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A. G. Leonard

be stated briefly. They are best set forth by Whitney* and more recently, and in greater detail, by Chamberlain†.

First, then, as to the formation of the crevices. Extending east and west through the zinc region are numerous and abrupt undulations of the strata. These were caused by a horizontal pressure acting from the south resisted by a corresponding force from the north. To state it differently, the oscillations are due to lateral force from the Interior Sea to the south and resisted by the Archæan land area to the north. These flexures produced the crevices. As the strata were elevated the heavily bedded limestones were fissured parallel to the axis of elevation and more or less open crevices formed. In a direction at right angles little force was exerted and the beds were only fractured, producing north and south fissures.

As suggested by Whitney, the shrinkage of the rocks may account for some of the crevices, at least to their open character, though it is difficult to see how shrinkage could have the great influence attributed to it by that writer.

The ore receptacles having been formed, whence came the zinc to fill them? It will be necessary simply to mention here the rejected hypotheses, namely, those of sublimation, and of thermal waters. Facts are well nigh overwhelmingly against the idea that the fissures extend to any great depth, being confined chiefly to the Galena and Trenton limestones, and without such extension downwards either of the above theories are very improbable if not impossible. All the facts indicate that the zinc comes not from below, but from the limestones in which occur the crevices. It was deposited along with the sediments by the waters of the Silurian sea. The latter derived its metallic salts from the waste of the pre-existing land surfaces. Chamberlain describes in detail the cause of localization of the deposits to a few areas, ascribing it to the currents of the ancient sea, taken in connection with the precipitating agencies of organic matter.

After their deposition in the limestone beds the zinc was concentrated in the crevices by the action of drainage waters percolating through the metal-bearing beds. In this way the zinc was concentrated in the fissures where it is now found.

SATIN SPAR FROM DUBUQUE.

BY A. G. LEONARD.

Located less than six miles south of Dubuque and one and three-fourth miles due west of Massey station on the Chicago, Milwaukee & St. Paul Railroad are some curious "spar caves" as they are appropriately called. In these caverns are some occurrences of satin spar that are very unusual and of much interest. It is

*Geology Wisconsin, vol. I, 1862.
†Geology Wisconsin, vol. IV, 1873-1879.

doubtful whether there is another locality where such peculiar forms of calcite are found, two varieties being associated together in the stalactites. The latter have also undergone a change in structure since first formed. The caves were discovered by Mr. Baule, of Dubuque, while prospecting for lead. They are openings in the crevices of the Galena limestone like those in which the lead and zinc ores occur. Large and productive crevices have been worked less than a half mile to the north, and the spar-bearing fissures also carry lead at a lower horizon. Followed west out on to the high prairie land back from the river these crevices are marked by sink holes, and on a winter day the moisture is seen rising from them. The magnesian limestone of the region is cut by innumerable large and small fissures that at certain horizons form extensive openings that can be followed for thousands of feet, and form a labyrinth of underground passages. All the latter are formed by approximately east and west, north and south, and "quartering" crevices. The openings vary in size from those so small that one can scarcely force his way through, to others having a width of ten or twelve feet and height of five feet. Some are over forty feet in height.

These caverns are either empty or filled entirely or in part by clay. The deposits of lime carbonate occur only in certain portions of these openings where the moisture is most abundant. At these points the top and bottom are decorated with stalactites, stalagmites, and a wonderful variety of beautiful and fantastic forms. The passages are in places closed up by thick deposits requiring blasting to remove them. Strong currents of air pass through these caves and are doubtless instrumental in producing the curious formations.

In these underground passages two varieties of calcite occur.

1. Satin spar, formed of radiating fibers with silky luster. Colorless and white varieties both occur.

2. Argentine (Schieferspath). This variety has a pearly luster and is composed of more or less undulating lamellæ. Color, white. It agrees with the descriptions given by Dana and Tschermake for Argentine, and is to all appearances that variety of calcite. The latter author mentions it as occurring in Bohemia, Saxony and Cornwall.

Satin spar occurs in several different forms: (1) Includes those which are pearly white, on the surface of fracture and have a silky luster due to the radiating fibers that form a velvety surface of great beauty. This variety occurs in bunches or clusters of twisted and gnarled stem-like forms. (2) Includes those stalactites proper which are formed of radiating fibers. These have in cross section a subvitreous luster, but on the surface they are (a) either covered with a fine white powder (which under the microscope is seen to be composed of irregular grains or minute crystalline bodies), and have no luster, or (b) the outer surface is formed of little rhombohedrons and has a silky luster. These stalactites are white or colorless, opaque or translucent.

There are still other stalactites differing from any of the above that have a concentric, banded structure. These are of unusual interest. Beginning at the center they have (1) a crystalline or granular core, often showing bright rhombohedral cleavage faces; (2) a thin band of clay apparently wanting in some cases; (3) peary white lamellar calcite (Argentine); (4) band of clay; (5) fibrous calcite and (6) outer surface composed of little rhombohedrons. There are several points in the structure of these stalactites deserving special notice. They have not, as yet, been studied microscopically, as is hoped may be done later, but the following facts regarding them are reasonably well established. There is every indication

that the crystalline core was once fibrous, but this structure has mostly disappeared, especially in the larger stalactites and the rhombohedral cleavage has replaced it. In the smaller forms the transition from the radiating fibrous condition to the crystalline aggregate of rhombohedrons can be traced; the long acicular crystals become less distinct, but traces of them can still be seen after the rhombohedral form makes its appearance. Recrystallization has taken place and the particles have rearranged themselves to conform with the interior structure of the rhombohedrons; in other words, they are identical with the crystal form of the latter in all but external outline, and this has been prevented from developing, showing itself only on cleavage faces. A strong indication that this granular core was once fibrous is the fact that this is the common structure found in all these caves. The small forms all show the fibers, but as they increase in size alteration has taken place.

Another point of interest about these stalactites is the band of pearly, lamellar calcites occurring between the granular, crystalline core and the fibrous external layer. These white, undulating lamellæ form concentric rings in marked contrast to the radiating fibers associated with them. Occurring on both sides of the Argentine there is in most cases, if not in all, a thin band of clay. It is this that has doubtless stopped deposition for a time and the different variety was formed on account of the changed conditions.

The rhombohedrons forming the outer surface, while the interior is still formed of the radiating fibers, also deserve more than passing notice. They occur on the larger stalactites, not on the delicate branch-like forms. The outer surface of the latter owes its silky lustre to the innumerable fibers composing the surface. These frequently form delicate, cotton-like masses covering the outside of the satin spar. But on the majority of the stalactites occur the crystal aggregate of rhombohedrons. These may have have been deposited after the radiated interior was formed, but they seem to be due, rather, to the alteration or recrystallization of the fibrous mass, as in the case of the granular core. The conditions under which the fibers were formed have changed and there has been a corresponding alteration in the crystalline condition of the calcite.

If not the most interesting to the mineralogist, the white satin spar occurring in the large branch-like clusters is at least notable on account of its great beauty and rarity. It is difficult to give any idea of the rare and delicate appearance of these masses as they hang suspended from the roof of the caverns. At a distance they resemble white branching coral as much as anything. But near at hand the twisted and gnarled stems with their beautiful silky luster bear no resemblance to coral. The peculiar shapes assumed by these forms, differing so much from the ordinary stalactites, are no doubt due to the air currents moving through these passages. The wind coming now from one direction, now from another, causes the drops holding the lime in solution to be blown to one side and another of the slowly growing stem, the drop being held by the surface tension. The water does not trickle down undisturbed, as when forming the long straight stalactites depositing an even layer on the end and sides, but the carbonate is deposited for a time on one side of the branch and then, later, on another side. These clusters are extremely delicate and are removed with difficulty from the rock to which they are attached.

In these caves are found many large and fine stalactites and stalagmites. Some are short and stumpy, others long and slender. In one small opening

three by three feet the deposition of calc spar had gone on to such an extent that there was a deposit several feet thick on the floor, while hanging from above were numerous stalactites. These were arranged mostly in two rows along the sides of the cavern and touching the bottom or joining the stalagmites below they formed columns. The passage-way thus made resembles a miniature colonade.

OCCURRENCE IN IOWA OF FOSSILIFEROUS CONCRETIONS SIMILAR TO THOSE OF MAZON CREEK.

BY ARTHUR C. SPENCER.[1]

The wide celebrity of the fern-bearing concretions from the Carboniferous beds of Mazon creek, Illinois, attaches more than passing interest to the occurrence of similiar structures in the Coal Measures of Iowa.

These concretions are found in a small ravine near the Des Moines river, north of Dunreath, in Marion county. Careful search for similar concretions in the gullies of the neighboring streams has not been successful, from which it seems that the strata, which are cut by the streams in question, lie above their general level on a slight anticline. The other alternative is that the concretions are limited to a very small area, but from the relations of the overlying beds the first explanation seems to be correct.

The plant remains are found in nodules or concretions, scattered through beds of drab shale. These, when broken open, often display very perfect forms. Plant remains are not, however, present in all the concretions. Others are like small septarial masses and are filled with zinc blende.

The nodule-bearing shale is from three to perhaps ten feet in thickness, and of a light drab color. It rests upon an irregular layer of large septarial masses which, exposed in the dry bed of the stream, resemble roche-moutenees on a small scale. Above are shales in part bituminous and in part areaceous. Four inches of compact gray limestone, bearing fern impressions follows, above which is more sandy shale and a thin seam of coal which has been mined near by. The coal is about fifteen feet above the concretionary bed.

Many of the concretions have been washed out and are found already opened, but the best specimens are those recently exposed, which afford very perfect leaflets of several ferns. Among the forms identified were: *Neuropteris hirsuta*, *Neuropteris angustifolia* and *Annularia longifolia*. Others will undoubtedly be found when more material is examined.