

# On the poikilitic nature of Jabal Al Hasawinah eudialyte

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## Abstract

Poikilitic eudialyte outcrops in a strongly peralkaline phonolithic cumulo-dome in Jabal Al Hasawinah, Libya. Textural relationships reveal that the eudialyte has formed at a very late stage of the rock petrogenesis. Electron microprobe analyses confirm its volatile (hydrous) nature and low *REE* content.

**KEYWORDS:** eudialyte, phonolite, Jabal Al Hasawinah, Libya.

## Introduction

THE occurrence of eudialyte;  $(\text{Na,Ca,REE})_5\text{-}(\text{Fe}^{2+},\text{Mn})(\text{Zr,Ti})\{(\text{SiO}_3\text{O}_9)_2\}(\text{OH,Cl})$  in Jabal Al Hasawinah (also known as Jebel Fezzan) was first reported by Bordet *et al.* (1955). His specimen, which was collected from wadi deposits constituted the first eudialyte to be reported from phonolites (Deer *et al.*, 1986). Regional geologi-

cal mapping (Jurak, 1978*a*) has determined two localities where eudialyte phonolite crops out. These are the Kaf Trunzah and Wadi Damran phonolitic cumulo-domes (Fig. 1).

Jurak (1978*b*) reported *REE* analyses of separated eudialyte crystals from the Wadi Damran outcrop with comments on the possible use of such a find as a commercial *REE* source. However, he presented analyses which show very low

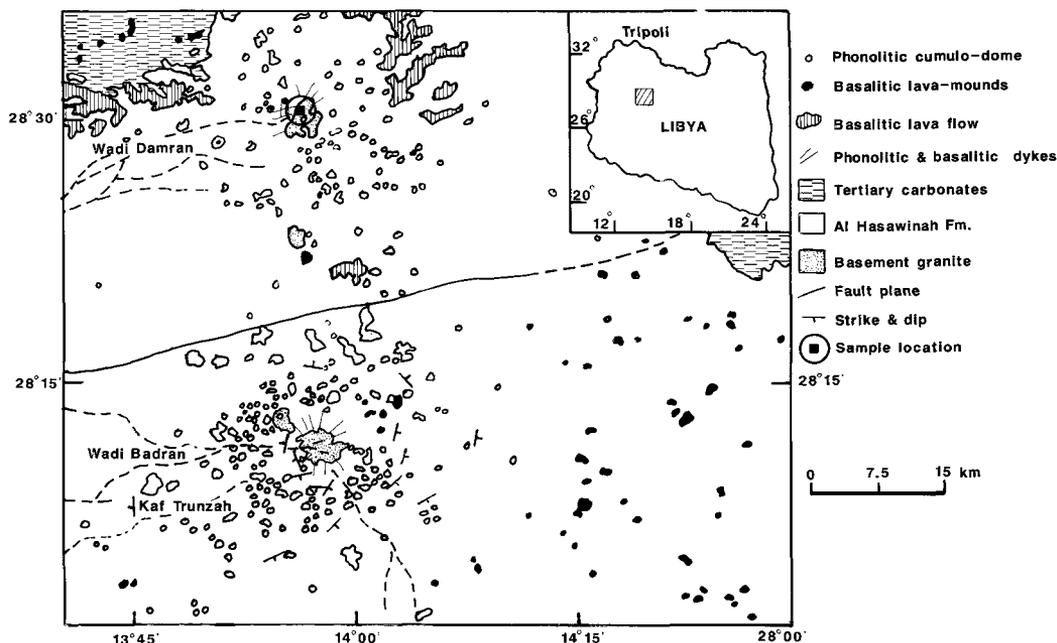


FIG. 1. Location map of Jabal Al Hasawinah modified after Jurak (1978). Inset location of map area.

*REE* (<0.2 wt.%) content! In this paper, a rock sample from the same locality (D-6A) is studied and whole-rock analyses as well as electron microprobe studies of the eudialyte are presented.

### Petrography

The phonolite is dark brown, altered and highly porphyritic with phenocrysts up to 0.6 mm in size and a conspicuous trachytic texture. The phenocrysts are equidimensional nepheline, tabular sanidine, light to dark pink poikilitic eudialyte, and needle-shaped and rhombic strongly zoned dark green aegirine. The aegirine phenocrysts form both radiating spherulitic and glomeromorph textures. The eudialyte crystals are pink, strongly pleochroic, poikilitic (Bordet *et al.*, 1955) and form aggregates in optical continuity (Fig. 2). The groundmass is highly altered to zeolite and cancrinite with relict nepheline, K-feldspar and aegirine crystals.

### Chemistry and mineralogy

*Analytical method.* Whole-rock analyses were obtained at Trinity College, Dublin, using a Link systems Meca 10-44 energy dispersive X-ray fluorescence spectrometer following the method of Potts *et al.* (1984). Glass disks were used to determine the major elements together with the trace elements Ba, Cr, and V. The trace elements Rb, Sr, Y, Nb and Zr were determined on pressed pellets. The *REE* analyses were obtained by INAA techniques at the Katholieke Universiteit Leuven (Belgium). The data are given in Table 1.

Analyses of phenocrysts in phonolite were

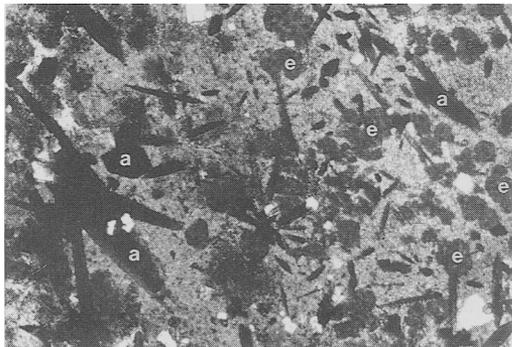


FIG. 2. Photomicrograph showing eudialyte (e), zoned aegirine (a) and resorbed nepheline phenocrysts in highly altered groundmass. PPL. Field of view is 3.5 mm in width.

carried out using a Cambridge Instruments Microscan V instrument. The electron microprobe was fitted with two automated crystal spectrometers enabling ZAF corrections to be made on-line (Sweetman and Long, 1969). The operating conditions were 20 kV operating potential, 30 mA probe current measured in a Faraday cage and beam focused to its minimum spot. Natural and synthetic minerals together with pure metals were used as standards. Analyses of eudialyte crystals were carried out using a Cameca Camebax Microbeam electron microprobe fitted with four crystal spectrometers. The operating conditions were 20 kV operating potential and 20 mA probe current. The electron microprobes are housed at the University of Edinburgh (Grant Institute of Geology). The eudialyte crystals and enclosed sodalite were unstable, therefore, a defocused beam was used. The data are given in Table 2.

*Whole rock.* The phonolite whole rock analyses are presented in Table 1. The rock is peralkaline with 3.7 wt.% normative acmite. The sodic character of the mineralogy (abundance of nepheline and aegirine) is reflected in the high  $\text{Na}_2\text{O}:\text{K}_2\text{O}$  whole-rock ratio (2.2). The trace element analyses show normal high abundances of Nb, Zr, Y and Th.

The *REE* abundances are typical of a highly fractionated phonolite but are not extreme. They are the most fractionated of Jabal Al Hasawinah phonolites (Busrewil and Oun, in press, and Oun, unpublished data). Their chondrite normalised pattern shows high fractionation of *LREE* and a flat *HREE* pattern with a negative Eu anomaly. The pattern is explicable in terms of feldspar and clinopyroxene fractionation.

The nepheline is strongly sodic with 16 to 18%  $\text{Na}_2\text{O}$  and 4 to 5%  $\text{K}_2\text{O}$ . The aegirine has a composition in the range  $\text{Ac}_{92}\text{Di}_3\text{Hd}_3$  to  $\text{Ac}_{72}\text{Di}_7\text{Hd}_{21}$ . Comparison with the eudialyte-bearing phonolite dyke of south-eastern Queensland, Australia (Carr *et al.*, 1976) shows remarkable resemblance between the two in terms of field occurrence, mineralogy and chemistry.

*Eudialyte.* The eudialyte is strongly poikilitic (Fig. 3). The chadacrysts include orthoclase, nepheline, aegirine and sodalite. Of these phases, the sodalite has never been noticed in other phonolites in Jabal Al Hasawinah. The mineralogy of the remaining chadacrysts resembles those of the host rock. Furthermore, careful examination of the backscattered images shows that the enclosed phases exhibit the same orientation as their host-rock counterparts in a manner which suggests that they were engulfed by the subsequent eudialyte phase. The sodalite which is

Table 1. Major, trace and REE analyses of host rock.

		CIPW Norm					
SiO <sub>2</sub>	57.73	Or	28.39	Rb	285	La	195
TiO <sub>2</sub>	0.27	Ab	35.34	Sr	275	Ce	268
Al <sub>2</sub> O <sub>3</sub>	21.67	Ne	26.89	Y	102	Nd	57
FeO(t)	3.36	Ac	3.70	Zr	2903	Sm	7.2
MnO	0.37	Di	2.31	Nb	529	Eu	2.14
MgO	0.37	Ol	1.80	Th	85	Tb	1.56
CaO	0.71	Il	0.46	U	41	Yb	7.9
Na <sub>2</sub> O	10.53	Ap	0.31	Ba	331	Lu	1.1
K <sub>2</sub> O	4.77			Cr	19	Hf	46.7
P <sub>2</sub> O <sub>5</sub>	0.21			V	29	Ta	19.8
Total	99.99						

believed to have crystallised with the eudialyte exhibits the same unstable nature resulting in a low total. The eudialyte is very unstable due to Na volatilisation, resulting in low analytical totals (Table 3). However, an independent check of Cl content in the eudialyte showed very high contents (2 to 3 wt.%). This, together with the undetermined H<sub>2</sub>O and F may account for the balance of the totals.

The eudialyte shows very high SiO<sub>2</sub> (53-57%) content (cf. Deer *et al.*, 1986, and references cited therein) which is partly artificial since the low totals were accompanied by loss of Na<sub>2</sub>O and apparent increase in SiO<sub>2</sub>. Similar silica contents were reported from eucolites in the eucolite syenite of Tanzania (Dawson and Frisch, 1971). The analyses are typical of eudialyte with Na<sub>2</sub>O > CaO and ZrO<sub>2</sub> in the range of 10 to 12%.

Table 2. Microprobe analyses of chadacrysts enclosed in eudialyte and representative analyses of host rock phenocrysts.

	1	2	3	4	5	6	7
SiO <sub>2</sub>	52.98	47.24	52.82	45.20	47.68	63.64	39.79
TiO <sub>2</sub>	2.50	n.d.	2.69	-	-	0.03	0.03
Al <sub>2</sub> O <sub>3</sub>	0.78	29.17	0.96	32.20	30.79	18.43	33.08
FeO(t)	25.41	1.61	24.22	0.68	1.52	0.28	0.83
MnO	0.58	n.d.	0.47	n.d.	n.d.	0.08	0.09
MgO	1.10	0.06	1.13	0.03	0.08	0.47	0.03
CaO	3.05	n.d.	2.74	n.d.	n.d.	-	0.02
Na <sub>2</sub> O	12.54	16.64	13.00	16.86	16.09	0.47	19.48
K <sub>2</sub> O	0.02	4.52	0.07	4.30	4.25	15.76	0.11
Cr <sub>2</sub> O <sub>3</sub>	0.05	n.d.	ZrO <sub>2</sub> 0.14	0.01	0.03	0.01	0.05
Total	99.01	99.24	98.24	99.28	100.44	98.70	93.69
Atomic Percentage							
Si	1.99	9.08	2.12	8.66	9.01	11.93	5.30
Ti	0.07		0.08				
Al	0.04	6.61	0.05	7.27	6.85	4.07	4.56
Fe <sup>3+</sup>	0.76	0.26	0.18	0.11	0.24	0.04	0.09
Fe <sup>2+</sup>	0.04						
Mn	0.02		0.02	0.01	0.01	0.01	0.01
Mg	0.06	0.02	0.07				
Ca	0.12		0.12				
Na	0.91	6.20	1.01	6.26	5.89	0.17	1.38
K		1.11		1.05	1.02	3.77	2.72

n.d. = not determined

- = not detected

1 & 2) Representative aegirine and nepheline phenocrysts (respectively) from host rock.

3) Aegirine chadacryst in eudialyte.

4 & 5) nepheline chadacrysts in eudialyte.

6) K-feldspar chadacryst in eudialyte (Or<sub>96</sub> Ab<sub>4</sub>).

7) Sodalite chadacryst in eudialyte.

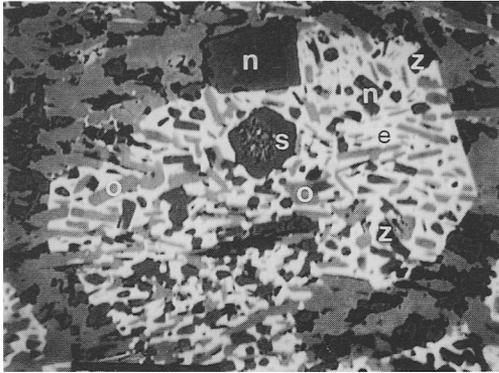


FIG. 3. Electron-microprobe backscattered image of poikilitic eudialyte (e) oikocyst enclosing orthoclase (o), zeolite (z), sodalite (s) and nepheline (n) chadacrysts. Blemishes in sodalite crystal surface are beam damage during analysis.  $\times 270$ .

Determination of *REE* in the eudialyte showed very low or insignificant amounts which precludes

the possibility that the *REE* analyses reported by Jurak (1978*b*) may have been diluted by the enclosed phases.

### Discussion

Eudialyte is found mainly in peralkaline nepheline syenites. However, its occurrence in oversaturated igneous rocks has also been reported (e.g. the peralkaline granite of Ascension; Harris *et al.*, 1982). Its occurrence in phonolites is rare and has so far been reported only from one other locality (a phonolitic dyke from south-eastern Queensland, Australia; Carr *et al.*, 1976). Eudialyte is considered to be a late crystallising phase derived from a residual magma and therefore is commonly present in pegmatites. The eudialyte is normally primary (magmatic) but can also be the product of alteration of other Zr-rich phases (e.g. dalyite; Harris *et al.*, 1982).

Fryer and Edgar (1977) suggested that the late-stage *REE* enrichment of eudialyte is not a function of preferential concentration of *REE* in

Table 3 Microprobe analyses of Jabal Al Hasawinah eudialyte. Atomic percentages are calculated on the basis of 19 Oxygens (anhydrous basis)). Oldoinyo Lengai eucolite (Tanzania) and *REE* rich Ascension Island eudialyte are added for comparison.

	1	2	3	4	5	6
SiO <sub>2</sub>	55.07	57.31	53.06	53.35	53.40	49.36
TiO <sub>2</sub>	0.32	0.39	0.38	0.39	0.21	0.50
Al <sub>2</sub> O <sub>3</sub>	2.96	0.22	0.81	0.87	-	-
FeO(T)	2.50	3.15	2.69	2.75	5.94	9.35
MnO	1.60	1.75	1.92	1.93	0.42	2.19
MgO	0.02	0.03	-	-	-	0.02
CaO	7.46	10.12	9.99	9.98	16.20	3.92
Na <sub>2</sub> O	6.40	1.23	11.50	11.66	12.40	13.48
K <sub>2</sub> O	3.22	0.44	0.76	0.41	0.94	0.52
ZrO <sub>2</sub>	10.25	12.59	11.81	11.46	10.30	14.39
REE <sub>2</sub> O <sub>3</sub>	-	-	-	-	-	5.97
Total	89.90	87.23	92.92	92.80	99.81	99.70
Atomic Percentage						
Si	7.082	7.407	6.796	6.821	6.542	6.468
Ti	0.031	0.038	0.037	0.037	0.014	0.050
Al	0.449	0.034	0.122	0.131	-	-
Fe	0.269	0.340	0.288	0.294	0.597	0.655
Mn	0.147	0.192	0.208	0.209	0.043	0.243
Mg	0.004	0.006	-	-	-	0.004
Ca	1.028	1.401	1.371	1.367	2.153	0.551
Na	1.596	0.308	2.856	2.890	2.944	3.424
K	0.528	0.073	0.124	0.067	0.145	0.087
Zr	0.614	0.792	0.722	0.697	0.615	0.918
REE	-	-	-	-	-	0.347

1-4) Jabal Al Hasawinah eudialyte.

5) Oldoinyo Lengai eucolite, data from Dawson & Frisch (1971).

6) Ascension Island eudialyte, data from Harris *et al.* (1982).

eudialyte, but a result of complexing involving volatiles (Na and F) in late-stage magmatic and postmagmatic fluids. The eudialyte of Jabal Al Hasawinah has very low *REE* contents. Textural relationships indicate that this mineral crystallised very late in the cooling history of the rock. Furthermore, the extreme alteration of the rock, the absence of its common zonation with euclite and the identical mineralogy and orientation of the chadacrysts with the whole-rock phenocrysts may suggest a hydrothermal origin. However, the euhedral character of some eudialyte crystals would suggest a magmatic origin. It is interesting to note that the *REE*-poor euclites of Tanzania (Dawson and Frisch, 1971) which were also reported to be silica-rich may also be magmatic or metasomatic in origin.

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