American Mineralogist, Volume 60, pages 328–330, 1975

A Macrocrystalline Attapulgite-Palygorskite Occurrence in Calcite Veins

ANDREAS HAJI-VASSILIOU, AND JOHN H. PUFFER

Geology Department, Rutgers University, Newark, New Jersey 07102

Abstract

Fibrous attapulgite-palygorskite, with fibers generally measuring several millimeters in length, is found associated with calcite in hydrothermally deposited veins. The veins represent fracture filling in a shear zone through Triassic siltstone (Brunswick Formation) near Limerick, Pennsylvania. Heretofore attapulgite-palygorskite has been known to occur only in the form of microcrystalline to cryptocrystalline aggregates. The macrocrystalline character of this occurrence is attributed to recrystallization that took place during an episode of mild deformation or slippage along the vein contacts.

Introduction

This paper describes what is believed to be the first known occurrence of macrocrystalline attapulgite-palygorskite. This clay mineral, like all clays, has been known to be typically microcrystalline to cryptocrystalline; it generally occurs in elongate lath-shaped units and bundles of laths where individual laths are often several microns in length (Grim, 1968, p. 183). In the veins near Limerick, however, the mineral is fibrous with individual fibers or bundles of fibers commonly measuring over one centimeter in length.

The use of the compound term "attapulgite-palygorskite" is in compliance with the fact (as noted by Grim, 1963, p. 45) that both names have been used interchangeably to describe what is clearly the same material; Singer and Norrish (1974) use the name "palygorskite" exclusively even in reference to other studies such as Elgabaly (1962) and Gremillion (1965) in which the name "attapulgite" had been used instead. The Powder Diffraction File and some mineralogy texts (*e.g.*, Kostov, 1968) list them as synonyms. Carroll (1970) also lists the two minerals as synonymous but points out that "palygorskite" has precedence and that "attapulgite" is the name used for occurrences of this clay material in the United States.

Occurrence

An excavation site in siltstone (Triassic Brunswick Formation) near Limerick, Pennsylvania (about six miles east of Pottstown) revealed a small shear zone between two vertical, northeast-trending faults that diverge in strike by about fourteen degrees. Tension cracks or fractures created in this zone are now represented by a network of veins or veinlets filled with well-crystallized calcite. The most extensive of these veins are between 0.5 and 1.5 cm thick and generally contain the soft, white, fibrous attapulgite-palygorskite associated with the calcite. The long fibers or bundles of fibers typically appear continuous but are commonly bent and interwoven (Fig. 1). The fibrous clay is concentrated in the veins at their contacts with the siltstone, and the resulting smooth, slippery, striated surface of such contacts represents a typical picture of slickensides or shear surfaces (Fig. 1A).

Experimental

The attapulgite-palygorskite has been identified on the basis of X-ray diffraction patterns. Reflections of sufficient intensity to appear on diffractograms and powder film occur at 10.48, 6.42, 5.43, 4.48, 4.14, 3.66, 3.23, and 2.54 Å. With minor exceptions, these reflections are similar to those listed in the Powder Diffraction File, and correlate well with published data from several sources (Molloy and Kerr, 1961; Calliere and Henin, 1961, p. 352). An X-ray pattern of A.P.I. standard attapulgite, obtained under the same experimental conditions, correlates perfectly with the fibrous clay material. Furthermore, the structure of the clay was completely destroyed when heated to 700° C for two hours, but showed no expansion when glycolated (Molloy and Kerr, 1961; Carroll, 1970).

Data on optical properties of the mineral such as index of refraction, birefringence, and extinction, as

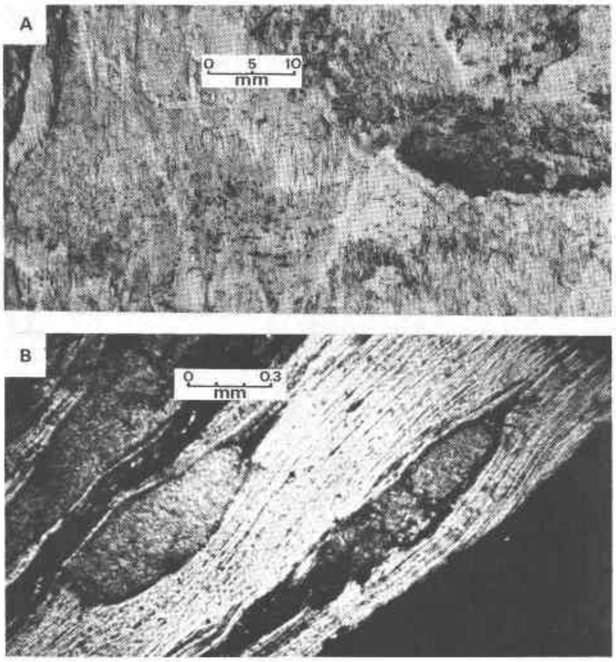

FIG. 1. (A) Hand-specimen photograph showing shear surface of vein material (fibrous attapulgite-palygorskite with some fine calcite) at the contact with the siltstone (black). (B) Photomicrograph of vein material at the contact with the siltstone (black on lower right corner) showing long attapulgite-palygorskite fibers and elongated calcite grains, with elongation direction parallel to the vein walls.

well as evidence on its solubility and fusibility, also correlate well with published information on attapulgite and palygorskite as outlined by Grim (1968).

Attapulgite-palygorskite is generally considered to be a basic magnesium silicate hydrate ($Mg_5 Si_8O_{20}(OH)_2 \cdot 8H_2O$). Chemical analysis of the Limerick occurrence (Table 1) shows the presence of aluminum as a major component. Analyses for several attapulgite or palygorskite samples (Calliere and Henin, 1961; Grim, 1968, p. 582) show similarly high percentages of Al_2O_3 (up to 15.44 percent). It is generally believed that Al^{3+} substitutes for Mg^{2+}, but some substitution of Al^{3+} for Si^{4+} is also considered probable (Bradley, 1940).

Discussion

Hydrothermal solutions are believed responsible for the vein deposition of calcite and clay at Limerick. Associated diabase intrusives in the area (a few hundred feet from the shear zone) probably provided such solutions. Attapulgite-palygorskite is known to occur in hydrothermal veins and in calcareous material (Kostov, 1968; Grim, 1968).

The fact that the clay is macrocrystalline may be explained in terms of recrystallization taking place during an episode or episodes of mild deformation that affected the vein materials. The deformation caused shearing along planes of weakness in the calcite vein, especially along or close to the siltstone contacts. Evidence for such deformation was obtained through petrographic studies and includes the following:

Calcite grains, directly associated with large attapulgite-palygorskite concentrations at vein contacts, are generally elongated, the maximum elongation parallel to the vein walls and to the orientation of the clay fibers and, therefore, to the direction of maximum slippage (Fig. 1B). Calcite grains in all areas of deformation or slippage exhibit smooth, sometimes rounded, boundaries that suggest abrasion; furthermore, some exhibit "pressure shadows" (Fig. 1B), and some also show fracturing with clay deposition in the fracture. Calcite twinning is also present but not widespread. Calcite grains in relatively thinner veins (without associated clay matter) show a strong sinusoidal or S-shaped pattern with elongation normal to the vein walls.

Recrystallization due to deformation is suggested by the following relationships: the greatest concentration of clay in the veins is represented by extremely large, elongated fibers that occur near and parallel to the vein walls. Where the clay occurs further away from the contact, it is either in the form of smaller fibers whose elongation is much less parallel to the vein walls, or in the form of tiny blebs or micro-fibers that are variously oriented in and around calcite

TABLE 1. Chemical Composition of the Limerick Attapulgite-Palygorskite*

	Weight Percent
SiO_2	56.80
Al_2O_3	15.52
CaO	0.72
MgO	5.06
H_2O^-	6.11
H_2O^+	13.90
Total	98.11

*SiO_2 was determined spectrophotometrically (Shapiro and Brannock, 1956); CaO and MgO were determined with EDTA titrations (Maxwell, 1968); H_2O^- and H_2O^+ were determined gravimetrically (Shapiro and Brannock, 1956).

grains. Since the vein contacts represent the most obvious planes of weakness, a direct relationship is indicated between the degree of crystallinity or size of the fibers and the amount of slippage or intensity of deformation.

Acknowledgments

The writers are indebted to Mr. Joel Marks and Dr. Joseph L. Wallach, of Dames and Moore, for providing samples, thin sections, and photomicrographs, as well as helpful suggestions. We are also indebted to Professors Sam L. Agron and Warren Manspeizer for comments and suggestions, and to John Szalkowski for aiding in the production of photomicrographs. Professor William Lodding is particularly thanked for critically reading the manuscript.

References

BRADLEY, W. F. (1940) The structural scheme of attapulgite. *Am. Mineral.* **25,** 405–410.

CALLIERE, S., AND S. HENIN (1961) Palygorskite. In, G. Brown, Ed., *The X-ray Identification and Crystal Structure of Clay Minerals,* 2nd Ed. Mineral. Soc. London, p. 343–353.

CARROLL, D. (1970) *Clay Minerals: A Guide to Their X-ray Identification. Geol. Soc. Am. Spec. Pap.* **126.**

ELGABALY, M. M. (1962) The presence of attapulgite in some soils of the western desert of Egypt. *Soil Sci.* **93,** 387–390.

GREMILLION, R. L. (1965) *The Origin of Attapulgite in the Miocene Strata of Florida and Georgia.* Ph.D. Thesis, Florida State University, Tallahassee, Florida.

GRIM, R. E. (1968) *Clay Mineralogy.* McGraw-Hill, Inc., New York, 596 p.

KOSTOV, I. (1968) *Mineralogy.* Oliver and Boyd, London, 587 p.

MAXWELL, J. A. (1968) *Rock and Mineral Analysis.* Interscience Publishers, New York. 584 p.

MOLLOY, M. W., AND P. F. KERR (1961) Diffractometer patterns of A.P.I. reference clay minerals. *Am. Mineral.* **46,** 583–605.

SHAPIRO, L., AND W. W. BRANNOCK (1956) Rapid analysis of silicate rocks. *U.S. Geol. Survey Bull.* **1036-C,** 19-56.

SINGER, A., AND K. NORRISH (1974) Pedogenic palygorskite occurrences in Australia. *Am. Mineral.* **59,** 508–517.

Manuscript received, August 23, 1974; accepted for publication, September 13, 1974.