

economically useful ; it has also a popular and a systematic name ; but to utilitarian and Linnæan alike, the form and substance seems the main thing, not the life. 'Great Pan is dead,' the botanist is as prosaic and unseeing as the woodcutter, in fact, essentially is one ; at best with finer tools, and like him does his best work away from the wild wood altogether. But as the ages of fetishism, of Hellenic anthropomorphism passed away, so now the formal and utilitarian and analytic spirit is passing also in its turn. Science is entering a new and brighter Hellas ; the Dryad, living and breathing, moving and sensitive is again within her tree ; nay, better, the plant is herself the living Dryad, her beauty radiant in the sun."

PAPERS READ.

GEOLOGY.

ON THE INDURATION OF CERTAIN TERTIARY ROCKS IN NORTHEASTERN ARKANSAS. By R. ELLSWORTH CALL

In northeastern Arkansas, west of the St. Francis river, stretching from the Missouri line to the Mississippi river at Helena, is Crowley's Ridge, the only pronounced topographic feature in the region. The width of this particular ridge varies from six or seven miles to a half mile, the northern portion being the widest. The general geological features of Crowley's Ridge have been elsewhere given* and need not be rehearsed at this time. It will be sufficient to say that the ridge is the remains of a plateau to the westward of which once flowed the Mississippi river which cut out the great valley now occupied by the White and Black rivers and other streams of the region. Later its channel was changed to the eastward by the penetration of the previous barrier near Cape Girardeau, in Missouri ; it still occupies a portion of that ancient valley across which it has several times shifted its course. It has resulted from these great changes that the eastern valley has been dug deeper and wider than was the ancient channel on the west. Crowley's Ridge, therefore, stands as a residual product of erosion.

*Vide Geological Survey of Arkansas, report for 1889, Vol. II, "The Geology of Crowley's Ridge," by R. Ellsworth Call.

The investigation of the ridge, which was undertaken under the direction of the Arkansas geological survey, revealed its general geological structure to be about as follows: The top of the ridge is, in portions of its extent, capped with pleistocene deposits of relatively both early and late epochs. The newest deposit of value is the loess which caps or lines the highest portions of the ridge; this material shows a bi-partite character which is believed to be connected with at least two glacial epochs the facts concerning which have been collated and discussed by Messrs. Chamberlain and Salisbury in several papers in the geological journals. Below this material, where it crowns the ridge, is a heavy deposit of a cherty gravel, much ferruginized, water-worn, not well assorted, and of varying thickness. This is elsewhere shown to be of tertiary age. Below this member is a great thickness of tertiary sands, usually non-indurated and soft, yielding readily to erosive action. The lowest member disclosed to the observer is made up of alternating pure and sandy clays, with much lignite in masses or disposed in great beds often many feet in thickness. Towards the base of the exposed clays many localities have yielded large numbers of fossil leaves which determine the age of the clays as early eocene. Added to their evidence is that furnished by the rather rare localities where fossil shells have been found. These are all marine and are unequivocally eocene. At numerous localities in the northern half of the ridge the gravel member alone forms the highest points of the hills the loess, if it ever existed there, having been entirely eroded away. The gravels often have small masses of a very compact and fine grained quartzite and much rarer large masses often weighing several hundred pounds. These increase in frequency along the west side of the ridge until near the Missouri line, some twenty-five miles south of it, where they no longer appear. They are usually quite white in color but in the gravels the smaller ones seem to have acquired the characteristic ferruginization of the gravels of the orange sand.

It happened that one of the problems connected with these nodular or pebbly quartzites related to their origin. They presented nothing in common with such quartzites as are familiar to all students of the northern drift and were to be in no way connected therewith. It was noticed that they became more and more abundant as progress was made towards the northern portions of the ridge, but this fact only added another phase to the riddle to be solved. Dr. D. D. Owen, whose geological work needs no introduction or word of commendation to an Indiana scientist, had years

before our visit made some hasty examinations of this portion of Crowley's Ridge. On pages 28-29 of his report on his work in this section he called attention to* a low "range of quartzose sandstone" which had "all the lithological characters of the Potsdam * * *", as it occurs on the Minnesota and Wisconsin rivers in the northwest." Two localities had been noticed by him both of which were in Craighead county. The reference of these rocks to the Potsdam or to any part of the paleozoic made the locality one of great interest, occurring, as it does, in the heart of a region of pleistocene soils underlain by rocks known to be of tertiary age. There was a peculiar satisfaction when Mr. William Lane piloted me to the very spot where, forty years before, he had piloted Dr. Owens and placed me on the pinnacle of the very rock from which that eminent geologist had looked over the heavily forested valley of the Cache. It is not surprising that these rocks were with some hesitation referred by Owen to the Potsdam. They present every characteristic of the Potsdam of northern New York except that they are entirely devoid of fossils, or at least this locality yielded none. His reference was plainly made from lithologic characters and though wrongly made was excusable for his time. This particular locality is at the foot of a high spur of the ridge forty feet or more above the Cache bottoms. The hills are high and are crowned with heavy beds of gravel which, in turn, are overlain by a thin sandy and gravelly soil supporting a strong growth of the common short leaved pine (*Pinus mitis*) and much scrub oak. At this point the quartzose bed is a huge mass of very hard rock, ringing like clinkstone when struck with the hammer, having its sand grains and the few accompanying pebbles well waterworn and exhibiting the characteristic structural features of sandstones deposited in swiftly running waters or tide swept shallows. The dip that appeared so patent to Owen developed into simply planes made by false bedding. A few hundred feet north of the roadway across which this mass of rock extends, in a deep ravine in which the rock is exposed to excellent advantage, the sandstone outcrops as a series of ledges from near the level of the bottoms to a point two-thirds of the way up the hill, thus showing a thickness of fully ninety feet. The several strata are from five inches to five or more feet in thickness and are nearly or quite horizontal. The total exposure of the rocks in this locality is about half a mile in length. At this point the underlying strata could not be seen

*First annual report of a geological reconnoissance of the northern counties of Arkansas. Pp. 28-29.

but a section beneath non-indurated sandstones of the same age exposed on a small stream about three miles south of this locality discloses the horizontally stratified clays of the tertiary. From Lane's to the southernmost part of the county where the outcrops cease two or three less important exposures occur.

Several other outcrops are to be found in Crowley's Ridge but with one or two exceptions, they are all on the west face of the ridge. The most important are all in Greene county and all present practically the same characters and vertical distribution. The northernmost exposure is in R. 19 N., 6 E., section 19, where they appear for the last time as indurated sandstone. They here outcrop in and extend across the road and disappear to the west in a low hill which rises a few feet above the Cache bottoms. To the east the outcrop extends for several hundred feet into the ridge, as traced in a deep ravine, where it is surmounted by a two foot layer of exceedingly hard, fine-grained, flint-like sandstone. The highest point above the valley which is crowned by these rocks has a barometric elevation of about one hundred and fifty feet above the lowermost rocks and these are in turn some forty feet above the valley. In but one locality on the west side did fossil plants or fossils of any sort occur in this sandstone. This was in 17 N., 4 E., in section 10, where after a long and difficult search a small fragment of a plant was found deeply imbedded in the very hardest rock which here caps the hills. It possessed very little structure but it was quite sufficient to determine the rocks to be of tertiary age. However, the form was not sufficiently well preserved to tell us exactly to what part of the tertiary the rock belonged but the evidence which was wanting here was later supplied a little further on. We now had the necessary clew and now the work of unravelling the mystery of the ridge was play! To make a long story very short these sandstones of supposed paleozoic age, standing isolated in the midst of tertiary rocks through which they boldly protruded their waterworn and time begrimmed tops were found to be themselves tertiary and to share in the common history of the region.

A secondary problem now concerned the process or cause of induration; a process which had been so complete and left so little traces that a score or more geologists had been puzzled into determining these rocks as of paleozoic age. So to this task were the succeeding investigations directed.

All of the outcrops of quartzitic sandstone occur in about the same vertical position in the hills. They are to be found as spurs, extending in

various directions from the main axis of the ridge, or at the heads of ravines. They may extend from the bottom of the hills to near their top, or they may form a layer of only a few feet in thickness at the very top. In every case the outcrops are found to be surmounted with a series of very hard layers which are usually from one to three feet in thickness. In several places they pass into the soft sands beneath and these in turn give way to the ordinary tertiary clays still further down. In nearly every case the rocks weather greenish and are irregularly stratified. In one locality, near Hardy's Mill, in Greene county, occurred numerous fossil leaves among which there have been determined *Magnolia* and *Kalmia* leaves; the entire absence of beech, chestnut and hornbeam leaves among those found indicate the base of the tertiary rather than any portion of the tertiary above the eocene. This is the position in the geological column assigned these forms by Professor L. W. Ward, who studied the materials collected by the writer.

The result of the studies made on these irregular deposits, occurring with such extreme irregularity in the ridge and of such peculiar hardness, stated in brief, was that they were metamorphosed sandstones. The compact character of the quartzites, their glassy surface on fracture, which is remarkably conchoidal, might lead one to imagine dynamical disturbances of marked nature. But there are no attendant facts such as continuity or great extent of surface. They are exhibited in localities some distance removed from each other and with no connecting deposits that show any metamorphic characters. But that they have become indurated on exposure, here and there, and constitute immense quartzite blocks, often acres in extent, was evident. At a locality known as Lovelady's, on Beech creek, in Greene county, there are several exposures that are quite hard on the surface but are softer within, finally yielding to moderate pressure to say nothing of blows. From this point to that of greatest induration is but a few hundred yards; it was hence concluded that the metamorphic processes were still in vogue and these most certainly were not dynamical in character. In Brazil, Dr. J. C. Branner has observed similar facts of metamorphosis,* and these corroborate the view here suggested of metamorphism through weathering processes. Where longer weathering has obtained the masses are often rounded as if water worn, but in the great number of exposures this feature is scarcely apparent.

*Transactions Am. Phil. Soc., 1889, XVI., pp. 419-420.

Summing up the facts, then, in few words these rocks are of limited occurrence, covering a few hundred acres all told; they are found at rather low elevations in the hills though they sometimes occur as far as the very tops of the highest points in the ridge country; they have yielded fossils of lower or eocene tertiary age; they have probably resulted from weathering processes; are metamorphic in character; and have no history of dynamic origin or of present or past dynamic change. Their former reference to the paleozoic is no longer tenable and they stand as a unique instance of the induration of soft sandstones in the southwest.

The sketch map accompanying gives that portion of Crowley's Ridge in which indurated sandstones have been found. It will serve to indicate the relations of the ridge to the low-lying country surrounding as well as helping to make clear the geographic distribution of the quartzites.

THE WHITE CLAYS OF INDIANA. By AMOS W. BUTLER. Published in the Trans. of the Ind. Horticultural Soc. for 1893.

BIOLOGY.

ON THE HABITS OF TURTLES. By A. W. BUTLER.

[ABSTRACT.]

In the White Water valley the soft-shelled turtles are never found active in winter. They seem to seek the deepest water and then bury beneath the surface of the mud or sand. They disappear earlier in the fall and reappear later in the spring than the hard shelled forms. They rarely appear before April 15th, and sometimes not until about May 1st. In the canal none have ever been found in winter. Possibly they seek the deeper water. The hard-shelled turtles winter in the more shallow water, and seem to prefer a mud bank where a musk rat hole has caved in. There they may be found by prodding with an iron rod.

ON THE OCCURRENCE OF KIRTLAND'S WARBLER (*Dendroica kirtlandi* Baird) IN INDIANA. By A. B. ULREY.

Owing to the rare occurrence of Kirtland's Warbler in North America and the fact that its life-history is almost entirely unknown, considerable