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Topography of the Granite and Porphyry Region of Missouri

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Near Coburg the Cretaceous appears to be quite heavy, but if this formation is found to extend southward and into Missouri where no areas, however limited in extent, have yet been found, it would no doubt be quite thin unless in exceptionally rare cases, for towards the southern boundary of Page county the Carboniferous rocks are not infrequently found, where exposed, a considerable distance above the drainage line, the ridges are not more elevated above them nor the drift less thick upon the upland.

Just how far the shore line of the Cretaceous sea extended southward cannot definitely be figured now, but, considering the position and abundance of outliers to the south and southeast along the present border, the direction the glaciers advanced and the readiness with which the friable beds could be broken off and carried away, one can immediately conceive how this shore line and the main deposit have been extensively altered, and how the present southern boundary may be far northward of the southern shore-line of the then probably continuous deposit.

For the present, however, it seems desirable to call the exposure near Essex at least very near the farthest south any Cretaceous *in situ* exists in Iowa; realizing at the same time the possibility, if not probability, that such may yet be found southward and in Missouri.

The finding of Cretaceous boulders amongst the drift is by no means uncommon. At the foot of the Missouri bluffs near Henton, in Mills county, a number of irregularly shaped masses of pudding stone were secured. Those were quite similar to the bedded stone in some of the counties further eastward. Just across into Missouri from Blanchard, Iowa, on the bank of the West Tarkio is, in a cut recently made, a fifteen-foot bed of more or less clayey sandstone doubtless Cretaceous in origin but modified on being removed and deposited here by the glacier. It would not seem that this sandbed nor the pudding stone had been carried away any great distance from their place of original deposition but their sources are yet to be traced.

TOPOGRAPHY OF THE GRANITE AND PORPHYRY REGION OF MISSOURI.

BY E. H. LONSDALE.

When speaking of the Archæan hills of Missouri Pumpelly has likened them unto "an archipelago of islands in the Lower Silurian strata which surrounded them as a whole and separate them from one another." To one who knows this interesting territory with its isolated and grouped knobs hills and mountains of crystalline rocks standing out more or less prominently and dotting the broad expanse of more recent sedimentaries, this figure is an exceedingly happy one; one most admirably taken.

In order to appreciate the picturesqueness of the scenery there presented it becomes requisite that not merely a birds-eye view be taken but also to

look deeply and well into the mountains and vales, trace out the tortuous water courses as they have etched their tangled way through oftimes seemingly impenetrable measures and softer strata; to survey the streams and behold there the narrow chasms or gorges with mural escarpments which occur in irregular succession. Thus will the hidden scenery, the beauty of the landscape, sculptured by nature, be revealed.

The crystalline rocks of Missouri are for the most part porphyries and granites and are confined exclusively to the southeastern portion of the state. They occur southeastward, almost to the northern limit of the earthquake or sunken area of Missouri; they occur westward more than one hundred miles from the Mississippi, the nearest known outcrop to this stream lying less than twenty miles distant. If a quadrilateral with township lines be here drawn to include all exposures of Archæan rocks, it would contain about four hundred square miles; a circle drawn to surround these exposures would have a diameter of more than eighty miles. Yet the surface of either of these figures which is occupied by the crystallines is less than one-tenth of the total enclosure. Occurring in ten counties, they are more abundantly exposed in Iron, Saint Francois, Madison, Wayne and Reynolds counties. In the others the exposures are scattering and not unfrequently quite isolated. In fact, some of these isolated outcrops being quite low, not much, if any, above the general level, are found, perhaps, only by chance. These crystalline rocks are the oldest in the state. They stood long prior to the forming of the latter sedimentary rocks. After standing for ages as parts of the continental body, they now appear with sandstones and limestones originating from the degradation of this continent surrounding them.

The Archæan hills often occur in groups each separated by divides or valleys of the same formation or they occur as individual and grouped points separated by Lower Silurian or Cambrian beds. The distance from Archæan, across Cambrian, to Archæan, may be a few feet or twenty or twenty-five miles and the length or broadest diameter of the continuous crystalline areas varies to about this extent, though the great majority of these are much smaller than the upper extreme.

Made up almost wholly of the crystallines and other hard rock and void of any glacial drift, southeast Missouri abounds in excellent exposures of the beds there existing. Presenting such varieties of rock, frequently in occurrences somewhat singular, the attention of the geologist is ever attracted. Problem after problem has arisen and been solved, yet to-day the field is new; many problems of great importance stand out for solution.

In addition to the porphyries and granites here present there are large areas of sandstone, limestone, or limestone capped with chert masses and fragments. Each of these is represented by a type of topography entirely distinct from that of any the other formations. The valleys of the sedimentary rocks do not resemble the valleys of the crystallines more than the hills of the former the mountains of the other. Of course in some places the type may be less characteristic than in others.

To the east of the southern limit of the crystalline region the elevation of the Mississippi river is approximately 300 feet above sea level. The highest ascertained altitude of the Archæan hills is 1,800 feet whilst the greatest elevation of the Cambrian hills is about 1,700 feet. Of the former the porphyry hills are the highest; of the latter the chert-capped limestone ridges are more elevated, consequently more conspicuous.

The well known higher porphyry mountains may frequently be recognized many miles away; their position, and consequently name, being readily detected, owing to the peculiar or distinct topographic features characteristic of the individual mountains. Famous Pilot Knob and its neighbor just across the valley of Knob creek, Shepherd mountain, are excellent examples of such forms. In the case of the former it is especially so, for, besides standing out a rather sharp, conical mountain, singular in form it is also marked by the deep cut from which iron has been mined for years which extends almost to its summit. Although this mountain is not so high by nearly 300 feet as some others, the distinctive form which it possesses together with the artificial cut makes its recognition doubly easy.

In the extreme southeastern portion of the State extending northward from the Arkansas-Missouri line and westward from the Mississippi river lies what is known as the earthquake region. This is now a rather extensive territory composed for the most part of lowlands, swamps and marshes. The lowlands commonly rising not many feet above the "Father of Waters" on the east are of Tertiary and Quaternary age. Grading seemingly somewhat gradually on the west on account of the contact with the low or bottom land naturally approaching the waters of the Black river, and quite abruptly on the north, the topography of the swamp region stands in marked contrast with the rough topography of the Archæan and Cambrian hills; the first with far separate contours and sluggish streams, the last with a magnificent drainage, high hills and narrow valleys.

As has been said, each formation in distinct area, whether it be porphyry, granite, limestone, sandstone or a combination of two or more of these will have its own special type of topography, each peculiar in itself as well as when compared with others. So by means of the topographic maps one can ordinarly discern the formations represented thereon.

Whilst in territories of limestones and sandstones the number of streams possessed by each is nearly the same, such may be said of granite and porphyry fields; but the number of larger streams and stream-ways in the Cambrian greatly exceeds the number in the Archæan. The streams in the former are more tortuous, the channels considerably wider and the flow less rapid. This is all largely due to the great difference in the texture of the rocks of the two geological formations, the comparative softness of the sedimentaries augmenting erosion. What is but a dull drainage line in the crystallines becomes, in a corresponding period, a well marked ravine in the sedimentaries.

The regularity with which the Archæan streams have been and are being formed depends primarily upon the form of the upland. If it consists of hilltop after hilltop the streams or gullies will be more common and more strongly marked than if the summit is not pointed, but is a narrow or wide plane of some length.

The limestone areas in southeastern Missouri are of two kinds; the common is the irregularly broken ridge with a crest having about the same level, from which extends more or less successively, often for a considerable distance, points or spurs of various lengths. Nearly the whole surface is covered with detritus which consists mainly of chert fragments often coated with drusy quartz. These ridges made up for the most part of the Magnesian limestones in heavy ledges, are only recognized as bearing such by

occasional out-croppings of the same at the base and on the slope at variable altitudes. The topography of this country is rather simple and in a way monotonous, yet somewhat difficult to map on account of the numerous protruding spurs or points. The contours appear near the base rather far apart; toward the summit they run closer together and at nearly regular intervals until the topmost contour is reached, when a break in the regularity is occasioned. Here when the interval is as great as twenty feet the line frequently extends perhaps a mile or more with little curvature, both sides parallel with the axis of the ridge. When these chert-covered areas are more limited in extent hills rise as individual points separated by synclines whose troughs are of nearly the same level. In this case the regular contouring is unbroken from base to summit.

The other limestone regions are recognized by gently sloping fields capping the heavily bedded stone which, upon decomposition gives rise to the dark red coloring prevalent in the soil above and the associated clay. The larger streams traversing a region of this character leave banks of roughly weathered rock and but little detrital material; along the smaller ones bedded rock is seldom exposed.

There is presented in a region distinctly of sandstone a barren, for the greater part level, area cut by ravines, one or both banks being of solid sandrock ofttimes left in overhanging ledges by the eating out of the under portions of the bed. Along the nearly level tops, outcrops of sandstone are frequent, as the overhanging soily material, which in time accumulates does not form a mantle of equal thickness over the surface of the stone, but being of a coarse, sandy nature, is transferred from place to place and collected in heaps leaving other portions bare.

Over southern Missouri the limestones and sandstones are so closely, albeit irregularly, associated that their mode of occurrence, extent and relative position in the geological scale has long been a subject of discussion. Here there are extensive regions where both kinds of rocks prevail. Outcrops are common; first one then the other appear, over-lapping and interlocking. The problem of classification becomes intricate. The general surface features of a combination of the two sedimentaries are not like those of either alone. However, the type exhibited is but little more than a combination of the types represented by the rocks separately.

The topography of the Saint Francois mountains, this name having been applied by Winslow to the porphyry and granite hills and mountains of the region in question, is indeed striking, much more so than is that of the Ozarks to the west.

These Archæan mountains stand out in bold relief among the knobs of the Cambrian. Where both occur the beauty of the relief maps is greatly enhanced by the presence of narrow gorges and steep acclivities which not uncommonly form solitary high peaks of conical form, which are surrounded on all sides by lower lands of the Cambrian.

Porphyry makes up by far the greater portion of the 400 square miles of crystallines. The style of topography although varying is impressive, and in not a few instances at all similar to that of the granite. But as a whole, the type which represents either rock will almost invariably prove itself strictly characteristic of the ancient rocks. The nearest approach to the porphyry type is that of the chert-capped limestone hills previously men-

tioned. These occasionally do resemble in outline the lower pointed porphyry knolls, though the angle of slope is commonly greater in the latter and the contours less sinuous.

From the sandstone and limestone uplands great hills of granite or porphyry not unfrequently ascend abruptly to diversified heights. Often do the sedimentary rocks almost completely conceal the crystalline. In other cases the stratified rock now extend only a short distance up the hill and across the valleys and shallow divides.

As a rule the porphyry mountains are either pointed at the top or have a long, narrow crest, but occasionally large mountains have summits quite broad, grading into the steeper hillsides; Taum Sauk mountain, perhaps the highest in the region, is a good example of this form.

The contouring of these mountains is quite plain, yet distinguished in being as a whole different from that of other hills in this region. The angle of slope from base to summit is, of the larger mountains, almost constant, no matter whether this angle be small or great, whether the mountain top be pointed or narrow crested. Pilot Knob may again be taken as an example to illustrate the former and Buzzard mountain, adjoining the Knob on the north, to illustrate the latter.

Over the inclines of the steeper porphyry hills great blocks and fragments of the rock have accumulated as they weathered from the body mass. This detritus is often of great thickness and hides the solid rock except in case of almost perpendicular faces. Thus it modifies somewhat the otherwise rugged surface. Soily material is here commonly very thin, and vegetation is not abundant and the rocks are of slow decomposition.

Cañons are not unfrequent in their appearance over the Archæan region. They are found of variable lengths in the granite as well as in the porphyries. The many water-courses, in seeking an outlet, have cut through great bodies or hills of these excessively hard beds, which as yet confine the water to very narrow channels with more or less expansive precipitous walls, bare and rugged in outline. The beds of the streams are broken and waterfalls abound.

It has been mentioned incidentally that the topography of a granite field is essentially different from that of the porphyry. The porphyries, almost without exception, have an aphanitic structure, whilst the granites are often extremely coarsely crystalline and are, therefore, subject to much more rapid erosion, erosion on all exposed faces to about the same extent leaving a rounded surface in every case. Of the porphyry, weathering takes place not in decomposition of the surface, but by merely a separation of the stone into blocks and fragments along joint planes, in this rock always numerous whilst comparatively rare in the granite. Occasionally large blocks of granite break away along joint planes and, weathering, are transformed into huge boulders, which either remain on the solid rock bed or tumble into the streams at the foot of the mountain.

Granite mountains are commonly rounded at the tops and often the upper gently rolling surface extends over quite a large territory. They are of less height and may make up the greater part of a mountain whose highest point is of porphyry. The slopes are irregular and broken. To map (using compass, aneroid and level) with accuracy and detail, a field of granite must necessarily be traversed at frequent intervals, perhaps more so than is

required in the mapping of any other formation in the Archæan regions. Where cañons occur in the granite their walls are more rugged, less precipitous and higher than in the porphyry, and the waterways are broader.

Closely associated as they are, the crystallines and the Cambrian ledges exhibit the contact of the two formations in many places. In some portions of the region it is not uncommon to find sandstone more closely accompanying the granites; limestone, the porphyries. Dikes are found more commonly in the granite. Iron ores are found mainly in the porphyry, while the lead ore in the crystallines is confined largely to the granite.

Specimens from many localities show an almost continual change in the hue, if not in the texture, both of the granites and porphyries. Between fifty and one hundred hues are represented in the former, while in the latter about two hundred distinctly different hues are shown, each in the corresponding number of specimens collected.

Associated as a dike rock in the granite, olivine diabase is also found, making up a few areas of considerable size. These have a topography much like that of the smaller granite fields. Limited areas of so-called syenite occur; also other forms of crystallines, rocks which will not here be mentioned.

OCCURRENCE OF ZINC IN NORTHEASTERN IOWA.

BY A. G. LEONARD.

In the Upper Mississippi valley for a considerable period after the mines began to be operated much more lead than zinc was produced. It was not until 1860 that the latter metal came into market. Since then the zinc production has rapidly increased. During the ten years previous to 1882 the output of zinc more than doubled that of lead, while in 1889, according to the last federal census report the proportion between the two was as 13 to 1 for the entire region.

On account of their increasing importance the zinc deposits will be especially described in this paper, but as the two metals are so closely related in occurrence what is said of one will, in many cases, apply equally well to the other.

Not until the year 1880 were the Iowa mines worked for zinc carbonate or "dry bone," as it is called by the miners. Up to that time the carbonate, though found in many of the mines, was thought to have no special value and had been thrown away as worthless, or when found in the diggings the latter were abandoned.

In the fall of 1880 two wagon loads of zinc were taken to Benton, Wisconsin, by Mr. William Hird and sold for $16.00 per ton. So far as known this was the first zinc ore sold from the mines of the State, and from this time on the carbonate has been mined in rapidly increasing amounts. The