Locality of Permian terrestrial vertebrates in cupriferous sandstones in the southwestern vicinity of the Urals

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With the blossoming of the copper-ore mining industry in the southwestern Ural foothills since the middle of the past century, during underground work there began to be turned up the remains of terrestrial vertebrates, which were gathered chiefly by Wangenge von Kualen. These remains, belonging to amphibians and reptiles, were described in the works of Kutori, Echwald, Seeley, von Meyer, Twelvetrees, and others—unfortunately without the necessary morphological approach, and with a muddled synonymy. The originals of the works are either lost or scattered throughout museums abroad. The fauna of the cupriferous sandstones, in as far as it is possible to judge, is very interesting and at present furnishes the indispensable starting point for studying the Permian and Permo-Triassic fauna of the terrestrial vertebrates of the U.S.S.R.

In the summer of 1929, the Geological Museum (now the Paleozoological Institute) sent me to the Urals for the purpose of investigating the possibilities of obtaining new materials. In addition to this, in 1930 I took part in the work of the Kargalin party of the GGRU, which was studying cupriferous sandstones. During the period there, two regions of cupriferous sandstones of the Ural foothills known for previous discoveries of vertebrate remains were studied: the Kargalin region, 50 km northwest of Orenburg territory in the 130th layer, and the Izyaksko-Sterlibashevski region of Steritamak state of the Bash Republic in the 129th layer.

The Kargalin region, with a total area of about 3,000 sq. km, presents a wide strip northwest of the expanse, a strip that includes the tract between Yanghiz and Middle Kargalin creeks, approximately from the middle of their course to their courses and farther north up to

* Original citation: Efremoff, I. A. 1931. Mestonshkorzdenie Permskyhk Nazemnihk Pozvonochnyhk v Medistyhk Peschanikahk yeugozapadnovo Preeurallya. *Izvestiia Akademii Nauk SSSR, Otdelenie Matematicheskihk i estestvennyhk Nauk*, Seriia VII, 5:691–705. Unknown translator. Generously donated by the Biosciences Library, University of California, Berkeley, and courtesy of Patricia Holroyd and William Clemens. UCB call number AS 262 A44 1919. Transferred to electronic copy and edited by Abree Murch and Matthew Carrano, Smithsonian Institution, 2014.

the village of Novo-Sposanie. Over all this territory are scattered groups of mines that now are deserted, and their diggings cover considerable areas of the steppes. As a result of the negative character of the relief and the absence of energetic erosion, the orography of the region is unsuitable for geological investigation. Most of the slopes of the valleys and ravines long ago attained the normal slope and are drawn, but because they are denuded as a result of denudation and the firmness of the sandstone, they do not show new cuts. Morphologically the region presents a continuous system of small mountains and plateaus cut through by various sequences of dry valleys and ravines. Such a partition came about as the result of the washing away of lenses of the more porous strata: the firmer ones, the more closely cemented strata, were left in the form of mountain-remains in front of the monolithic plateau of the sandstone-like layer P^b_2.

The geology of the region is in general not complicated, because everywhere there is only one series of overlying layers, a thickness of gray sandstones P^b_2. All the younger formations are washed out, but the thickness of this series exceeds 1,000 meters, according to the borings of the 1929 Kargalin party whose data were so graciously communicated to me by N. K. Razumovskii. In this region there are no noticeable tectonic disturbances.

The strata that are represented in the region are uniform as to their basic components. The sandstone and marl bound together by various transverse layers (marl-like sandstone and sandy marl, and as if a derivative of both), also a conglomerate of marly pebbles in the sandstone, fill all the layers encountered. All three strata yield innumerable variations caused by different processes of deposition and lithification. The sandstones vary as to the coarseness of grain, the admixture of grains, the composition and density of the carbonate cement and of the conglomerate not only in the size, form, and composition of the marl pebbles, but likewise in the cement. Two types of marls are found—red ones typical of continental Permian deposits, always oreless, and gray marls, slightly bituminous, often containing organic remains and copper as a cementing substance*. No considerable concentrations of gel formations were observed—oxides of iron, silicic acid. Gypsum and salt are absent, as well as all complex chemical fractions characteristic for basins with large-scale evaporation of inflowing waters rich in dissolved minerals. The strata of the Kargalin region undoubtedly were formed by means of an energetic washing down of material, already sorted and washed

* lit.: fusion.

out. This fact is attested by the complete absence of pebbles, even the smallest pebbles, as well as of coarsely broken material, and erupted material.

The general character of the overlying layers is typical for similar continental layers and requires a special approach for studying it. All the overlying layers, as well as the varied size of the lenses of marls, sandstones, and conglomerates, are irregularly oriented, lenticular, and replace each other. Very often the cutting of one series of overlying layers by another is observed, an angular discordance and tilting of the washed-out surface. The various types of oblique stratification, and the variations in the very petrographic composition, form a complex picture of stream deposits of varied power and speed; they give the impression of a "surviving" of some series over others as a result of greater cementation and consequent firmness. The lenses in the complex form structures of the most complex formations—meandering bands[*], semicircles, and flat "cakes," the edges of which are cut by a washout at the contacts with other lenses along the horizontal.

The entire P^b_2 layer (exclusive of its underlying strata, which nevertheless form with it one single complex, but strata extending into unknown depths and requiring deep drilling for the purpose of studying them) clearly falls into two divisions. The lower division is exposed somewhere along the bottom of the deep caverns and is invariably found in all the drillings at a depth of 70 to 80 meters. This is a rather thick layer of red-brown and brownish marls, on the washed surface of which lies, generally speaking, the upper division of gray and red sandstones and marls which include nests of ore and organic remains. In the denuded portions of the lower layer are seen only the uppermost part without the slightest traces of fauna. Directly upon the layer of marls there rests a basal conglomerate of the upper layer with large (as much as 30 cm in diameter) pebbles of limy marl. The upper layer has a thickness of more than 100 meters and it alone is of value for paleontological study. I propose to designate it by the ore layer of the continental facet P_2-P^r_2.

The overwhelming predominance of the ore layer belongs to the gray and red sandstone and to the red marls. In general, the entire layer presents a rather even alternation at right angles to the sandstones and red marls; these and others often attain a considerable thickness and alternate no more than once in the entire thickness of the layer. This fact indicates certain cycles in the course of the deposition of the layer, as if indicating the

[*] "ribbons"

pulsations of the powers of the factors of deposition, a pulsation that has been several times reduced.

The divisions of the gray and red sandstones are not oriented either stratigraphically or altitudinally. Without doubt, these layers are identical as to mechanical composition and mechanical conditions of formation, being distinguished only as to their facies and distribution in the stratum, underlying the known facies. It is remarkable that neither in the red sandstones nor in the red marls have there been found organic remains. All organic remains are characteristic exclusively of the gray sandstones and gray marls. This very same fact is noticed even in the distribution of cupriferous ores, the connection of which with organic remains was pointed out long ago. In the underground workings of the Nicholski and Michaelovski mines, I had the opportunity to see the changing of red marl into gray at the point of contact of the layer of red marl lenses with the ore lens in the pendant side. Analyses of the metamorphosed marl showed an average of 0.80% Cu. The great quantity of animal remains in the pendant side, remains that most likely created a zone rich in carbonic acid and hydrogen sulfide, likewise played a well-known role. Even such a metamorphosis of marl was observed by me in pebbles and small shallow marly lenses in the ore-bearing conglomerates of the Novo-Myasnikovskii mine conglomerates, created by the energetic process of accumulation. The gray marls are found much more rarely than the red ones, sometimes, as soon proved to be the case, as marls transformed from the red marls. These marls form tiny lenses and inclusions in the mass of gray sandstones of coarse ore-bearing bodies and contain a large amount of copper (5 to 6%). The primary gray marls are observed in the lower parts of the layer in the form of lenses, always containing finely distributed cupriferous minerals and remains of plants and animals. On the pendant side of such lenses always appear the schistose sandstones that run upward and change into lumpy gray sandstones. Such marls are usually slightly bituminous.

The Izyasko-Sterleebashevskii region has been studied by me rather superficially within the limits of the water-divide and of the middle course of the Tyater and Izyak[a] rivers, but it includes an incomparably larger area, while it is also being extended by the strip sweeping NNW and SSE In this region is also developed the ore-bearing layer P_2, in which numerous mines have been worked and which is celebrated for the discoveries of fossil Amphibia and Reptilia (*Deuterosaurus*, *Rhopalodon*, *Zygosaurus*, *Melosaurus*). Eastward from the region there is a strip of dislocations and outcroppings of the Ufimiskii Series, also ore-bearing. There are no remarkable dislocations within the limits of the region investigated. Morphologically the region is similar to the Kargalinskii one, except that the ranges (mountains) and plateaus in this locality attain a much greater height, blending into the general system of the southern spurs of the Ural range. All the general conditions of bedding and placing of the overlying ore-bearing strata of the region are identical with those of the Kargalinskii region. The essential distinction of the ore-bearing layer of the Izyak region from such a Kargalinskii layer consists in the presence of a considerable ore-bearing conglomerate with an admixture of pebbles from the gray marl, and of well-defined erupted strata—of porphyriess, but also hornstones, quartz[es], jaspers, etc. These conglomerates, while varying from extremely dense ones to the porous (almost gravel-like) ones, do contain ore-bearing material in the cement and often form lenses that are almost equal in thickness to that of the entire ore-bearing strata. The gray marls are found more often in this place and form whole series with the remains of carbonized plants and the meager fauna of small Productidae. I did not find any red layers, but nevertheless I cannot express more definitely on the matter of their absence in the Izyak-Sterlibash[evskii] region. There is no doubt that the predominance of gray layers here is decidedly more considerable than in the Kargalinskii region. I found no remains of vertebrates. All the old discoveries were made during underground work, so that in the further exposition all factual material will refer to the Kargalinskii region. Theorizing based upon geological data and in accord with old information about discoveries of vertebrates will be common to both regions.

As even in the Kargalinskii region, the ore-bearing layer of the Izyako-Sterlibah[evskii] region lies upon a washed-out surface of a layer of red marls. The thickness of the ore-bearing strata here is much smaller and evidently does not exceed 50 or 60 meters.

The organic remains form rather considerable accumulations at times, always inferior to a given lens. There are found in the ore-bearing gray marls and in the schistose fine-grained sandstones impressions of plants (*Walchia*, *Dadoxylon*, *Calamites*, etc.), a few Invertebrata, mostly *Nayadites* and *Estheria*, and the fishes *Platysomus*, *Amblypterus*, and *Acrolepis*. In the coarser sandstones the vegetable remains are carbonized and either deposited in thin layers, or scattered and chaotically distributed within the mass of sandstone. In the coarse lumpy and porous sandstones are found petrified fragments of huge trunks (up to 1 meter in diameter), rich in iron and belonging evidently to the *Dadoxylon* group. Just such trunks are found even in conglomerates in which no other vegetable remains are found.

These trunks do not have bark with the encircling layer and they show foreign elements. For the most part such trunks, infiltrated with copper, were first found in the conglomerate zone of the mines in the Izyako-Sterlibash[evskii] region, where continuous piles (heaps) were formed reaching 15 meters in length.

Remains of land vertebrates are found very rarely. In the larger lenses of gray marl, together with good impressions of plants and the remains of fishes, skulls and skeletal elements of aquatic Labyrinthodontia were found. *Discosaurus*? from the marl lens of the Kuzyminoskii mine was described by A. N. Ryabinin. In this same lens and the lens of the Nicholayeff mine we collected remains of Labyrinthodontia, although they are not yet identified. Previously, discoveries of skulls of the Amphibia *Melosaurus*, *Platyops*, and *Zygosaurus* were made in the marl inclusions and small lenses of the lower pocket of ores in the Kargalinskii and Izyako-Sterlibashevskii regions. Besides this, we turned up fragments of the large bones of Labyrinthodontia in the conglomerates and gray sandstones in the workings of mines on the divide between the Yanghiz and Vyerknaya Karghalka rivers.

Bones of Reptilia are usually found in the lumpy gray sandstones with carbonized remains of plants, and with ore-bearing veins—piecemeal and sporadically, together with stalks of *Dadoxylon*. In general, the most complete discoveries of the part—skulls and complexes of parts of a postcranial skeleton—were made in the Izyako-Sterlibachevskii region. The Kargalinskii region yielded rarer and more fragmentary remains. After the mines were closed, all later collections were conducted in the tailings and furnished remains of Tetrapoda, remains that are only fragmentary and therefore devoid of serious scientific significance.

The investigations of 1929-1930 make it possible to give the following conclusions:

(1) The fossil remains of vertebrates are found sporadically only in a few lenses scattered throughout the ore-bearing stratum, and are not governed by any definite horizon or zone. The presence of remains of plants and invertebrates in a given lens indicates a facies suitable for the deposition and preservation of the remains of Tetrapoda. I shall say that in not all lenses by far, in lenses that were formed under favorable conditions of deposition, is it possible to expect with certainty to find bones of Tetrapoda. For example, out of 10 given

lenses satisfying all conditions for the preservation of the remains of terrestrial vertebrates, only one may be bone-bearing. In large lenses, only part of the lens may be bone-bearing. For example, just such a one is the bulky marl lens of the Kuzminovskii mine where the remains of vertebrates are found only in the northern corner of the lens. In the lumpy gray sandstones—in the facies with the occurrence of reptile bones—there is a still lesser possibility of discovery. Reptilia of the Kargalinskii fauna—*Deuterosaurus* and *Rhopalodon* —lived on the continents outside of [the] water basins; their skeletons were subjected to quick subareal destruction and only in rare cases were buried. In looking for vertebrates in continental strata it is necessary to be guided not only by the laws of favorable facies and lithogenesis, but by a certain law that has been hitherto unknown to us. I shall designate this law as the law of sporadicity, a law based upon the facts set forth above, namely on the fact that even in favorable facies remains of Tetrapoda are found sporadically. This law has its roots only in the biosphere and needs to be studied by all fossil hunters by establishing local biodiagnoses and migration, and also the recent factors of burial and concentration of animal remains. Taking this law into account, we can say that all the continental strata, exclusive perhaps of the barren and gypsum-bearing and salt-bearing facies, should contain remains of Tetrapoda that sooner or later will be turned up, but we also should warn paleontologists against being quick to label given layers as "dead layers" or as "barren layers."

(2) No bone-bearing overlayers were disclosed, not even in a single working of an ore-bearing stratum in the Kargalinskii region. The same cannot be said about the Izyako-Sterlibashevskii region, because it has been investigated very incompletely.

(3) All the mines that have previously furnished remains of terrestrial vertebrates, which are ruined and have had their shafts filled in, should be struck off from the lists of localities.

(4) The collection of fossil vertebrates from the tailings are useless for the purpose of studying the Kargalinskii forms. The finding of remains in the tailings is hampered because of the scarcity of remains and the multitude of tailings; and because in the tailings the material was found almost exclusively to be broken and ground to bits, the value of any possible finds amounts to almost nothing.

At present it is possible to show a few places where we turned up remains of Tetrapoda, and these places require a searching examination.

(1) The Petrovelikanskaya drift in the Nicholayevskii cave is about 1 km from Gornovs farm on the Upper Kargalka. Beyond the first "crest" on the left side along the course of the drift, the ore-bearing sandstone is about 1.5 meters thick with a mass of carbonized plants and silicified stalks of *Dadoxylon*. In this place was found the shoulder of a huge reptile of the *Rhopalodon* type.

(2) The Kuzminovskii mine is 7 km north of the Gornov farm. In the eastern part of the mine were left piles of a marly ore (over 100,000 poods)* undelivered to the mill. In the ore are many remains of plants, impressions of the shells of *Nayadites* and *Estheriae*, rare wings of insects, ganoid fishes (*Platysomus*, *Amblypterus*, *Acrolepis*, and others), and remains of small Stegocephalia.

(3) There is a small valley on the divide between the Yanghiz and Vyerhknaya rivers of the [Upper] Kargalka, whence we received the bone of a large labyrinthodont from a layer of dense conglomeratic sandstone in a series of lumpy red sandstones.

(4) There are good impressions of plants, fishes, and insect wings, all of which can be collected from the marl tailings of the Nicholayevskii, Nicholskii, Karpovskii, and Staro-Beryezovskii mines.

In summing up all the adduced data, it is possible to say that only because of the work in the mines have we found out the little that is known about the Karyalinskii fauna, buried as rare remains in the ore-bearing stratum P_2. There is no doubt whatsoever that future discoveries will be found in complete dependence on the opening of mining activities in both regions. Then, by means of well-informed workers and expert mining personnel, it will be possible to realize an increase of discoveries, 90% of which were lost in times past.

The distribution of cupriferous ores in the layer is very important for the paleontologist because it is always connected with animal and plant remains. The ore-formation in the ore-bearing stratum shows up in the impregnation of separate lenses or whole zones of the stratum with solutions of cuprous minerals. Of the latter, the most frequently found are earthy malachite and azurite, next is cuprous tinsel, cuperous niello (copper sulfide), and cuprite. Just as in the case of organic remains, the ore-bearing nests are found only in the gray-colored layers and do not occupy any definite horizon in the stratum. The variety of heights of the location of ore nests ranges between 2 and 80 meters, i.e. they

* = 3,600,000 pounds.

include the whole thickness of the ore-bearing vein. The types of ores that are found in both regions can be reduced to the following basic ones:

(1) A stony ore—a lumpy gray sandstone permeated rather evenly with azurite and malachite, usually without accumulation of organic remains. The copper content is between 1% and 5%.

(2) A "Vapovaya"* ore—a gray marl with impressions of plants and fishes, and a thin scattering of metal ores, oxides, and sulfides. The copper content is between 2% and 7%.

(3) A "Pulyechnaya"** ore—a schistose, porous, ore-bearing sandstone with small concretions—chalcocite—in the center of the concretion, and azurite along the surface. The average content of Cu is 3 to 4%; that of a particular vein is 1 to l.5%; and that of high-concentration concretions is as high as 25% Cu.

(4) A slaty ore—a schistose, dense, close-grained sandstone with an even sprinkling of ore salts without organic remains. Copper content is between 1 and 3%.

(5) A veiny ore, lamp-black, and "Chyernyetz"***, are obtained as a result of the accumulation of layers of carbonized plants. The carbonized matter is stored up, yielding a rich carbonate (or oxide) (up to 30% Cu), and on its recumbent and pendant side the sandstones are enriched, forming a crust of chalcozine, and a crust of azurite along the periphery. The thickness of the ore layer is not greater than 30 cm. The copper content averages between 16 and 20% .

(6) The "Chubarka"**** is generally some sort of ore conglomerate, but mostly porous conglomerates with a coarse inclusion of a dark-brown, almost black, marl. The pebbles contain up to 3% copper, but even the sandstone cement also contains copper. The usual content is between 2 and 3.5%, and at times as high as 6% Cu.

(7) "A white sandstone with broken veins"—a lumpy, dense, gray sandstone with a mass of carbonized stalks and stems of plants with a large quantity of the shells of *Nayadites*. The enriched plants, mostly those that have been carbonized, as well as the sandstone are cut through by a network of fine veins. The copper content is usually not higher than 2.5%. The separate stalks of plants are transformed into a fine chalcocite.

* lit.: "vaporized", perhaps "porous"
** lit.: "pellet-like"
*** lit.: "black ore," apparently a black copper oxide or carbonate
**** lit.: motley or heterogeneous "layer"

The ore nests have the following three peculiar types of occurrence:

(1) A lenticular type, in which the copper bearing strata underlie only the particular lens. To this type belong the nests of pellet-like and schistose ores that are found usually in the upper horizons of the ore stratum, and the large lens of gray ore marls that rightly occurs in the very lowest parts of the stratum.

(2) The veiny type, in which the cuprous minerals are greatly concentrated throughout the layers of carbonized plant remains and form something like a thin cake.

(3) The zonal type. To this type belong all large concentrations and especially the concentrations of the lower horizons. In these, all the layers of strata, the inclusions and lenses that are included in a given zone, are infiltrated by means of mineral solutions

The form of ore bodies is extremely arbitrary, but usually the large concentrations have the form of narrow bands, very thin compared with the thickness of their layer, bands that are locked in the very depths of the layer, as if they were lying directly on the lower strata of red-brown marls, which evidently represent the water-refracting bed. The ends of the coarse inclusions often appear to be a transition of the ore sandstones into the gray sandy marl which is poor in ore.

Genesis and facies. The well-known fauna from the ore-bearing stratum of both regions is distinguished by the diversity of biological specializations along with a small number of forms. The fishes are typical middle Permian freshwater ganoids, represented by the genera *Amblypterus*, *Acrolepus*, *Platysomus*, and *Palaeoniscus*.

After examining many problematic species previously described and the species in the Kargalinskii fauna, there are five authentic species of Amphibia and two species of Reptilia.

The Amphibia belong to the group of rhachitomous labyrinthodonts and include the following forms:

Melosaurus—a peculiar form of semi-aquatic adaptation; *Platyops*, an elongated carnivore of the rather large water basins; *Zygosaurus*, a dry-land labyrinthodont related to the American type; Dissorophidae; *Chalcosaurus*, an indefinite form disclosing an origin from Brachyopidae, and consequently adapted for mud; and *Discosaurus*?, a. small, mud-living stegocephalian.

The Reptilia are clearly relatives of the South African forms of the Karroo, but unfortunately they are not yet thoroughly studied. These are exclusively dry-land forms and belong to the groups Dicynodontia—*Deuterosaurus*, and Dinocephalia—*Rhopalodon*. It is necessary to call attention to the discovery of a fragment of a *Venjukovia* skull, of a type closely resembling that of mammals.

From the list adduced here the variety of vertebrate faunas of the ore stratum is evident, to which corresponded the variety of subaerial (or sub-surface) biological stages in the epoch of the genesis of cupriferous sandstones in both regions. There is no doubt as to the extreme interest of the Tetrapod fauna, because in it we see the coming together of Gondwana with Laurasia, and at least from the Upper Carbon[iferous] up to the middle Permian we also find an indication of the lines of migration and evolution of the Tetrapod fauna in the U.S.S.R. A study of this fauna should be urgent. In contrast to the Tetrapoda, the fauna of aquatic Invertebrata is uniform, small in number, and indicates a uniform physico-chemical regime and a short existence of the water-feeding-grounds. From the nature of the burial of the organic remains, it is already possible to establish that the process of the genesis of the strata went along various courses. The disorderly distribution of the plants in the sandstones is the product of deposition of fast waters, in contrast to the layers of carbonized plants, in which layers material was deposited in whole areas by the flow of shallow waters, as in the case of the mouths of small rivers. The marl lenses are the formations of calm basins of still water that leave the fine material precipitated with the fauna of fish and Amphibia, and with growths of marsh plants without wood. On the bottom of these basins, processes of putrefaction went on that implemented the precipitation of copper ores out of solution. The layers of other facies in which vertebrate remains are found—schistose and marly sandstones—are distinguished by fineness of grain, solid carbonate cementation, and considerable content "pelitovyhk"* fractions, i.e. by traits of still-water precipitation. Among the coarser ore-bearing sandstones in the Kargalinskii region, and the conglomerate ore concentrations in the Izyaksko-Sterlibashevskii region, whole skulls of Amphibia are found exclusively in the gray marl inclusions and small lenses, i.e. in local zones of still water where they were contained during precipitation and buried. The sharpest attention should be given to such lenslets and inclusions, both during the search and during the workings.

In close connection with the formation of vertebrate localities stands the genesis of copper ores in both regions. According to all data, the deposition of ores in an ore vein is

* li.: "pellet-like"

syngenetic. The formation of ore bodies is various; there are both syngenetic and epigenetic ore nests. Predominantly syngenetic are the marly ore lenses in which precipitation of ores took place only during the existence of the basin, which is born out by the abundance in the marly sandstones of the beds in the lenses of organic remains not enriched with copper. Evidently the pellet-like and schistose ores of the upper horizons are also syngenetic. The coarse, ore-bearing zonal concentrations are epigenetic, but in all probability the process of enrichment proceeded up to and during the time of lithification, otherwise it is difficult to understand the enrichment of the marl inclusions and lenslets. The concentration of veiny and small bodies proceeded by the action of subterranean waters that circulated in the stratum. Very often the ore body appeared at the same time as the basin of subterranean waters. It is necessary to point out that the basins of underground waters in the ore vein belong to a special type, present probably in all ancient strata, not dislocated, and composed of highly mixed water-permeated and non-permeated layers. These basins also are not dependent upon any definite horizon and join lens-like in the bowl-shaped water-retaining layers at various heights in the ore-bearing stratum. The subterranean waters in the stratum occurred in a condition of a steady equilibrium, in view of the absence of fissures and tectonic disturbances from the moment of formation of the stratum. The greatest number of basins is found in the depths of an ore vein on the waterproof bed of the lower layer of red-brown marls. Even the stability of the ore bodies with easily dissolved oxidized copper ores is explained by such inactivity of the subterranean waters.

The general picture of the genesis of the ore vein in both regions may be restored in the following features. The material of the deposit was derived during the denudation of the Ural range. The coarser fractions and pebbles of the erupted layers in the presence of a comparatively large quantity of waters were left nearer to the region of the denudation—in the Izyaksko-Sterliboshevskii region. The Kargalinskii region received the already sorted fine material that was transported a long way in the long streams. In the vicinity of the erosion there was proceeding simultaneously a disturbance of the copper magma beds of a type of quartz veins with an expansive zone of oxidized copper ores which were dissolved and during deposition saturated the entire layer, subsequently being concentrated in the ore nests. Fully understood is the connection of copper ores and organic remains with gray strata. These strata were deposited in the presence of a large quantity of water, which explains the possibility of the growth of flora and fauna, and the simultaneous influx of cupriferous solutions. The band-like form of the larger ore bodies points to their cropping up in the subterranean streams of comparatively steady flow. The copper in the Kargalinskii region was hardly brought in in the form of mechanical particles, because together with the copper there inevitably would be transferred various undissolved sulfate compounds of a type of barite with which the magma concentrations are loaded. However, similar compounds were not found in the Kargalinskii region. Such an investigation in the Izyaksko-Sterliboshevskii region would yield extremely interesting data concerning the genesis of the ore stratum, if the region proved to yield mechanical fragments of barites, pyrites, etc.

In conclusion it is well to point out that copper ores are peculiar to all continental deposits of the Ural vicinity, deposits that extend far north along the Ural range. The chemical and petrographic composition of the layers of the continental Permian facies is extremely uniform and similar. The factors of deposition are identical, differing perhaps only in quantity of waters. All the data indicate that the formation of the continental copper-bearing strata of the near-Urals took place under identical conditions and was connected with a disturbance of a single mountain massif—the Urals. As was shown, the “roots” of the strata extend very deep. Evidently, all continental strata that survived the later washing and are found in zones of tectonic extinctions have a very considerable thickness. The age of such strata may be exceedingly great. Although the deposition of continental sediments proceeds faster than does that of sediments of a shallow sea, still this inequality is partly leveled down, because each thick continental layer is deposited by means of an endless washing in of an already deposited but still unlithified series. In the sea the deposition of sediments is continuous. In all probability all three bands of the continental deposits of the Urals—Ufimskii, Kazanskii and Tartarskii—do gradually run through one another without a break or defection in suitable places. Definite cycles are noticed only along the vertical, cycles connected with epeirogenic movements, and cycles that depended on variations in denudation. For example, such is the deposition of marls and gypsums at the end of every lower band and the beginning of the upper one; these defects mark the completion of the cycle. Geographical facial insulations could take place in various districts—lagoons, deltas, deserts with appropriate changes of sediments into dolomites, gypsums, shales, etc. The depths of the thick layers evidently belong to the “Permo-Carbon[iferous],” which is indicated by the development of the terrestrial vertebrate fauna. Sections of the continental deposits of North America in the states of Texas, Illinois, and Oklahoma show a joining of the marine layers containing Carboniferous fauna with Lower Permian. It is possible that a study of the depths of our continental strata in the Urals will result in the discovery of analogues of the Wichita layers of the North American Permian.

Thus in the Russian Permian "Gondwana" is noticed the separation of the continental and non-Zechstein facies, which are distributed through the Lower Permian.

The migration of terrestrial vertebrates began not in the Upper, as one is apt to think, but in the Middle and even partly the Lower Permian. The rhachitomous labyrinthodonts of Gondwana type, dinocephalians and theromorphs, are found even in the Ufimskii horizon. The abundant fauna of the labyrinthodont *Platyops* in the Kazan horizon arose through a long evolution. At the same time the North Dvina fauna of the Upper Permian is no doubt a relictual type. All the accumulated facts show that the continental layers of the Paleozoic in the U.S.S.R. still require continued study for the purpose of a definite stratigraphy. The peculiar conditions of deposition of the strata exclude the designations usually used, such as "sandstone stratum," "marly series," etc. Only the detailed subdivision of the overlying layers found in the given stratum, study of their chemical and petrographic peculiarities, [plus] study of the mechanics of deposition and erosion can clearly throw light upon the genesis of the continental strata. In the presence of such a program of study there will be ever more frequent discoveries of the remains of Tetrapoda, which although still little known, yet undoubtedly played a huge role in the evolution of the bygone animal kingdom of the region between Gondwana and Laurasia.

I shall take the liberty of conveying my gratitude to the leader of the research group from the Scientific-Researchers of the Metal Institute of Geological Studies of the G.G.R.U.—i.e. to engineer N. K. Fazumovskii for his assistance and valuable advice in the field and laboratory work.

Leningrad, 1931

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