

THE AMERICAN MINERALOGIST, VOL. 49, SEPTEMBER-OCTOBER, 1964

AUTHIGENIC MORDENITE IN THE ESMERALDA "FORMATION,"
NEVADA¹R. J. MOIOLA, *Socony Mobil Oil Company, Dallas, Texas.*

While examining thin-sections of pyroclastic and sedimentary rocks from the Esmeralda "Formation" (late Cenozoic) of the Silver Peak region, Esmeralda County, southwestern Nevada, the writer noticed that the vitric material comprising the matrix of a crystal vitric tuff had been replaced by a slightly birefringent mineral with a low index of refraction. Subsequent *x*-ray analysis of the matrix of the tuff shows that the alteration product is the zeolite mordenite, $(\text{Na}_2, \text{K}_2, \text{Ca})\text{Al}_2\text{Si}_{10}\text{O}_{24} \cdot 7\text{H}_2\text{O}$. On the basis of field and petrographic evidence the mordenite is assigned an authigenic origin.

The presence of authigenic mordenite in sedimentary or pyroclastic rocks has been reported previously from the U.S.S.R. (Rengarten, 1945; Bushinsky, 1950; Vasil'ev, 1954; Ermolova, 1955; Vasil'ev *et al.* 1956) and Japan (Sudo *et al.*, 1963), but only Sudo *et al.* (1963) have presented *x*-ray results to confirm the identification.

Mordenite occurs in a whitish crystal vitric tuff interbedded in a sequence of continental, dominantly fluviatile, claystones, siltstones, sandstones, and conglomerates of Early Pliocene? age. The tuff bed is 5 feet thick and can be traced approximately $\frac{3}{4}$ of a mile laterally before it disappears under alluvium. Neither the tuff nor the associated sequence of rocks show evidence of hydrothermal alteration.

Vitric material which forms the matrix of the host rock, a slightly reworked crystal vitric tuff of rhyodacitic composition, has been altered to mordenite. Mordenite forms colorless to lavender-tinted cottony aggregates with diameters of .010 to .045 mm. The birefringence of the mordenite is very weak, and the refractive indices lie between 1.472 and 1.484. Approximately 65 per cent of the sample consists of mordenite.

Authigenic opal and clinoptilolite(?) are also present in minor amounts, occurring together as pseudomorphs after shards. In nearly all cases opal replaces the outer margin of the shards and clinoptilolite(?) fills the central portion.

Heavy liquids (Bromoform and methyl alcohol, sp. G. 2.30) were used to separate the alteration product from the other constituents of the tuff, and *x*-ray diffractograms and powder patterns were made of the altera-

¹ This paper is a portion of a study on the Esmeralda "Formation" supported by a grant-in-aid from the American Association of Petroleum Geologists.

TABLE 1. X-RAY POWDER DATA FOR MORDENITE

1		2		3	
d(Å)	I	d(Å)	I	d(Å)	I
13.7	5	13.4	3	13.4	6
9.10	9	9.10	8	9.10	9
6.61	9	6.61	8	6.60	9
6.38	4				
6.10	5			6.10	2
5.79	5	5.79	1	5.79	5
5.03	1				
4.87	2	4.95	1	4.89	1
4.53	8	4.54	5	4.54	6
4.14	3				
4.00	9	4.00	6	4.00	10
3.84	6	3.82	6	3.86	5
3.76	2			3.78	4
3.62	1				
3.56	1				
3.48	10	3.48	10	3.48	10
3.39	9	3.39	4	3.39	5
3.31	1				
3.22	10	3.22	9	3.22	10
3.10	2			3.10	1
2.95	2			2.94	3
2.90	6	2.89	2	2.89	6
2.74	1	2.71	1	2.72	1
2.70	3			2.70	2
2.64	1				
2.56	4	2.56	3		
2.52	5			2.51	6

1. Mordenite from Aros, Isle of Mull, Scotland (alteration product of pitchstone glass) (Harris and Brindley, 1954).
2. Hydrothermally synthesized calcium-mordenite (Ames and Sand, 1958).
3. Authigenic mordenite, Esmeralda "Formation," Nevada.

tion product. This procedure positively served to identify the alteration product as mordenite. Powder data of mordenite from the Esmeralda "Formation," natural mordenite from Scotland, and hydrothermally synthesized calcium-mordenite are compared in Table 1.

REFERENCES

- AMES, L. L. AND L. B. SAND (1958) Hydrothermal synthesis of wairakite and calcium-mordenite. *Am. Mineral.* **43**, 476-480.
- BUSHINSKY, G. I. (1950) Mordenite in Jurassic, Cretaceous, and Paleocene marine sediments. *Dokl. Akad. Nauk S.S.S.R.* **73**, 1271-1274.

- DEFFEYES, K. S. (1959) Zeolites in sedimentary rocks. *Jour. Sed. Petrology* **29**, 602-609.
- ERMOLOVA, E. P. (1955) Analcime and mordenite in Oligocene and Miocene deposits of western Transcaucasia. *Trans. Mineral. Mus.* **7**, 76-82.
- HARRIS, P. G. AND G. W. BRINDLEY (1954) Mordenite as an alteration product of a pitchstone glass. *Am. Mineral.* **39**, 819-824.
- RENGARTEN, N. V. (1954) A zeolite from the mordenite group in the Upper Cretaceous and Paleogene marine deposits of the eastern slope of the Urals. *Dokl. Akad. Nauk S.S.S.R.* **48**, 591-593.
- SUDO, T., T. NISIYAMA, K. CHIN AND H. HAYASHI (1963) Mordenite and clinoptilolite in glassy tuffs of Japan. *Jour. Geol. Soc. Japan.* **69**, 1-14.
- VASIL'EV, V. S. (1954) Mordenite in Mesozoic and Cenozoic sediments of the lower Volga Basin and western Kazakhstan. *Dokl. Akad. Nauk S.S.S.R.* **95**, 149-151.
- , M. F. KOBLIN AND V. N. KRASNOVA (1956) Zeolites in the Mesozoic and Cenozoic deposits of the Penza area. *Dokl. Akad. Nauk S.S.S.R.* **111**, 410-412.

THE AMERICAN MINERALOGIST, VOL. 49, SEPTEMBER-OCTOBER, 1964

A MODIFIED GRAPHICAL METHOD OF ABSORPTION CORRECTION
FOR THE DISPLACEMENT OF LINES IN A POWDER PHOTOGRAPH

K. VISWANATHAN,¹ *Dept. of Geology and
Geophysics, University of Madras, India.*

While working on the problem "Optical, chemical and x-ray studies of the mineral suites of some South Indian rocks," the author had to take a number of powder photographs and calculate the interplanar spacings and cell dimensions. It was found that the most important silicate minerals, such as garnets, pyroxenes and amphiboles, have fairly large linear absorption coefficients, μ , and hence can be called, following Peiser *et al.* (1955), "strongly absorbing specimens." Because of strong absorption, these substances give rise to errors in the measured Bragg angles owing to the displacement of powder lines. The aim of the present paper is to show that the graphical method, suggested by Azaroff and Buerger (1958) can be slightly modified for these "strongly absorbing specimens" and that this method gives more accurate values than that of Ramberg and Devore (1951).

In the course of this investigation all the powder photographs were taken in a 114.7 mm Seifert camera. Both Cu-K α and FeK α radiations were used. The powder was packed in a Lindemann tube, whose wall thickness was very small. Much attention was not paid to the intensities of the lines. Only comparative intensities of the lines were taken into

¹ Present address: Institut für Kristallographie und Petrographie ETH, Zürich, Switzerland.