

## REFERENCES

- (1) MATIGNON, CAMILLE (1924), The existence of carborundum in certain crystals of aluminum nitride: *Compt. rend.*, **178**, 1615-1617.
- (2) OTT, H. (1924), The lattice of aluminum nitride: *Z. Physik*, **22**, 201-214.
- (3) STACKELBERG, M. v., AND SPIESS, K. F. (1935), The structure of aluminum carbonitride  $Al_6C_3N$ : *Z. physik. Chem. (A)*, **175**, 127-139.
- (4) JEFFREY, G. A., AND PARRY, G. S. (1954), The crystal structure of aluminum nitride: Abstract of paper read before joint meeting of Pittsburgh Diffraction Conference and American Crystallographic Association, Pittsburgh, Pennsylvania, November 3.

## MINERALOGY OF THE MIDDLE DEVONIAN TIOGA K-BENTONITE

CHARLES E. WEAVER\*

A thin bed of "meta-bentonite" overlies the Onondaga limestones and cherts of southern New York, central and western Pennsylvania, southeastern Ohio, and West Virginia (Ebright, Fittke, and Ingham—1949), (Flowers—1952), (Fettke—1952).

These bentonite samples<sup>1</sup> have a relatively uniform clay mineral content and are similar in composition to the Ordovician K-bentonites (Weaver—1953). Table 1 contains some 00 $l$  values for the untreated and glycolated less than one micron fractions of the Devonian material and a typical Ordovician sample.

These data indicate that the Devonian K-bentonites consist of randomly interstratified layers of illite and montmorillonite in the approximate ratio of 4:1 to 3:1. X-ray patterns of samples which contain euhedral flakes of "bleached biotite" indicate the presence of chlorite and muscovite. Figure 1 contains x-ray spectrometer patterns of the Albany sample.

The differential thermal curves are also similar to those of the Ordovician K-bentonites (Fig. 1). The molecular water is removed at 100 to 125° C. The hydroxyl water is usually removed in two fractions: 550-600° C. and 675-700° C. The 550-600° C. hydroxyl-endotherm is usually considerably smaller than the 675-700° C. endotherm. The high temperature endotherm occurs at 925° C. and the following exotherm near 1000° C.

Except for more  $Al_2O_3$  and less  $Fe_2O_3$  and  $MgO$ , chemical analysis and mineral formula of the West Virginia sample is similar to that of the

\* Shell Development Company, Exploration and Production Research Laboratory, 3737 Bellaire Boulevard, Houston 25, Texas.

<sup>1</sup> Outcrop samples from Syracuse, New York, were furnished by Dr. N. E. Chute, Syracuse University, and from Albany, New York, by Mr. B. Nelson, University of Illinois. Dr. R. E. Baylor supplied a sample from Chester Co., Pennsylvania, and Mr. W. S. Lytle furnished a sample from Cameron Co., Pennsylvania, and another from Erie Co.

TABLE 1. DEVONIAN K-BENTONITE

*Calculated 4:1	Ordovician K-Bentonites		Syracuse		Albany		Clinton		Eric		Cameron		West Vir.		Indices		
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
		†11															
10.3-10.9		11.0	11.0		11.0												001/001
	9.5 - 9.7	10.3-10.9	10.6	9.7	10.6	9.7	10.3		10.5	11.0	10.5	9.7	10.6	9.7			001/001
5.05-5.1	5.0 - 5.2	5.0-5.1	5.07	5.03	5.01	5.2	5.4		5.1	5.1	5.07	5.1	5.06	5.09			002/003
3.31	3.35-3.37	3.30	3.28	3.34	3.30	3.34	3.30		3.30	3.25	3.30	3.35	3.30	3.36			003/004

1 = Untreated.

2 = Ethylene glycol.

\* Data from Brown and McEwan (1950).

† Data from Weaver (1955).

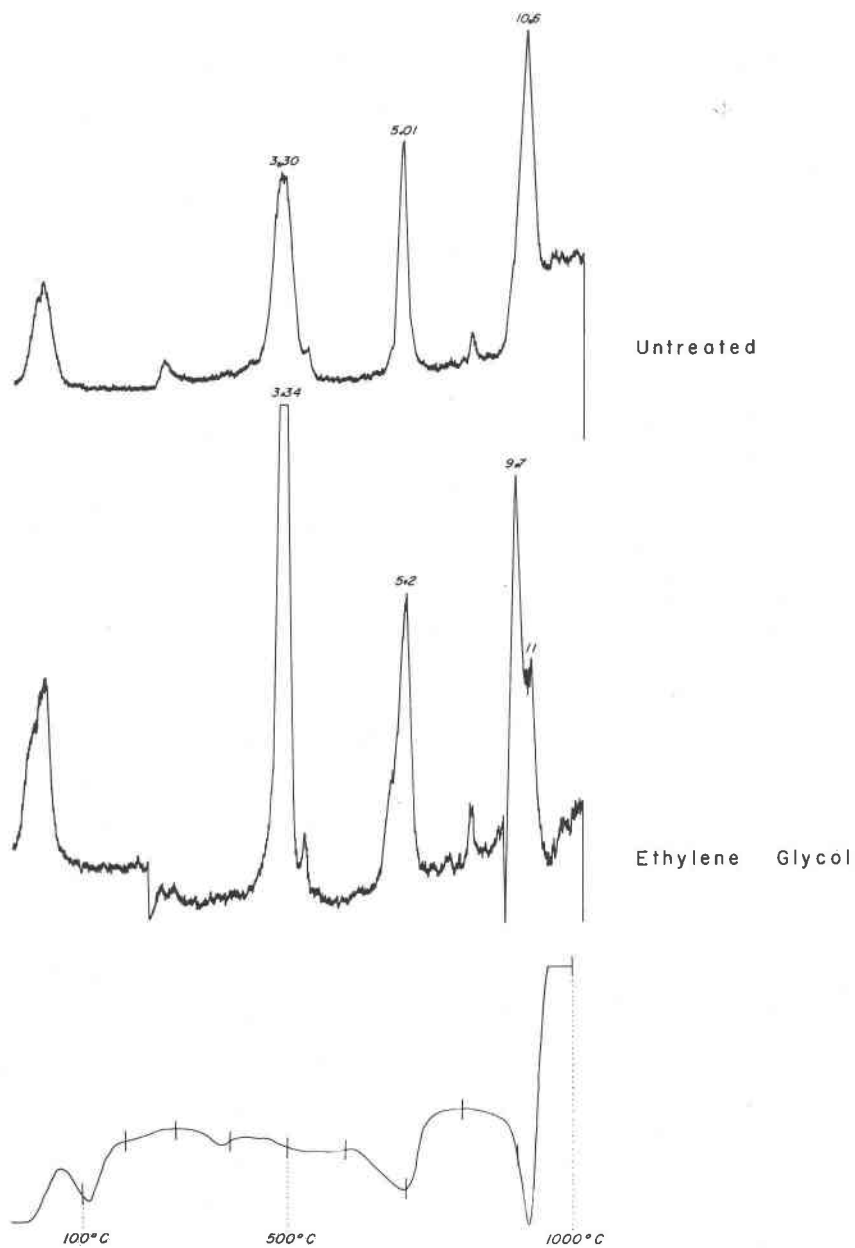


FIG. 1. X-ray spectrometer tracings of untreated and glycolated sample of Devonian K-bentonite from Albany, New York. Differential thermal analysis curve of sample from Syracuse, New York.

Ordovician K-bentonites. The Devonian sample has several per cent more water than is found in the Ordovician samples, but the *x*-ray and *DTA* data indicate that this may be an analytical error. As was noted in the Ordovician K-bentonite the potassium cations, presumably between the non expanded layers, and the calcium and sodium cations, between the expandable layers, are present in an approximate ratio of 4:1.

<i>West Virginia</i> <i>Devonian K-Bentonite</i>		<i>Ordovician</i> <i>K-Bentonites*</i>
SiO <sub>2</sub>	47.0	52.7
Al <sub>2</sub> O <sub>3</sub>	28.4	22.1
Fe <sub>2</sub> O <sub>3</sub>	0.15	2.24
MgO	1.92	3.45
CaO	0.91	1.20
Na <sub>2</sub> O	0.4	0.46
K <sub>2</sub> O	5.0	6.06
TiO <sub>2</sub>	0.3	0.4
H <sub>2</sub> O—	11.50	3.78
H <sub>2</sub> O+	4.26	5.79

\* Average of six analyses.



The heavy minerals consist almost entirely of biotite, euhedral zircon and euhedral to subhedral apatite. The suite is similar to that found in the uncontaminated Ordovician K-bentonite beds.

Over an area of at least 40,000 square miles the mixed-layer clays of the Devonian K-bentonites appear to maintain a relatively consistent ratio. This ratio is similar to that of the Ordovician K-bentonites which extend over a much larger area. This 4:1 ratio of non expanded to expanded layers apparently is a relatively stable combination and it may be inferred that the source was an ash with a particular chemical composition (possibly low iron and high potassium and aluminum content) which was altered in a similar environment (carbonate).

#### REFERENCES

- BROWN, G., AND MACEWAN, D. Mil-(1950), The interpretation of *x*-ray diagrams of soil clays, Part II. *Soil Sci. Jour.*, **6**, 234-253.
- EBRIGHT, J. R., FETTKE, C. R. AND INGHAM, A. I. (1949), East Fork—Warton gas field, Potter County, Pennsylvania: *Penn. Geol. Survey*, 4th Series, *Bull.* **M. 30**, 10-11.
- FETTKE, C. R. (1952), Tioga bentonite in Pennsylvania and adjacent states: *AAPG Bull.*, **36**, 2038-2040.
- FLOWERS, R. R. (1952), Lower Middle Devonian meta-bentonite in West Virginia: *AAPG Bull.*, **36**, 2036-2038.
- WEAVER, C. E. (1953), Mineralogy and petrology of some ordovician K-bentonites and related limestones: *Bull. GSA*, **64**, 921-943.
- WEAVER, C. E. (1955), Distribution and identification of mixed-layer clay in sediments. *Am. Min.* In Press.