

THREE IRON SULFATE MINERALS FROM COAL MINE REFUSE DUMPS IN PERRY COUNTY, ILLINOIS

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ABSTRACT.—Three iron sulfate minerals have been found on coal mine refuse dumps in Perry County, Illinois. Szomolnokite ($\text{FeSO}_4 \cdot \text{H}_2\text{O}$) usually occurs on oxidizing pyrite on the dump surface, rozenite ($\text{FeSO}_4 \cdot 4\text{H}_2\text{O}$) is found beneath the surface and along some watercourses, and melanterite ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$) appears to be restricted to moist areas. The occurrences indicate the hydration state of the ferrous sulfate is at least partly dependent upon relative humidity of the microenvironment.

Pyrite is a common accessory mineral in the coal deposits of southern Illinois and elsewhere. During the beneficiation of the coal, pyrite, as well as clay, shale, and other impurities, is discarded and piled up in refuse dumps. Oxidation of pyrite in the upper portion of these dumps has resulted in a variety of products, three of which are described in this paper. This study was conducted on dumps located in Perry County, Illinois, but conditions similar to those found in this area are so common throughout coal mining regions of midcontinent United States and elsewhere that the minerals described herein are probably of widespread occurrence.

METHODS

The samples used in this study were collected from two coal mine refuse dumps located two miles southwest of DuQuoin and five miles

south of Pinckneyville, Perry County, Illinois. Collection of samples was accomplished during the months of September and October, 1969, in fairly dry conditions. Approximately 100 specimens were collected from dry runoff ditches, along flowing streams and seeps, and from fresh bulldozer cuts in the refuse dumps. Samples were grouped in the laboratory on the basis of observable properties. They were then hand cleaned under a microscope to remove impurities in order to insure relatively pure specimens for X-ray identification. The purified minerals were finely ground and identified by X-ray powder diffraction techniques.

RESULTS

X-ray diffraction study reveals the occurrence of three hydrated iron sulfate minerals: szomolnokite ($\text{FeO}_4 \cdot \text{H}_2\text{O}$); rozenite ($\text{FeSO}_4 \cdot 4\text{H}_2\text{O}$); and melanterite ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$). About 15% of the fifty samples identified by X-ray diffraction were melanterite, 30% rozenite, and 55% szomolnokite (percentages do not necessarily reflect relative abundance on the refuse dumps, but rather proportion of X-ray test samples; however, the abundance of the various minerals in the test runs are approximately proportional to their abundance

in the total samples collected.) These three minerals have sufficiently different physical properties so that they can generally be identified in the field without the aid of sophisticated equipment. A brief description of each mineral follows.

Szomolnokite. Szomolnokite occurs as a white powdery coating on pyrite and occasionally over the entire surface of an area where oxidizing pyrite is abundant. Thus far we have found it only on material exposed directly at the surface.

It is distinguished by its occurrence as a white powder on pyrite, its hardness of 2.5 (determined only with considerable difficulty), and its slow rate of dissolution in water. It is reported that a brown residue is left when the mineral is dissolved in water (Palache, et. al., 1951), but we have not found this to be an important characteristic. It does not have a cleavage. The specific gravity is about 3.05 (Winchell and Winchell, 1964), but its mode of occurrence generally makes an estimation of specific gravity impossible.

Rozenite. Rozenite is rather common in Perry County. The best occurrences are a few inches beneath the surface of the spoil piles, where considerable masses of granular crystals can occasionally be found. It also occurs along the sides of some small streams that drain the spoil piles, but in such locations it usually turns to a crumbly white material if the water dries up.

Rozenite has a hardness of 2.5, which is the same as szomolnokite but clearly harder than melanterite. The specific gravity is about 2.3. Winchell and Winchell (1964) report artificial rozenite has one direc-

tion of good cleavage, but the well developed conchoidal fracture of the Perry County material often makes the cleavage difficult to discern. Most samples used in this study were blue to blue-green, but occasionally colorless or white material was found. Unaltered specimens are transparent to translucent and have a vitreous luster; partially dehydrated specimens are translucent to opaque and have a dull luster. The mineral is readily soluble in water and gives a metallic, astringent taste.

Melanterite. This mineral is generally found as a crust on rocks and mud along the sides of flowing drainage ditches, usually within a few inches of water. It occasionally is found as small clumps of white radiating crystals.

Melanterite is transparent to translucent and has a vitreous luster. The color ranges from colorless to green or blue-green. Both its hardness (2.0) and its specific gravity (1.90) are considerably less than those of rozenite, with which it can easily be confused. Like rozenite, it dissolves easily in water and has a metallic, astringent taste. Its three directions of cleavage are not easily seen in most specimens. The most useful field test to distinguish melanterite from rozenite is the hardness.

DISCUSSION

Collection precautions. In collecting samples of these minerals for research or mineral collections, care must be taken to preserve them in their natural hydration states. It is suggested that they be placed in airtight containers and tightly sealed

immediately upon collection, because only a few hours exposure to dry air will cause drastic changes in appearances. Rozenite appears to be particularly susceptible to alteration, for it will change from a glassy, transparent blue or blue-green material to a dull, opaque, white, crumbly material overnight if exposed to dry air. On the other hand, we have successfully kept one sample for over a year with no sign of alteration by storing it in a tightly sealed polyethylene bottle.

Another problem in the handling and storage of these minerals is their decidedly acid reactions. Dissolving appreciable quantities of the minerals in water will lower the pH to the range of 2 to 4. Paper or aluminum foil left in contact with the minerals, particularly in a moist atmosphere, will rapidly decompose.

Stability relations. The occurrence of melanterite and rozenite in Perry County does not seem to entirely conform to the present state of knowledge of the system ferrous sulfate-water-sulphuric acid. Experimental work by Cameron (1930) indicates that melanterite should be the stable ferrous sulfate phase crystallizing from solutions with less than 28 percent sulphuric acid at 25° C. Ehlers and Stiles (1965) proved that melanterite can be reversibly dehydrated to rozenite under relative humidities of less than 70 to 80 percent at temperatures that would be found on the surfaces of the refuse dumps. Taken together, these two studies suggest that the ferrous sulfate phase crystallizing from coal mine drainage water ought to be

melanterite and subsequent exposure to low humidity air could cause dehydration to rozenite. The close association of melanterite with water is in agreement with this conclusion. However, we have repeatedly obtained rozenite directly by evaporation of a saturated solution of rozenite in water under conditions that should have given, according to Cameron (1930), melanterite. Furthermore, the subsurface occurrence of rozenite in moist soil suggests that it can exist under conditions of high relative humidity. This is in disagreement with the earlier studies and suggests the natural system differs in some significant way from the artificial one. Work is being initiated in this laboratory in an attempt to discover the factors that stabilize rozenite in the coal mine refuse dumps of Perry County.

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