DICKITE IN MISSOURI

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The first occurrences of dickite found in Missouri are described in this paper. The initial discovery was made by Tarr in 1913 in a clay pit east of Columbia, Missouri, but the material was identified as kaolinite at that time. After the appearance of the valuable paper on the kaolin minerals by Ross and Kerr,[1] Tarr, thinking from its mode of occurrence that the supposed kaolinite might be dickite, submitted some of it to Professor Kerr for *x*-ray examination. The examination proved it to be dickite. During last year, 1934–35, while engaged in the study of the lead ores of the southeastern Missouri "lead belt," Tarr found a similar white micaceous mineral in the ores. Microscopic examination by the junior author, Keller, and *x*-ray examination by Kerr, showed that this mineral also was dickite. A short time afterwards Keller discovered what he thought was dickite in a limestone quarry south of Columbia, and a few days later the same mineral was found by Tarr in another limestone quarry southwest of Columbia. Microscopic studies, supplemented by *x*-ray examinations by Kerr, proved these occurrences to be dickite also.

The authors visited the Keokuk, Iowa, area last spring and found an abundance of a clay mineral in geodes and geodial cavities in several quarries and cuts but, altho some of the material possessed the same outward appearance as dickite, it was all proved by *x*-ray examination (by Kerr) to be kaolinite. The writers had hoped to find some of the material in this locality which Ross had determined as dickite, but apparently they did not, unless it was mixed with the kaolinite in such small amounts as to be indeterminable.

Description of the Occurrences

The material discovered by Tarr in 1913 came from the interior of a large brachiopod on the inside of a chert nodule a foot or more in diameter. The cavity containing the dickite was within two or three inches of the surface of the nodule. The dickite adjacent to the cavity walls was stained by limonite, but that on the interior was snow-white and glistened brilliantly. This glistening snow-whiteness has been a distinctive feature of every occurrence of the dickite found by the authors. Likewise, under the microscope, a feature of dickite is its typical hexagonal shape (see Figs. 1–4). The chert nodule containing the dickite was residual from limestone and occurred at the bottom of a white clay deposit. A return visit, in 1935, to the locality (long since abandoned as a clay pit) was but mildly productive, as only small amounts of dickite were found

[1] Ross, C. S., and Kerr, P. F., The kaolin minerals: *U. S. Geol. Survey*, Prof. Paper **165,** pp. 151–180, 1931.

in the chert. Pyrite was found in considerable abundance on the residual chert nodules.

The dickite found in the lead ores of southeastern Missouri was the most coarsely crystalline of any studied (Fig. 2). The discovery of the

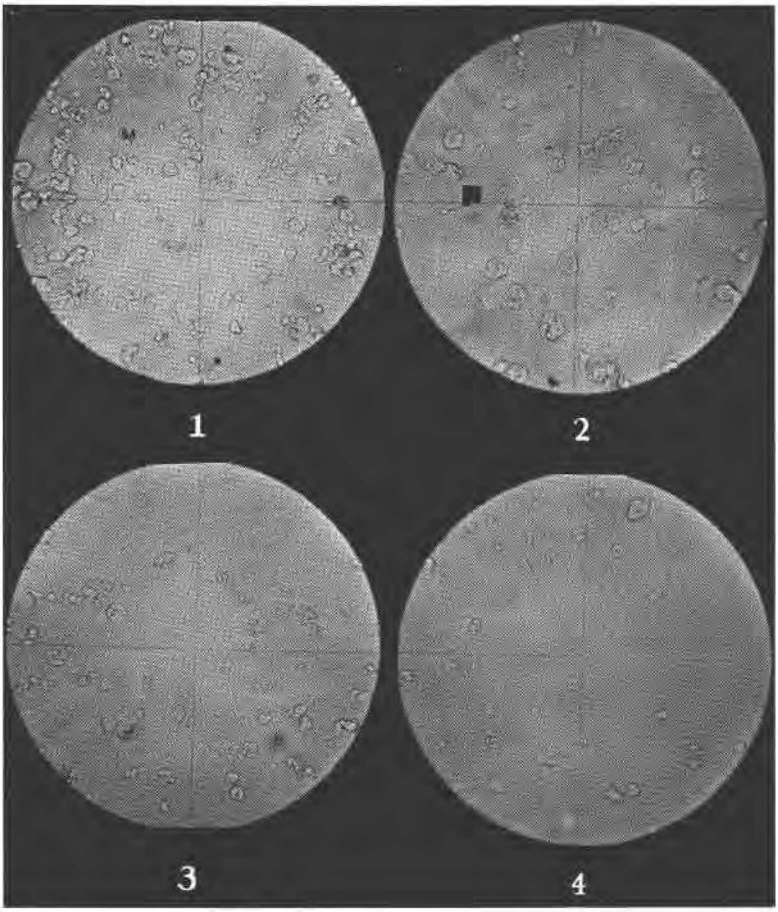

FIG. 1. Dickite from interior of fossil, clay-pit, Columbia, Mo. ×450.

FIG. 2. Dickite from lead ores, Flat River, Mo. Black square is galena. ×450.

FIG. 3. Dickite from chert nodule, Fellow's Quarry, Columbia, Mo. ×450.

FIG. 4. Dickite from chert nodule, Katy Quarry, Columbia, Mo. ×450.

dickite was made in connection with Tarr's study of the origin of the ores of that very productive lead region. The best specimens came from the St. Joseph Lead Company's mines at Flat River. The dickite presents its usual glistening snow-white appearance. It occurs chiefly associated with galena in cavities in marcasite, but is found also in cavities in the Bonneterre dolomite (the country rock of the lead ores). The dickite may entirely fill cavities as large as one or two centimeters across. It was deposited last and covers the marcasite, galena, and dolomite crystals. It was noted that some cavities were only partly filled and that under these conditions the dickite was in the lower part of the cavity, indicating that it had crystallized from solution and settled to the bottom. The dickite is apparently most abundant where associated with considerable marcasite, as it was observed in only two specimens of the Bonneterre dolomite: one a drill core, and the other the dolomite adjacent to a marcasite-galena ore body. In both these occurrences, the dickite was in small cavities not exceeding two millimeters across. It may be that this dickite had replaced the dolomite. The significance of the occurrence of dickite with the lead ores is discussed in Tarr's forthcoming paper on the origin of the lead ores.

Keller, aware of the occurrence of dickite in chert, searched for and found it in a limestone quarry (Fellow's quarry) south of Columbia. Some of this dickite fills geodial cavities in the chert, but most of it has replaced parts of the chert in which it occurs. It may replace fossils (particularly sections of crinoid stems) or it may replace the chert itself. Whether the fossils replaced were calcite, or had been replaced previously by silica, it was impossible to determine, as the dickite had replaced every part of them, save the chert that had filled the canal of the stem. This suggests that the fossils were calcite at the time of replacement, a suggestion supported by the fact that in other specimens dickite replaces calcite in veins or replaces calcareous portions of the chert. Some of the replaced crinoid stems are one centimeter across.

Where the dickite replaces the chert it is usually surrounded by a leached and porous zone, as wide as five millimeters, but this zone may be missing and the dickite thus be in contact with the hard solid chert. This leached zone is very porous (pore space, 25 per cent or more) and consists dominantly of silicified fossil fragments. The dickite completely replaces this material in areas that may be $1\times2\times3$ centimeters. The dickite is snow white, and occurs in crystals that may be as large as 0.3 millimeters in diameter (Fig. 3).

The most interesting and significant feature of this occurrence is the association of four sulfides with the dickite in the cavities (which are lined with quartz crystals). These sulfides are: chalcopyrite, galena, pyrite, and millerite. The chalcopyrite occurs as sphenoids as wide as three millimeters; the galena as cubes, one millimeter across; the pyrite as tiny cubes and grains; and the millerite in typical capillary crystals that may attain one centimeter or more in length. The dickite was deposited last, so surrounds the sulfides. This association of dickite with sulfides has a bearing upon its origin. Sphalerite occurs commonly in this quarry in cavities in the chert, and replacing and filling fossils in the limestone. Large masses of barite (some weighing 200 pounds) and pyrite occur in solution channels in the same quarry.

The occurrence of dickite in another quarry southwest of Columbia (the Katy quarry) was discovered in February, 1935, by Tarr. This quarry is about a mile northwest of the Fellow's quarry. The dickite occurs in geodes, along joints, and replacing the chert. It usually occurs near the central part of a chert nodule, sometimes in irregular elliptical areas; in other occurrences, along a plane parallel to the longest axis (which was also parallel to the bedding of the limestone). Some dickite areas are within one or two millimeters of the outer weathered part of the nodules, and others show an irregular distribution from the larger central areas to the surface of the nodules. Most of the occurrences in this quarry are replacements of chert and of fossils (which were either calcareous or siliceous), or of calcite deposited along joints in the chert. Where the chert is replaced there is the usual leached porous zone surrounding, in part or completely, the areas of dickite which has evidently replaced the porous siliceous residue of the leaching. Some of these replaced areas are strongly calcareous, which may account, in part at least, for their leaching and replacement. Altho, apparently, the dickite usually replaced calcareous areas, it undoubtedly replaced the chert also. The dickite in quartz-lined geodes in this quarry is associated with the same sulfides (millerite, chalcopyrite, pyrite, and galena) as it is in the Fellow's quarry, but a new one also is found here. This rare mineral is wurtzite. It occurs in pale, dull greenish gray crystals, 0.5 millimeters or less in diameter. The crystals give an excellent microchemical zinc reaction, are anisotropic with low birefringence, and possess a hemipyramidal crystal form. Pyrite, sphalerite, and chalcopyrite are common throughout this quarry also, and barite is found in the solution channels. The dickite is the usual gleaming snow-white material, but it averages a somewhat finer grain size (Fig. 4). It should be noted that in all replacement occurrences the dickite areas end sharply, and that the surrounding porous siliceous material is free from it.

Optical Properties

The optical properties of these specimens were determined with some difficulty because of the small size of the individual grains which average only about .020 mm. in maximum diameter. Indices of refraction were determined by the immersion method using white light. Measurements are probably accurate to $\pm .002$. Inasmuch as kaolinite is the only mineral with which dickite is liable to be confused in identification, special care was used in determining chiefly those properties in which the two minerals are dissimilar. The properties are:[2]

(1) Extinction angle on {010} against base; dickite 15°–20°; kaolinite, 1°–3½°.

(2) Optical character: dickite, positive, with Bx_a normal to cleavage edges; kaolinite, negative, with Bx_a normal to flat cleavage flakes. The high transparency and excellent euhedral development of the hexagonal shaped crystals of dickite (see Figs. 1–4) are valuable qualitative characteristics suggestive of dickite.

Dickite from interior of fossil, clay-pit east of Columbia, Mo. (Fig. 1)

Indices of refraction: $\alpha=1.562$, $\beta=1.563$, $\gamma=1.565$.
Optical character: Positive, large 2V (over 45°).
Extinction angle: Maximum observed, 12°.
Size of crystals: .015 mm. average diameter, maximum .023 mm.

Dickite from lead ores, St. Joseph Lead Co., Flat River, Mo. (Fig. 2)

Indices of refraction: $\alpha=1.562$, $\beta=1.563$, $\gamma=1.566$.
Optical character: Positive, large 2V.
Extinction angle: Maximum observed, 18°.
Shows some undulatory extinction, with possible maximum extinction of 21°.
Size of crystals: .030 mm. to .035 mm. maximum diameter.

Dickite in chert, Fellow's quarry, Columbia, Mo. (Fig. 3)

Indices of refraction: 1.560 to 1.565.
Optical character: Positive, large 2V.
Extinction angle: Maximum observed, 16°.
Size of crystals: .030 mm. maximum diameter.

Dickite in chert, Katy quarry, Columbia, Mo. (Fig. 4)

Indices of refraction: 1.560 to 1.565.
Optical character: Positive, large 2V.
Extinction angle: Maximum observed, 17°.
Size of crystals: .025 mm. maximum diameter.

Origin

The mode of occurrence of the dickite as cavity fillings and replacements; and its association with sulfides, in one occurrence abundantly (i.e., in the lead ores of southeastern Missouri), and in the others with the unusual sulfides, millerite and wurtzite, favor the interpretation that these occurrences in central and southeastern Missouri are in keeping with the generally accepted origin of dickite as a hydrothermal deposit. Another sulfide, cinnabar, was found in association with dickite in an adjoining state, Arkansas, by Sohlberg,[3] who assigns a hydrothermal

[2] *U. S. Geol. Surv.*, Prof. Paper, No. **165 E.**

[3] Sohlberg, R. G., Cinnabar and associated minerals from Pike Co., Ark.: *Am. Mineral.*, vol. **18,** pp. 1–8, 1933.

origin to those minerals. In this connection, it is of interest to note that Ewell and Insley[4] synthesized dickite from coprecipitated $Al_2O_3 \cdot SiO_2$ gels at 350° and 365°C., but kaolinite at lower temperatures. More details as to the origin of the dickite in Missouri will be given by Tarr in a forthcoming paper dealing with the origin of the lead ores of southeastern Missouri.

Summary

Dickite has been found in three localities near Columbia, Missouri, and in the lead ores of southeastern Missouri (at Flat River). Two of the Columbia localities are limestone quarries in which the dickite, in association with millerite, chalocopyrite, galena, pyrite, and wurtzite, occurs in chert. The associated country rock contains sphalerite and barite. In the other locality, the dickite occurred inside a fossil in a residual chert nodule found near the bottom of a clay pit. Pyrite occurred on the chert in this pit. The dickite from the lead ores is associated with marcasite and galena, and is also a replacement of the dolomite country rock. Microscopic and *x*-ray examination proved the material to be dickite. Its mode of occurrence and the associated sulfides are evidence of a hydrothermal origin.

[4] Ewell, R. H., and Insley, Herbert, *Jour. Research Nat. Bur. Stand.*, vol. **15**, (2), pp. 173–86, 1935; R. P. 819.