* compared with same bones from Anau.
e. Tibia of small *Eq. cab. pumpellii* from a turbary at Tschontschitz (Bohemia).
f. Tibia from Anau. *g*. Tibia from Vindonissa.
2. Phalanges. *a* and *b*, the three phalanges of Anau horses. *c*. Same of horse of Vindonissa. *d*. Same of horse of Solutré.

are about alike. *Equus prezewalskii* is, according to Salenski's measurements, somewhat larger; the two tibiæ from Vindonissa, on the other hand, which are larger than those of *Equus stenonis*, are almost equal to those of the horses of Cardammone and Westeregeln.

TARSUS.

Calcaneus.—My material consists of two calcanei from Anau, one calcaneus from Hostomitz (bronze age), one calcaneus of *Equus przewalskii* juv., one calcaneus from Solutré. While Hensel* finds characteristic features only on the processus anterior, Major and Rütimeyer and Kowalewski name the articular surface for the cuboideum as the most important. As in the Pliocene horse, so in the horse of Anau the articular surface for the cuboideum is remarkably steep, in contrast with the horses of Solutré and Hostomitz. *Equus przewalskii* also does not show as steep a position of this facet. The back, narrow part of the cuboid joint, which in *Equus caballus* is often separated from the forward part, forming a facet for itself, is connected in one of the Anau horses and in the horses of Solutré and Hostomitz in the same manner as in *Equus stenonis* and Hipparion, while one of the calcanei from Anau shows a condition similar to that of the horse.

Table of dimensions (in millimeters).

Calcaneus.	Method of Major.					Method of Salenski and Nehring.	
	Length.	Length of articulation of cuboideum.	Greatest width.	Least width.	Greatest posterior width.	Greatest length.	Greatest width.
Anau	105	31	12	7	9	105	48
Anau	100	32	12	....	5	100	42
Solutré	100	33	12	5	6	....	....
Equus przewalskii	92	31	11	4	5	100*	60*
Hostomitz	100	30	11.5	4	5	....	....
Equus stenonis	108	34	11.5	6	7	....	....
Ass	107	35	12.5	....	5	....	....
Cardamone	112	37	13.5	....	9	....	....
Kesslerloch	112	....	....	....	....	112	52–54
Tarpan	....	....	....	....	....	104	57
Westeregeln	....	....	....	....	....	117	55
Spandau	....	....	....	....	....	91	38

The other articulating surface, for the astragalus, mentioned by Rütimeyer on the inner edge of the processus anterior, which latter, according to Major, is strikingly small and isolated in the ass and mule, is here large and connected with the facet lying above it. On the other hand, in the horse of Solutré it is isolated, and in that of Hostomitz extremely narrow but connected.

The measurements, which were made conformably to those of Major, confirm what is said above, and according to them a certain primitive relation must be ascribed to the horse of Anau.

Astragalus.—For the proportions of the astragalus the reader is referred to the measurements given on page 395. I repeat here only because as regards

*R. Hensel, Ueber Hipparion Mediterraneum. Abh. Kaiserl. Akad. d. Wissensch. Berlin, 1860.

Major's index of the position of the facets the horse of Anau ranks very close to *Equus stenonis* and the horse of Solutré. In the following table I give again the mean values of this dimension for the different horses:

Anau	26.0	Stenonis, after Major	32.5
Przewalski	27.0	Solutré	33.1
Asinus, after Major	28.9	Cardamone	34.0
Siberian horse, Tscherski	32.0		

In the neck of the astragalus the horses of Anau and of the Bohemian localities resemble throughout *Equus stenonis* and the recent horse. Kowalewski says that the cuboidal facet of the astragalus (which in the tridactyl ancestors of the horse was useful in transferring the weight of the body to the metatarsus externus) is very small in Hipparion and the horses and stands too steep to support the cuboideum. Moreover, Major has shown that it is still less steep in the horses than in Hipparion, but he admits that in *Equus stenonis* it is steeper in some specimens than in others. Among the Anau specimens small differences of this kind can be observed, showing that this characteristic is in a preeminent degree dependent on the individual use of the limbs.

Naviculare tarsi.—From Anau we have two specimens which were not considered in the earlier chapter. For comparison, I have only those of *Equus przewalskii* and of a recent domestic horse. In the Anau horse, the indentation in the posterior edge of the naviculare (first mentioned by Kowalewski and of which he finds the first trace in *Paleotherium medium*) is uncommonly pronounced and deep, giving the tarsus great strength. In comparing this part of the naviculare with that in *Equus przewalskii* we see that this indentation is here more round and hollowed out and not provided with so sharp-edged a notch as in the Anau horse. I find in the horses of Solutré and Kesslerloch the same condition as in *Equus przewalskii*.

We know that the posterior edge of the astragalus joint is occupied by two projections which border this indentation. In *Equus caballus* the outer one usually projects strongly and is, as already stated by Rütimeyer (p. 11), much more strongly developed than in Hipparion. In the Anau horse the outer one projects the more; but in contrast with *Equus przewalskii* and the horse of Solutré, both of the Anau specimens show it connected in an almost straight line with the inner projection, and not separated by a deep notch as in those horses. Thus *Equus pumpellii* is, in this respect, very similar to *Equus stenonis*, in which the outer projections are described by Major as equal.

The articulating surfaces for the cuneiforme I and II, which in *Equus caballus recens* are much enlarged transversely, while in Hipparion and *Equus stenonis* the fore-and-aft diameter predominates, show in *Equus pumpellii* and *przewalskii* the same relation as in *Equus stenonis*.

The articulating surfaces for the cuboideum: As Major observes, the center of gravity in the tarsus has been steadily moved forward from geological to recent time, hence the posterior articulating surfaces diminish in size and the anterior surfaces increase. The posterior one of the two existing articulating surfaces is, especially in Hipparion, much extended from above down and stands here almost erect; in *stenonis* it still touches the small facet for the calcaneus. In *Equus przewalskii* and *Equus pumpellii*, on the other hand, this articulating surface reaches only half the distance between the points mentioned, and it appears indeed still smaller in some modern horses. In the horses of Solutré and the Kesslerloch this facet is still larger than in the domestic horse. In the Anau horse the anterior facet is relatively small, but always larger than that of *Equus przewalskii* Pol.

The absolute sizes of the naviculare, cuneiforme, and cuboideum are shown in the following table:

Table of dimensions (in millimeters).

	Naviculare.		Cuneiforme.		Cuboideum.		
	Length.	Width.	Length.	Width.	Length.	Thickness of forward part.	Thickness of posterior part.
Anau	46 44	38 36	41	38	31	15	19
Equus przewalskii	46	37	43	42	31	16	19
Solutré	49	39	....	....	38†	20†	23†
Kesslerloch	50–53	39–44	48–50*	42–43*	....	....	....
Westeregeln	62	45	....	....	....	....	....
Cardamone (after Major)	....	....	....	....	40 43	22 24 5	25 23
Equus stenonis (after Major)	....	....	....	....	37 37	17.5 18	25 25
Ass (after Major)	....	....	....	....	37.5	15	21
Horse (after Major)	....	....	....	....	40.5	22	21

* After Hescheler. † After Major.

Tarsale distale tertium (cuneiforme).—Here my material is very limited. I have only one cuneiforme from Anau, and one of *Equus przewalskii*. Unfortunately the posterior edge of the Anau cuneiforme is so injured that we can say nothing in regard to the position and shape of the posterior articulation surface. Contrasting it with *Equus przewalskii* we notice the greater slenderness of the facet for the naviculare. The contraction before the forward facet of the cuboideum is much deeper than in the Przewalski horse. Likewise the lateral facets for the cuboideum and the cuneiforme I and II are much smaller and more elongated, owing to the uncommonly strong development of the surfaces of the ligamental attachment of the borders. The table indicates also that the Anau horse represents *the type of high speed more than does Equus przewalskii.*

Cuboideum.—Since the classic investigation of Rütimeyer and Major, the cuboideum is regarded as one of the most valuable and characteristic bones of the horse. According to Major, the cuboideum of the ass is quite different from that of the horse; not only is it much more slender, but the posterior part is considerably thicker than the anterior; the same may be said in comparing the horse of Solutré and *Equus stenonis* with *Equus caballus.* The table on the following page shows clearly this relation.

We see that our horse of Anau is the smallest, and our specimen is a very old individual, as is evident from the attachment surfaces for muscles and sinews, which can not be said of *Equus przewalskii.* It seems to me, therefore, that this distinction from the ass, which Major thinks he has found, stands on a very weak foundation.

Proximal part of the cuboideum.—Major states that in Hipparion the forward part of the articulation surface is similar to the posterior part; that in *Equus stenonis* the narrowest place in the forward part is equal to the widest of the posterior part; that in the Quaternary horses the forward part has somewhat increased; that in recent horses the posterior articulating surface sometimes disappears and the forward one is broadened; and that in the ass both surfaces are very narrow, the posterior being the narrower. Judging by Major's illustrations (plate VI, figs. 26, 36), our Anau horse resembles an ass in the size of the forward articulating surface, but in the posterior surface is quite like the Quaternary horse of Cardamone. In *Equus przewalskii* the forward part is wider, the posterior narrower.

Inner side of the cuboideum.—Here there is nothing to say in opposition to Major and the Anau horse is wholly like that of Cardamone.

Table of dimensions and percentages.

Cuboideum.	*Equus pumpellii.*		*Equus asinus.*		Hipparion.		*Equus przewalskii.*	
	mm.	*P. ct.*	*mm.*	*P. ct.*	*mm.*	*P. ct.*	*mm.*	*P. ct.*
Length of bone	31	100	37.5	100	30.5	100	31	100
Longitudinal diameter of facet for metatarsus medius	8	26	9	24	7	23	11	35.5
Transverse diameter of same	7	23	6.5	17.3	6.5	21	10.5	34
Longitudinal diameter of facet for metatarsus externus	17	55	15	40	17	56	20	64
Transverse diameter of same	7	23	8	21.3	9.5	31	7	23
Width on smallest part	3	..	..	..	6	..	..	..

Cuboideum.	Solutré.		Cardamone.		*Equus stenonis.*		Recent horse.	
	mm.	*P. ct.*	*mm.*	*P. ct.*	*mm.*	*P. ct.*	*mm.*	*P. ct.*
Length of bone	38	100	45	100	40.5	100	40.5	100
Longitudinal diameter of facet for metatarsus medius	12	31	14	31	12	29	16	39.5
Transverse diameter of same	10.5	27	12.5	27.7	9.5	23.4	13.5	33
Longitudinal diameter of facet for metatarsus externus	24	63	25.5	57	20	50	20.5	50
Transverse diameter of same	10	26.3	11	26.8	11	27	10.5	26
Width on smallest part	7	..	6	..	8.5	..	5	..

More important is the *distal articulation surface of the cuboideum.* The small joint for the metatarsus medius possessed by *Paleotherium minus* and Anchitherium, but enlarged in the genus Hipparion and in horses, is in the Anau horse uncommonly small, in *absolute* measurement smaller even than in the ass, and approaches wholly in dimensions the Hipparions of Mt. Léberon. This dimension is greater in *Equus przewalskii.* Nevertheless, the *relative* dimensions show that the Anau horse stands midway between *Equus asinus* and *Equus stenonis,* and that *Equus przewalskii* even surpasses the recent horses in the size of these dimensions.

While in many recent horses and in *Equus przewalskii* the forward part of the facet for the metatarsus externus is separated from the posterior part, there is no breach of continuity in *Equus pumpellii* nor in the horses of Solutré and Cardamone. The narrowest place in the articulating surface for metatarsus externus—

where the forward and back parts come together—is just as much hollowed out in the Anau horse as in *Equus stenonis*, therefore much more deepened than in the Quaternary horses and in *Equus przewalskii*. The Anau horse has, therefore, in this respect also, preserved an ancient character.

Table of dimensions.

Ossa metatarsi medii.	Greatest length.	Length of exterior side.	Width. Proximal part.	Width. Median part.	Width. Distal part.	Diameter. Proximal part.	Diameter. Median part.	Diameter. Distal part.	Index.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	
Anau – 10 ft. North Kurgan	256	250	40	27	37	38	27	30	10.5
Anau + 26 ft. North Kurgan	264	....	....	25	38	....	25	31	9.5
La Tène, Mus. Bern	214	205	41	24	40	36	20	30	11.2
La Tène, Mus. Bern	230	220	38	23	37	33	21	28	10.0
Langugest, Slavian time	234	226	40	25	42	30	23	....	10.5
Schlossberg, iron time	237	228	44	28	44	41	28	37	11.8
Spandau, bronze time	237	229	42	25	40	....	....	....	10.6
Gross Czernosek, La Tène	238	230	42	28	42	34	25	33	12.2
Vindonissa castrum	242	235	47	31	46	42	26	34	12.2
Gross Czernosek, Lausitz	246	238	46	30	45	38	27	32	11.8
Schlossberg, large breed	256	250	44	30	45	40	29	33	13.6
Equus przewalskii juv., Bern	257	250	46	25	44	39	23	33	9.0
Solutré paleolithic	258	252	50	35	51	44	32	35	11.8
Solutré paleolithic	258	247	50	35	50	44	32	38	13.5
Petersinsel, bronze time	259	250	45	27	41	27	23	32	10.4
Vindonissa circus	260	253	48	30	47	40	27	34	11.5
Equus przewalskii Salenski	262	252	49	31	47	....	....	....	11.8
Kesslerloch, paleolithic, after Hescheler	....	....	....	....	48–55	....	....	....	....
Hostomitz, iron time	268	260	45	31	48	42	31	36	11.5
Gross Czernosek, neolithic time	273	265	50	29	47	43	29	38	10.6
Schlossberg, large breed	274	260	50	33	47	43	30	38	12.0
Vindonissa circus	273	261	49	30	49	43	33	36	10.9
Westeregeln, diluvial horse, after Nehring	281	270	56	37	57	....	....	....	13.1
Remagen, diluvial horse, after Nehring	285	....	60	39	57	....	....	....	13.6

With respect not only to the metacarpi, but also to the metatarsi, the limbs of the horse of Anau appear remarkably slender and much more gracile than in the horse of La Tène and of Schlossberg. The indices show this very clearly; still, it must be remarked that the horse of Solutré, according to the metatarsi before me, is not nearly so thick-footed as the diluvial horse of Westeregeln and some of the Roman horses from Vindonissa.

Phalanges.—The abundant quantity of phalanges before me from the North Kurgan at Anau was sufficiently considered in the earlier chapter; therefore, I will give here only a comparison of the mean of all of the 29 Anau phalanges with those of the most important European horses.

In respect to their index of width the phalanges of the Anau horse are uncommonly typical. No other horse has an index of 2.8; even the La Tène horse is far from approaching it. *It is just in this uncommon slenderness of phalanx I that I see the main evidence of desert life and of training for speed*, since the Przewalski horse (3.7), and even the Turkestan horse of Nehring (3.9) show the next indices.

Table of dimensions.

Phalanx I.	Length.	Median width.	Index.
	mm.	*mm.*	
Anau	72–87	20–28	2.8–3.2
La Tène, after Marek	71–77	27–29	3.8–3.7
Gross Czernosek, La Tène time	72–73	30–31	4.1–4.2
Lignitz, neolithic	71	31	4.3
Spandau, bronze age	68	29	4.2
Kesslerloch, paleolithic, Hescheler	70–80	....	....
Solutré	77–84	34–37	4.4
Vindonissa	76–78	31–36	4.0–4.5
Briesen, Marcomannian time	80	33	4.1
Westeregeln, after Nehring	86–91	39–42	4.5–4.6
Przewalski horse	75	28	3.7
Turkestan horse, after Nehring	81	32	3.9

The variations in phalanx II can not be called particularly great. For the La Tène horse of Bohemia I find a length of 41 to 44 mm., with a width of 39 to 41 mm.; in the Anau horse the corresponding dimensions were 37 to 42 and 31 to 40 mm.; in the horses of Vindonissa, on the other hand, I find 42 to 45 mm. for length and 46 to 52 mm. for width; likewise for the Solutré horses 42 to 46 mm. for length, and 45 to 50 mm. for width. In the horses of Westeregeln these measurements may have been about 50 to 55 mm. Thus here we see again how narrow is the phalanx II of the Anau horse and how wide those of the horses of Vindonissa, Westeregeln and Solutré.

Concerning phalanx III it is to be remarked that the conditions are similar.

CALCULATED SIZES OF THE HORSES.

As final characteristic we may here once more tabulate the calculated absolute height of the horses (withers-height).

	cm.
Diluvial horse, Westeregeln, after Nehring	155
Equus przewalskii, 10 years old, stallion, after Grum-Grshimailo	153
Diluvial horse, Remagen	151
Siberian horse, Yana River, after Tscherski	146
Schlossberg (large breed)	146
Vindonissa	145
La Tène, after Marek	141
Auvernier, after Marek	138
ANAU, *Equus caballus pumpellii*	137
Ziel Canal (bronze time)	136
Equus przewalskii, adult stallion, after Salenski	128
Solutré, after Gaillard	125
Equus przewalskii, young mare of Tsarski-selo, after Salenski	120
Schlossberg, small breed	118

No direct measurements have been made of the withers-height of *Equus przewalskii*, except on the young mare; in the other instances only the height of the croup has been measured. But Salenski gives for the same mare the croup-height of 116 cm., that is, 4 cm. less than the measured withers-height; I have, therefore, calculated on this basis an approximative withers-height for the two stallions, for which we had already the croup-heights of 147 and 124 cm. respectively. In doing this I consider that a centimeter can make little difference if we wish only to learn the approximate ranking of the horses among themselves,

CONCLUSIONS.

To present, free from subjective influence, not only the methods of investigation, but also the inferences; that is, to build objectively and scientifically, I apply here the known system of points, thus avoiding bias by some pronounced characteristic and premature or wrong conclusions through neglect of other important points. The plan is as follows: The questions which are of especial interest are listed and each one considered with regard to each characteristic treated in this investigation. Where there is absolute agreement, the highest degree of positive answer to the question, a value of 10 points is assigned, which decreases by units to 0 for a directly negative answer. Adding the points obtained and dividing by the number of answers, the result is an objective answer to the question and as accurate as the accidents of the find and a comparison of the material investigated will permit. The questions which we will here present are eight in number.

1. How does the horse of Anau agree with that of the late neolithic and bronze ages and the La Tène time, with the exception of the Schlossberg horse?
2. How does the Anau horse agree with those of Solutré, Kesslerloch and of the paleolithic and early-neolithic localities of Italy and France?
3. How does the horse of Vindonissa compare with these?
4. What relation do these paleolithic and neolithic horses bear to those of Westeregeln and Thiede of the North German lowland?
5. How does the Anau horse agree with *Equus przewalskii* Poljakoff?
6. How do the above-mentioned horses of Solutré, etc., stand in relation to *Equus przewalskii*.
7. How do the Bronze and La Tène horses stand in relation to the Anau horse?
8. How does the horse of Anau compare with that of the Schlossberg?

The answers yield the following:

	Question—							
	1	2	3	4	5	6	7	8
1. Dentition	5	5	5	5	8	7	8	5
2. Skull and indices	8	....	....	4	9	....	8	....
3. Scapula	6	....	....	....	....	....	....	6
4. Humerus	6	....	....	8	....	....	7	....
5. Radius	8	....	10	6	....	....	6	....
6. Metacarpus	8	4	9	8	7	10	8	4
7. Femur	10	5	5	9	9	6	8	....
8. Tibia	9	2	10	8	8	6	8	....
9. Tarsalia	....	6	....	8	9	7	....	....
10. Metatarsus	9	7	10	7	7	6	10	9
11. Phalanges	8	4	9	8	8	5	8	....
12. Size	10	9	8	7	9	8	8	8
Total	87	42	66	78	74	55	79	32
Resulting answer =	8.0	5.2	8.2	7.1	8.2	6.8	7.9	6.4

These results are, therefore, to be expressed in the following manner:

1. From our foregoing investigation it follows with the greatest certainty that the Roman horse of Vindonissa was a horse of the size and shape of those of Solutré, Kesslerloch, Cardamone, Arezzo, Devenzano, etc., and it was apparently closely related to these animals, since only very slight osteological differences can be recognized.

2. With equal certainty it follows that the Anau horse is ancestrally closely related to the *Equus przewalskii* Poljakoff. The difference is chiefly in the more slender form of the limbs of the Anau horse.

3. With similar certainty it is ascertained that the Anau horse is closely connected with the small horse which appears on the scene in Europe in the late-neolithic and bronze ages and in the La Tène period, and has a wide distribution.

4. As a consequence, it is probable that the Przewalski horse stands, presumably through the Anau horse, in close relationship with that of La Tène, etc.

5. The relationship and similarity, however, of the southern, Italian, French, and Swiss paleolithic and early-neolithic horses to the North German horse are slighter, chiefly because of the greater size and the stouter, heavier build of the latter.

6. Thus the horses of Solutré, etc., notwithstanding their ancestral relationship, stand more distantly removed from *Equus przewalskii* than from the North German diluvial horse, naturally because of their geographical distribution.

7. The horses of the Schlossberg, especially on account of their stouter limbs, do not stand in as close a relationship to the Anau horse as do the La Tène horses.

8. The horse of Anau agrees still less with that of Solutré and Kesslerloch, and though there exists a resemblance this is much slighter than to *Equus przewalskii*.

These, therefore, are the theses on which we will now base our conclusions.

THE TERTIARY HORSES OF EUROPE.

If, following the assertion of the always cautious Tscherski, we look upon *Equus stenonis* Cocchi as the precursor of the diluvial horse of Southern Europe, which agrees on one side with the diluvial horse of Siberia, and on the other side with that of Remagen and Westeregeln (that is, with *Equus caballus fossilis robustus seu germanicus* Nehring); and if we consider the other varieties of diluvial horses: *Equus spelæus*, varieties A and B, and *Equus plicidens* Owen, *Equus piscinensis* Gervais, *Equus quaggoides* F. Major (formerly called *intermedius*), *Equus stenonis affinis* Woldrich and *Equus quaggoides affinis* of the same author,* all of which will perhaps disappear some day, before a more far-seeing and more scientific criticism, based on more abundant and better preserved material, we must assume the existence during Pliocene and Pleistocene times, on the whole Eurasiatic continent of *only one* type of wild horse, which without doubt was differentiated into many local varieties or species, according to hairiness and color, size and shape, which (and I emphasize this) we can not determine with certainty by osteological and paleontological methods. As Major already insists, *Equus stenonis* Cocchi agreed absolutely in type with the horses of the uppermost Miocene of the Sivalik Hills and Narbada Valley of India—*Equus sivalensis* and *namadicus* Falconer and Cautley. It can, therefore, be assumed at once that *Equus przewalskii* Poljakoff stands as the last representative of that Tertiary and Quaternary horse, although Salenski would await more abundant data concerning *Equus przewalskii* before reaching such a conclusion. I hardly believe that, reasoning from osteological data, and this is here the only applicable method, more can ever be said than we have here indicated. Notwithstanding conclusion No. 6, which does not exclude it, I would state that *Equus przewalskii*, in the examples published by Salenski and Noack,

*Woldrich, Beiträge z. Fauna d. Breccien u. a. Diluvialgebilde Oesterreichs, etc. Jahrb. k. k. Geolog. Reichsanstalt, Wien, 1882, Bd. 32, pp. 435–470.

harmonizes best with the diluvial horse of Solutré, while the larger animal, published by Grum-Grshimailo, inclines rather towards the Siberian diluvial horses of Tscherski and those of Nehring, both of which lived on succulent pastures of the loess-steppes. Indeed I state decidedly that, from among a somewhat comprehensive collection of bones from Solutré, one can choose at pleasure bones wholly identical with those of specimens of *Equus przewalskii*.

The disappearance of the tundras and loess-steppes of North Germany, as Nehring particularizes, caused the disappearance of at least the greater part of the wild horses, while those that remained had henceforth to adapt themselves to forest life. After this change we find, in the paleolithic and neolithic localities, remains of horses which, without having lost the broad, strong forms of the diluvial horse, show a diminution in size of the race. I recall here the metacarpi and metatarsi of the Bohemian localities (Wohontsch and Leitmeritz) and of the French (Couvres, Curchy, Louverné, Cindré, Fouvent). Not until the latest neolithic age, the copper and bronze stages of the bronze age, and the iron time, do we meet with the characteristic slender bones of the horse in the Bohemian as well as in the Swiss, French, and German (Spandau) localities. As much as the horses of Wohontsch, Leitmeritz, Cindré, Fouvent, etc., agree with the Schlossberg horse of the ancient Germans, so much do the bones of the animals of this new La Tène race resemble those of the horse of Anau, or *Equus caballus pumpellii*.

In Anau, however, before the founding of the Anau culture, that is, during the paleolithic or latest early-neolithic culture of Europe, a horse lived on the *loess-steppes*, as shown by R. Pumpelly,* probably the same horse as that described. But we see how, during the existence of the two North Kurgan cultures at Anau, it became gradually more gracile and slender-limbed. The growing desert of Transcaspia, acting through changing nourishment and especially through the mechanical action of increased motion and adaptation to oasis life—as in all desert animals—created the extremely slender-limbed horse, which so preeminently embodies in its limbs Frank's Oriental race.

Should not importance be conceded in Europe, too, to the climatic and physiographic conditions which had such deep-reaching influence in Anau? Do we not see the action of fundamental climatic and physiographic conditions in the fact that the home of the modern heaviest horses is the whole of the North German, Belgian, northern French, and English lowlands not very far from the sea; and that, except in some more southern localities with deep rich soil and extensive farming (Lombardy) nowhere else in the world have they succeeded in producing a heavy horse? I certainly believe it. The natural surroundings that condition the growth of horses and of their bones were active then as now.

After the eminent investigations of Kraemer on the hollow bones of the horse, I have become convinced that the small-boned horse of the bronze age and La Tène time could not have been formed in the boundless primeval forests that grew up in Europe after the disappearance of the steppe vegetation, for we know that just these physiographic changes, by restricting the freedom of motion, thicken the extremities. Hence, it follows necessarily that this small, slender-limbed horse must have been *imported*. But whence?

*Pumpelly, Raphael, Interdependent Evolution of Oases and Civilizations, Presidential Address before the Geol. Soc. of America, 1905. Bull. Geol. Soc. Amer., vol. 17, pp. 55, 56.

Here we are enlightened by our thesis 3, which points out the close family connection with the horse of Anau. The horse of the bronze age and iron age of Europe must have been imported directly or indirectly from Anau. Interesting and confirmatory is the appearance of the shepherd-dog, *Canis matris optimæ*, in the finds of the same ages in Bohemia and of Europe in general—the dog of whose occurrence in Anau we have spoken in an earlier chapter. The people who brought the horse of the bronze age to Europe were undoubtedly accompanied by the shepherd-dog. Therefore, I no longer hesitate to give to the horse of the bronze age and early iron time of Europe the name that is its due, *Equus caballus pumpellii*.

Coming now to *Equus caballus nehringi*, the small, stout horse of the ancient Germans, our thesis 7 proves that its agreement with the Anau horse is not very marked, less so indeed than that of *Equus caballus pumpellii* with the horse of Solutré, etc. I believe also that, considering the experiences of modern breeders in crossing Oriental and Occidental blood, we can assume that we have here not a cross of the German horse with that of the Gauls, that is, with *Equus caballus pumpellii*, for otherwise the Oriental blood would have struck through and have found expression in gracile bones, of which we have evidence only in the configuration of Gallic horses, concerning which Cæsar says (Bell. Gall., IV, 2) that they were considered to be better than those of the Germans, since they were improved by costly, imported horses of noble breed. This improvement probably consisted in an increase in size. At least the Roman horses of Vindonissa point in that direction, for, as pointed out by Kraemer,* we find in Vindonissa a larger horse than those of the ancient Germans and Helveto-Gauls. It is found both in the amphitheater—where it might have been wild—and in very great numbers in the talus of refuse below the castrum, where it may well represent the remains of the horse of the Roman cavalry. The bones of this horse of the size of that of Cardamone, Arezzo, Devenzano, and of the larger ones of Solutré, point, through their texture and relative slenderness, to an admixture of foreign blood; indeed the occurrence of a series of small bones shows the contemporaneous presence of the bronze-age horse—*Equus caballus pumpellii*. It seems, then, very probable that it is this horse that was used by the Gauls in their ennobling experiments, for that the Romans could have brought it with the legions from Italy to Vindonissa is shown by the fact that camels too were used in the amphitheater, whose origin can not possibly be sought in Helvetia. Cæsar says (Bell. Gall., VII, 65) that he gave Roman horses—the best he had—to his German soldiers, who were good riders but had bad horses.

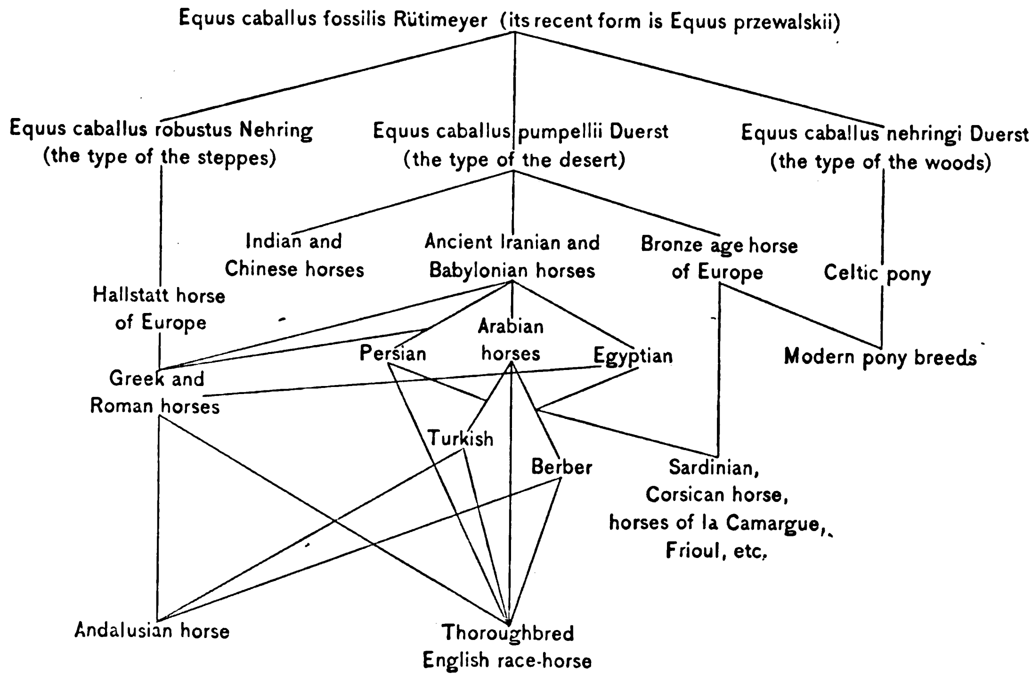
The *Equus caballus nehringi* must be regarded as the autochthonous *forest type* of the wild horse, originating in the primeval forests of Germany; surviving from the previous steppe-conditions, and becoming stunted in the forest period, to be at last, under the coercion and privations of severe winter life in the forest, brought by man under domestication, as was the Anau horse through the growth of desert conditions. I have already spoken in some detail† of the manner in

* Die Haustierfunde von Vindonissa, pp. 264–266.
†Tierzucht, Tierkult und Kulturgeschichte. Vortrag. Abstract in Neue Züricher Zeitung, Feb., 1907.

which I imagine this domestication to have been brought about and I shall treat of it again later.

That this horse did not descend from the Anau horse, which was trained for speed, is already shown in the remarks of Cæsar (Bell. Gall., IV, 2), Tacitus (German., 6), and Appianus (d. r. Celt., 3), that the native horses, which were badly shaped, not well-set and not fast, but of great powers of endurance through daily strain, and in emergencies contented with the bark of trees, were nevertheless preferred by the Germans to those imported.

Already Modi* has said that speed was the characteristic in a horse that impressed most an ancient Iranian. He, therefore, in common with his *Aryan* brothers, named this swiftest of the animals "aspa" from the old Aryan root "aç" (to go rapidly). The word means one who goes rapidly. It seems that the speed of the horse was the cause which connected horse-racing with the festivals in honor of Mithras, the god of light. The primitive ancient Iranian, being much exposed to influences of Nature and coming into greater contact with Nature, began to clothe the greatest of Nature's objects with the ideas most common to him on the surface of the earth. Just as he saw his swift horse cover long distances in a short time, he saw the sun go over the immense vault of heaven in a short time. So he called the sun, in his Avesta, by the name of "Aurvat-aspa"—the swift-horsed.



Thus, then, is the horse of Anau the first fleet, the first desert, the first oriental domestic horse; and his genealogy, as well as his connection with the other European horses is shown instructively in the above diagram.

*Modi, Jivanji Jamshedji, The horse in Ancient Iran. Journ. Anthropolog. Soc. Bombay, vol. IV, No. 1, p. 5, 1895.

CHAPTER XX.—CONCLUDING REMARKS.

We have reached the end of our discussion, in which we have examined methodically and objectively the fragmentary remains which the cookery and the teeth of the ancient Anau-li have allowed to descend to our times. In considering each animal we have drawn our conclusions with all possible moderation in order that they may stand the test of future discoveries. We have kept a firm rein on our imagination, which might be easily excited by contact with the primitive remains of so remotely ancient a culture in a region which one is accustomed to look upon as the cradle of the human race. It was a saying of my honored teacher, Albert Gaudry, that the eye and the spirit of a poet were essential to the paleontologist. Perhaps, then, I may be permitted to review the history of the domesticated animals of ancient Anau and clothe them in the dress of a comparative representation of the breeding of animals at the present day in Central Asia.

The modern stock-raising of Transcaspia* is carried on principally in a nomadic manner, partly by natives who live as nomads throughout the whole year, and partly by those who also cultivate the soil, moving their herds on to the steppe only after the harvest.

In consequence of the hot climate the grass of the steppes begins to dry up in the second half of April, only the kolutschka, which is liked by the camels, and similar deep-rooted plants remaining. The dried steppe is exposed to fires, which often devastate immense areas. Besides this, the pasturing is often limited by the prevailing lack of water. Rivers are almost wholly wanting; even wells are rare, and then, for the most part, very deep and often yielding only bad water. In this respect the sand deserts are better off than the loess-steppes, since in the depressions between the dunes it is not unusual to find good water at a slight depth below the surface, especially in those places where the desert borders on the lower part of the oases. These places form the most desirable pasturage in midsummer and winter.

However, the grazing areas of Turkestan, taken in the aggregate, are so large that even at the present time stock-raising forms a very important part of the industry of the land. The official statistics estimate the number of animals on the first of January, 1903:

Horses	142,285	Sheep	2,948,118
Camels	217,049	Goats	318,360
Cattle	37,996	Asses	12,253

In all probability these figures are far below the truth. They give, however, a good picture of the relative abundance of the different animals.

By far the most important occupation is that of sheep-breeding, which is best adapted to the utilization of the scanty pasturage.

*Cf. Auhagen, Die Landwirtschaft in Transkaspien. Berlin, 1905.

The breeding of camels, in the domestic economy of the Turkomans, furnishes principally milk and wool; the flesh is not willingly eaten. The principal use of the camel is for the transportation of goods, but among agricultural natives it aids also in field-work.

The breeding of asses stands in connection with that of the camel, since in the shorter journeys the leader of the caravan is always mounted upon an ass, whose short trot adapts it to the pace of the train.

The breeding of horses lies mostly in the hands of the Kirghiz of the Manghishlak district. Their small animals, gifted with great powers of endurance, are kept on the steppe in herds through the whole year and form among these people an important object of commerce. The Turkoman, on the other hand, breeds rather for his own use than for sale. The Turkoman horse is also much taller and more noble than that of the Kirghiz and, therefore, requires more careful treatment.

Fig. 492.—Natives Mounted on Cattle and Horses. From the Badminton Magazine.

Under the conditions in which the Turkomans formerly lived the possession of an enduring fast horse was of great importance, for on it depended the success of the alamans or the slave-hunting raids in Persia. Since the Russian conquest put an end to this, horse-breeding has fallen to a great extent. It is preserved only from complete decay by the passionate love of the Turkoman for very fast riding and for organized races.

The least position in the animal industries of Transcaspia is occupied by cattle-breeding, which under the existing climatic conditions is not adapted to the nomadic life. In the agricultural oases, also, cattle are bred only to a small extent, and principally to produce work-animals (fig. 492). The use of beef is avoided by the Mohammedans. The care extended to the cattle is most defective. It is only in winters abounding in snow that they receive sufficient fodder to barely protect them from starvation. At other times they are dependent wholly upon the scanty pasturage. It is no wonder, therefore, that the Turkoman cattle are unusually small and yield very little milk. How entirely different from the animal breeding of to-day in that region was that which the bone-remains of ancient Anau indicate!

At the time when the lowest layers of the North Kurgan at Anau were formed man lived in this region entirely without domestic animals. The mighty wild ox (*Bos namadicus* Falconer & Cautley), and the small wild horse—possibly in the form that Wilckens thought he discovered among the finds of Maragha in Persia, or in that of *Equus przewalskii*—roamed on the steppes and the oases of the Kara Kum desert and sought shelter in the forest which probably then occupied the valleys and slopes of the Kopet Dagh. There lived, too, the large-horned wild sheep (*Ovis vignei arkal* Lydekker) and the gazelle (*Gazella subgutturosa* Gueldenstedt).

From the absence of all stone weapons in the oldest period, we may conclude that man lived on a friendly footing with these animals and that he could gain possession of them only by depriving the wolves of their prey or by the use of fire-hardened wooden weapons. The absence of weapons among the primitive Anau-li presents an actual condition such as that which forms the basis of the very plausible theory of the domestication advanced by R. Mucke.* It would be guesswork to attempt to picture the method of domestication, and to assume with Mucke that the wild horse, the wild sheep, and the wild ox voluntarily (or compelled by the necessity of food from outside the oasis) approached human dwellings to graze on the weeds and other plants and so were gradually brought into companionship with man, who then assumed the care of their nourishment. We know only that after the accumulation of the lowest 10 feet of the strata in the North Kurgan this same ox occurs in an almost equally large, but certainly a domesticated form, becoming more and more frequent in the higher strata, when the horse and the sheep also pass over into the domesticated condition. It seems probable, however, that little use was made of the milk of the cattle and that they were used for riding and as working animals, as is the case to-day.

In the −8-foot layer, *i. e.*, 12 feet from the bottom, there appears the pig, of which we had no trace in the lower layers. Was it a domesticated pig or the wild *Sus vittatus*? This can not be determined with certainty. In any event it was the same animal, and the breeding of swine was actively followed by the Anau-li into the metal period, whereas at present it is entirely wanting among the Mohammedan population.

In this remote period also the breeding of sheep, which to-day forms the principal part of the Turkoman's animal industry, began to be developed. The first remains of the domesticated sheep that we find point to an unusually heavy and stout-horned form, which, in the earlier layers, is very closely related to the wild sheep of the Kopet Dagh. Gradually the horns of this sheep became smaller and smaller and there arose that form which has been designated as "turbary

*R. Mucke, Urgeschichte des Ackerbaues u. der Viehzucht. Greifswald, 1898.

sheep." With the metal period there appear hornless sheep; but whether this was a new race which was imported with the metals can not be determined with absolute certainty. The long-tailed sheep living to-day in the Anau district is not always horned. At all events, the breeding of sheep began very early and increased as long as we were able to follow it.

Connected with this breeding is the appearance of the shepherd-dog (*Canis familiaris matris optimæ*) during this second culture. It was possibly derived from the small Russian wild dog (*Canis poutiatini* of Studer) or from the dingo. In Europe this form of dog occurs first in the bronze age, but very much later than in Anau.

Thus the animal industry of Anau shows, in the second half of the first culture period, a very considerable breeding of cattle and horses; a less-developed, because just beginning, breeding of sheep; and a still less-developed breeding of swine.

The second culture of the North Kurgan, however, shows a shifting of the conditions. New domesticated races appear suddenly, pointing to external communications, either as a result of hostile immigration or of friendly exchange. There is still represented the ox—which through bad nourishment has diminished in size—as well as the horse, the sheep, and the swine, but now there appear among the herds of the Anau-li the high-legged, long-necked camel, the hornless sheep, and the short-horned goat.

During this period the breeding of sheep and swine has increased while that of the horses is unchanged, and that of the cattle has diminished. This is probably due to the fact that the newly imported camel, under changed climatic conditions, was better adapted to, and performed more contentedly, the duties of milk and work animal. The animal industry of the region of Anau at this period seems to approach more closely to the character of that of modern Turkestan, especially when one considers that in the course of centuries, under the influence of the changed religious observances, the breeding of swine and cattle has been still more suppressed.

The cattle industry of the æneolithic or first culture of Anau was, however, different from that of to-day. The climate, too, was probably not as unfavorable as it now is. The animal industry of the second culture or first copper age approaches modern conditions and the races of domestic animals have very likely remained the same. The paralleling of these living races with the subfossil remains and their exact comparison can not be undertaken in this memoir because of the lack of material, but it is to be hoped that it will be made possible through a continuation of the study of bone remains from Turkestan.

Mucke* in his theory of domestication contends that domestication could not have been accomplished by a people in the hunting stage, but only by a primitive people who did not make use of weapons against the animals. This would agree quite well with the conditions at Anau. If, however, we do not consider the Anau-li unqualifiedly as the direct domesticators and breeders of the domestic animals, this is because, according to Mucke, the essential basis of breeding is the possession

*Mucke, J. R., Urgeschichte d. Ackerbaues u. d. Viehzucht, p. 256. Greifswald, 1898.

of inclosures. Mucke assumes, further, that in primeval times breeders of cattle and cultivators of the soil lived separately, but that gradually there occurred warfare and amalgamations in which the restless nomadic cattle-breeders became the representatives of civilization and progress.

In starting from this hypothesis, we are met with the question whether the Anau-li of the oldest culture-strata were already cultivators of the soil and found themselves under the necessity of using and regulating the watercourses of the Kopet Dagh; and whether the need of a larger working force led to the founding of some kind of polity, as happened on a larger and more civilized scale in the control of the inundations of the Euphrates and of the Nile. I infer from the communications of Professor Pumpelly that a decisive answer to the latter part of this question is not yet possible, but that they were already agriculturists who, according to Professor Schellenberg's determinations, raised wheat and two-eared barley. Since they were clearly cultivators of the soil, we are, according to Mucke, not justified in assuming that the Anau-li were the people who first effected the domestication, however plausible and probable this seems from the bones found in the culture-strata.

One might, however, admit that a tribe of real nomadic cattle-breeders—who, like the modern Turkoman or Kirghiz, lived in round *kibitkas* or *yurts*—may have domesticated the wild animals living in the neighborhood of Anau, and that the settled agricultural Anau-li obtained the domesticated animals from the nomads and continued the breeding.

It is clear that these unknown cattle-breeders did not possess stone weapons, since these would have been adopted by the Anau-li, who did not possess arrow-points or spear-heads of stone, nor stone axes. Therefore, these cattle-breeders, even if, according to Mucke's theory, they were a separate people, could not have come to Anau from any wider culture-sphere than that of Western Turkestan and the Iranian highlands, which, according to Professor Pumpelly, was so sharply limited and shut off from the rest of the world.

But a closer consideration of Mucke's hypothesis seems to show an important contradiction: Mucke insists that a hunting people could never become cattle-breeders, and we must admit after his own explanation of the process of domestication that the people who domesticated the ruminants must have cultivated the soil. Mucke says that the wild animals, in want of food, came spontaneously to the round dwellings of the men. Therefore, these people must have cultivated plants and harvested them; for ruminants like the ox and sheep would not, like dogs, be attracted by meat or other products of a hunting or fishing life. Consequently, the agricultural state of human development must also have preceded the state of cattle-breeders, but through the accomplished domestication of ruminants men obtained freedom of motion for traveling with cattle after good pasture and commenced a nomadic life. This must be the real explanation of the origin of the wandering peoples, which Mucke can not explain, and he consequently considers *a priori* that nomadic peoples were nomads before the domestication of cattle. Among the Turkomans of to-day occur also cultivators of the soil and breeders of cattle designated as Tschomru and Tshorwa, who intermarry and whose children choose either the life of nomads or of farmers.

If breeders of cattle or cultivators of the soil lived separated in primeval times, it is certain that there was no opportunity to adopt a nomadic life unless animals who supplied food had already been domesticated. Consequently, the first domestication of cattle must have been made—in my opinion—by a settled agricultural people such as the ancient Anau-li were. Hence, either Mucke's theory does not satisfy the requirements, and a settled agricultural people was able to effect domestication; or if nomads wandering from oasis to oasis, from plateau to plateau, were able to accomplish this, then it is certain that this people came from within the local sphere of culture of Anau. That the sphere of Anau's intercourse widened later and was brought by nomadic tribes into relations with other spheres—perhaps the Indian—is shown, aside from the importation of metals, by the sudden appearance of *Canis familiaris matris optimæ*, the shepherd-dog of the European bronze period, as well as by that of the camel and the goat—animals which arrived during the æneolithic period of Anau's culture II, between 6000 and 5100 B. C.

Until this time, therefore, the Turkestan-Iranian sphere of culture remained free from foreign influences, and the domestic animals—whether tamed by the settled Anau-li or by nomadic neighbors—were autochthonous products. This is the essential point. For this reason, as far as the theory of the descent of the domesticated animals is concerned, it matters little whether domestication was effected by the settled Anau-li or by their nomadic neighbors. The most important point for us now is the fact already noted, that the climatic and physiographic conditions at Anau facilitated the domestication of the wild animals, which sought refuge on the oases during the dry time before the foundation of the settlement. Another very probable change to aridity took place at the end of culture I, possibly initiating a migration westward of the nomadic cattle-breeders, accompanied perhaps by some cultivators of the soil, who, passing through the Caucasus, brought the domestic animals of Anau to Europe.

What influence the climatic and physiographic conditions exercised upon the fauna of Anau is made very clear by the following combination of the relations of the approximate ratio of distribution, mentioned before on pages 341, 342.

Culture I*a*, the lowest 8 feet of culture-strata, extending down to 7800 B. C., contains: Cattle, 27 per cent; sheep, 22 per cent; horse, 20 per cent; gazelle, 20 per cent; wolf, 11 per cent. The bovines keep the principal place, and by the same percentage of occurrence of the horse and gazelle the opinion can be intimated that the horse here occurs in a wild state like the antelope.

The following period, the æneolithic culture, from 7800 to 6000 B. C., shows us a very changed relation: Horse, 28 per cent; cattle, 25 per cent; sheep, 25 per cent; pig, 12 per cent; gazelle, 7 per cent; fox, 2 per cent; deer, 1 per cent. The horse forms now the most important stock, and this would seem to indicate that the people had become in part nomads, as I mentioned in my hypothesis in opposition to Mucke's.

The next period (culture II, North Kurgan) shows how the sheep predominates still more and more among the other animals: Sheep, 25 per cent; cattle, 20 per cent; horse, 20 per cent; pig, 15 per cent; goat, 10 per cent; camel, 5 per cent; dog, 2 per cent; gazelle, 2 per cent; other wild animals, 1 per cent. This development, increased by the progress of the aridity of Turkestan, reached its point of culmination in the relations of the figures shown by census of 1903: Sheep, 80 per cent; goat, 8 per cent; camel, 7 per cent; horse, 4 per cent; cattle, 0.1 per cent.

Never have figures spoken clearer! The agriculture and pasture of the ancient times is gone. The large animals which want much food for their support, like cattle and the horse, can not be kept; only the sheep accommodates itself well to the dryness of the climate, and so forms nearly the entire part of the domestic animals of Turkestan. The later importations from the south, as the goat and the camel, continued to be useful down to the modern inhabitants. Certainly the physiographic changes were one of the primeval causes of the frequent emigrations to Europe or Southern Asia undertaken by the cattle-breeding nomads of ancient Turkestan. It is clear that the establishment of a genetic relationship between the domestic animals of Turkestan and those of Europe is especially important, and I consider that the appearance at Anau of the long-tailed *Ovis aries palustris* is of the greatest importance in this connection.

According to Professor Pumpelly's stratigraphic chronology, which is without doubt the most exact prehistoric chronological table that we possess, the 20 feet of culture-stratum at the base of the North Kurgan dates from the latter half of the IX millennium (8250) B. C. The turbary sheep (*Ovis aries palustris*) attained its full development 6250 B. C., while we find the large-horned transitional form from *Ovis vignei arkal* about 7000 B. C. Therefore, a migration, which, leaving Turkestan between the VI and VII millenniums B. C., penetrated Western Europe, might have taken with it this sheep as well as *Sus palustris* (the turbary pig) and the long-horned cattle. It follows that the turbary sheep could not have arrived in Europe earlier than in the VII millennium B. C., and since we find its remains in the oldest lake-dwellings and early neolithic stations of Central Europe, these can not be of greater age. In passing through the Caucasus and Southern Russia these emigrants may have adopted and brought to Europe the small dog, *Canis familiaris palustris*, which had possibly been domesticated by a hunter tribe. Further on we will consider the small turbary cattle (Torfrind) which they brought with them instead of the long-horned cattle of Anau.

I must say here that these statements do not agree with former ideas concerning the age of the domestic animals.* The subfossil occurrences in the Forest Bed, Tidal Basin, London; Lea Alluvium of the Mills and Canningtown, as well as the remains of *Ovis aries palustris* at Schweizersbild, led me to assume that they dated from paleolithic times. This was because there then appeared no valid reason to the contrary and because I believed then, as now, in the domestication of the European diluvial horse in the paleolithic age. Stimulated by the exact consecutive chronological dating of our finds from Anau, I have had, in company

* Die Tierwelt der Ansiedelungen am Schlossberge zu Burg an der Spree, pp. 292–293.

with Professor Pumpelly, the opportunity to examine the finds from Schweizersbild and to test the correctness of the published determination of their age. We became convinced that the disagreement is more apparent than real between the datings of the Anau time-scale and those of Dr. Nuesch, who places at 8000 B. C. the beginning of the "Gray Culture" stratum at Schweizersbild, which contains both *Ovis palustris* and *Sus palustris*. (1) The gray culture-stratum is very variable in thickness, causing uncertainty in the estimation of the age, at any one point, of the contents; it may vary thousands of years. (2) The excavation was not conducted, as at Anau, in such a manner that the bones of each layer were kept separate. On the contrary, all the contents of the gray culture-stratum were mixed, the whole stratum being taken as a unit. Any find from this stratum may have come either from the bottom or from the top.*

As regards the occurrence in the paleolithic "yellow stratum" (Gelbe Schicht) of a sheep called by Studer "*Ovis* sp., small form," but by me *Ovis palustris*, it is evident that any one acquainted with the locality must admit the possibility of the displacement of the respective pieces from the "gray stratum" to the underlying "yellow stratum." It is easy to understand how, in very thin layers, such a displacement could occur in any one of many ways, such as the digging of one of the 27 graves, the removal of a large stone and the refilling of the cavity, etc.

According to a friendly communication of Dr. Frank Conner, the age of the English remains is uncertain to the extent that they may be early neolithic quite as well as paleolithic. As far as the history of the domestic animals is concerned, there is consequently no objection to the assumption that that part of the early neolithic period which is characterized by the turbary fauna began after the VII millennium B. C.

The question of the distribution of the cattle is here much more complicated. The first remains of the long-horned breed (*Bos taurus macroceros*) belong at Anau about 8000 B. C. We find the same animal again about 3000 to 4000 B. C. in Babylonia and Egypt. At about 6000 B. C., however, we find that the large long-horned animal of Anau has become small and small-boned and had developed into a short-horned breed (*Bos brachyceros*). Therefore, all who do not believe in an autochthonous domestication of the animals for each separate culture-sphere must admit that the original large and stately long-horned ox of Anau was spread by tribal migrations before 6000 B. C. to Persia and Mesopotamia and into Egypt and Central Africa on the one hand; and on the other hand, to India and Eastern Asia, where, according to Chinese accounts, it arrived 3468 B.C. (compare plate 85).

Did the migration to the west occur only after the small breed had become established, *i. e.*, about 6000 B. C., or even between 6000 and 7000 B. C. when the turbary sheep had formed? To this question we have as yet no answer. We must, however, add that it was not in Anau alone that through unfavorable conditions of life the originally large and stately ox was changed into the stunted short-horned form (*Bos taurus brachyceros*). The same change took place in

*This was not the fault of Dr. Nuesch, but was due to the thinness of the stratum, which averaged less than 1.5 feet, while its slow accumulation of refuse from meals and occasional falls of small fragments from the rock above represent a long period of time during which so thin a layer would be subject to frequent disturbance of the mass.—R. P.

Mesopotamia, as one may easily perceive in comparing the long-horned cattle of the Chaldean or Sumero-Accadian times with the Assyrian small, short-horned and the modern loose and short-horned or hornless cattle. There is, therefore, no reason for rejecting the assumption or hypothesis that the ox of Anau, which about 7000 B. C. was undergoing this change of form finally reached Central Europe, after its migration through Southern Russia and Eastern Europe, in the stunted form of *Bos taurus brachyceros*. Nehring* and I† have already treated of the development of such stunted forms through insufficient nourishment, too early pairing in the free state, and the climatic influences on the desert, as well as of the reverse process, *i. e.*, the lengthening of hair and horns and increase of bodily size under more favorable conditions.

After having treated of the outward migrations of the domesticated animals of the culture-sphere of Turkestan, we may now touch briefly on the contributions this sphere received from without. Leaving out of consideration *Sus palustris*, whose provenience is, as already stated, not yet fully determined, we have, as first importations, the shepherd-dog, about 5850 B. C., and in the middle of the same millennium the camel, the goat, and possibly the hornless sheep. As has been already stated under the respective headings, these importations point to Iran and even to the Indian sphere as ancestral lands. The regions, which through 2000 years received the tame cattle from Turkestan, now reciprocated with the domestic animals of their sphere of culture.

It is demonstrable that the shepherd-dog (*Canis matris optimæ* Jeitteles) first appeared in Europe between 1500 and 1000 B. C., together with bronze, *i. e.*, about 5000 or 6000 years later than the turbary sheep, turbary pig, and turbary ox. Since this dog appeared at Anau about 5850 B. C., its provenience must certainly have been outside of Europe and probably, as we have stated, within the Indian sphere of culture.

We may here at last state briefly a closely related hypothesis concerning the question of the origin of the Ox-cult. It is known that all peoples who possessed and in part now possess the long-horned ox practised this cult. Among these we naturally name foremost the Indians and Egyptians as well as the Babylonians and Persians. The Assyrians also had the last remains of this cult, which they had adopted, as appears in the massive schematic representations of the winged sacred bull on their bas-reliefs. Especially highly developed is the Ox-cult among the Egyptians and older Indians. As the Egyptians ranked both bulls and cows among their gods, looking upon the Apis as an incarnation of Osiris, so the earlier Indians in their sacred books attributed their whole state and their whole life to the Ox.

May we not draw from this the inference that these religions had the same ancestral home, and that the initial momentum of their rise lay in the precedent of domestication? If it were true, as Salomon Reinach once said, "le culte précédait la culture," there could no longer be any doubt as to the origin of the Ox-cult;

*Torfrind. Zeitsch. f. Ethnologie, Bd. 21, Verh., pp. 363–369.
†Naturgeschichte d. Haustiere von Wilckens, II Auflage, pp. 263–264.

nor should we need the corroborative evidence of the terra-cotta figurines of cattle that were used in Anau 3000 B. C. In any event we may be permitted to suggest this hypothesis, leaving its fate to be decided after further investigations.

In the cattle-cult of the followers of Zoroaster—the Parsees—whose ancestors down to the end of the Sassanian dynasty ruled over Anau, we may see an especially important point in connection with precedents of the culture-sphere of ancient Turkestan. The Zend-Avesta contains a hymn lauding the value of cattle, which may indicate that a people who could hold cattle in such high estimation in their own culture might really have accomplished the domestication of the ox.

> "In the ox is our strength, in the ox is our speech,
> in the ox is our victory, in the ox is our nourishment,
> in the ox is our clothing, in the ox is our agriculture
> which furnishes to us food."

PART VII.

DESCRIPTION OF SOME SKULLS FROM THE NORTH KURGAN, ANAU.

BY PROFESSOR G. SERGI.

[CHAPTER XXI. PLATES 92, 93.]

CHAPTER XXI —SKULLS FROM ANAU.*

PLATE 92.

Figs. 1–3, No. 1, A.N.K., +25 feet.

Skull of adult individual, probably female, imperfect. Length, 185 mm.; breadth, 141 (?) mm.; index, 76.2. Height from auditory foramen to bregma, 107 mm. Frontal breadth, minima, 95 mm. Orbital width, left, 36 mm.; orbital height, 30 mm.; index, 83.3. Malar bone, left, breadth, 25 mm.; height, 26 mm. Nasal bone, left, length, 26 mm.; width, 10.5 mm. Angle of nasal bone with frontal, 130.7°. The skull is *mesocephalic*, *chamæcephalic*, with frontal suture; with inclined orbit; malar bone is small. Only the left part of the nasal bone; in form and type it is identical with the nasal bones of the Mediterranean race, and very different from the Mongolian type of nose. The skull is a *pentagonoides*.

Figs. 4–5, No. 2, A.N.K., Terrace III.

We complete this description with another fragment of adult skull, *i. e.*, with one complete maxilla, and with part of the left mandible. Palato-maxillary breadth, 61 mm.; length, 55 mm. Pyriform aperture of nose, width, 22 mm. Nasal height, 47 (?) mm. Index, 46.8. Spino-alveolar height, 23 mm. Little prophatnia or alveolar prognathism; teeth strongly worn.

PLATE 93.

Fig. 1, No. 3, A.N.K., +23 feet.

Skull of child, 2 to 3 years, imperfect. Length, 166 mm.; breadth, 122 mm.; index, 73.4. Maxilla of the same individual; it has the second molar milk tooth. Skull, *ovoides*, dolichocephalic.

Fig. 2, No. 4, A.N.K., +32 to +37 feet.

Skull from 2 to 3 years, imperfect. Length, 170 mm.; breadth, 120 mm.; index, 70.5. Maxilla with mandible, with 2 milk molars. *Pentagonoides*, dolichocephalic, a little deformed.

Fig. 3, No. 5, A.N.K., −11 feet.

Skull of child, 4 to 5 years, imperfect, without the frontal bone. Breadth, 124 mm.; length, from 170 to 175 mm. (calculated); index, from 72.9 to 70.8. Dolichocephalic, probably *ellipsoides cuneatus*. The left fragment of mandible has 2 milk molars.

Fig. 4, No. 6, A.N.K., +32 to +37 feet.

Skull of child, imperfect. Length, 188 mm.; breadth, 125 mm.; index, 66.4. Ultra-dolichocephalic, *ellipsoides*, very long.

Fig. 5, No. 9, A.N.K., +25 feet.

Fragment of skull of child, *ellipsoides cuneatus*. Breadth (probably), 124 mm.

*Although the skulls found in our excavations were as a rule badly crushed, Mr. Langdon Warner was able to save the more important parts of several individuals. Professor Sergi has kindly volunteered to examine these and gives the results herewith.—R. P.

OTHER SPECIMENS, NOT SHOWN ON PLATES.

No. 7, A.N.K., Terrace I, Skeleton a.

Fragment of skull of child, type of dolichocephalic skull.

No. 8, A.N.K., +37 feet.

Skull of child, fragment. Breadth, 127 mm. It is an *ovoides*, or *ellipsoides cuneatus*.

RESULTS.

From examination of these skulls it is found that—

The characters of the skulls of Anau, both in calvaria and in facial bones, do not show any different structure from the characters which commonly we find in the skulls of the Mediterranean variety with long dolichomesocephalic form.

The cephalic indices, together with the nasal index in the fragment No. 2 (plate 92, figs. 4 and 5), the form of the maxilla and of the nasal bone, show apparently this convergence of characters.

The prophatnia of the same fragment, No. 2, is not absolutely absent in the Mediterranean race.

The pentagonal form of the skull is also common in the Mediterranean race, and is a general character in the skulls of the fetus and children.

(See my memoirs: Le forme del cranio umano nello sviluppo fetale; Rivista di Biologia, Como, 1900. Nuove osservazioni sulle forme del cranio umano; Atti Società romana di antropologia, 1904. Die Variationen des menschlichen Schädels und die Klassification der Rassen; Archiv f. Anthropologie, N. F. III, 1905.)

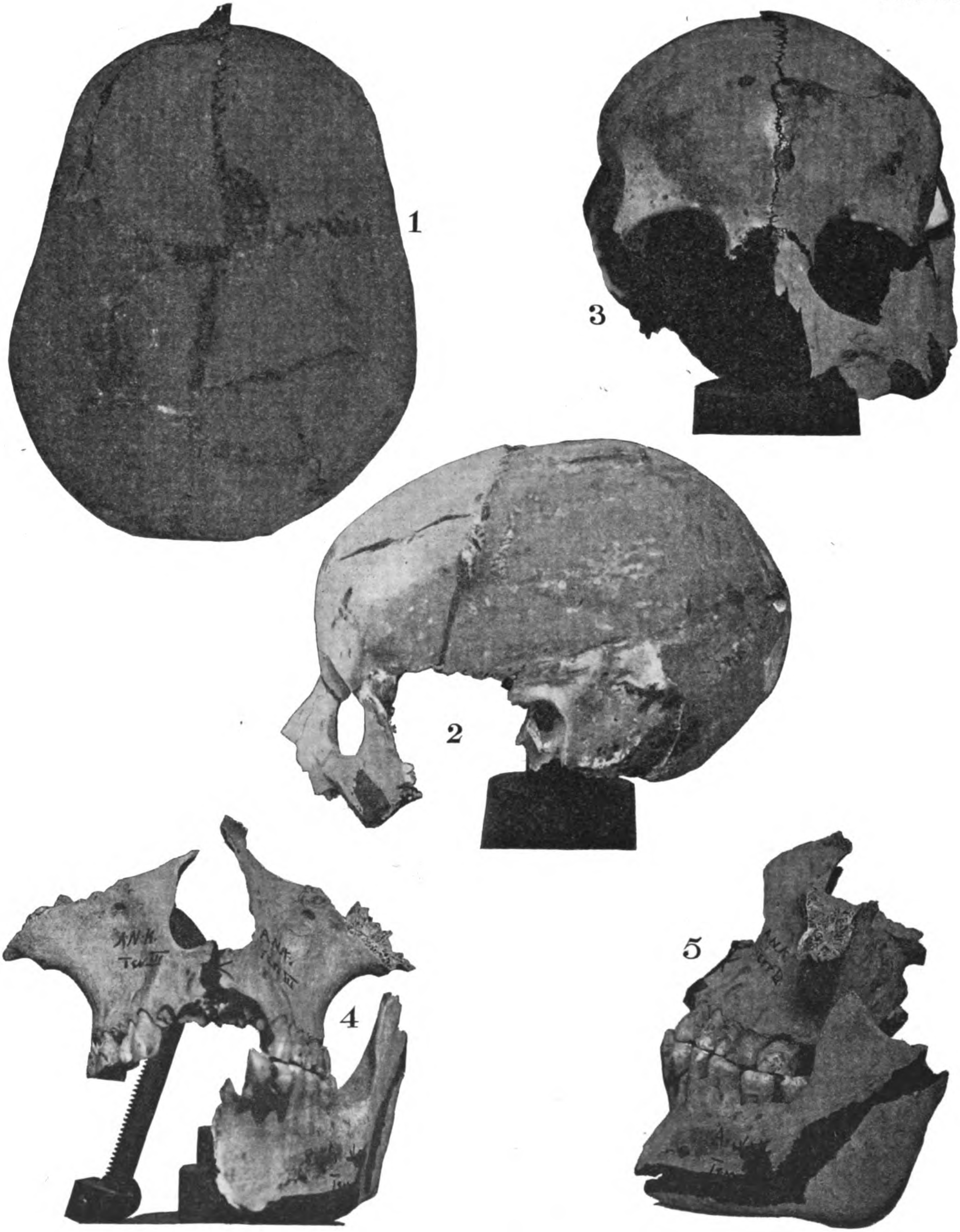
These skulls differ absolutely from the so-called Mongolian type.

The results shown above give a certainty to my hypothesis of some years ago on the probable penetration into Central Asia of one branch of the Mediterranean variety. (See Gli Arii in Europa e in Asia, Torino, 1903.)

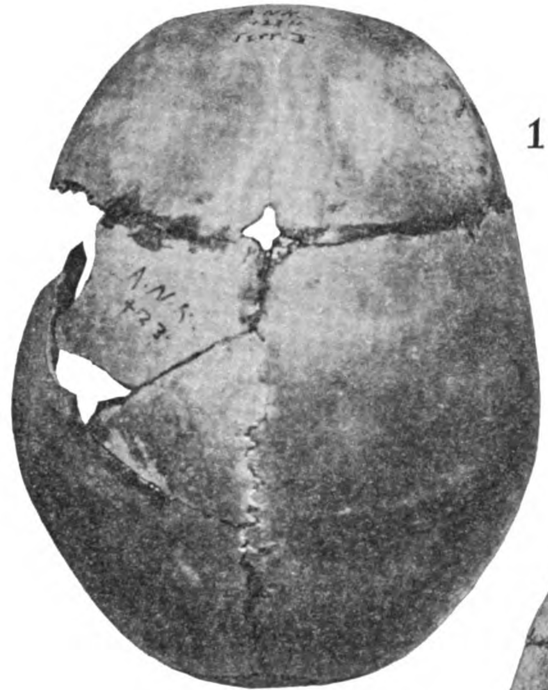
Table of measurements (in millimeters) of the fragmentary skulls, adult and infant, of North Kurgan, Anau.

+ = feet above, − = feet below datum.

	1 +25. Adult.	2 Terr. III. Adult.	3 +23. Inf.	4 +32 to +37. Inf.	5 −11. Inf.	6 +32 to +37. Inf.	7 Terr. I. Inf.	8 +37.	9 +25.
Length	185	....	166	170	170–175?	188	....	....	....
Breadth	141?	....	122	120	124	125	....	127	124?
Index	76.2	....	73.4	70.5	72.9–70.8	66.4	....	....	....
Frontal breadth (min.)	95	....	....	....	....	....	....	....	....
Height from auditory foramen	107	....	....	....	....	....	....	....	....
Nasal height	....	47?	....	....	....	....	....	....	....
Nasal width	....	22	....	....	....	....	....	....	....
Index	....	46.8	....	....	....	....	....	....	....
Orbital width	36	....	....	....	....	....	....	....	....
Orbital height	30	....	....	....	....	....	....	....	....
Index	83.3	....	....	....	....	....	....	....	....
Palato-maxillary breadth	....	61	....	....	....	....	....	....	....
Palato-maxillary length	....	55	....	....	....	....	....	....	....
Cranial form	Pentag.	....	Ovoid.	Pentag.	Ellips.	Ellips.	....	Ellips.	Ellips.



Figs. 1–3. Skull of adult, probably female (No. 1, A.N.K., + 25 feet). From top of first culture, North Kurgan, Anau.
4–5. Fragment of adult skull (No. 2, A.N.K., Terrace III). From near end of first culture, North Kurgan, Anau.

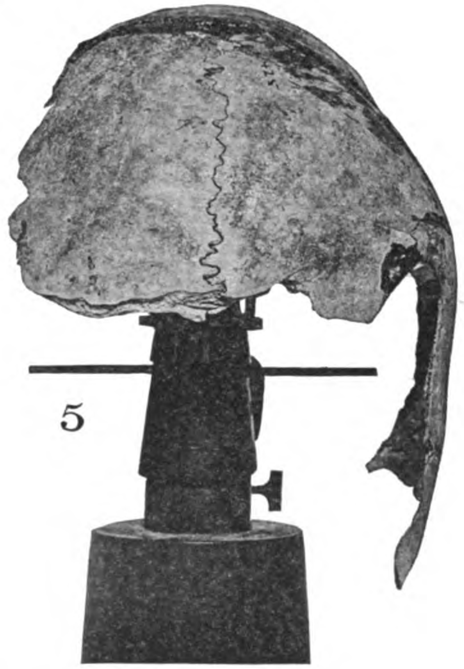


1

3

2

4



5

FIG. 1. Imperfect skull of child, 2–3 years (No. 3, A.N.K· + 23 feet). Near end of first culture, North Kurgan, Anau.

2. Skull of child, 2–3 years (No 4, A.N.K., +32 to +37 feet). From second culture, North Kurgan, Anau.

FIG. 3. Skull of child, 4–5 years (No. 5, A.N.K., — 11 feet). From the earlier centuries of the first culture, North Kurgan, Anau.

4. Imperfect skull of child (No. 6, A.N.K., +32 to +37 feet). From second culture, North Kurgan, Anau.

FIG. 5. Fragment of skull of child (No. 9, A.N.K., +25 feet). From end of first culture, North Kurgan, Anau.

PART VIII.

SOME HUMAN REMAINS FOUND IN THE NORTH KURGAN, ANAU.

BY DR. TH. MOLLISON,

Assistant in the Anthropological Institute, Zürich.

[CHAPTER XXII. PLATES 94–96.]

CHAPTER XXII.

SOME HUMAN REMAINS FOUND IN THE NORTH KURGAN, ANAU.*

Some remains of human bones having been sent to the Zürich Institute by the Director of the Pumpelly Expedition, through Dr. Duerst, Professor Dr. Martin has kindly transferred them to me for examination.

Unfortunately the material belongs in by far the greater part to children, in some cases, indeed, to infants, and one fetus.

The bones of adults come from at least five individuals, while the rest are distributed among about twenty or twenty-five children.

As regards the original position, all the bones come from the North Kurgan, and the greater part of those of children is supposed to belong to the culture that is below +25 feet. Those of adults, on the other hand, are supposed to come from the overlying metallic period, about +25 feet.

Unfortunately, as Dr. Duerst informs me, a certain amount of confusion has occurred in the numbering of the bones through a change in the nomenclature of the different culture-periods. The bones marked II (Nos. 52*b*, 68, 107, 486, 487, 622, 623, 624, 626, 644, 648, 750, 753, 1057, 1060, 1064, 1066), which, according to this communication, come from the layers +26 to +31 feet of the second terrace, belong to the II or Copper period. This period is on the other bones still marked by its old denomination, III. These bones marked III come from the strata +28 to +31 feet of the second and fifth terraces, therefore from the same layers as those marked II. This explains why, in several cases, bones which belong to one individual, or even exactly fitting pieces of one bone, carry the numbers of two different culture-periods.

This complication makes it necessary to determine the bones belonging to one individual through a study of the shape and size. Fortunately the greater number and the best-preserved remains belong to the largest individual. In the following we have brought together the bones belonging to the separate adult individuals and add the reasons for their individual identity.

INDIVIDUAL I.

Fragments of left half of pelvis, II 86*x*.
Left femur (composed of two pieces), III 862 +II 487, fitting into acetabulum of pelvis.
Right femur (number lost), symmetric with the left.
Right tibia, III 867, tibio-femoral index, similarity in modeling.
Upper end, III 854, and lower end, III 866, of left tibia, symmetric with the right.
Upper end, 844, and lower end, III 816, of right fibula.
Lower end of left fibula, III 839, fitting to tibia.
Right talus, III 859.
Left talus, III 851, fitting to tibia.
Right calcaneus, III 819.
Left calcaneus, III 853, fitting to talus.
Right naviculare, III 841, fitting to talus.
Right cuneiforme I, III 823, fitting to naviculare.
Right metatarsus I, III 852, fitting to cuneiforme.

Apparently belonging to individual I:
Right metatarsus II, III 843.
Right metatarsus III, III 833.
Right metatarsus IV, III 835.
Left metatarsus I, III 817.
Left metatarsus II, III 842.
Left metatarsus III, III 827.
Left metatarsus IV, III 834.

*These remains, which were not recognized as human during the excavation, were separated by Dr. Duerst from the bones of animals which I sent to him for study.—R. P.

INDIVIDUAL II.

Fragment of left half of pelvis, II 486.
Head of right femur, II 1086:
Width of os ischii (from limbus acetabuli to incis. isch.), II: id. I=37 mm.: 40 mm.
Height of head of femur I=49 mm.
Height to be expected for head of femur II=45 mm.
Height of the one in hand=47 mm.
Fragment of neck of left femur, II 1057, symmetric with neck of right femur.
Left calcaneus (number lost):
Length of calcaneus, I: width of os ischii, I=87 mm : 40 mm.
Length expected of calcaneus, II=79 mm.
Length of calcaneus in hand=82 mm.
Talus, II 86x, fitting to calcaneus.
Right metatarsus II (no number). } Appear to be-
Left metatarsus III, II 1064. } long here.

INDIVIDUAL III.

Lower third of right tibia, III 641.
Lower half of left tibia, II 68, symmetric with right tibia.
Lower half of right fibula, II 626, fitting on tibia.
Right talus, II 644, fitting on tibia.
Left calcaneus, III 58:
Length of tibia from foramen nutritivum to lower joint-surface, III : id. I=231 mm. : 257 mm.
Length to be expected of calcaneus=78 mm.
Length of calcaneus in hand=76 mm.

INDIVIDUAL III.—*Continued.*

Right metatarsus I, II 1060:
Length of metatarsus I (from upper edge of proximal joint-surface to capitulum), I : length of calcaneus, I=69 mm.: 87 mm.
Length to be expected of metatarsus I, III=60 mm.
Length of metatarsus in hand (measured as above) =60 mm.

INDIVIDUAL IV.

Left metatarsus I, III 77.
Right metatarsus I, II 648, symmetric with the left.
Right metatarsus III, II 622. }
Right metatarsus IV, II 624. } Belong apparently
Right metatarsus V, II 623. } IV.
Left metatarsus II, III 66. }

INDIVIDUAL V.

Upper half of right femur (in two pieces), II 52*b* + III 686.
Right metatarsus I, II 750:
Length of metatarsus I, I : length of femur from head to middle of diaphyse= 69 mm. : 267 mm.
Corresponding length of femur V=about 215 mm.
Length to be expected of metatarsus I, V=about 55 mm.
Length of metatarsus in hand=52 mm.
Right metatarsus II, II 753, appears to belong to V.

There are some more fragments of bones, the connection of which with the above-stated individuals was not determined.

1. Right angle and proc. condyl. of lower jaw, II 107.
2. Outer end of right clavicula, III 636.
3. Fragment of right spina scapulæ (without number).
4. Right metacarpale V, III 644.
5. Right cuboid, III 675.
6. Right naviculare, III 335.
7. Base of left metatarsus V, III 79.

We will turn first to the description of the bones of individual I and then consider any variations occurring in the others.

INDIVIDUAL I.

The fragment of the pelvis is too incomplete to be of use for a comparative study.

The two femora belong unquestionably to a strong man. They are bones of strongly marked character, rather slender, with sharply marked relief. Particularly striking is the marked curvature of the diaphyse (plate 94, fig. 1). Unfortunately we are not able to express in figures a comparison of this curvature with that of other races, since most authors use an index of curvature which is obtained by measuring the height above the plane on which the bone lies; this is useless, because it is too much influenced by the form of the epiphyses. If one wished to express the curvature through an index obtained from height and chord, the termini of this chord should be the two points between which the curvature of the anterior surface lies; that is, on the upper end of the diaphysis, a point at the level of the lower edge of the trochanter minor on the anterior side, and on the lower end about in the place where it is customary to measure the lower sagittal diameter, both points being of course in the medial plane. The height would be the greatest height of the anterior surface above this base.

By this method we obtain for the two femora under consideration a chord-height index =5.5 right and 5.3 left. The curvature is not evenly distributed along the diaphysis; it is greatest at the boundary between the upper and middle thirds. The contrary is the case in *Homo primigenius*, where the strongest curvature is in the lower part of the diaphysis. Thirty femora of the Anatomical Institute show, with the single exception of two belonging to the same individual, the same character in this respect as our Anau femora; this seems, too, to be the rarely broken rule among modern Europeans. I measured the greatest curvature, and obtained the curvature value, which is to be defined as the reciprocal value of the radius of curvature (in meters) for a distance of about 80 mm. on both femora =2.7, which would correspond to a curvature radius of 37 cm.

Notwithstanding the impression of slenderness made by this femur alongside of that of the Neandertal man or even of that of most Europeans, its length-thickness index (respectively 24.8, 23.9) lies above the mean value, 22.8, given by Bumüller (1899, p. 21). This, however, is due to the fact that the circumference of the middle of the diaphysis is much enlarged by pilaster-formation, as Broca has called the ridge which sometimes extends down the posterior side of the femur and carries the linea aspera. To characterize the degree of development of the pilaster Broca calculated an index pilastricus, taking the sagittal diameter at the point of greatest elevation of the pilaster, in relation to the transverse diameter. This index amounts for our femora, for both sides, to 121.4. We may use for comparison the following figures compiled by Klaatsch (1901, p. 627) from different authors:

Japanese (Bumüller)	100.0	Eskimo (Hepburn)	118.4
Aino (Bumüller)	103.1	Negro (Bumüller)	119.8
Malayan (Hepburn)	104	Australian (Hepburn)	122.2
Maori (Hepburn)	110.1	Cro-Magnon (Bumüller) (one individual)	128.0
Andamanese (Hepburn)	113.5		

Marked curvature of the diaphysis has been held responsible for the growth of the pilaster. Manouvrier and Bumüller find its cause in muscular action. Neither view seems to me to be correct. Bumüller shows that curvature and pilaster-formation do not stand in any correlation. If we visualize the direction in which the bone is compressed by the weight of the body, it will seem very probable that the strongest tendency to break will be somewhat below the middle of the diaphysis; that is, at that point where the pilaster-formation is as a rule most marked. An exact proof of this view can be had only experimentally. The strongest tendency to break moves elsewhere when the bone is deformed by abnormal curvature. This can happen, for instance, in rachitic changes. Then the pilaster can move up into the upper third of the diaphysis. As Bumüller remarks, a strong pilaster-formation is often accompanied by a marked convexity of the anterior surface, in a sense an anterior pilaster (fig. 493 *d*). This is equally the case when the pilaster is in the normal position or when it is moved. It follows from all this that the pilaster can not be caused by muscular action, but rather by the static demands of the bone. We know, indeed, that bone substance is deposited especially in those places through which the lines of greatest pressure and tension run. It is natural that pilaster-formation is found especially in such femora as have the muscle ridges well developed, since in individuals having strong muscles greater demands are made on the femora, and individuals whose femora are brought severely into play have their muscles strongly developed.

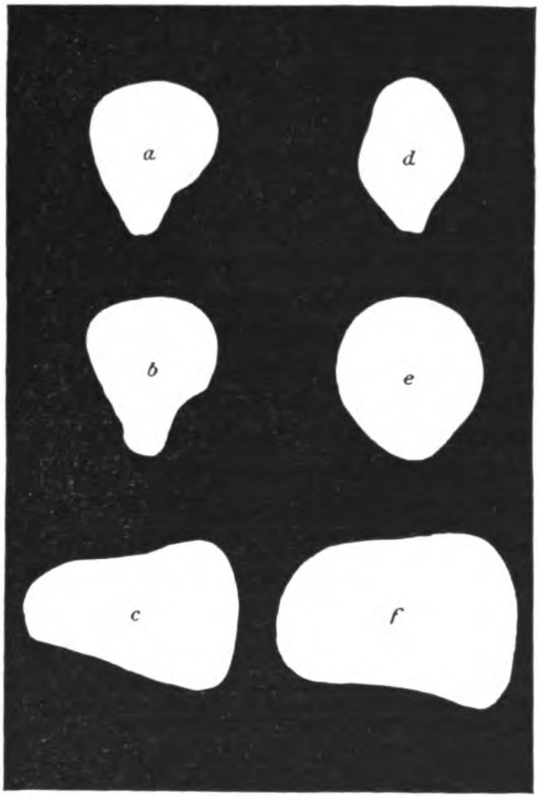


Fig. 493.—Cross-sections of femora: (a) Left femur, Anau I, in middle of diaphysis. (b) Left femur, Anau I, below middle of diaphysis. (c) Left femur, Anau I, at lower end of diaphysis. (d) A rachitic recent femur in upper third. (e) Right femur of a European, below the middle. (f) Right femur of a European, at lower end of diaphysis.

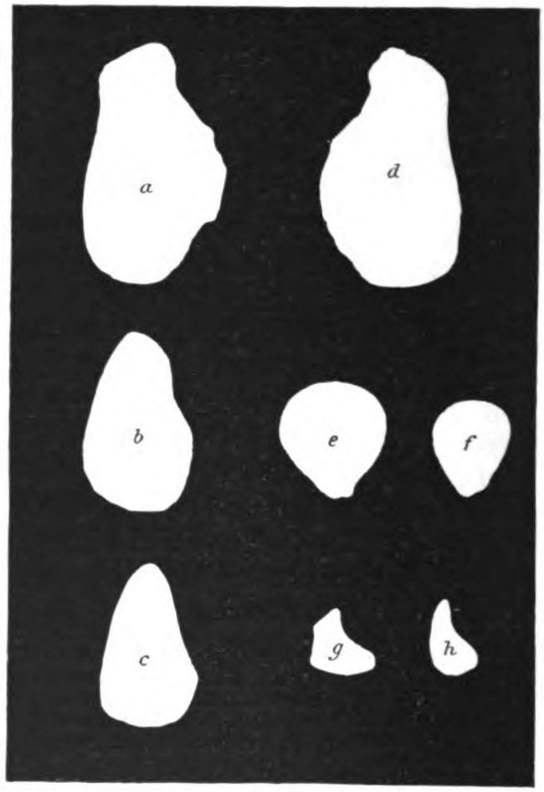


Fig. 494.—Cross-sections of the Femora, Tibiae, and Fibulae. (a) Right tibia of Anau I at height of tuberosities. (b) Same at the height of foramen nutritivum. (c) Right tibia in middle of diaphysis. (d) Left tibia of Anau I at height of tuberosities. (e) Right femur of Anau V somewhat below middle. (f) Left femur of a child (III 865) somewhat below middle (g) Right fibula of Anau III about middle of diaphysis. (h) Right fibula of a European at same place.

Figure 493, *b*, shows the cross-section of the left femur of Anau I somewhat below the middle. This as well as the other represented cross-sections were obtained by the method with wax and plaster given by E. Fischer (1906, p. 184). The well-dried plaster casts, after being polished smooth on the section surface with fine glass-paper, were laid on photographic developing paper and copied under a circular movement beneath a gaslight.

Figure 493, *d*, is the cross-section of a rachitic femur with curvature and pilaster-formation in the upper third, which shows clearly the anterior pilaster, as we mentioned it above. It has been attempted to trace the cause of the pilaster in all cases back to rachitis; this is wholly unfounded. The pilaster is formed always when the demands upon the bone continually approach its ultimate strength, so that the elastic flexures produce sufficient excitation for the apposition of bone substance; it is quite indifferent whether this limit is reached through excessive demand or through insufficient strength. We may therefore trace this characteristic of the Anau femora, and indeed also their strong curvature, to very considerable exertion on the part of the lower extremities, which, as we shall see later, has also produced considerable changes in the tibia.

The upper end of the diaphysis shows scarcely anything worthy of remark. The index of the diaphysis cross-section amounts here to 85.3 and 82.3 respectively; it is therefore at the limit between platymerism and eurymerism. On the other hand, the lower end shows a shaping differing essentially from the form of that of the modern European. The anterior surface is here considerably more depressed. It is also strongly inclined towards the medial side; on the other hand, the planum popliteum is also inclined toward the medial side, so that a very considerable narrowing of the bone is caused on this side, which shows itself in a triangular cross-section (fig. 493, *c*). In contrast to this, the corresponding cross-section of a European femur has a much more rounded form (fig. 493, *f*). The preponderance of the lateral sagittal diameter is clearly recognizable when we express it in percentage of the sagittal diameter of the median plane. We find here an index of 133 right and 137 left.

A further peculiarity in the form of the Anau femur is the rather abrupt attachment of the lower epiphysis upon the diaphysis, in contrast to the gradual "trumpet-like" flare present in the more common European form (plate 94, fig. 4). This sudden enlargement of the end of the slender diaphysis is very pronouncedly present in the man of Neandertal and in Spy I. Martin (1905, p. 617) has described this form also in the Senoi femur. Plate 94, fig. 4, shows the lower end of the femora of Neandertal, Anau I, and of a modern European.

An examination of the upper epiphysis shows a striking torsion of the collum. If we imagine a plane laid through the head, the trochanter major, and the saddle-point of the lower joint-surface, we shall see that the greatest diameter of the collum forms with this plane an angle which, according to Lehmann-Nitsche (1894, p. 25 and p. 43), amounts to 19.5° in the Bajuvars; 17° in the Suebians and Alemanni; in the Anau I femora, both right and left, this angle reaches 33°. In the Neandertal femur we find this torsion angle of the collum = 26°. A high value for this angle would seem from this to be a mark of primitive form.

The linea obliqua is strongly developed and stands remarkably steep, reaching the medial edge about 4 cm. below the trochanter minor. It forms with the axis of the diaphysis an angle which we can mark with a needle and measure direct with the protracter. It is 19° right, 17° left. In the Neandertal femur, which has the linea obliqua very faintly indicated, this angle is about 22°; in the Senoi femur, male, right 27°, left 22°; on modern Europeans I measured 36° and 45°. I would, therefore, look upon this steep position of the linea obliqua as another primitive mark which our Anau individual seems to share with recent lower races and also with *Homo primigenius*.

The strongly-drawn-out trochanter minor extends considerably beyond the inner edge of the femur in the manner described and represented by Martin (1905, p. 614); for the rest this condition seems to occur also among modern Europeans of strong muscular development. With this movement of the trochanter minor towards the medial side, there is related the more transverse course of the strongly developed crista intertrochanterica (plate 95, fig. 1). The upper end of the linea aspera rises to a strong trochanter tertius.

The lower epiphysis is, as stated above, attached rather abruptly to the slender shaft of the diaphysis. It is specially characterized by the far backward extension of the condyles. This shows itself also in the relation of the radii of the ligamenta (see Bumüller), that is, of the vertical and horizontal distances (in projection) of the places, where the ligamenta collateralia are attached, from the joint-surface. It we take the points of attachment of the ligamenta on the epicondyli tuberosities, the horizontal radius is in all cases considerably greater than the vertical. If, however, we assume also that the ligamenta had their origin in the slight grooves which lie behind every epicondyle, then the horizontal radius would be reached by the vertical only on the lateral side (plate 95, fig. 4). All this would represent a condition which Bumüller considers so typical of the apes that on this account he declared the pithecanthropus femur to be that of an ape.

The planum popliteum is in all directions concave, and the concavity increases vertically from above downward. There is also a distinct transverse concavity in the middle (curvature value, right 6, left 4).

Notwithstanding the decided prominence of the condyles towards the rear, the length of the projection of the lateral condyle is somewhat slight, from which there results a very low condyle index, right 73.9 and left 74.7, which is still below the value of 75, given by Bumüller as the minimum of Europeans.

In comparison with the length of the bone the lower epiphysis can not be thought especially broad. This is at once evident if, using Klaatsch's method (1900, p. 652), we calculate an index from the two measurements, taking for length, as Klaatsch does, the trochanter length, in order to have comparable figures. Unfortunately Klaatsch has, probably through mistake, calculated the reverse ratio and moved the point one place to the left, and other authors have followed his procedure. Therefore we, too, are forced to express the trochanter length in percentage of the width of the epiphysis; but in doing this we have put the point in its proper place, and have added the values found by Martin for Senoi.

It would have been more useful to have calculated the index as was originally intended, that is, to express the condyle width in percentage of the length. We should then, in using Klaatsch's trochanter length, have values of 19.7 right and 19.2 left. Comparing the width of the lower epiphysis with the diaphysis length according to Bumüller, the index is 21.8 right and 21.3 left, therefore tolerably near the mean value found by the above author.

	Trochanter length (*a*).	Epicondyle width (*b*).	Index, *a* : *b*.
Spy I, right	about 410	90	455
Neandertal, right	423	87	486
Neandertal, left	425	87	488
Japanese	390	78	500
Anau I, right	447	88	508
Anau I, left	452	87	519
Senoi, male, right and left	366.5	69	530
Senoi, female, right and left	367.5	66	556
Malays	410	76	539
Wedda	425	78	545
Negrito	390	70	556

The torsion measured between the collum axis and the condyle tangent amounts to right 26° and left 28°. These are high values, as high as those observed by Martin in Senoi (1905, p. 625). European femora have, according to Martin's determinations, in the mean a torsion of only about 8°.

Of the two tibiæ the right one is almost wholly preserved; of the left one, on the other hand, there is only the upper end, which is very defective in the right one. This makes it possible to reconstruct the right tibia, so that the measurements of length can be determined closely within a few millimeters. There can be very little doubt that the two tibiæ belong to one individual; not only do the measurements agree well, but the more delicate features, such as the form of the tuberosities, etc., are almost as if reflected in the mirror.

The tibia also shows a series of indications that refer it to an inferior race. Thus one is at once struck by the considerable lateral flattening of the upper and middle part of the diaphysis, which one is used to designate as platycnemy, and by a decided curvature of the shaft toward the front (plate 95, fig. 5). These two features stand, as Manouvrier has shown, in a certain relation, and indeed so that platycnemy is found more often on tibiæ with forward convexity than on straight ones. Manouvrier (1888, p. 497) has traced both of these peculiarities to one and the same origin, the powerful function of the lower part of the leg under severe exertion in walking and running, as it is brought into play especially among primitive hunting peoples. According to his view, platycnemism is caused by the constant work of the musculus tibialis posticus, which has to keep the lower limb upright, while the curvature toward the front is caused by the pressure working under similar circumstances with a tendency toward fracture, a strain which recurs at every step, especially in going downhill.

As regards the two mentioned features, it is clear from the investigations of Manouvrier and other authors, that such flattening of the tibia is found especially among peoples of the lower stage of civilization. Platycnemy occurs, it is true, occasionally everywhere, even among modern Europeans, but it occurs here much more rarely and to a lesser degree than among peoples living in a so-called state of nature, where it is in places the rule. But not among all: the Negroes, for instance, form an exception.

Broca has obtained an index platycnemicus to characterize this feature, by expressing the width-diameter of the tibia in percentage of its sagittal diameter. He and most of the later investigators took these two measurements at the height of the foramen nutritivum, since in most cases the flattening diminishes further down. Some data are given in the following table:

Index cnemicus.

Groups.	Investigator.	Index.
Modern French, male	Manouvrier	74.5
Lothringer I (before the XIX century)	Manouvrier	74.1
Lothringer II, male and female	Manouvrier	72.4
Negroes, different origins	Manouvrier	72.4
Bajuvars	Lehman-Nitsche	72.2
Senoi and Semang	Martin	about 67
Negrito, male and female, I	Manouvrier	64.5
Negrito, male and female, II	Manouvrier	64.7
Negrito, male and female, III	Manouvrier	65.7
Andamanese, male (measured in middle of diaphysis)	Flower	64.7
New Caledonians	Manouvrier	63.5
Aino	Koganei	63.5
Dolmen of Port Blanc I	Manouvrier	63.3
Dolmen of Port Blanc II	Manouvrier	64.3
Upper California Indians I	Manouvrier	63.7
Upper California Indians II	Manouvrier	60.2
Upper California Indians III	Manouvrier	59.2
Upper California Indians IV	Manouvrier	62.7
Prehistoric tibiæ of Feigneux	Manouvrier	62.8
Weddas, males	Sarasin	60.5

Thus our Anau tibia with an index of 61.5 approaches the extremest form that is found as a mean value in a race.

As was remarked above, platycnemy is usually most pronounced in the upper third of the bone. On the other hand, P. and F. Sarasin found in the tibiæ of the Weddas that the flattening extended over the upper two-thirds. It is so also in the Anau tibia. Instead of diminishing from the foramen nutritivum (fig. 494, *b*), it increases downward, so that in the middle of the diaphysis (fig. 494, *c*) we find an index of only 61.1.

The already mentioned curvature of the tibia forward, which is not rarely connected with platycnemy and has shared with this and with the pilaster formation of the femur the fate of being declared rachitic, is clearly expressed on our tibia (plate 95, fig. 5). Also, the posterior surface is more concave than is usual, for instance, among recent Europeans.

In order to measure the amount of this curvature for comparison with others, one must lay a straight line from the lowest point (the tibia lying horizontal) below the tuberosity to the deepest point above the edge of the distal joint and measure the height of the ante or edge above this line. This method gives with our tibia a height of 7 mm. Since the distance between the two above-named points is about 230 mm., we find, by expressing the height in percentage of the chord, an index of 3.1. Unfortunately no investigations, so far as I can learn, have been made of this peculiarity of form, which we might use for comparison. Only Manouvrier mentions that he found it in the Guanches together with platycnemism, and he gives a figure of such a tibia (1888, p. 506). A measurement on this reduced picture can, of course, give no exact result, still the corresponding index seems to amount to 3.5. The two Wedda tibiæ Nos. 178 and 179, on plate LXXXII of the frequently mentioned work of Sarasin, yield indices of 3.5 and 4.7. In contrast to these values the curvature of the Anau tibia must be considered moderate.

A further character of great importance exists on the anterior edge of the lower joint-surface, where this goes over into the anterior surface of the bone. In European shin bones a sharp edge usually separates the joint-surface from the anterior surface of the tibia. In our tibia, on the other hand, the joint-surface extends in one place over the just-mentioned edge, and makes on the anterior surface of the tibia a small facet whose condition shows clearly that it was originally covered with cartilage (plate 95, fig. 3, *a*). At this point the edge, instead of being sharp, is rounded softly off. On the right tibia the facet is less large, but it is still clearly present. The difference in the form of the joint-surface from that of a European is best recognized in a sagittal section that was drawn with the aid of a lead wire through the place of the facet (fig. 495, *c* and *d*).

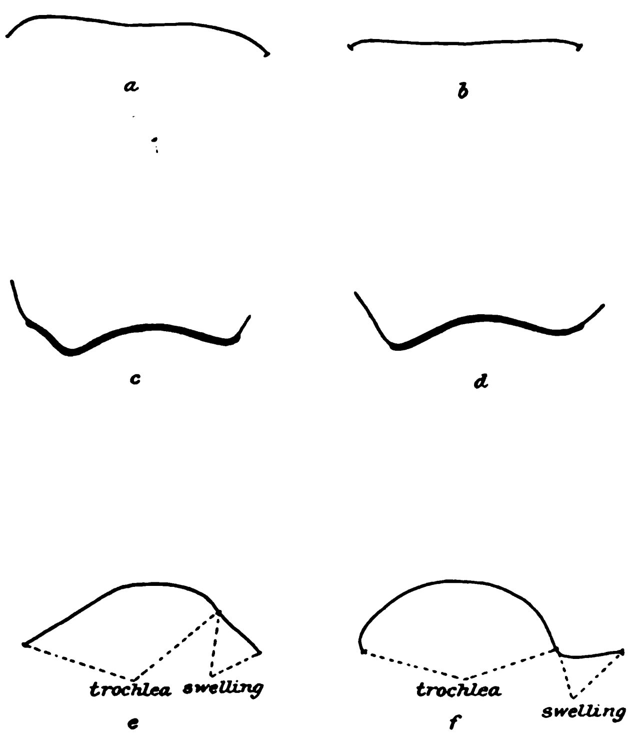


Fig. 495.—(a) Sagittal section of joint surface of condylus lateralis tibiae from Anau I. (b) Same section from a European tibia. (c) Sagittal section through lower joint-section of left tibia through facet, Anau I; thick line marks cartilage cover. (d) Same section through European tibia. (e) Sagittal section through medial edge of trochlea and medial neck-swelling. (f) Sagittal section through trochlea and lateral neck-swelling.

This characteristic has been found among different lower races, and also in anthropoids; thus by Thomson (1890, p. 213) in the gorilla, orang, and in the Weddas; by Martin in the Fuegians (1894, p. 198) and Senoi (1905, p. 635).

The occurrence was already rightly interpreted by its first observer, Thomson (1889, p. 624), who sought the cause of this facet in frequent strong dorsal flexure of the foot which occurs especially in a squatting position. Let us look a little more closely into the mechanism of the object before us.

As one can see in a skeleton, in strong dorsal flexure of the foot the talus presses with the anterior upper surface of its neck on the forward edge of the joint-surface of the tibia. In this action it is especially the medial and lateral edges of the neck which are subjected to the pressure, while the central depressed part is less affected. Accordingly the cartilaginous covering of the joint is spread especially over the two lateral swellings of the neck; the depression between these remains free (plate 95, fig. 3, *b*). But now the two swellings act very differently. The medial swelling presents a direct continuation of the medial edge of the surface of the trochlea, as we can see by taking a corresponding impression with lead wire (fig. 495, *e*). The action of the lateral swelling is wholly different. It rises sharply from the surface of the trochlea (fig. 495, *f*). Consequently, when the foot is flexed in a dorsal direction, the medial swelling slides smoothly under the articular surface of the tibia, without altering essentially the edge of the latter; at most it deepens a little more the depression of the articular surface at the base of the malleolus. On the other hand, the lateral swelling presses itself against the edge of the articular surface, flattens it and produces the above-mentioned overspreading of the cartilage on the anterior surface of the bone. If this explanation is right, the edges of the cartilage-covered surfaces on the astragalus and tibia must fit each other exactly, when brought into an extreme dorsiflexion. Indeed that is so in our case. This, too, gives a certain proof that our astragalus belongs really to the fragment of tibia.

That the squatting position gives rise to this strong dorsal flexion is shown by the fact that the change just described on the lower joint is often accompanied by a corresponding one on the upper joint. We find there often a rounding off of the posterior edge of the joint-surface, which shows itself especially on the lateral joint-groove and causes the joint-groove to appear convex in its posterior segment. Also this characteristic is indicated on the left tibia head, even if not very marked (fig. 495, *a*). It would correspond about to No. 2–3 of Thomson's scheme (1890, p. 211). The cause of this variation is doubtless to be found in the strong flexure of the knee, through which the posterior, upper surface of the condyles is brought against the posterior edge of the joint-surface of the tibia. It is at least doubtful whether the backward divergence of the head of the tibia (plate 95, fig. 2) is also produced, or increased, by strong bending of the knee, since it seems to occur in cases where such a function can not be shown as a cause. An examination of this divergence by Manouvrier's method (1893, p. 231) gave an angle of inclination of 10°. The angle of retroversion could not be measured; with the considerable curvature of the tibia it is not possible to speak of a straight diaphysis axis so that we have no criterion for the position. An inclination angle of 10° lies perfectly within the range of variation of modern Europeans and exceeds but little the average value, 8.5°, found by Manouvrier for 72 European tibiæ (French) (1893, p. 236). The described curvature of the thigh bone, as well as of the tibia, by enlarging the space for the flexure muscles of the upper and lower part of the leg, facilitates squatting; this is so self-evident that one might consider whether this habit did not contribute to the increase of those curvatures.

Also the low position of the condylus medialis tibiæ seems to be more common among 'primitive' peoples (plate 96, fig. 1).

The relief of the bone is well elaborated, the crista interossea standing clearly out, especially in its upper part. In front and parallel with it there runs a depression through the proximal two-thirds, which shows itself also in the cross-section (fig. 494, *b*). There is scarcely an indication of a crista posterior.

The measurement of the torsion angle gave 26°; but in view of the extremely great variability of this characteristic it can scarcely have racial importance.

That these upper and lower leg bones come from the same individual is so certain that I may base on it an investigation. If we compare the length of the tibia with that of the femur, we find a femoro-tibial index of 84.9. In doing this we have measured the length of the tibia without the spina intercondyloidea, but have included the malleolus, and have used the length of the femur in its natural position. In a similar manner the following values were found:

Europeans (Topinard)	80.8	Andamanese (Flower)	84.5
Europeans (Flower)	82.1	Negroes (Humphrey)	84.7
Fuegians (Martin)	82.2	Australians (Flower)	84.9

For Senoi Martin found (1905, p. 642), by applying the condylo-astragal length of the tibia and using the results of Turner, Duckworth, Annandale, and Robinson, a mean value of 81.7. If we apply the method of these authors we shall have an index of 82.8. The race to which this Anau individual belonged is to be called moderately dolichocnemic; that is, the lower leg is relatively long in proportion to the length of the thigh, a peculiarity which presents itself as a primitive characteristic not only in that it occurs more often in primitive races, but especially because the new-born European has also a relatively long lower leg.

Of the fibulæ we have unfortunately only a few short fragments from which but few inferences can be drawn as to their complete form. Therefore we content ourselves with the presentation of a statement of the absolute measurements, which will be found in the appended tables. These bones also show that sharply expressed modeling which seems to be a characteristic of these Anau individuals.

The talus also shows several points of interest. In the first place the considerable development in width. If with Leboucq (1902, p. 144) we take the length of the talus from the highest elevation of the head to the sulcus pro musculo flexori hallucis longo = 100, then the width from the lateral point of the fibular facet to the most medial point of the processus posterior left = 82.5. This index amounts, according to Leboucq, in the mean among Europeans to 77.0. Martin found it for Senoi = 79.5 and 80.9. The Spy talus has 91 (Leboucq). Thus we find here, too, an approach in this Anau skeleton to primitive forms. Next, the narrowing of the trochlea at the posterior end. According to Volkov's determinations this narrowing seems to belong in a higher degree to primitive races. Also among new-born Europeans it is strongly marked. If, according to Volkov's method (1903, p. 695), we take the anterior width as 100, the relative width of the posterior end is among—

New-born Europeans	56.9	Fuegians, males	79.0
Japanese, males	74.5	Polynesians, males	79.4
Negritos, males	74.7	Eskimos, males	80.3
Australians, males	74.7	Europeans, males	81.3
Melanesians, males	76.2	Negroes, males	81.9
Weddas, males	77.3		

The same index for the trochlea of our Anau talus on both sides amounts to 79.4. The narrowing is therefore somewhat more pronounced than in adult Europeans, but does not attain any exceptional degree.

On the other hand the Anau talus differs in another characteristic considerably, not only from Europeans, but also from all other races concerning which we have the results of investigations, viz, in the angle by which the axis of the neck and head differs from the longitudinal axis of the trochlea (plate 96, fig. 2). For this angle Volkov (1903, p. 706) gives the following values:

Negroes, males	24°	Eskimos, males	21°
Melanesians, males	23.4°	Weddas, males	20°
Negritos, males	23°	Patagonians, males	20°
Fuegians, males	22°	Europeans, males	17.8°

In Anau I the deviation of the neck for both sides is 31°; it is therefore higher than the average of any of the races enumerated. But even individual values as high as this were found by Volkov only in new-born children, where he measured angles up to 35°. The values given for Japanese up to 47° are clearly wrong, since the mean is stated as 19° and the minimum as 28°. Still, Adachi found among Japanese a mean of 19°, but individual variations up to 32°. Thus the Anau talus takes an extreme position in this clearly primitive characteristic, only Japanese occasionally showing as high a divergence.

The torsion of the head of the talus is important, because the transversal arching of the foot is in part dependent on it. According to Volkov's investigations (1904, p. 320) its values form an increasing series:

New-born Europeans	16.5°	Negroes	36°
Negritos	34°	Japanese	39°
Melanesians	35°	Europeans	49°

In the Anau talus the torsion is less than in any of the races investigated by Volkov, 30° to 33°, and is therefore a primitive characteristic of high importance.

The calcaneus also shows peculiarities which differ from that of the European. Its sustentaculum tali is very strongly developed; as Volkov has shown "the lower races" form in this respect "a real transition between the foot of the anthropoids and the foot of the European." Plate 96, fig. 3, shows this difference.

Still another characteristic is to be seen in this figure, one that points to a slight height of the arch of the foot. The joint-surface of the calcaneus intended for the cuboid is more wide than high, and, looked at from below, is less visible than in the European, because it stands more vertical in relation to the longitudinal axis of the calcaneus. The wide, low form of this joint-surface is especially striking in Anau I. We find in this a breadth-height index for both sides of 62.5, while 5 Europeans gave a mean value of 92.0.

The anterior inner joint-surface for the talus on the left is divided into two separate facets, while on the right these are connected by a narrow isthmus.

The right naviculare is very thick on its medial edge; on the lateral, on the other hand, it is narrow. An index which we calculate, taking the thickness at the inner edge as 100, amounts to 47.4. It is interesting to compare this with the figures given by Volkov (1904, p. 38) as shown at top of next page.

Weddas, males	44.9	Japanese, males	53.2
Fuegians, males	45	Negritos, males	54.5
Negroes, males	45.8	Australians, males	54.8
Polynesians, males	48.5	Europeans, males	56.4
Melanesians, males	52.5	Patagonians, males	60.9
Peruvians, males	52.8	Eskimos, males	63.8

The index calculated by us belongs therefore with the lowest; the naviculare has a form which seems to belong more often in general to the primitive races.

The shape of the joint-surface which articulates with the talus is also worthy of remark. It shows that more ovally rounded form that Volkov ascribes especially to primitive races. The relation of the height to the width is 74.2. Volkov (1904, p. 46) found for:

New-born Europeans	67	Negroes, males	82.2
Peruvians, males	72.2	Melanesians, males	83.5
Negritos, males	73.1	Europeans, males	84.2
Japanese, males	75.8	Polynesians, males	86.9
Eskimos, males	80.0		

This index also approaches the primitive forms.

In cuneiforme I we are especially interested in the difference in its height at its proximal and distal ends. The last measures according to Volkov (1904, p. 204) in percentage of the proximal among:

Europeans, males	121.2	Negritos, males	139.5
Negroes, males	126.0	Australians, males	140.9
Melanesians, males	127.7		

We find for this index a value of 160.0, which, if inserted in this table, would range beyond the most primitive forms. It would perhaps be more appropriate to bring the two joint-surfaces into relation with each other; the proximal would then measure 56.7 per cent of the distal.

The slender form of the metatarsus (plate 96, fig. 4) shows itself most clearly in the relation of the epiphysis width to the length. Since for comparison we have to use the investigations of Volkov, we must, in calculating the indices, choose the length taken by him, which reaches from the middle of the upper edge of the proximal joint-surface to the posterior edge of the first phalanx. Though we do not have this, it is not difficult to say how far it may have extended, and we shall not be far out of the way in assuming a measurement of 61 mm. for the right and 60 mm. for the left. The index for the basal width would then be for the right 31.1. Volkov (1904, p. 238) finds for:

Melanesians, males	30.5	Japanese, males	32.9
Australians, males	31.1	Negroes, males	33.7
Fuegians, males	32.3	Patagonians, males	35.6
Polynesians, males	32.7	Europeans, males	36.0
New-born Europeans	32.8	Peruvians, males	40.6

Our metatarsus as regards its basis belongs to the most slender forms, as we find them especially among primitive races. On the other hand the capitulum, with an index of width 40.0 right, 39.3 left, is not more narrow, but rather somewhat broader than is usual among Europeans; Volkov found for this, mean values from 33.6 among the Weddas to 45.5 among Eskimos; the mean value for Europeans is given by him as 38.6.

INDIVIDUAL II.

The bones of this individual repeat in almost all points the forms found in individual I. Still, the development of thickness is more accentuated. This makes itself evident, for instance, in the length-breadth index of the talus, which amounts here to 86.8 and is therefore still higher than in individual I. The torsion of the head is still less; the foot was therefore probably still less arched. The divergence of the neck and head is almost as strong as in I; it amounts to 29°.

In the calcaneus the anterior inner joint-surface for the talus is as in individual I divided into 2 facets, of which the posterior one, lying on the widely projecting sustentaculum tali, is especially large. The joint-surface for the cuboid has also that more vertical position, but is, however, higher than in individual I; still here, too, the width-height index of only 71.9 remains far behind that of the European.

INDIVIDUAL III.

What interest us most here are the pieces of the tibiæ, of which unfortunately only the distal parts are preserved. The left reaches fortunately just to the foramen nutritivum, so that we can form an opinion of the lateral flattening. The index cnemicus amounts, at the height of the foramen nutritivum, to 66.7; it shows, therefore, a moderate platycnemism, but far from the degree shown in tibia I. Here, too, the index diminishes from above downward, so that the flattening in the middle of the diaphysis is still somewhat more marked than higher up. The index at this point amounts to 64.5.

Here we find again on the lower end the joint-facet produced by squatting on the anterior surface, which corresponds with a facet on the lateral swelling of the talus. The last is not, however, connected with the normal joint-surface of the trochlea, but is separated from it by a depression of the neck.

Of the fibula we have the lower half. It resembles wholly in the form of its malleolus that of individual I. The cross-section through its middle (fig. 494, *g*) is interesting, as it shows the strikingly wide posterior surface in contrast to the narrow one in the European (fig. 494, *h*).

The angle of the talus-head with the longitudinal axis of the trochlea is large here also, a proof that we did not have to do with individual variations in the cases of individuals I and II.

INDIVIDUAL IV.

Unfortunately we have only some metatarsi; one can see from these that they probably belonged to a more solidly built person. The metatarsi I are considerably broader in proportion to length than in individual I. The index of basis width to length (measured as on individual I) amounts to 34.5 left and 36.4 right. On the other hand the breadth index of the capitulum is 40.0, the same as on individual I.

INDIVIDUAL V.

Of this there are only 3 bones: a piece of the right femur, the right metatarsus I, and the right metatarsus II. The reasons for associating the three pieces have been given above.

The femur seems very small and graceful alongside of the same one from individual I (plate 94, fig. 2). Also the modeling does not stand out nearly as sharply. It evidently comes from a small female individual, who was, however, fully grown; for there is no trace of epiphysis line. The curvature of the diaphysis can not be well estimated, because the lower part is missing. It seems to have been somewhat less than in individual I. The strongest curvature of the preserved part amounts on a length of about 8 cm. to 1.7. There is here also a slight pilaster formation, as is shown in the cross-section taken at the middle of the diaphysis (fig. 494, *e*). The index of this point amounts to only 108.3. The upper end of the diaphysis is flattened somewhat more in the sagittal direction than that of individual I, so that one can speak of a moderate platymerism (I = 76.7). Both trochanters are unfortunately broken off. It is also not possible to determine whether there was a trochanter tertius. The collum shows almost as strong a torsion as in individual I, about 30°. The caput is somewhat less round, but still in its sagittal diameter hardly 1 mm. narrower than in the vertical.

The metatarsus I has a still higher index of length and basis width, −38.8, which thus exceeds the mean for Europeans. The width index of the capitulum (about 40) is, on the other hand, the same as that of Anau I.

A comparative study of the bones of children from Anau promises little result, as long as detailed investigations of the child-skeleton are wanting. Only two femora, which seem to belong to a child 13–14 years old, present some interest. Already on these are indicated the features that characterize the grown man: curvature, pilaster-formation (fig. 494, *f*), slight platymerism, trochanter III, slender form suddenly widening out at the lower epiphysis (plate 94, fig. 3).

Lastly some remarks as to the presumable size of the separate individuals.

Using Manouvrier's tables, we calculate the height of individual I from the two femora to be 170 cm., from the right tibia 170.2 cm. The height of this man can therefore be estimated about 170 cm.

For individual III we find the probable length of the whole tibia from the lower end to the foramen nutritivum = 349 mm., and the presumable bodily height would be 161 cm.

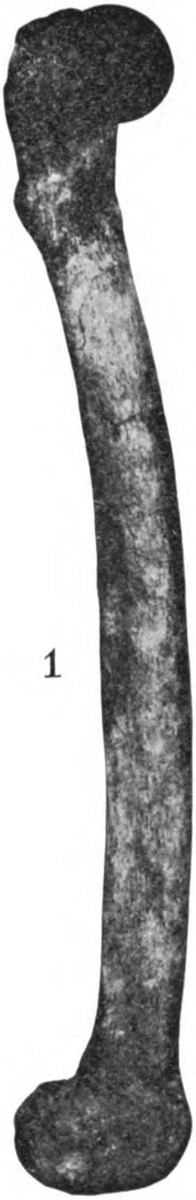
The height of individual V, the smallest of all, may be approximately estimated from the size of the piece of the femur. If we determine the probable middle point of diaphysis and compare its distance from the femur-head with the corresponding distance in individual I, we obtain for the whole length a measurement of about 378 mm., which would correspond to a bodily height of about 149 cm. If we assume the maximum range of error in estimating the middle point (1 cm. each way), the minimum length of the femur calculated from this range of values would be 361 mm. and the maximum 396 mm. These values would give heights respectively of 142 and 156 cm. If we take into consideration the fact that Manouvrier's tables are probably apt to err in the direction of diminishing the height of small individuals, we shall not make our women too high if we decide on 150 cm.

Determination of the heights of the other individuals is not possible, because we have not, even for Europeans, the correlation of the measurements of the bones of the foot with bodily size. Still, we can judge from the size of these bones that the height of individual II was between that of I and III, while individual IV stood between III and V. Therefore, Anau I is to be considered above the average and Anau V relatively small.

Since it is customary to look everywhere for pygmies, we might attempt also to construct a dwarf race out of our individual V. There are, however, several obstacles. In the first place there are no differences present that would warrant our assigning individual V to a different race from individual I. In the next place the difference between V and I may be due to a considerable range in size, such as we find among many races. A further reason for considering this the correct explanation is that we fortunately have intermediate forms, which constitute an unbroken series. We realize this best when we place side by side the preserved metatarsi I of at least four individuals. In plate 96, fig. 4, the missing metatarsus I of individual II is replaced by a bar of its presumable height.

A satisfactory comparison, or even a racial diagnosis, is naturally impossible in view of the scanty material at hand; all the more so since in the bones of the extremities functional influences come so strongly into action that it is difficult to distinguish between peculiarities due to such functional action and those inherent in the race.

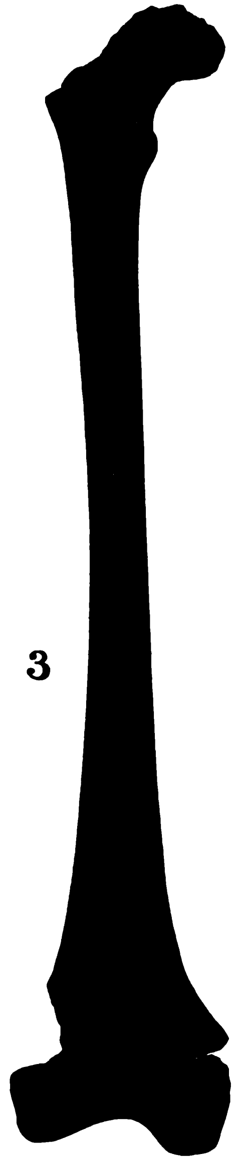
But even if we disregard all those characteristics for which a functional cause is thinkable, there remains still a number which can with great probability be traced back to the race, and which differentiates these Anau individuals at least from the recent European, with whose skeleton we are better acquainted than with that of other races, and assign it to a primitive form. More we can not say from a study of the bones at hand. The problem would be much more simple if more abundant material, especially skulls of adults, should be found. This seems to be a possibility, for the condition of the preserved pieces allows us to assume with certainty that there are preserved many more of these interesting bone remains than have been collected.



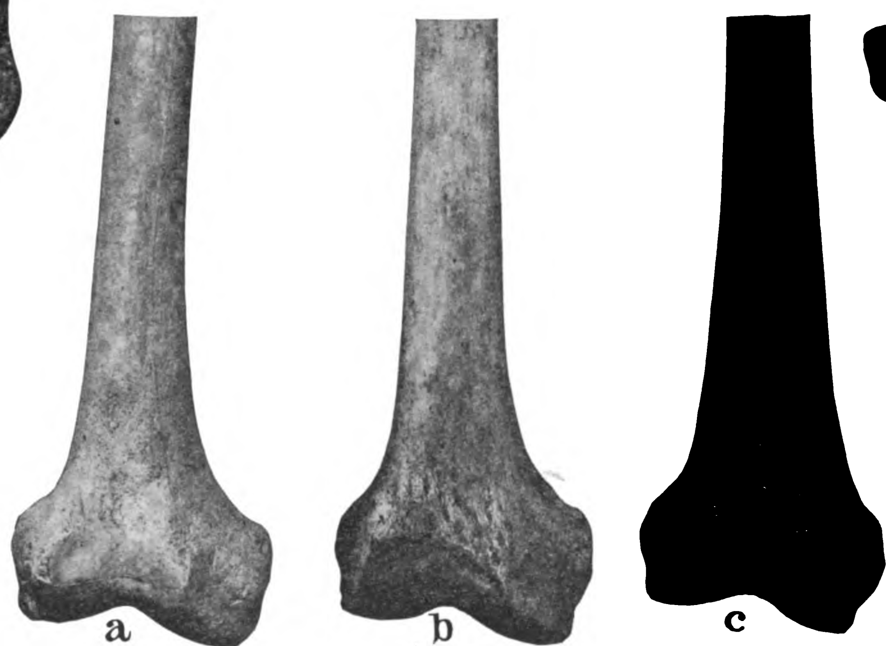
1

a b

2



3



a b c

4

FIG. 1. Right femur, Anau I, from lateral side.
2. Right femur, *a*, Anau I; *b*, Anau V.
3. Left femur of child, III 865, from behind.
4 Lower end of femora, *a*, Neandertal man; *b*, Anau I; *c*, a recent European.

PLATE 95.

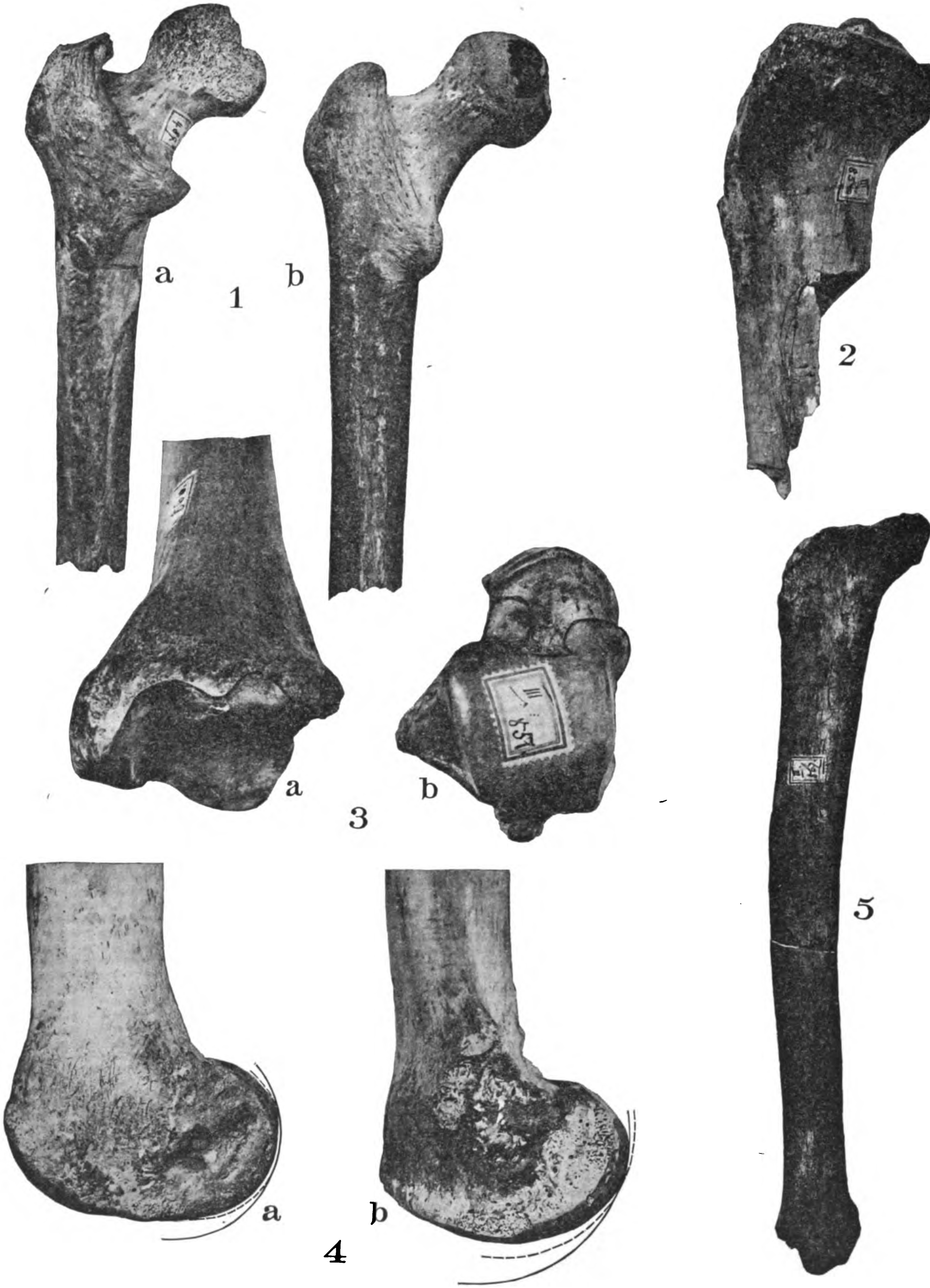
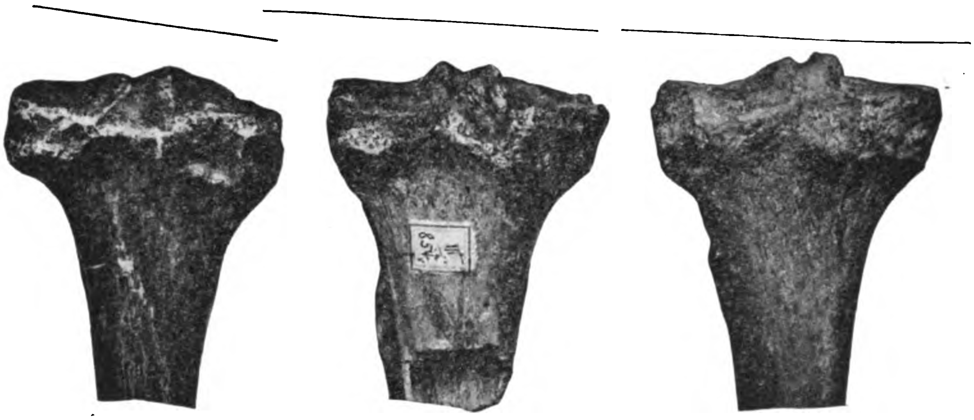


FIG. 1. Upper end of femora from behind, *a*, Anau I; *b*, a recent European.
2. Head of left tibia of Anau I from lateral side.
3. Facet, *a*, on anterior side of left tibia, and *b*, on neck of talus of Anau I. The joint surface is bordered by a black line.
4. Lower epiphyses of the femora of Anau I; *a*, left, from lateral; *b*, left, right, from medial side; with representation of the "Bandradien."
5. Tibia of Anau I from medial side.

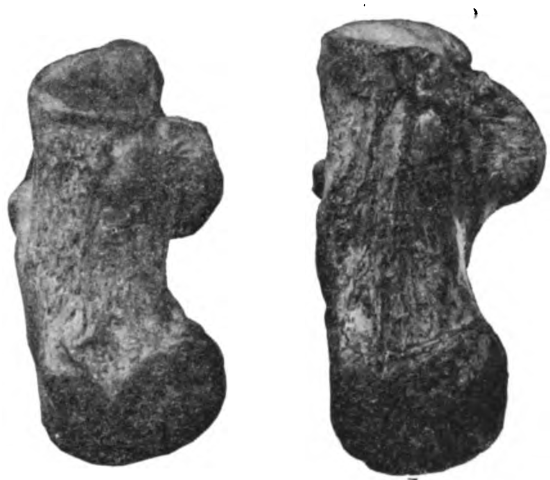
PLATE 96.



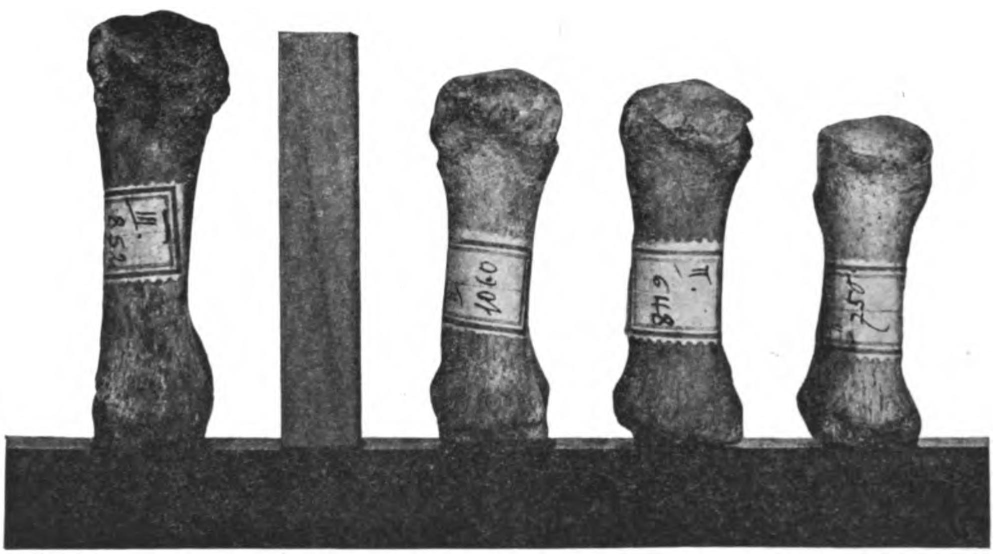
a b c

1

a 2 b



a 3 b



4

FIG. 1. Upper end of tibia, *a*, Spy I; *b*, Anau I; *c*, recent European.
2. Left talus, *a*, recent European; *b*, Anau I.
3. Calcaneus from below, *a*, recent European; *b*, Anau I.
4. Metatarsi I of individuals I, III, IV, V. The presumable length of Metatarsus I of individual II is represented by a bar.

Table of dimensions in millimeters.

Femur.	I.		III.
	Right.	Left.	Right.
1. Greatest total length	472	482	....
2. Greatest trochanter length	456	463	....
3. Total length in natural position	470	478	....
4. Trochanter length in natural position	448	452	....
4*a*. Length after Virchow : from trochanter major to condylus ext.	447	453	....
5. Length of diaphysis after Bumüller	403	406	....
5*a*. Length of diaphysis after Martin	382	388	....
6. Sagittal diameter of middle of diaphysis	34	34	26
7. Transverse diameter of same	28	28	24
8. Index of diaphysis section at middle (No. 6 : No. 7)	121.4	121.4	108.3
9. Circumference of middle of diaphysis	100	97	78
10. Length-thickness index after Manouvrier (No. 9 : No. 3)	21.3	20.3	....
10*a*. Length-thickness index after Bumüller (No. 9 : No. 5)	24.8	23.9	....
11. Upper sagittal diameter of diaphysis	29	28	....
12. Upper transverse diameter of diaphysis	34	34	30
13. Index of upper diaphysis cross-section (No. 11 : No. 12)	85.3	82.3	76.7
14. Circumference of upper diaphysis cross-section	102	101	86
15. Lower sagittal lateral diameter of diaphysis	32	33	....
16. Lower sagittal diameter of diaphysis in medial plane	24	24	....
17. Lower transverse diameter of diaphysis	47	47	....
18. Lower sagittal index (No. 16 : No. 6)	70.6	70.6	....
19. Lower transverse index (No. 17 : No. 7)	16.8	16.8	....
20. Index popliteus (No. 16 : No. 17)	51.1	51.1	....
21. Upper width of femur	94	98?	....
21*a*. Upper width of femur after Martin	92	90?	....
22. Length of upper epiphysis	102	101	....
23. Greatest vertical diameter of collum	36	35	27
24. Least sagittal diameter of collum	26	25	20
25. Index of collum cross-section (No. 24 : No. 23)	72.2	71.4	74.1
26. Circumference of collum	103	100	80
27. Height of caput	49	49	40
28. Width of caput	49	....	39
29. Caput index (No. 28 : No. 27)	100	....	97.5
30. Circumference of caput	158	....	126
31. Length of collum and caput after Koganei	73	73?	....
32. Epicondyle width	88	87	....
33. Thickness resp. length of condylus lateralis	65	65	....
34. Condyle index (No. 33 : No. 32)	73.9	74.7	....
35. Index diaphysis width : epicondyle width (No. 7 : No. 32)	31.8	32.2	....
36. Index epicondyle width : diaphysis length, after Bumüller (No. 32 : No. 5)	21.8	21.4	....
37. Natural length of condylus lateralis	66	65	....
38. Natural length of condylus medialis	63	64	....
39. Condyle length index	104.7	101.7	....
40. Vertical "*Bandradien*," lateral	21	21	....
41. Horizontal "*Bandradien*," lateral	24	24	....
42. Vertical "*Bandradien*," medial	28	....	....
43. Horizontal "*Bandradien*," medial	35	....	....
44. Index of lateral "*Bandradien*,"	87.5	87.5	....
45. Index of medial "*Bandradien*"	80	....	....
46. Joint circumference of condylus lateralis	115	114	....
47. Joint circumference of condylus medialis	104	106	....
48. Greatest condyle width	82	81	....
49. Height of condylus lateralis	37	37	....
50. Height of condylus medialis	41	41	....
51. Height of diaphysis curvature	69	66	....
52. Index of diaphysis curvature, after Manouvrier (No. 51 : No. 2)	15.1	14.3	....
53. Strongest diaphysis curvature (reciprocal value of radius)	4?	4	3?
54. Angle of torsion	26°	28°	....
55. Collo-diaphysis angle	135	138	133
56. Condyle-diaphysis angle	7°	9°	....
57. Torsion angle of collum	33°	33°	*ca.* 30°
58. Angle of linea obliqua	19°	17°	20°

Table of dimensions in millimeters—Continued.

Pelvis.	I. Left.	II Left.
1. Vertical diameter of acetabulum	57	....
2. From posterior edge of joint-socket to incis. isch	40	37
3. Thickness of tuber	....	29
4. Greatest diameter of vertical branch of os ischii	....	34

Tibia.	I.		III.	
	Right.	Left.	Right.	Left.
Length:				
1. (a) Point of spina intercond. to point of malleolus internus	405	....	....	....
2. (b) Medial joint-surface to point of malleolus internus	398	....	....	....
3. (c) Middle of medial joint-surface to base of malleolus internus	389	....	....	....
4. Greatest proximal epiphysis width	....	80	....	....
5. Greatest depth of proximal epiphysis	....	55	....	....
6. Greatest diameter at tuberositas	52	52	....	....
7. Least diameter at tuberositas	31	31	....	....
8. Greatest diameter at foramen nutritivum	39	....	....	33
9. Transverse diameter at foramen nutritivum	24	....	....	22
10. Index cnemicus	61.5	....	....	66.7
11. Greatest diameter in middle of diaphysis	36	....	....	31
12. Transverse diameter in middle of diaphysis	22	....	....	20
13. Index of diaphysis cross-section in middle	61.1	....	....	64.5
14. Greatest distal epiphysis width	57	56	49?	....
15. Greatest depth of distal epiphysis	42	41	40	....
16. Circumference at foramen nutritivum	103	....	....	87
17. Circumference in middle of diaphysis	95	....	....	82
18. Least circumference	86	84	75	76

Talus.	I.		II. Left.	III. Right.
	Right.	Left.		
1. Total length (after Volkov)	62?	62	59	....
2. Total height	....	34	33	....
3. Length of trochlea	30	29	32	....
4. Posterior width of trochlea	27?	27.	....	....
5. Anterior width of trochlea	34	34	34	29
6. Width of whole joint-surface	43	41	40	35
7. Projected length of articulatio talo-fibularis	32	31	....	....
8. Length of lower posterior facet	....	35	36?	....
9. Mean width of lower posterior facet	21	21	22	....
10. Length of neck	20	22	18	13
11. Height of joint-surface of head	24	24	23	20
12. Width of joint-surface of head	34	31	33	32
13. Divergence angle of head	31°	31°	29°	25°
14. Torsion of head	....	33°	30°	....

Calcaneus.	I.		II. Left.	III. Left.
	Right.	Left.		
1. Total length	87	87	82	76
2. Posterior width	34	36	36	....
3. Mean width	45	45	48	....
4. Length of sustentaculum tali	15	16	14	....
5. Length of body	65	67	64	57
6. Least width	27	27	27	....
7. Least height	40	41	39	36
8. Height of insertion of Achilles tendon above bottom	25	24	22	24
9. Greatest width of facies cuboidea	32	32	32	....
10. Greatest height of same	20	20	23	....

Total dimensions in millimeters.—Continued.

Naviculare.	I. Right.
1. Least thickness on medial side	9
2. Greatest thickness on lateral side	19
3. Greatest diameter of facies talaris	31
4. Diameter of facies talaris perpendicular to former	23

Cuneiforme I.	I. Right.
1. Length on medial lower edge	28
2. Length in middle parallel to lower edge	25
3. Length on upper edge	27
4. Greatest height at distal end	32
5. Greatest height at proximal end	20
6. Height of distal joint-surface	30
7. Height of proximal joint-surface	17

Metatarsus I.	I.		III.	IV.		V.
	Right.	Left.	Right.	Right.	Left.	Right.
1. Greatest length	73	....	65	62	63	56
2. Length perpendicular to proximal joint-surface	70	....	61	59	60	53
3. Smallest sagittal diameter	13	13	11	11	11	11
4. Least transverse diameter	14	....	13	14	14	13
5. Width of diaphysis (after Volkov)	16	15	14	15	14	14
6. Sagittal diameter of proximal epiphysis	30	....	30	28	29	26
7. Transverse diameter of same	19	....	....	20?	19	19
8. Sagittal diameter of capitulum	23	23	19	20	20	16
9. Greatest width of capitulum	24	24?	22?	22	22	20?
10. Sagittal arch of joint-surface of head	39	40	33	34	33	25
11. Torsion of head	87°	....	96°	84°	80°	85°

BIBLIOGRAPHY.

ADACHI, B. AND Y. Die Fussknochen der Japaner. Mitteilungen der medizin. Fakultät der kaiserl. Japan. Universität, Tokio, Bd. VI, 1905, pp. 308–344.

BUMÜLLER, J. Das menschliche Femur. Inaug.-Diss. München, 1899.

FISCHER, E. Die Variationen an Radius und Ulna des Menschen. Zeitschr. f. Morphologie und Anthropologie, Bd. IX, 1906, pp. 147–247.

FLOWER, W. H. On the osteology and affinities of the natives of the Andaman Islands. Journ. of the Anthropol. Institute, vol. IX, 1880, pp. 108–135.

KLAATSCH, H. Die wichtigsten Variationen am Skelet der freien unteren Extremität des Menschen. Ergebnisse der Anatomie und Entwicklungsgeschichte, Bd. X, 1900, pp. 599–719.

KOGANEI. Beiträge zur physischen Anthropologie der Aino. Mitt. der mediz. Fakultät d. kaiserl. Japan. Universität, Tokio, Bd. II, 1893, pp. 1–249.

LEBOUCQ. Ueber prähistorische Tarsusknochen. Verh. d. Anat. Gesellsch. Halle, 1902, pp. 143–145.

LEHMANN-NITSCHE, R. Ueber die langen Knochen der südbayerischen Reihengräberbevölkerung. Beitr. z. Anthropol. und Urgeschichte Bayerns, Bd. XI, 1894, pp. 1–92.

MANOUVRIER, L. Mémoire sur la platycnémie chez l'homme et chez les anthropoides. Mém. de la Soc. d'Anthropologie, II Sér., vol. III, 1888, pp. 470–548.

MANOUVRIER, L. Étude sur la rétroversion de la tête du tibia. Mém. de la Soc. d'Anthropologie, II Sér., vol. IV, 1893, pp. 219–264.

MANOUVRIER, L. Étude sur les variations morphologiques du corps du fémur dans l'espèce humaine. Bull. de la Soc. d'Anthropologie, IV Sér., vol. IV, 1893, pp. 111–144.

MANOUVRIER, L. La détermination de la taille d'après les grands os des membres. Mém. de la Soc. d'Anthropologie, II Sér., vol. IV, 1893, pp. 347–402.

MARTIN, R. Zur physischen Anthropologie der Feuerländer. Arch. f. Anthropologie, Bd. XXII, 1894, pp. 155–218.

MARTIN, R. Die Inlandstämme der Malayischen Halbinsel. Jena, 1905.

SARASIN, P. and F. Ergebnisse naturwissenschaftl. Forschungen auf Ceylon. III. Die Weddas von Ceylon. Wiesbaden, 1893.

THOMSON, A. The influence of posture on the form of the articular surfaces of the tibia and astragalus in the different races of man and the higher apes. Journ. of Anat. and Physiol., vol. XXIII, 1889, pp. 616–639.

THOMSON, A. Additional note on the influence of posture on the form of the articular surfaces of the tibia and astragalus. Journ. of Anat. and Physiol., vol. XXIV, 1890, pp. 210–217.

TOPINARD, P. Anthropologie. Uebersetzung von Dr. R. Neuhauss. Leipzig, 1888.

VOLKOV, TH. Variations squelettiques du pied chez les primates et dans les races humaines. Bull. et Mém. de la Soc. d'Anthropologie, V Sér., 1903, pp. 632–708, and V Sér., 1904, pp. 1–50 and 201–331.

PART IX.

WHEAT AND BARLEY FROM THE NORTH KURGAN, ANAU.

By Dr. H. C. Schellenberg,
Professor in the Federal Swiss Polytechnicum.

[Chapter xxiii. Plate 97.]

CHAPTER XXIII.

THE REMAINS OF PLANTS FROM THE NORTH KURGAN, ANAU.

My colleague, Dr. Duerst, has sent me for examination some pieces of burnt clay and charcoal which he found among the great quantity of bones from the excavations of the Pumpelly Expedition, in the North Kurgan at Anau. They are: Charcoal from Culture I; charcoal from Culture II; brick from Culture (?).

CHARCOAL.

Two different kinds of wood are recognizable among the different small pieces of charcoal. Both are dicotyledonous woods; it is, however, not possible to say to what particular plants they should be referred.

Charcoal from Culture I.—A piece of charcoal derived from a branch 4 cm. thick shows 5 annual rings. The pith is slender, 2 mm., the separate rings 4 mm., thick. The medullary rays are wide, up to 0.2 mm., and all nearly equally thick. In the wood, the vessels are distributed evenly through the whole width of the annual ring. They attain a diameter of 150 μ, while they show a mean value of 120 to 140 μ. The boundary of the annual ring is produced by slightly thickened cells and is very uniform. This wood must be referred to one of the softer kinds. The broad and abundant large vessels recall the structure of the wood of creeping and climbing plants. The four pieces of this kind of coal are alike throughout.

Charcoal from Culture II.—Of this there are six different pieces, all alike in structure. The largest piece comes from a branch 3.5 cm. thick, having 6 annual rings, each 3 mm. wide. The boundary of the rings is very indistinct. The pith is very small; the medullary rays are very delicate and all of equal thickness, consisting of 3 to 6 cell-layers, closely placed and 40 to 60 μ wide. In the width of the annual ring the vessels are abundantly and uniformly distributed in the vernal and autumnal wood. They are small, 60 to 90 μ in diameter, often two or three in a row. The libriform fibers are strongly developed, with strong thickening of the walls; in longitudinal section the libriform fibers show small inclosed pores. Plicated libriform occurs also.

The wood was therefore of a hard variety and belonged probably to a shrub-like plant. The occurrence of the inclosed pores in libriform and the plication of the libriform indicates that the plant is related to the Rosaceæ or Leguminosæ.

CRUDE BRICK.*

We have only one piece of a crude brick 8 cm. long by 6 cm. wide. This contains a great quantity of the husks and beards of grain and remains of straw. The present condition of the glumes is not favorable for study, since we have

* Bricks were not burned in Transcaspia before a much later time; this was probably a piece of a pot. See appendix to Professor Schellenberg's report.—R. P.

only casts in clay of the outside of the pieces. The carbonaceous substance has disappeared; only the incombustible part, the ash, remains in the form of a white powder, which we find as we break the specimen and expose the cavities. We have therefore to examine both the impressions in the clay and the ash-skeletons in the cavities.

These cavities are only the molds left by the hulls and other substances. The best way to reproduce the original form is to make casts with putty, which gives very fine representations of the original substance.

From this examination we find that the grain was derived from two plants: from a wheat, and from a barley.

The wheat shows the glumes, glumelles, and hull form that belong to the group of *Triticum vulgare.* There are also present the remains of ear-spikes and of straw. The barley is represented by remains that belong certainly to *Hordeum distichum.* Especially characteristic of *H. distichum* are the side-flowers in the ear. Of barley, we find parts of the stalk and of the ear-spikes, very many beard-spicules, and very few glumes. The results obtained from the casts are confirmed by the study of the ash remains contained in the cavities. We find under the microscope the remains of the highly silicated epidermis of these varieties of cereals; and especially characteristic is the rippled form of the wall of the epidermis cell, which is much thickened. The short cells of the glumelles which occur between the long epidermis cells are especially characteristic for distinguishing between wheat and barley. In *wheat* the short cells have a circular contour with undulated cross-walls. In the silicated substance there are often small pores. This form occurs in the epidermis of the glumes and in parts of the stalk. I was able to prepare some slides from the ash, which showed these characteristic short cells. In many places the silicated substance of the short cells has become detached from the epidermis.

In the *barley* the short cells of the epidermis are pressed closely together. The cells are often so narrow that the *lumen* appears only as a fissure. The cross-walls on both sides are generally of unequal thickness. I was generally able to recognize these characteristic short cells of the barley in the ash-skeletons. They do not detach themselves from the tissues, but generally remain connected with the remains of the adjoining long cells of the epidermis. Remains of barley-beards are very abundant and easily recognizable on the epidermis cells.

These ash-skeletons included in the brick supply the clearest proof that hulls and remains of the stalk were used in preparing the bricks. In consequence of the silicification, the characteristic form of the epidermis cells is observable—as in this case—even after incineration. It can not be mistaken for anything else.

While the examination shows that remains of barley and wheat were used in mixing the clay, it is only possible, by aid of the casts of the cavities, to determine that the wheat belonged to a small form of the common wheat *Triticum vulgare* and that the barley came from the two-rowed form—*Hordeum distichum.*

The great number of impressions present in this piece is evidence that these plant remains are not there by accident, but that they were intentionally mixed with the clay. Further, this occurrence *en masse* of the remains of cereals shows that these grains were cultivated; otherwise it would not have been possible to have used such quantities of straw and chaff.

The state of preservation of the plant remains permits the further inference that the piece has been exposed to fire. The carbonaceous substance is burnt. The piece offers no evidence as to whether the burning was accidental or not. Lastly, it is to be remarked that the seeds of some weeds were contained in the brick and have left their impressions in cavities.

APPENDIX.*

Potsherd from North Kurgan, West Shaft I, 23 to 24 feet below the plain.—This consists of a light-yellow clay. Casts of glumes of wheat are rare; those of the stalks are somewhat more frequent. Barley, on the other hand, is especially well represented in numerous remains of beards.

Potsherd from North Kurgan, West Digging.—This shows very few casts of glumes of wheat, also very few of the stalks and beards. Only a very little chaff was used in mixing the clay of this pot.

Potsherd from North Kurgan, North Digging.—Glumes of wheat and beards of barley are present in great abundance; both in about equal proportion. The separate parts of the glumes and beards are best preserved in this specimen.

Remains of wheat and barley are present in all three of these potsherds. The barley belongs, at least in part, to *Hordeum distichum*. The species of the wheat can not be accurately determined.

*Since receiving Professor Schellenberg's report I have examined in Berlin the potsherds from the oldest cultures at Anau, and have found that chaff and straw were invariably used in making one, and apparently only one, of the varieties of pottery used during the life of the two oldest settlements of the North Kurgan. This variety forms the large pots, of coarse texture and painted designs, peculiar only to culture I, and is represented in plate 20, fig. 1.

This pottery is found in all the layers from the bottom to the top of the oldest culture. As the bottoms of these pots are from one to two inches thick it is probable that the piece examined for this report was from one of these.

I sent to Professor Schellenberg, from Berlin, a piece of this pottery, from the lowest four feet of culture-strata of the oldest culture of the North Kurgan—23 to 24 feet below the surface of the plain—in N. K. West Shaft I; and two from higher strata of the same culture. Professor Schellenberg writes the results of his examination of these three potsherds as follows.—R. P.

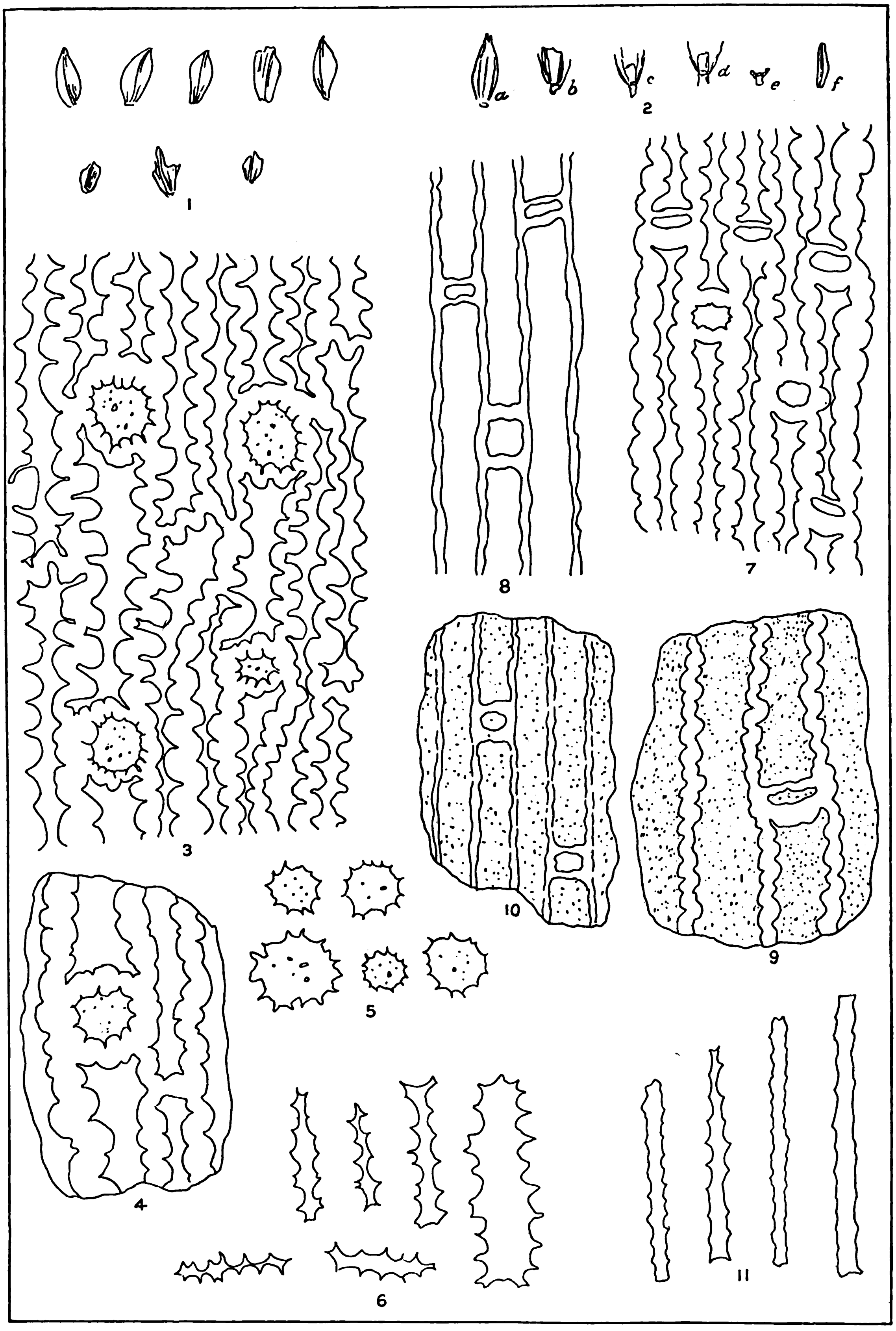


FIG. 1. Glumes of wheat in potsherd from Anau, natural size.
2. Particles of barley from potsherds from Anau. *a*, Kernel; *b*, *c*, *d*, *e*, parts of spikelet-spindle; *f*, side-flowers (taube Blüthen).
3. Epidermis of glumes of wheat with characteristic short cells. Recent. ×500.
4. Ash-skeleton of glume of wheat in potsherd from Anau. ×500.
5. Silicated substance from short cells of glume of wheat in potsherd from Anau. ×500.

FIG. 6. Silicated epidermis-cells from glumes of wheat in potsherd from Anau. ×500.
7. Epidermis of barley glumes with characteristic short cells. Recent. ×500.
8. Epidermis of barley beard with characteristic short cells. Recent. ×500.
9. Ash-skeleton from epidermis of barley glumes or spikelet-spindle in potsherd from Anau. ×500.
10. Ash-skeleton from epidermis of barley beard hair in potsherd from Anau. ×500.

FIG. 11. Ash-skeleton of long epidermis-cells in potsherd from Anau. ×500.

PART X.

STONE IMPLEMENTS AND SKELETONS EXCAVATED IN ANAU.

By Langdon Warner.

[Chapter xxiv.]

CHAPTER XXIV.

REPORT ON THE LARGER STONE IMPLEMENTS OF THE KURGANS AT ANAU.

Of the larger stone implements found in the northern kurgan at Anau and not treated of by Dr. Schmidt in his report, there are few types, and those are roughly made, common utensils.

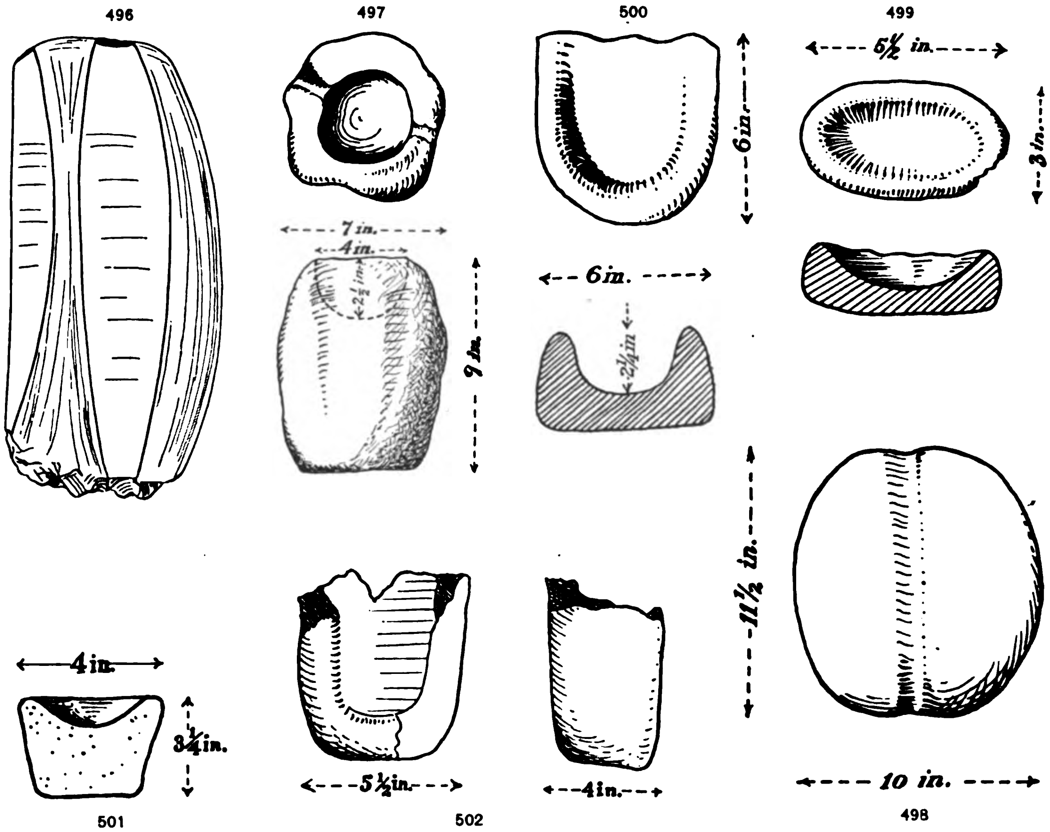
Commonest and most important of all are the flat or gently curved mealing-stones on which the household supply of flour was evidently ground. These occur at intervals all through the culture-strata, and are sometimes accompanied by the muller, a more or less smooth, cylindrical kind of stone, which was rolled or rubbed over the flat surface of the larger ones. All the mealing-stones found in this kurgan—and they were many—were composed of a fine-grained quartzite conglomerate. In form they were the exact counterparts of the "metates" used to-day by many Indians of Arizona, New Mexico, and Mexico, to grind their wokus and parched corn. It is probable that these were made by cracking apart a small quartzite bowlder and rubbing the two new surfaces together till they became flat. Then, if the mealing-stone would not stand true, it was either chocked up with pebbles under the curve, or in some cases chipped flatter with a few blows of a stone maul. I am convinced that when first made, these "metates" were perfectly flat, and took on the shallow curve we found in so many only after a considerable amount of use; and also that the muller was held fast in the hand, and not rolled, for the only two I found, one of which lay on its mealing-stone, showed worn facets running longitudinally, which intersected the original curve of the cylinder (see fig. 496).

There were in this kurgan no true mortars for grinding grain or roots, although in the southern hill we found almost as many of them as of the flat mealing-stones. The single possible exception to this was a barrel-shaped stone 9 inches high, with a round depression in one end 2.5 inches deep and 4 inches in diameter (see No. 4, fig. 497). My reason for not classing this utensil with the flour mortars of the South Kurgan is that, unlike them, the inner edge is sharp and delicate and would not allow for the gyroscopic wobbling motion of the pestle which gives the grinding crunch so necessary with kernels. It may have been used to powder earths or charcoal for colors, or even for ceremonial uses as a mere receptacle. This stone was also grooved longitudinally, perhaps for after-use as a weight. In this respect it is obviously to be classed with No. 43, fig. 498, found in the South Kurgan.

Figs. 499 to 504 represent a number of small quartzite dishes or saucers of indeterminable use. For the most part they were fairly well finished both inside and out, and suggest ceremonial intention. It is hardly possible that the oval form would be used for crushing anything, so they must be classed as receptacles.

Catalogue No. 39 A.N.K. can best be described as a "doughnut-shaped" stone of fine-grain quartzite conglomerates. Its diameter is 3 inches and that of the hole 0.7 inch (fig. 505). Its use can be only conjectural—perhaps a ceremonial mace-head, perhaps a chucking-stone in some game.

Fig. 506, from +30 feet in terrace II of North Kurgan, I have classed with figs. 507 and 508 and also with the stones found in the South Kurgan (figs. 509 and 510). It is a large stone 10 inches by 17 inches by 2.5 inches, weighing 33$\frac{3}{16}$ Russian pfund (=13.59 kilos). It has a hole cut near the top to form a handle, which is much worn by use. I know of no analogous form among stone implements



Figs. 496–502.—Stone Implements from the Anau Kurgans. Fig. 498 from the South Kurgan, all others from the North Kurgan.

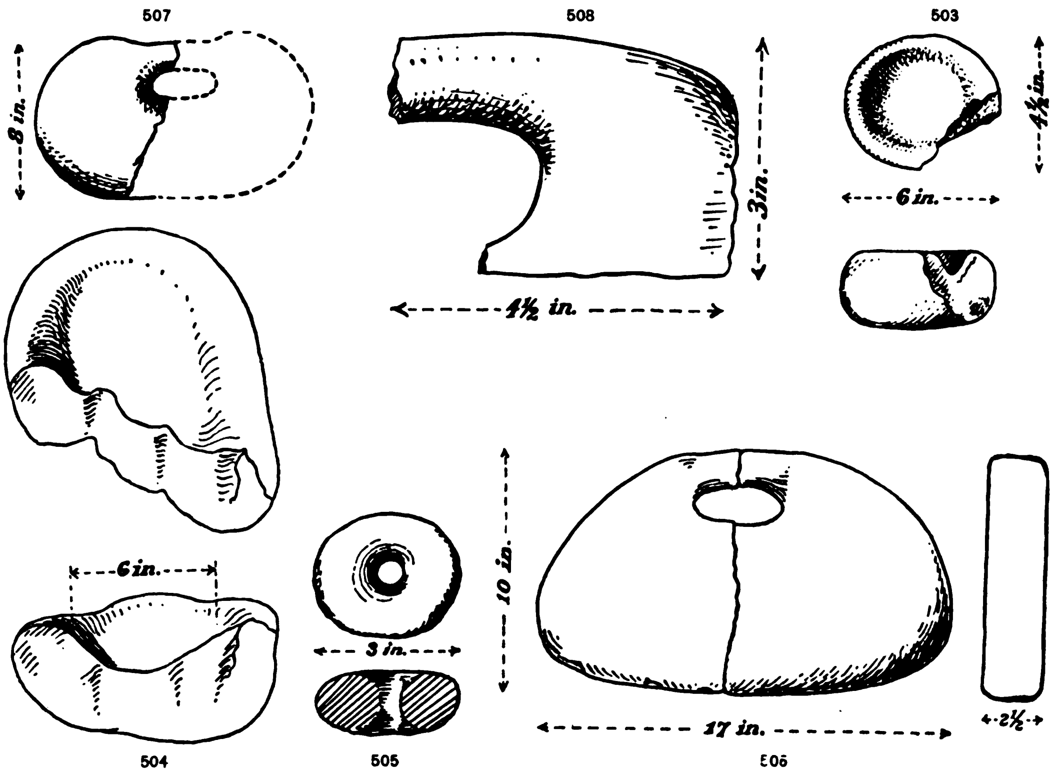
of other countries. Professor Pumpelly suggested the possibility of its use as a standard of weight. This seemed the more likely when we came upon other smaller stones, all broken, but showing the same form.

From the loose wash earth of the South Kurgan the workmen took a millstone-shaped stone (fig. 511), 12 inches in diameter, with a 2.5-inch hole in the center. The edges were much scarred and chipped in a manner that could not have come from horizontal use against a similar stone; nevertheless, I took it to be a more or less modern implement from a Persian mill, of which there were several on the little watercourses flowing from the mountains south of our work.

Fig. 498 (A.S.K. 43) shows an oval stone of great weight, grooved longitudinally. One can only conjecture its use, but stones not unlike this are used in other parts of the world for anchoring the hide roofs of huts, for straightening the green wood to be made into bows and lances, and for ceremonial purposes.

Fig. 512 (A.S.K. 13) shows a fragment of a round stone disk, with a shallow, saucer-like depression on one side, across which runs a smooth groove, apparently made afterward. This groove on a stone, if found in North America, might be thought to be the straightener and polisher for arrow-shafts.

Fig. 513 (A.S.K. 34) is a shallow saucer, broken, but once evidently oblong in shape, with rounded corners.



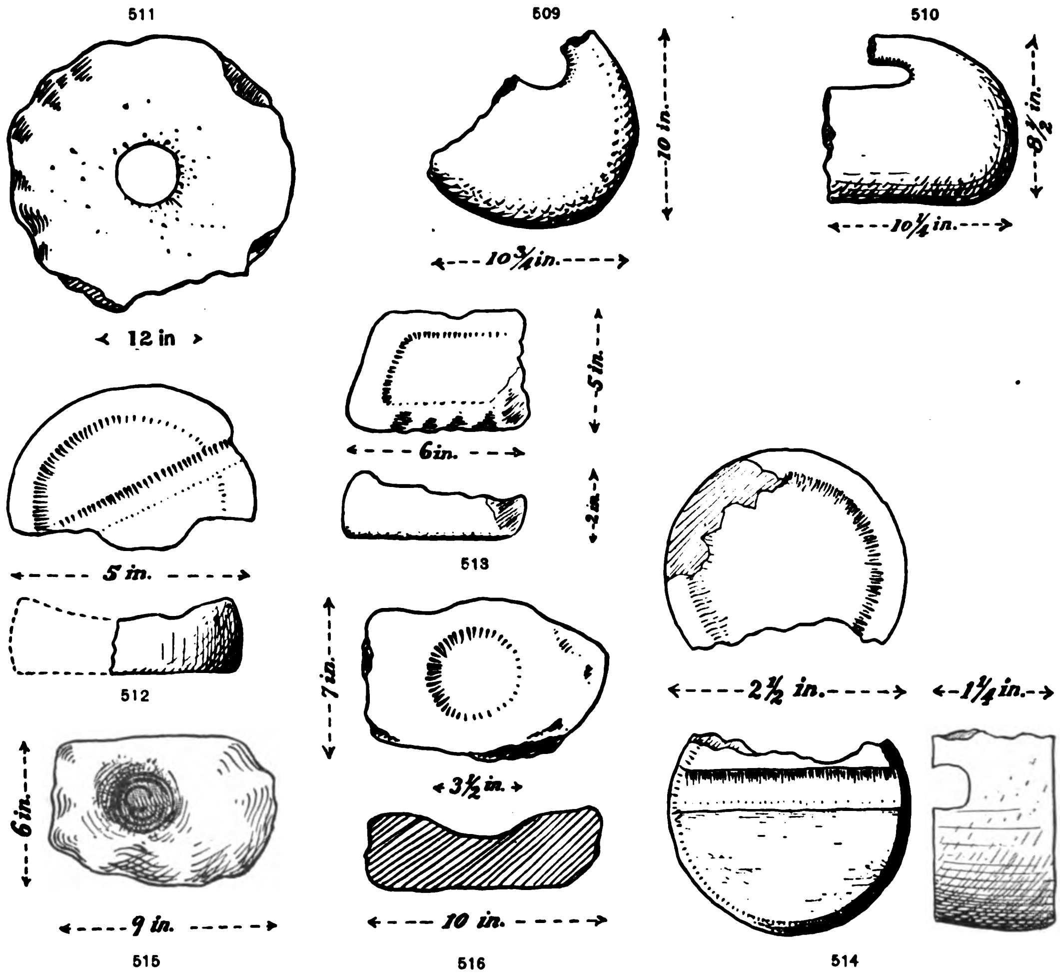
Figs. 503-508.—Stone Implements from the North Kurgan.

Fig. 514 (Spec. Finds Cat. S.K. 325, plate 48, fig. 11) shows three views of another disk with the saucer-like depression, and a deep groove running across the bottom, not quite intersecting the center.

Fig. 515 (A.S.K. 42) is the "door-stone" found in place with the rest of the threshold in terrace B over skeleton No. 27 (see "Report on Burials, South Kurgan, Anau"). It was a rough, unshaped piece of fine-grain quartzite conglomerate, with the well-defined marks of a swinging pivot that had left ridges in the hole. (*Cf.* Dr. Schmidt's report.) Several others of this sort were found scattered through this digging.

Fig. 516 shows a stone cupped not unlike a door-hinge stone, but lacking its characteristic ridges; these for want of a better term I call "cup-mortars."

The pestles and mullers of the South Kurgan show many more diversities in form than the simple cylinder of the northern. Figs. 517 to 524 show the shapes found. Fig. 524 (Spec. Finds Cat. S.K. 196, plate 48, fig. 8) from +21 feet in Terrace C, South Kurgan, is included among them because of its evident after-use for pounding, but it is doubtful if it was intended originally for that purpose. The



Figs. 509-516.—Stone Implements from the South Kurgan.

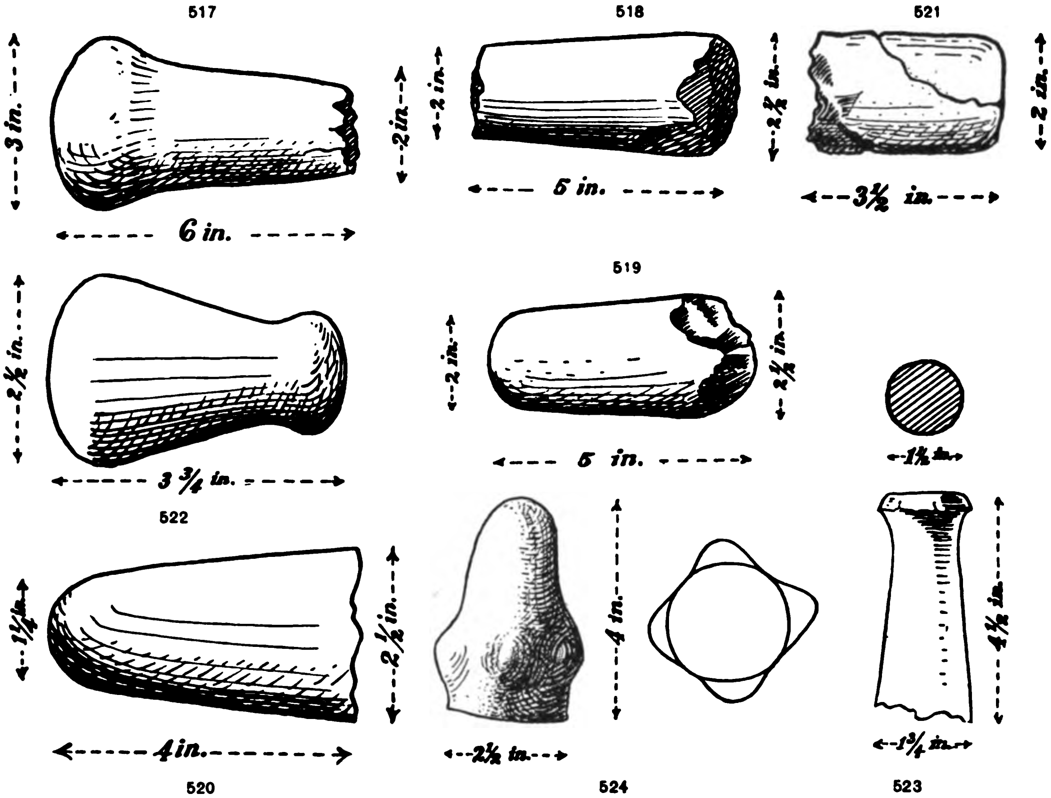
implement shown in figs. 525–527 (A.S.K. 119) owes its shape only partly to design, being a curiously weathered stone adapted by man (see plate 48, fig. 7). The same may be said of fig. 528 (A.S.K. 220, plate 48, fig. 2).

Fig. 529 (A.S.K. 53) shows a cylinder broken at both ends, made of micaceous schist.

Fig. 521 shows a broken pestle of the cylindrical type found on the North Kurgan. It is similar to that shown in fig. 496, except that it lacks signs of lateral after-use as a muller.

By far the best worked of the larger stone implements taken from either kurgan, if we except the mortar shown in fig. 532, is shown in fig. 530. The shattered end is roughly squared; the other has a circular cross-section and is carved with beautifully smoothed flutings, converging to a point at the center. The ridges between the flutings are sharp and their bottoms are even and round. If the ancient inhabitants of this kurgan had other use for it than ceremonial, it must have been on soft material, for the repeated, and seemingly intended, blows which have shattered one end have had no corresponding effect on the other.

Fig. 531 shows a large mealing-stone found in the South Kurgan, but typical of those of both, after they had been worn down in the middle by continued friction with a muller such as is seen in fig. 496.

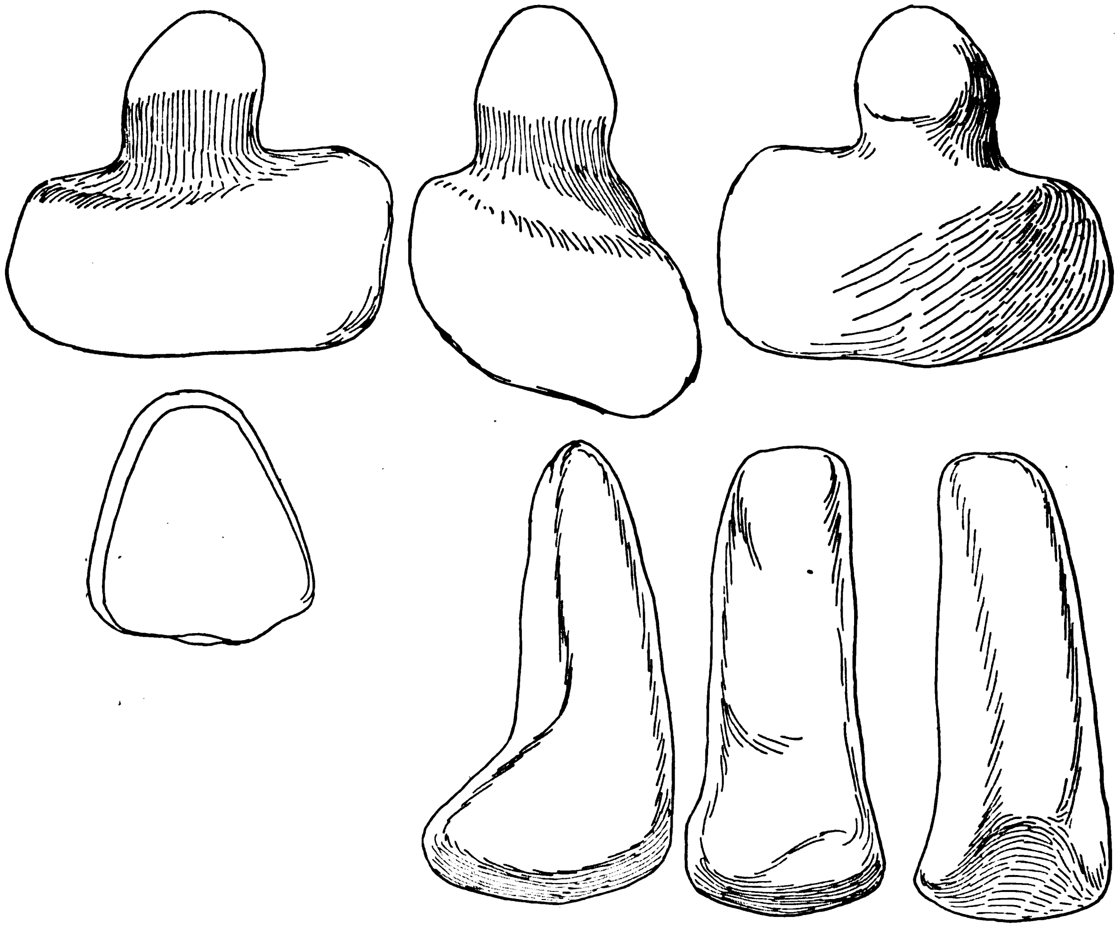


Figs. 517-524.—Pestles and Mullers from the South Kurgan.

Figs. 532 and 533 represent a highly developed form of stone mortar, which is all the more interesting from its close resemblance to that still in use. Fig. 532 is about 5 inches high. It is from the IV or Iron Culture at the top of the South Kurgan.

The information we can get concerning the daily life of these people is but slightly augmented by examination of their larger stone implements. We find that by far their commonest household tool that has come down to us (not counting the spinning weight described in Dr. Schmidt's report) is the mealing-stone and muller with which they ground their flour. But whether it was a grain, wild or cultivated, that they used, or whether they were acquainted with some tuberous root, there is nothing to show. What, then, brought in the mortar form in the younger kurgan, where it exists side by side with the flat, matate-like stones? Did they find the cup easier for pounding cereals, or did they, perhaps, with the new culture, learn the use of a new vegetable from which they extracted juice? Did the more elaborate pestles of the younger kurgan mean different uses, or a budding artistic sense? Nothing but more extended excavation and better opportunities for studying the great climatic changes could ever tell us.

525 526 527



528

Figs. 525–528.—Stone Implements from the South Kurgan.

SUMMARY OF WORK DONE IN TERRACE II, NORTH KURGAN.

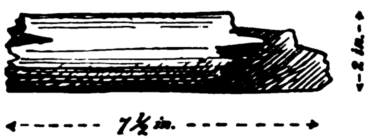
On March 28 I was given charge of terrace II, which had then been in process of excavation three days and been sunk to a level of +26.5 feet above datum. The digging extended north from the end of terrace I and measured 20 feet on the sides and 9 feet and 7 feet respectively on the south and north ends (see fig. 31).

At +26.5 feet we came to a layer of fire-hardened earth extending out from the edges of a circular hole which was filled to the mouth with ashes. This hole proved to be a sort of oven in the burnt earth, 5 inches deep and 6.5 inches in diameter at the rim. The ashes it contained were fine and white. It occurred 3 feet down the terrace from the south end and 4 feet from the east wall.

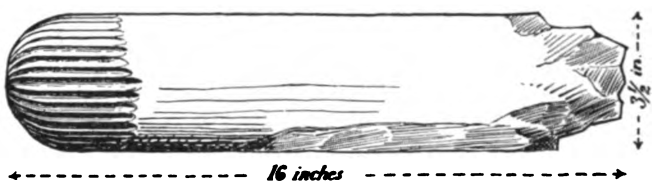
From 6 inches below the level of this hearth and some feet to the northwest of it, I took the child's skeleton No. 6 (see Report on Burials of North Kurgan). Below the body as it lay was a layer of ashes and burnt earth in which was embedded a part of the base and side of a huge thick jar containing a greenish-yellow slag of fused ashes, and what probably had been bone.

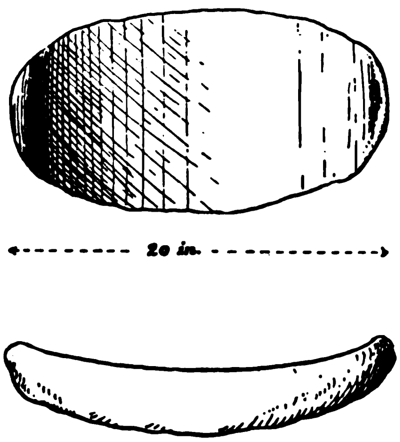
March 30, I took from the floor of the terrace at the same level (+26 feet) skeleton No. 7 (see Report on Burials of North Kurgan), which lay contracted on its right side and directly over a large stone with a small cup-mortar in one end (see Report on Larger Stone Implements, North Kurgan, fig. 497), the lip of which stood at +25 feet. This, however, was not taken out until later.

529



530





531 532 533

Figs. 529, 530.—Stone Implements from the South Kurgan.
531.—Type of Mealing-stone in both Kurgans.
532, 533.—Stone Mortars from the South Kurgan, Culture IV.

On April 1 we came upon a pithos *in situ* 12 feet south of the north end of the terrace, at a level of +26 feet. It was of heavy, undecorated clay. It contained earth and some few streaks and layers of white ashes. At the same level in the northwest corner of the terrace appeared another of the same sort, but much more badly wrecked than the first. Six inches lower down and some feet away lay another pithos, which proved like the others to be full of earth and ashes.

At +25 feet above datum, and directly below the first hearth and oven-like hole, occurred another of the same sort. The earth was baked red for a foot or so about the edge of the hole and the same fine white ashes were found inside. Three inches below the level of this hearth and out in the middle of the terrace was a plain undecorated pot like the others found above. Near it lay a half-burnt clay brick measuring 9 inches by 5.5 inches by 2.5 inches. This lay *in situ*, but was found to be broken into many fragments.

At this same level and directly below the site of skeleton No. 7, but lying to the west of the stone cup-mortar also found below it, were two pots *in situ*, showing remains of a decorative design done in black.

On April 4, 5, and 6, I excavated the four skeletons numbered 11, 12, 13, and 14 (see Report on Burials of North Kurgan), all at the level of +22.5 feet. They all occurred over layers of ashes mixed with bits of charcoal, and they all had near them burial objects, such as white stone beads (N.K. 114, 144; plate 40, fig. 2), carnelian beads (N.K. 114), lead tubes and copper corkscrew spirals (N.K. 185; plate 36, fig. 1). With numbers 12 and 14 air-dried bricks were laid to form a partial sepulture. No. 12 was found beneath a layer of ashes as well as above one, though in all probability the top layer belonged to a later period.

The last thing excavated by me in this terrace was a large pithos. It lay in the northwest corner of the digging and contained besides fine earth a mealing-stone of gently sloping surface (see Report on Larger Stone Implements, North Kurgan), on which lay a muller (see fig. 496) of cylindrical form, the battered end of which showed former use as a pestle. This was the only case in either kurgan where mealing-stone and muller were found together.

Dr. Schmidt in his report has treated the occurrence of the objects excavated in this terrace so fully that there is little to add. As it is just here that the transition period between the older and younger cultures of the kurgan occurs, his results and classifications of the finds in one or the other group is of the greatest importance.

REPORT ON SKELETONS EXCAVATED IN ANAU.

NORTH KURGAN.

When it became my duty to expose the skeletons in the Anau kurgans as they were come upon by the workmen, there had already been several fragments of human remains brought to light. One skeleton, more or less complete, was taken up in the north digging and reburied, as its position and orientation showed it to be the more or less modern grave of a native Turkoman. During the first few days there were also taken from the first terrace fragments of children's skulls belonging to at least five individuals.

When it had become clear to Professor Pumpelly and to Dr. Schmidt that human remains were likely to occur in more than a fragmentary and haphazard way, I was given the work of excavating them and noting their occurrence.

In every case where it was practicable, a large circle was drawn around the remains as soon as they were discovered and the men carried on their work outside its limits. In this way the floor of a terrace would be carried down 3 or 4 feet, leaving the skeleton untouched on a pedestal. This method was found to be of great help when the actual clearing of the bones was begun.

The material of the kurgan was so closely packed as to make fine work extremely difficult, and nearly all the skeletons were so delicate that exposure to wind and sun destroyed them. I found that a soft brush and a fine knife-blade were often none too nice for the work. When air-dried bricks appeared, often the only way of detecting them was by the faint outlined contours in the cutting, for they were as easy to work in as the material of the hill itself. The layers of ashes and charcoal that so often occurred under the skeletons as well as in other places came as a pleasant relief to the workers.

The human remains were uncovered from above and drawn and photographed while still embedded enough to be supported. When this was done the upper bones were removed and the position of the hidden portions carefully noted. Then the earth for some distance around was thoroughly searched for burial objects. In taking out the minute beads found with some of the skeletons, notably No. 9, it was found that even a very close sieve could not be trusted and that the fingers were more sensitive and sure. In this way many square feet of earth passed through my hands, and though the work was delayed it proved well worth while, for from that burial alone we took 1,066 drilled beads, each scarcely larger than a pin-head (see plate 40, fig. 5).

The three highest skeletons were excavated by Dr. Schmidt:* γ at +36 feet in terrace IV; δ at +34 feet in terrace V, and ϵ in terrace V, at +30 feet 2 inches above datum.

Skeleton No. 1 (ϵ).—For the description of the latter, I quote from his notes:

This child's skeleton is 62 cm. long, with its head to the south lying on the right side, but disturbed and partly destroyed by the pick. The trunk is on its back, inclined to the right, the left arm on the left side with that hand by the pelvis. The right arm is destroyed. The pelvis bones are spread to the left and right. The right leg, bent at the knee, is on the left side. The right leg is ill preserved, with the upper part drawn up and to the right; the lower bones of it are lacking.

Skeleton No. 5 (α).—The next skeleton in order of altitude was one I have called "No. 5" (see fig. 534). It lay at an altitude of +30 feet in terrace I. The bones were those of a young child, for the cranial sutures gaped wide and the epiphyses separated off the long bones. The body was placed on its right side, lying in a contracted position, with the head toward the southeast. The left arm

* Das beruht auf Missverständnissen. Ich finde in meinem Tagebuch folgende Notizen:

"*Sonnabend d.* 2. *April.* * * *

"*Terrasse IV.* Es wird wieder das Skelett (*i. e.*, γ) eines Kindes in der Lage der liegenden Hocker auf der rechten Seite von Herrn Warner freigelegt und photographiert. Beigaben fehlen.

"*Terrasse V.* * * * Neben dem Topf (*i. e.*, +34.5 feet) etwas unter dem Niveau, auf dem er steht, werden Skelette aufgedeckt und unter diesen die Spuren eines tieferen Topfes (*i. e.*, +33 feet) * * * Herr Warner legt die Skelette frei; es ist ein unentwirrbarer Haufen von mehreren Kinderskeletten (*i. e.*, δ), der von ihm beseitigt wird. * * *

"*Dienstag den* 5. *April.* * * *

"*Terrasse V, ca.* 20 cm. unter dem Niveau der Kalkschicht, südwestlich davon, neben der aufgedeckten Mauer, die Reste eines zerstörten Kinderskelettes (*i. e.*, ϵ). * * * Das Kinderskelett ist 62 cm. lang. Kopf nach Süden auf der rechten Seite, aber verschoben und durch die Hacke z. T. zerstört. Rumpf auf dem Rücken mit einer Wendung nach rechts, linker Arm auf der linken Seite, linke Hand in Beckenhöhe, rechter Arm zerstört; linkes Bein an der linken Seite und im Knie gebogen, rechtes Bein nur unvollständig erhalten, rechter Oberschenkel nach rechts und nach oben gezogen, rechter Unterschenkel fehlt."

Also nur Skelett ϵ habe ich herausgenommen und zwar weil Herr Warner gerade in Terrasse II beschäfligt war.

Dr. Hubert Schmidt.

Berlin, *d.* 29. *März*, 1908.

was bent in such a position as to bring the hand opposite the face and on a level with it, while the right arm was extended down at an angle of 40° with the trunk.

In front of this body and parallel with its main axis lay two air-dried bricks, 7.5 inches long by 2.5 inches wide, set on edge. At a right angle with these, 1.5 inches from the top of the skull, I came upon another brick of indeterminable length, but the same thickness. The three were laid in so deliberate a fashion as to suggest an attempt at sepulture. Between the heels and the end of the spine four lapis-lazuli beads (see N.K. 50, plate 40, fig. 6) came to light, drilled from both flat surfaces so that the hole was roughly double-conical. Four inches back of the neck appeared a smooth, clay, plummet-shaped object, possibly also a burial gift. Skeleton, bricks, and gifts all lay on an even bed of ashes mixed with small pieces of charcoal, resting on a layer of hard-burnt earth.

Skeleton No. 10.—In terrace VII on the southerly slope of the kurgan, the workmen came upon traces of human remains at +29.5 feet. These proved to be the jumbled bones of a child, evidently hauled about and dislocated by an animal, for I found a burrow extending straight down through the middle of it all. Two feet below this level, in what seemed to have been the bottom of the burrow, the missing bones that belonged above were found, together with two crania of small rat-like rodents. The loose earth that had filled the hole from the hillside above had allowed so much dampness to enter that all the bones were in an extremely fragile condition.

Skeleton No. 15.—In the same terrace VII, and at the same level, +29.5 feet, though nearer the outer edge of the hill, were found the cranium and a few vertebræ and long bones of a young child. The position in which the body had lain was indeterminable, and the bones fell to pieces as soon as they had dried.

Skeleton No. 9.—On April 7, in terrace V, we came upon a child burial at a height of 29 feet. No traces of the cranium could be found, though four teeth lay in an orderly row as if there had been no disturbance. The main axis of the body was approximately southwest to northeast. In the softer earth about the pelvis and lower limb-bones, I took out 1,066 minute white beads, apparently of stone (N.K. 222, plate 40, fig. 5). They were cylindrical, about $\frac{1}{16}$-inch in diameter and length, and so delicately bored that a very fine needle was required to thread them. Their presence on the leg-bones and pelvis, and their absence on the upper parts of the body suggest that they might have been sewn to a kirtle or other garment, and not used in strings, as were the larger beads we found later.

Skeleton No. 2 (β).—The next burial in order of altitude appeared in terrace I at +28 feet. It was the skeleton of a young child lying on its right side in a contracted position. From the top of the cranium to the end of the spine measured but 13 inches and the knees were so drawn up that the greatest width of the body in position was 8 inches. The main trend of the body was southwest and northeast. The right arm bones lay parallel with and behind the vertebræ, the left arm bent to bring the hand palm down in front of the face. (See fig. 535.)

When the bones were removed they were found to have been laid on a horizontal layer of wood-ashes and charcoal varying from 2 to 3 inches in depth and extending a foot or so beyond the body on all sides. The weight of the earth above had broken in the skull along the sutures and also warped it out of shape, so that no measurements could be made, but as it lay in position the effect of its shape seemed markedly brachycephalic.

Skeleton No. 3.—In this same terrace I, we came upon two other skeletons at the same level (+28 feet). One, very small, was left unexcavated in the east wall of the terrace, but the other, also in the east wall, I laid bare. The main axis of the body was southwest and northeast as far as could be determined by the few bones preserved. The body had evidently lain on its back, with the skull propped up in such a way that it now was set squarely on its base and lower jaw fitted over the first two vertebræ so as almost to suggest a dislocation of the neck. The left leg was extended straight down the main axis northeast from the skull, but the right knee was slightly bent and thrown over to the right above it. Only six of the ribs remained, all on the left side, and the top of the cranium had broken down, leaving only the side-walls and lower portions in place. (See fig. 536.)

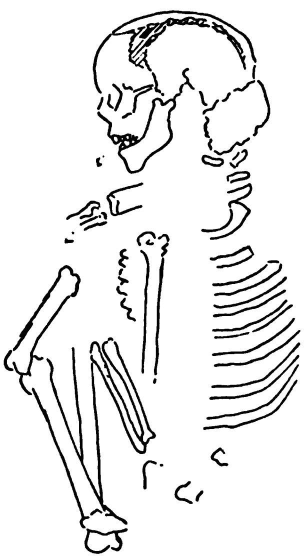


Fig. 534.—No. 5, Terrace I.

Fig. 535.—No. 2, Terrace I.

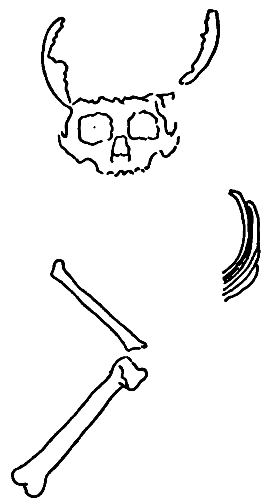


Fig. 536.—No. 3, Terrace I.

Skeleton No. 4.—The next burial was found at a height of +27 feet in the third terrace and more nearly approached adult size than any laid bare up to this time. The cranial sutures were not, however, closed and the ossification of the epiphyses was not complete in the limb-bones.

The body lay contracted on its right side with the main axis southeast and northwest. Both arms were drawn up as if to bring the hands (which were lacking) in front of the face, the left above the right. From the top of the badly broken cranium to the end of the spine measured 23 inches and from the back of the spine across to the ends of the leg bones was but 13 inches. (See fig. 537.)

Skeleton No. 6.—At a height of +26 feet in the second terrace the workmen broke with their picks into the skull of a child's body that on examination gave fewer evidences of deliberate burial than any others excavated up to that time. In general the trend of the body was southwest and northeast. The broken skull lay on its face, with a slight lean to the right, the knees were so bent that the lower leg bones stuck up to a height that would have brought the feet, had they been present, above the level of the top of the skull. It seems as if the body must have fallen in such soft material that it was partially buried at once and a support thus given to the feet and lower legs. Just beneath the skull was a large fragment of the bottom and side of a great earthen jar. Filling the cavity of this inverted fragment was a greenish-white slag partly fused with ashes; and under both pot-sherd and skeleton was a layer of rough charcoal and wood ashes. (See fig. 538.)

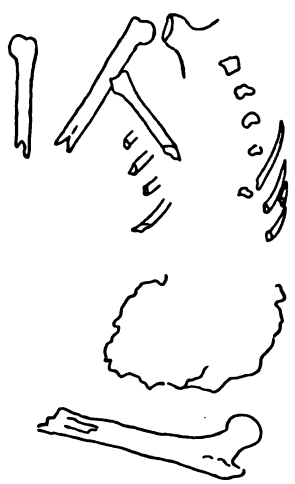


Fig. 537.—No. 4, Terrace III.

Fig. 538.—No. 6, Terrace II.

Fig. 539.—No. 7, Terrace II.

Skeleton No. 7.—In terrace II also, and on a level with the skeleton just described, I uncovered the first adult remains we had seen. The skeleton lay contracted on the right side, with the knees drawn up to a right angle with the main axis, which was southeast and northwest. The left arm lay extended down along the body, but the right was bent enough to bring the hand opposite the pelvis. (See fig. 539.)

Although the bones were too fragile to admit removal without elaborate gluing, and this was not thought advisable, the cranium showed the sutures well closed, and the teeth were worn flat and dull. The extreme length of the skeleton in position was 53 inches and the extreme width 15.5 inches.

Skeleton No. 8.—The next burial we came upon was in terrace VIII at +25.5 feet above the established datum. The bones were those of a young child and, though much lacking, it was possible to determine the main axis of the body as southwest and northeast. It was lying contracted on the right side with the left upper arm (all that remained of that member) stretched back of the body at an angle of about 40° with it. The right upper arm bones were absent, but the lower arm was traceable, extending along the main axis. The little that remained of the cranium showed the sutures still open and the walls of almost paper-like thinness. (See fig. 540.)

Skeleton No. 11.—From the last skeleton which occurred on the south slope of the kurgan I was summoned by the workmen, who had come upon remains again in terrace II at +22.5 feet. This burial, which I have numbered 11, proved to be that of a child lying contracted on the right side, with the main axis running southwest and northeast. I found no traces of the right leg or right arm; but

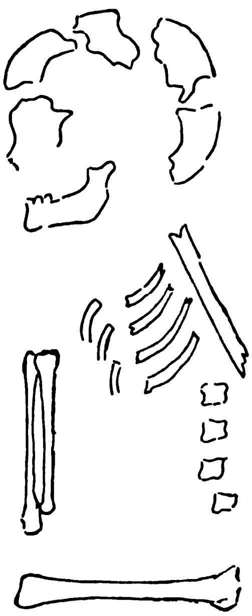


Fig. 540.—No. 8, Terrace VIII.

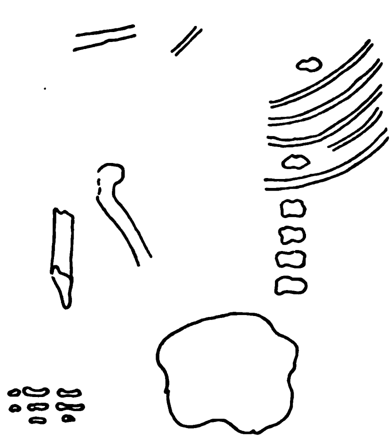


Fig. 541.—No. 11, Terrace II.

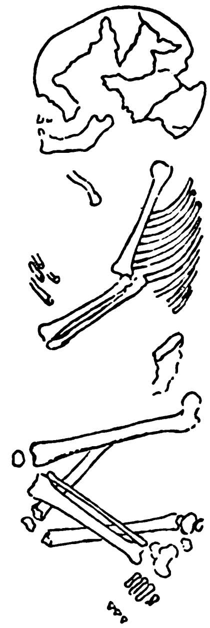


Fig. 542.—No. 14, Terrace II.

the left knee was drawn up at a right angle, and the left upper arm ran parallel with the vertebræ, the elbow being bent so that the hand lay out at the level of the pelvis. (See fig. 541.) From near the collar-bone I took out 58 small white stone beads (N.K. 114), many of them double-conical. One larger white stone bead of a cylindrical shape (N.K. 114, plate 40, fig. 2) and 11 flat beads of red carnelian (N.K. 114, plate 40, fig. 2).

To reach this skeleton it was necessary to remove a hearth-like layer of hard-burnt earth topped by a layer of ashes 1 to 3 inches thick; and after the bones had been lifted I came upon a similar hearth beneath, extending over about 4 feet square.

Skeleton No. 12.—In the same terrace (II) and at the same height, 22.5 feet, but about 5 feet north of No. 11, we uncovered a child's bones lying in the position now so familiar—contracted on the right side, with the main axis southeast and northwest. The right knee lay under the left, but doubled to a slightly sharper angle. The left arm was bent so as to bring the hand in front of the face, while the right lay along parallel with the vertebræ, the fingers underneath the pelvis. From between the lower jaw and the collar-bone, I took 67 small white beads (N.K. 144, plate 40, fig. 8), like those found with skeleton No. 11. Along the back and beyond the head, at a right angle to the main axis, were traces of air-dried bricks as in skeleton No. 5, and, as in that case, the whole lay upon a layer of charcoal and ashes.

Skeleton No. 13.—Again, at the same altitude in terrace II I came upon traces of a child's skeleton in the midst of the caved earth of an animal's burrow. The cranium and many other parts of the skeleton were entirely lacking. Among the jumbled bones, however, lay 2 small white beads of stone and 3 spirally wound cylinders of lead, possibly beads (N.K. 143, plate 40, fig. 3). Beneath the body was a layer of fine white ashes, below which the earth was burnt hard and red.

Fig. 543.—No. 16, East Gallery.

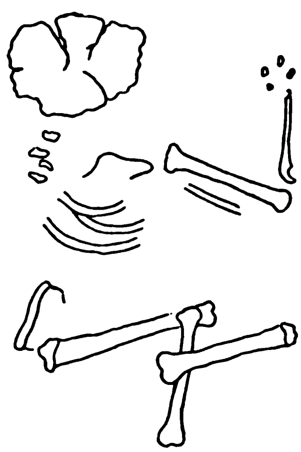


Fig. 544.—No. 17, East Gallery.

Fig. 545.—No. 18, North Digging I.

Skeleton No. 14.—The next remains in terrace II lay also at + 22.5 feet. They were those of a child and lay contracted on the right side with the left knee drawn up slightly higher than the right. The left upper arm lay parallel with the main axis (southeast and northwest) with elbow bent so as to bring that hand on a level with the pelvis. The right arm lay extended under the body and parallel to it. As in nearly every other case, the cranium was crushed by the weight of the earth. (See fig. 542.)

In connection with this burial were taken out three bits of spirally wound tubes of copper and two plain lead tubes and one flint edge. Air-dried bricks were traceable along the main axis before and behind the body, and the whole was on a layer of ashes and charcoal with fire-reddened earth beneath.

Skeleton No. 16.—Skeleton 16 next came to light, far below any human remains we had yet found. It was in the east gallery off from General Komorof's trench, at a level of 8 feet below datum on the plain. It was that of a young child and lay on its face, with the top of the cranium crushed in. The arm bones were jumbled together in an indistinguishable mass. The left leg was straight from the trunk, but the right knee was pulled up at an angle. Five vertebræ were found inside the skull. With the body I found two clay spin-whorls and two flint edges. Below was a layer of ashes and bits of charred wood over fire-hardened earth. (See fig. 543.)

Skeleton No. 17.—The next burial was at the same level (−8 feet) and, like the other, in the east gallery. As before, the bones were those of a child, but in this case when they were laid bare they were found to be in the familiar contracted position. The main axis was southwest and northeast. The body had lain on its left side with the right leg drawn up to a right angle with the main axis and the left leg seemingly disturbed. The arms were bent to bring the two hands, one over the other, in front of the face, much as in the predynastic Egyptian burials. (See fig. 544.)

From the earth between the knees and the lower jaw I took 6 flat bean-shaped turquoise beads and two pierced snail shells (plate 40, fig. 7). When the bones were removed a layer of ashes and charcoal over fire-hardened earth came to light.

Skeleton No. 18.—The lowest of all the human remains which we found in the North Kurgan occurred in the north digging No. 1 at a depth of −11 feet. As usual the bones were immature and the position was contracted, with the main axis southwest and northeast. The body lay on its left side, with the hands in front of the face, and beneath it I found ashes and charcoal mixed with occasional bits of burnt bone. (See fig. 545.)

The results to be superficially gained from the human burials in the North Kurgan may be thus briefly summed up:

Out of 18 different remains laid bare, 10 were in the contracted position, 4 indeterminable, and 4 definitely not contracted. Of these all but 3 headed to the southwest, with the trunk running northeast. These 3 varied to the southeast. Ten were found on hearths or layers of ashes topping burnt earth; 8 (6 of the lower culture and 2 above) were found with small objects in obvious connection with the burials, and 3 had not only hearths beneath them, but traces of bricks carefully placed in reference to the bodies.

These facts, taken in connection with the floors and walls found by Dr. Schmidt (see Dr. Schmidt's report), seem to prove that the children (for we came upon but two adults) were buried in or near the houses and often on hearths that were especially prepared for their reception, or, what seems more likely, the domestic hearths within or just outside the dwellings.

SOUTH KURGAN.

The burials which occurred in the South Kurgan were excavated in the same way we had attacked those in the north, that is, by carrying on the work around them till they were left isolated on pedestals at a convenient height, and then personally exposing them. Nine out of the 10 came to light in terrace B on the southern slope of the hill, and the altitudes at which they were found only included a range of 6.5 feet (+27 feet to +20.5 feet).

Skeleton No. 19 (α).—The first one of the skeletons found in terrace B was at +27 feet above datum. It proved to be the remains of a child lying contracted, with the main axis running northeast and southwest. Lying on the right side, the hands were spread in front of the face and the knees drawn up to an angle of 90° with the trunk. From among the bones of the left wrist was taken one small, cylindrical, yellowish-white stone bead (S.K. 244). (See fig. 546.)

Skeleton No. 21 (β).—Skeleton No. 21, a few feet south and west of No. 19, was again that of a child lying contracted on the right side. It was also at an altitude of +27 feet. The left hand was beneath the chin, with that elbow close in to the trunk. The right arm was slightly deranged. The position of the leg bones was traceable as contracted, but they were for the most part mere channels in the hard-packed earth. Below the body was a thin horizontal layer of ashes and charcoal.

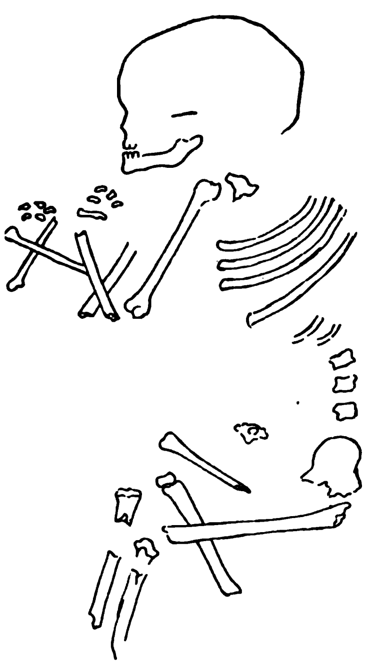


Fig. 546.—No. 19, Terrace B.

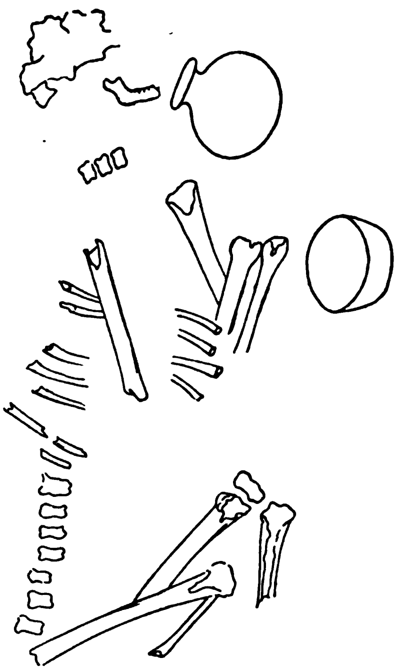


Fig. 547.—No. 23, Terrace B.

Fig. 548.—No. 28, Terrace C.

Skeleton No. 22 (γ).—Nearly due east from the last skeleton and about 8 feet from it we came upon the next burial at a level of +25 feet. The body was that of a child lying contracted on the left side, with the main axis of the trunk northeast and southwest. The position of many of the bones could be traced by their decayed remains, but little else could be learned. There remained no vestige of the left leg and foot or of the right lower arm and hand.

Skeleton No. 23 (ζ).—At a level of +25 feet, northwest from the site of skeleton No. 21, we found the contracted remains of a child (the fourth in this terrace). They lay on the left side, with the right knee drawn slightly closer to the trunk than the left, which was beneath it. For the only time in the burials of either kurgan the main axis was west and east. The left hand lay palm down in front of the breast just under a small clay bowl (see plate 10, fig. 2), while the fingers of the right hand lay around the neck of a little jar, the lip of which was tipped to within 0.5 inch of the teeth of the lower jaw. (See fig. 547.)

Skeleton No. 24 (ϑ).—North of these first burials and more in the body of the hill the workmen came to the ill-preserved remains of a child at +25 feet, lying contracted on the left side. The bones were little better than traces in the earth, but it was possible to determine that the main trend of the body was northwest by southeast, and that the right knee was drawn up so close to the ribs that the heel nearly touched the tip of the spine.

Skeleton No. 25 (ε).—Slightly north and 4 feet to the east of skeleton No. 24, in the north wall of the terrace, there occurred evidences of the burial of a child in a contracted position, on the right side. More details I could not gather about the mode of burial, except that the main axis ran southeast to northwest. Many of the bones had utterly disappeared, and the whole was so decomposed as to be the mere ground plan of what had once been a skeleton. Below the body was found a layer of ashes and charcoal, slightly depressed in the middle and ranging from 1 to 3 inches in depth. The level of this burial was the same as the one before it, +25 feet.

Skeleton No. 20 (δ).—From directly over a wall, which Dr. Schmidt was later able to trace for some feet north and south, I took the bones of a child which had been buried contracted on its right side. Its level was 23 feet 7 inches. Though the long bones of the right leg were wanting, the foot was in such a position as to clearly indicate that that leg, like the left, had been drawn up at an angle with the trunk. The trend of the vertebræ lay southwest and northeast.

Skeleton No. 26 (η).—Four feet northeast of skeleton No. 19, at a level of +23 feet, were human bones more nearly of an adult size than any that had yet come to light in the South Kurgan. They seemed of about the proportion of an Anglo-Saxon boy of 15 or thereabouts. The cranial sutures were almost ossified and the ephiphyses of the longer bones partly joined.

The body lay on its right side in a contracted position with the hands in front of the face. The main axis ran northeast to southwest. All the lower skeletal bones were in better condition than the cranium, which for some reason had quite disintegrated, all but certain portions of the front of the lower jaw.

Skeleton No. 27 (ι).—The last remains we found in this terrace were under the door-stone and threshold in the west wall described by Dr. Schmidt (see report of Dr. Schmidt). They consisted merely in an adult skull lying on its right side and beyond it the left arm with the elbow bent to bring the fingers under the chin. At a distance of 14 inches out from the body lay the fingers of the right hand, but not even a trace of other bones was found. This was all the more remarkable in consideration of the fact that those bones which were discovered were in a comparatively good state of preservation. The level of these remains was +23 feet. Beneath the body was a horizontal layer of ashes and charcoal, below which in turn were found the remains of an apparently tumbled wall.

Skeleton No. 28.—In terrace C, at a level of 20.5 feet, we found the lowest burial of any. The bones were those of an adult, as the closed cranial sutures, worn teeth, and ossified epiphyses to the long bones clearly showed. (See fig. 548.)

The skull was caved in and lying at one end of a neat bundle composed of the other parts of the skeleton. All the long bones had been gathered together as one would bundle sticks. That they had been previously dislocated was proved in that the lower ends in the case of the right leg and the right arm were found nearest the skull. But that the flesh had not been removed seems shown by the fact that the patellæ were both in their correct relative positions. It was also clear that the dislocation had been done with some nicety or else that the limbs had been twisted apart, for the ends of the bones showed no scars or evidences of chopping as must surely have been the case had the body been merely hacked into "lengths" at the articulations. The skull had been placed on its base at the eastern end of the bundle.

Looking over these burials brought to light in the South Kurgan at Anau, no such absolute results can be reached as from those of the northern one. Of the 10, only 3 are found in connection with the layers of ashes and burnt earth comparatively common in the other. Only two skeletons are accompanied by burial gifts, and no rule at all can be deduced from the orientation of the bodies, as we found them heading to nearly every point of the compass. However, on one point of prime importance the burials seem fairly constant, for we only found one case where the body was definitely arranged in a *non-contracted* position, and that, it is worth noting, was one of the two adults found in the kurgan. One burial was indeterminable in position, thus leaving 8 out of the 10 contracted.

If, now, there is any basis of comparison between the civilizations of the two kurgans to justify my treating them together, the burials removed from both give us, in tabular form, the following results:

Contracted on right side	13
Contracted on left side	5
Indeterminable position	5
Not contracted position	5
Total	28
Found on hearths	13
Found without hearths	15
Total	28

Found with burial gifts	10
Found without burial gifts	18
Total	28
Adult remains	4
Child remains	24
Total	28

One can deduce from these figures that the people with whose culture we have to do buried their infants and young children in or near the dwellings, often over hearths of burnt earth and ashes; that in general the body was placed upon its side with the knees drawn up in a contracted position, and that burial gifts were often placed with the bodies, such as beads of stone or copper, flint knives, and clay spin-whorls. The mere presence of these objects in connection with the burials does not prove belief in a future life, for parental affection and sentiment might go far toward explaining them. But since in all history and in all prehistorical research there are no evidences of a people existing without a religion or cult, we can fairly assume that the burial gifts found in the Anau kurgans throw some light on the beliefs of the inhabitants.

INDEX.

[NOTE.—The asterisk (*) indicates that the reference is to an illustration.]