UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

DIAGENETIC FLUORITE IN THE EASTGATE ZEOLITE DEPOSIT, CHURCHILL COUNTY, NEVADA

By

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Open-File Report 80-506

1980

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INTRODUCTION

Fluorite has long been known to occur in sedimentary rocks, particularly in marine carbonate and evaporite rocks older than Tertiary. Only in the last decade or so has fluorite been recognized in late Cenozoic lacustrine rocks that have not been subjected to hydrothermal activity. Studer (1967) identified fluorite in zeolitic tuffs of a Pliocene lacustrine deposit near Rome, Oregon. Subsequent studies of this deposit showed that fluorite occurs in tuffaceous mudstone and mudstone as well as in the tuff, and that the fluorite content is as much as 16 percent (Sheppard and Gude, 1969). Fluorite has also been recognized in lacustrine zeolitic tuffs in the Gila Conglomerate near Buckhorn, New Mexico, (Tourtelot and Meier, 1976) and in zeolite-bearing lacustrine sediments of Quaternary age in the Lake Magadi region of Kenya (Surdam and Eugster, 1976).

The fluorite described herein occurs in lacustrine mudstone, tuffaceous mudstone, and tuff of the Pliocene Monarch Mill Formation of Axelrod (1956). The fluorite was recognized in these rocks in 1974 during a routine examination of X-ray diffractometer records of samples collected for zeolite studies. Additional samples were then collected in 1975, and this preliminary report briefly summarizes our findings.

GEOLOGY

The Eastgate zeolite deposit is about 80 km east of Fallon and about 3 km east of the junction of U.S. Highway 50 and Nevada Highway 2 in the southeastern part of Churchill County (fig. 1). The deposit is about 5 km west of the small town of Eastgate. The zeolite deposit seems restricted to a narrow north-south belt about 4 km long, at elevations of about 1,494-1,530 m (4,900 ft - 5,020 ft).

Axelrod (1956) named the Monarch Mill Formation and mapped it in the area that includes the Eastgate zeolite deposit. He divided the formation into six mappable units, and the zeolite deposit is probably in his unit 4. Vertebrate fossils collected in the Monarch Mill Formation stratigraphically above the zeolite deposit are considered middle Pliocene in age (Axelrod, 1956, p. 205).

The zeolite-rich strata of the Monarch Mill Formation are poorly exposed, and the best exposures are in bulldozer trenches that were cut during exploration for zeolites in the 1960's. The rocks strike northeast to northwest and dip eastward 8-17 degrees. Papke (1972) mapped and studied the lower part of the zeolite deposit in an area between U.S. Highway 50 and Nevada Highway 2. This part of the zeolite deposit is characterized by one or two relatively thick beds of orange tuff that are rich in erionite. Tuffs south of Nevada Highway 2, but apparently stratigraphically equivalent to the orange beds, are chiefly white or light shades of gray or green and consist chiefly of fresh glass or mordenite and clinoptilolite.

The zeolitic rocks that have consistently anomalous amounts (greater than 2 percent) of fluorite seem restricted to the upper part of the Eastgate zeolite deposit--stratigraphically above the uppermost orange bed mapped by Papke (1972). These rocks are chiefly white, light-green, and light-gray zeolitic tuff, green tuffaceous mudstone, and greenish-brown mudstone (table 1). The fluorite-bearing zeolitic tuffs were sampled in trenches over a distance of about 3.5 km along the strike of the deposit (fig. 1). The thickness of the sampled fluorite-bearing unit is 1.45-4.83 m, but it is generally greater than 2 m. The total thickness of this fluorite unit is unknown because nowhere are both the base and the top exposed. Generally, the upper part of the fluorite unit has been eroded and is now overlain by Holocene alluvial sediments. Fluorite-bearing zeolitic tuffs in this part of the deposit commonly contain mordenite, molds of gaylussite or pirssonite, and discontinuous layers of nodules of Magadi-type chert. This distinctive chert occurs as lobate nodules that typically consist of light-gray, dense, homogeneous chert having a thin white rind showing a surface reticulation. Magadi-type chert is indicative of an alkaline lacustrine depositional environment (Surdam and Sheppard, 1978), and this type of chert has been recognized at other lacustrine zeolite deposits that contain diagenetic fluorite (Sheppard and Gude, 1974; Surdam and Eugster, 1976).

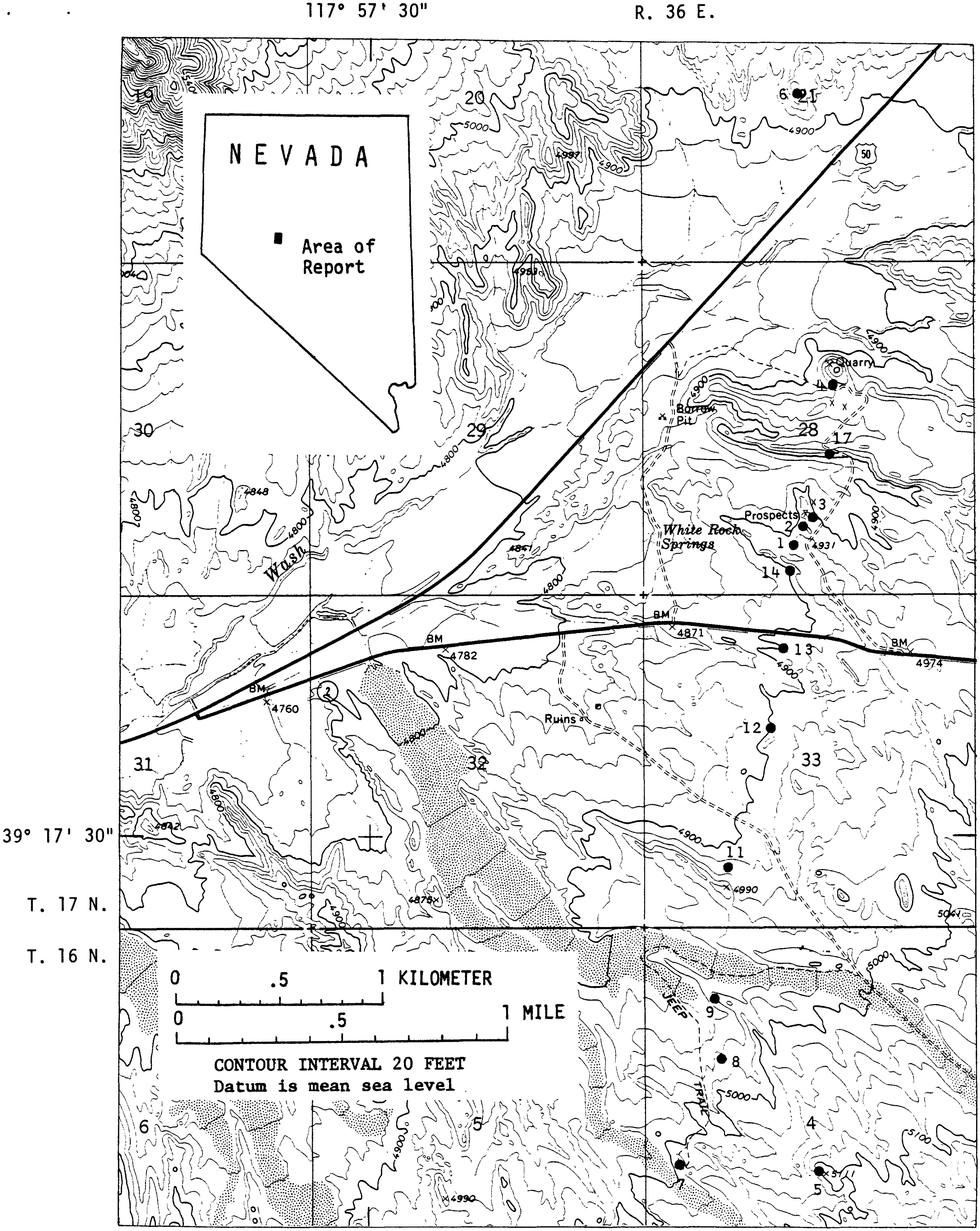

Figure 1.--Part of the U.S. Geological Survey Eastgate, Nevada 7.5-minute quadrangle topographic map showing sample localities indicated by dots. Lithology, fluorine content, and mineral composition of samples are given in table 1.

MINERALOGY AND FLUORINE AND FLUORITE CONTENTS

The mineralogy (table 1) of the sampled rocks was determined by examination of X-ray diffractometer patterns of powdered bulk samples. The tuffs consist chiefly of zeolites, clay minerals, quartz, opal, and calcite. The tuffs originally consisted mainly of silicic shards and minor crystal fragments. During diagenesis the vitric material reacted with saline and alkaline pore water to form the zeolites and the associated silicate minerals. Some sampled tuffs still contain major to minor amounts of unaltered glass. Although most constituents in the mudstones are probably detrital, some of the silicate minerals are undoubtedly authigenic, having formed from original vitric material or precursor silicate minerals during diagenesis.

The abundance and distribution of the fluorite were determined by chemical and X-ray techniques. Fluorite does not seem to impart to the Monarch Mill lacustrine rocks any recognizable physical property that would indicate its presence. Scanning electron micrographs of fluorite-bearing zeolitic tuff show that the fluorite particles are disseminated and are less than a micrometer in size. Table 1 gives the fluorine and calculated fluorite contents. Fluorine was determined by the specific ion electrode method, and the fluorite content was then calculated from the analyzed fluorine content, with the assumption that all the analyzed fluorine is in fluorite. The calculated fluorite content could be slightly in excess of that actually in the samples because a minor amount of fluorine may be in clay minerals. Thus, those samples having calculated fluorite contents of several tenths of a percent may not contain any fluorite.

The calculated fluorite content of the consistently fluorite-bearing tuffaceous unit in the upper part of the Eastgate zeolite deposit is about 1-14 percent. About half of the samples collected from this unit, however, have a calculated fluorite content greater than 5 percent. At locality 3 (fig. 1), an interval of zeolitic tuff about 1.22 m thick contains an average calculated fluorite content of 12.7 percent. Most fluorite-rich tuffs are also rich in mordenite. Magadi-type chert associated with zeolitic tuffs in this upper unit has a consistently low fluorine content (0.06-0.15 weight percent) and probably lacks fluorite.

Table 1.--Description of samples, fluorine content, calculated fluorite content, and mineral composition

[Samples at each locality are listed in descending stratigraphic order. Fluorine determined by M. K. Coss, Johnnie Gardner, and Patricia Guest by the specific ion electrode method. Mineral composition determined from X-ray diffractometer patterns of powdered bulk samples. Abbreviations: Ca, calcite; Cl, clinoptilolite; E, erionite; F, fluorite; G, glass; I, 10-angstrom clay mineral; K, potassium feldspar; Md, mordenite; Mt, 14-angstrom clay mineral; O, opal; P, plagioclase; Q, quartz. Minerals listed in order of decreasing abundance]

Sample locality (fig. 1)	Lithology	Sample	Sample position (in meters stratigraphically above lowest sample collected at locality)	Fluorine (weight percent)	Fluorite (calculated weight percent)	Mineral composition
1	Tuffaceous mudstone, greenish-gray, crystal molds	F	2.49	0.91	1.9	Q, Mt, P, Cl, I
	Tuffaceous mudstone, greenish-gray	E	0.86	0.94	1.9	Md, Q, Mt, I
	Tuff, orange	D	0.71	0.14	0.3	E, Mt, I
	Tuff, orange	C	0.43	0.08	0.2	E
	Tuff, orange	B	0.20	0.11	0.2	E, Mt, I
	Tuff, green, iron-stained	A	--	0.14	0.3	E, Cl, Mt, I
2	Tuff, greenish-gray, abundant crystal molds	H	4.24	1.40	2.9	Q, Ca, K, Mt, F, I
	Tuff, light-gray	15B	3.33	2.10	4.3	Q, Md, Cl, Mt, F, I
	Tuff, greenish-gray	G	3.17	2.96	6.1	Q, Cl, F, Mt, I
	Tuff, greenish-gray	F	2.05	3.68	7.6	Q, Cl, Mt, F, I
	Tuff, orange, platy	E	1.95	0.82	1.7	E, Mt, I
	Tuff, orange and gray, irregular cavities	D	1.29	0.13	0.3	G, E, Cl, Mt, I
	Tuff, orange and gray	C	1.19	0.21	0.4	E, Mt, I
	Tuff, gray, relatively unaltered	B	0.89	0.27	0.6	G, E, Mt
	Tuff, orange, sugary	A	0.43	0.45	0.9	Cl, Mt
	Tuff, light-gray	15A	--	0.48	1.0	Md, Q, Mt, I, Ca
3	Tuff, greenish-gray	E	8.06	4.72	9.7	Q, Md, Mt, F
	Tuff, greenish-gray	16D	7.45	6.00	12.3	Q, Md, F, Cl, Mt
	Tuff, greenish-gray	16C	6.84	6.00	12.3	Md, Q, Cl, F, P, Mt, I
	Tuff, greenish-gray	D	6.23	6.60	13.6	Q, Md, F, Mt
	Tuff, greenish-gray	16B	5.87	3.25	6.7	Md, Q, Cl, Mt, F, I
	Tuff, greenish-gray	16A	5.01	2.25	4.6	Q, Md, Mt, F, Cl, I
	Tuff, greenish-gray	C	4.40	0.50	1.0	Q, Md, Cl, Mt
	Tuff, greenish-gray crystal molds	B	--	0.60	1.2	Q, Md, Mt, Ca
4	Tuff, yellowish-gray	C	4.85	0.26	0.5	E, Md, Mt, I
	Tuff, greenish-gray	B	3.63	0.32	0.7	Md, Q, Mt, Ca, I
	Tuff, greenish-gray	A	--	0.84	1.7	Md, Q, Ca, Mt, I
5	Tuff, light-gray, unaltered	B	--	0.12	0.2	G, P
6	Tuff, gray, unaltered	A	--	0.12	0.2	G, Mt, I
7	Tuff, light-greenish-gray, crystal molds	J	6.48	0.60	1.2	Md, Cl, Mt, Ca, Q, I
	Tuff, light-greenish-gray, crystal molds	I	5.10	2.90	6.0	O, Md, Mt, Cl, F, I, Ca
	Chert, light-gray with white rind	K	4.88	0.06	0.1	Q, O
	Tuff, green, silicified	H	4.85	2.50	5.1	O, Md, Mt, F
	Tuff, white, crystal molds	G	4.34	3.00	6.2	Md, Mt, I, F, Ca
	Tuff, light-green	F	3.86	2.75	5.6	Md, Mt, I, F
	Tuff, greenish-gray	E	2.79	0.70	1.4	Md, Mt, Cl, I, Ca
	Tuff, white	D	2.18	0.55	1.1	O, Mt, Cl, I
	Tuff, gray, mostly unaltered	C	1.80	0.24	0.5	G, Mt, I, E
	Tuff, white, crystal molds	B	1.55	0.28	0.6	O, Ca, Cl
	Tuff, gray, ripple marks, calcareous	A	--	0.42	0.9	Ca, Mt
8	Tuff, light-greenish-gray, crystal molds	E	4.62	0.70	1.4	Md, Mt, I, F
	Chert, gray with white rind	F	4.11	0.15	0.3	Q
	Tuff, light-gray	D	2.90	2.10	4.3	Md, Mt, F, I
	Tuff, green, crystal molds	C	1.57	4.00	8.2	Md, Mt, I, F
	Tuff, green, crystal molds	B	0.96	2.75	5.6	Md, Cl, Mt, I, F
	Tuff, white	A	--	0.95	2.0	O, Md, Mt, F, I

Table 1.--Description of samples, fluorine content, calculated fluorite content, and mineral composition--continued

Sample locality (fig. 1)	Lithology	Sample	Sample position (in meters stratigraphically above lowest sample collected at locality)	Fluorine (weight percent)	Fluorite (calculated weight percent)	Mineral composition
9	Tuff, white, crystal molds	G	2.97	2.10	4.3	O, Cl, F
	Tuff, white, crystal molds	F	2.46	3.75	7.7	O, Md, F, Mt
	Tuff, gray, unaltered	E	1.65	0.08	0.2	G
	Tuff, yellow	D	1.12	0.12	0.2	E
	Tuff, white	C	0.99	0.45	0.9	Md, Mt, I, Ca
	Tuff, white, calcareous	B	0.51	0.60	1.2	Ca, Md, Mt, I
	Tuff, white	A	--	0.80	1.6	Md, Ca, Mt, I
11	Tuff, white	F	3.84	2.60	5.3	Md, F, Mt, I
	Tuff, light-gray	E	2.69	1.20	2.5	O, Ca, Md, Q, F
	Tuff, gray, ripple marks, mostly unaltered	D	1.75	0.12	0.2	G, Cl, Mt
	Tuff, yellow	C	1.50	0.03	0.1	Cl, E
	Tuff, white	B	0.96	2.10	4.3	Md, F, Mt, I
	Tuff, white	A	--	0.90	1.8	Md, Mt
12	Tuff, greenish-gray, crystal molds	I	5.21	2.10	4.3	Md, Mt, I, F
	Chert, light-gray with white rind	J	5.03	0.11	0.2	Q
	Tuff, greenish-gray, crystal molds	H	4.17	4.25	8.7	Md, Q, F, Mt
	Tuff, greenish-gray, crystal molds	G	3.15	4.75	9.8	Md, Q, Mt, F, I
	Tuff, white	F	2.36	4.00	8.2	Md, Mt, Q, I, F
	Tuff, light-brown	E	1.98	0.24	0.5	G, E
	Tuff, gray, mostly unaltered	D	1.79	0.13	0.3	G, E, Cl
	Tuff, orange	C	1.50	0.11	0.2	Cl, E
	Tuff, white	B	0.86	1.90	3.9	Md, Mt, F, I
	Mudstone, green	A	--	0.95	2.0	Md, Mt, I, Ca, F
13	Tuffaceous mudstone, light-brown	C	1.88	0.85	1.7	Q, E, Mt, Ca, I
	Tuff, light-green	B	1.02	1.80	3.7	Md, F, Mt
	Tuff, light-gray	A	--	1.60	3.3	Q, Md, F, Mt
14	Tuff, white, crystal molds	F	3.78	3.50	7.2	Md, Mt, F, I
	Tuff, white, crystal molds	E	2.51	1.95	4.0	Q, Md, F
	Tuff, white, crystal molds	D	1.24	0.55	1.1	Q, Md, Cl
	Mudstone, greenish-brown	C	0.79	1.20	2.5	Cl, Mt, I, F
	Tuff, white, crystal molds	B	0.41	1.28	2.6	Q, Md, F
	Tuff, orange	A	--	0.32	0.7	E
17	Tuff, light-gray	B	1.52	1.30	2.7	Md, Q, Mt, I, F
	Tuff, light-gray	A	--	5.50	11.3	Cl, Md, Mt, F, I

Tuffs collected stratigraphically below and above the zeolite deposit show only small amounts of fluorine. Relatively unaltered tuffs collected at locality 6 (fig. 1) from unit 3 of Axelrod (1956) and at locality 5 from unit 6 of Axelrod contain only 0.12 percent fluorine.

Neither the genesis nor the economic potential of the fluorite deposit will be considered in detail in this report. The fluorite formed in silicic volcaniclastic rocks during diagenesis, but the relationships and reactions of the fluorite with other diagenetic minerals are still being investigated and will be the subjects of another report. The Eastgate zeolite deposit obviously contains a sizable body of low-grade fluorite-bearing rock, but subsurface data are needed to adequately determine the tonnage, grade, and extent.

REFERENCES

Axelrod, D. I., 1956, Mio-Pliocene floras from west-central Nevada: University of California Publications in the Geological Sciences, v. 33, 321 p.

Papke, K. G., 1972, Erionite and other associated zeolites in Nevada: Nevada Bureau of Mines and Geology Bulletin 79, 32 p.

Sheppard R. A., and Gude, A. J., 3d, 1969, Authigenic fluorite in Pliocene lacustrine rocks near Rome, Malheur County, Oregon, in Geological Survey Research 1969: U.S. Geological Survey Professional Paper 650-D, p. D69-D74.

______1974, Chert derived from magadiite in a lacustrine deposit near Rome, Malheur County, Oregon: U.S. Geological Survey Journal of Research, v. 2, no. 5, p. 625-630.

Studer, H. P., 1967, Mineral analysis of natural zeolite deposits, in Bailey, S. W., ed., Clays and clay minerals--Proceedings of the 15th Clay Minerals Conference, Pittsburgh, Pa., 1966 [abs.]: New York Pergamon Press, p. 187.

Surdam, R. C., and Eugster, H. P., 1976, Mineral reactions in the sedimentary deposits of the Lake Magadi region, Kenya: Geological Society of America Bulletin, v. 87, p. 1739-1752.

Surdam, R. C., and Sheppard, R. A., 1978, Zeolites in saline, alkaline-lake deposits, in Sand, L. B., and Mumpton, F. A., ed., Natural zeolites: occurrence, properties, use: New York, Pergamon Press, p. 145-174.

Tourtelot, E. B., and Meier, A. L., 1976, Lithium in the Gila Conglomerate, southwestern New Mexico, in Vine, J. D., ed., Lithium resources and requirements by the year 2000: U.S. Geological Survey Professional Paper 1005, p. 123-127.