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Albitites and Orthoclasites: Two Extreme Na and K-fenites in Amba Dongar Carbonatite Diatreme

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ABSTRACT

Amba Dongar is one of the few carbonatite complexes in the world in which the host rock is pure Bagh sandstone with >99% SiO_2, offering a unique opportunity to study the mineralogical and chemical changes associated with fenitization. The diatreme is surrounded by an aureole of lateral fenitization extending up to 300 meters. The first description of the fenitization of the host Bagh sandstone, leading to the development of potassic fenite, was given by Deans et al. (1972, 1973). The presence of sodic fenite, which lay hidden beneath potassic fenite and sövite, was brought to the surface much later during extensive mining operations for the fluorite at the deeper level (Sukheswala and Viladkar, 1981; Viladkar, 1986, 1996). The vertical zonation of fenitization with sodic fenite at depth and potassic fenites in upper levels at Amba Dongar was subsequently supported during the logging of drill cores from a vertical borehole in the mining area. It was also evident that the sodic fenitization is superimposed on the predominantly potassic fenitization. This contribution deals only with ultrasodic (albitites) and ultrapotassic (orthoclasites), two extreme stages of fenites in the Amba Dongar carbonatite diatreme.

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1. Introduction

The most common feature observed in all carbonatite-alkalic complexes is wall-rock alteration by alkali metasomatism, termed fenitization (Brögger, 1921). Many large carbonatite bodies develop reasonably extensive aureoles of fenitization, and it is generally noticed that the size of the aureole of fenitization is related to the volume of the carbonatite mass. Usually, the aureoles of fenitization are lateral in extent, and there are only a few isolated examples where vertical zonation of fenitization is observed (e.g., Amba Dongar, Chilwa Province, Malawi; Le Bas, 1981; Woolley, 1982). A survey of the literature reveals that about 90% of the carbonatite-alkalic complexes are situated in terranes where the country rock is granite or granite–gneiss. At the same time, in a few instances in South Africa, carbonatites are emplaced in basic rocks (Verwoerd, 1966).

Brögger (1921) was the first to study the effects of fenitization in the protolith granite around alkaline rocks (volatiles emanating from melt-ejecta-ijolite magma) at Fen, Norway. He introduced the term "fenite" for such metasomatically altered rocks. Saether's work (1957) on the Fen leads to the conclusion, similar to Brögger, that fenitization was caused by a very basic residual magma rich in alkali and lime and loaded with water and CO_2. King and Sutherland (1960) and Garson (1965) took a similar view in their studies of fenitization around alkalic rocks in Africa. However, it was Von Eckermann (1948), in his classic work on the rocks of the Alnö complex, Sweden, who extended the term fenitization to include all metasomatically altered rocks formed by emanations from carbonatite magma. Thus, Von Eckermann was the first to suggest that the original carbonatite magma was alkali-rich, supplying Na and K during metasomatism of the wall rock around carbonatite complexes.

The detailed sampling of the potassic to sodic fenites from the higher level (potassic fenites) in the mining zone to deeper sections (sodic fenites) at Amba

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Dongar helped to establish the order of superposition of fenites. This led to the idea of vertical zonation of fenitization at Amba Dongar that was further supported by borehole data. Very few high-level subvolcanic carbonatite complexes have preserved such vertical zonation of fenitization, and Amba Dongar is a good example. Potassic fenites seem to have mobilized to some extent as veins of such fenites (Ca 3.5 cm) seen cutting across sodic fenites with sharp contact with the latter. Yet another kind of K-fenitization observed in Amba Dongar is the phlogopitization of pyroxene in sodic fenites and nephelinites.

This paper aims to present the field data, petrography, mineralogy, and geochemistry of two chemical end products of fenitization, albitites and orthoclasites, found in the vertically zoned fenitization of the carbonatite diatreme of Amba Dongar.

2. General Geology of the Amba Dongar Carbonatite Diatreme

The Amba Dongar carbonatite-nephelinite diatreme is located in the western part of the Deccan volcanic province. The diatreme intrudes Precambrian Dharwar-Cretaceous Bagh sandstone and the Deccan basalt sequence. The ring complex consists of a ring dike of sövite that has an inner rim of carbonatite breccia. The central sunken core of the complex is partly occupied by the older Deccan basalt, which is later intruded by post-carbonatite basalt, dolerite, and basanite dikes. Nephelinite forms a broken outermost ring of the complex in the low grounds. Phonolite plugs and dikes are associated with the nephelinites (Fig. 1). The central complex is surrounded by a fenite zone that extends in the Bagh sandstone up to 300. A vertical zone of fenitization has developed, with sodic fenites at deeper levels and potassic fenites exposed as xenoliths in sövite throughout the rind dike.

The unfenitized Bagh sandstone exposed in the Amba Dongar area is uniformly quartzitic. Quartz pebbles in sandstone are seen to be replaced from the rims to the centre by pink feldspar (Fig. 2).

In shattered sandstone, numerous cracks are filled solely with K-feldspar. It is possible that several radial fractures produced as a result of doming up of the sandstone during forceful injection of carbonatite acted as channels for the fenitizing fluids.

An advanced stage of K-feldspar fenitization resulted in the formation of pure K-feldspar fenites (orthoclasites). These, on the other hand, are comparatively coarse-grained rocks with remnants of original gneissic or sedimentary texture. Most of the feldspars are either microcline or orthoclase (Or around 93%). No relict quartz is noticed in these rocks. It appears that feldspathisation is superimposed on the earlier sodic fenites, converting them into feldspar rocks. The feldspar in these rocks is generally highly clouded. However, as the feldspathisation process progresses, clouding disappears, and in most orthoclasites, most of the feldspar is free from clouding. K-feldspar has replaced the original albite, and aegirine has been oxidized to haematite, while preserving the original needle-shaped habit of aegirine. Some of the aegirine-augite is formed around feldspar grains, while some penetrate the large feldspar crystals. Feldspar in places show sieve structure. Calcite has formed in patches replacing the feldspar.

Exposures of sodic fenites are found either in valleys or in the deeper workings of the fluorspar mine. They also occur as small- and large-sized xenoliths in sövite. More intense effects of fenitization are observed along contacts between sövite and sandstone. Here, the fenite acquires a syenitic texture and is composed of feldspar and aegirine-augite with abundant calcite and apatite. The mining company had drilled several boreholes in the mining area, and some of these are exclusively in the fenite zones, indicating that sodic fenite is encountered at the deeper levels. In comparison, potassic fenites occur at the higher levels in the boreholes—the gneissic xenoliths in sövitewere collected during mining operations across different parts of the mining zones. The majority of these are totally feldspathised, retaining the original gneissic texture.

3. Petrography

3.1. Orthoclasites

Orthoclasites are comparatively coarse-grained rocks with remnants of original sedimentary texture. Most of the feldspars are either microcline or orthoclase (Or around 93%). No relict quartz is noticed in these rocks. The feldspar in these rocks is generally highly clouded. However, as the feldspathisation process progresses, clouding disappears, and in most orthoclasites, most of the feldspar is free from clouding. Clouding is seen only in the centres of the feldspar

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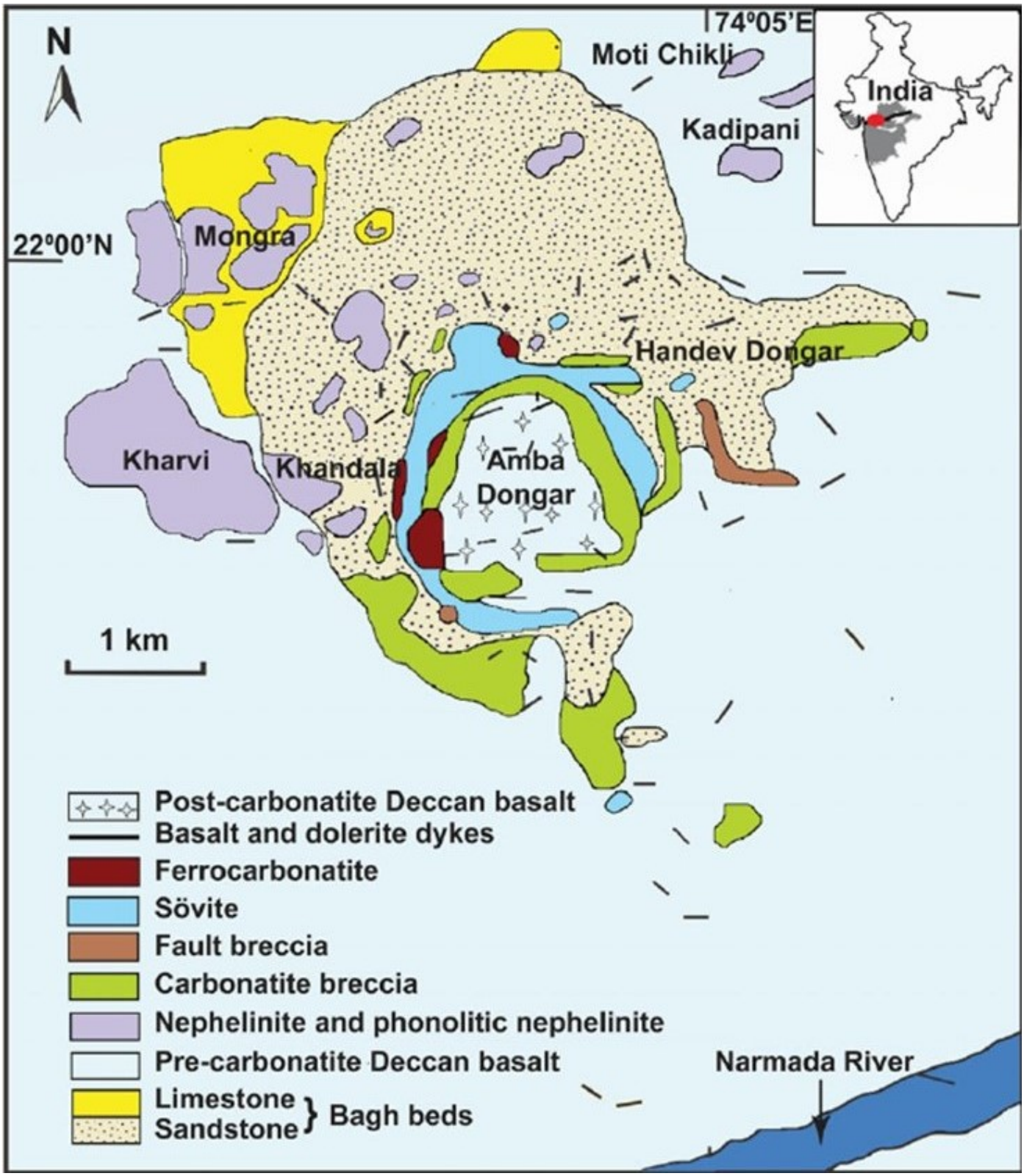

Fig. 1. Geological Map of Amba Dongar diatreme (Sukheswala and Viladkar, 1981, modified by Fosu et al. (2018)).

grains, while the margins are totally free from clouding. The effect of potassic feldspathisation superimposed on sodic fenitization is seen in many of the thin sections, where albite has been replaced by K-feldspar and aegirine has been oxidized to haematite, which still preserves the original needle-shaped form

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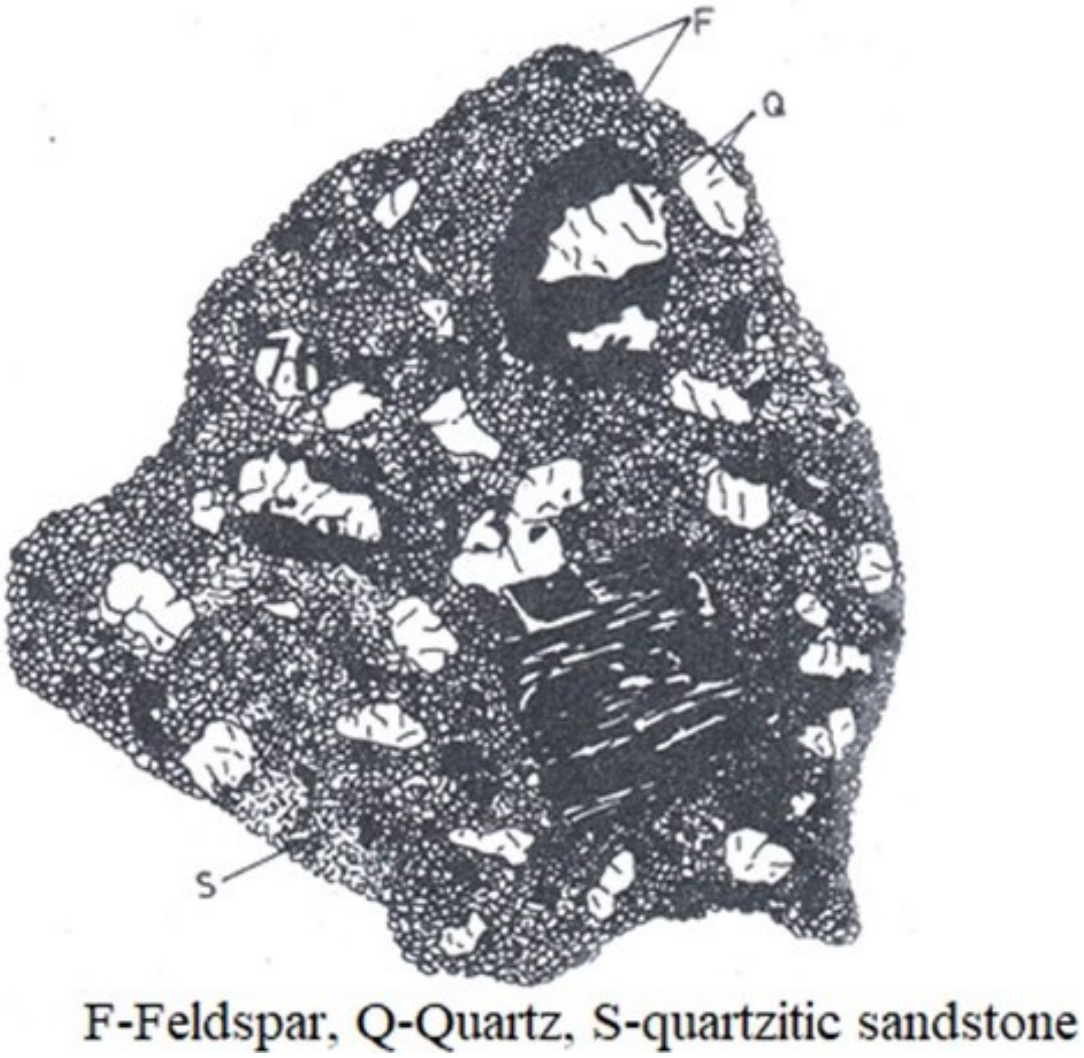

Fig. 2. K-feldspathised pebbly sandstone.

of aegirine. Calcite has formed in patches, replacing the feldspar.

Since detailed descriptions of orthoclasites are given in Deans et al. (1972, 1973), Sukheswala and Viladkar (1981), and Sukheswala and Viladkar (1981); Viladkar (1986, 1996), more emphasis is placed on the petrography of albites.

3.2. Albitites

These are Na-analogue of orthoclasites in Amba Dongar. The albitites are fine-grained in most cases and almost saccharoidal or quartzitic in texture, and consist solely of untwinned albite, preserving the original rounded form of the quartz in the protoliths' sandstone. This texture points to the process of albitization of original quartz. Most of the albitite xenoliths in sövite are monomineralic (Fig. 3), whereas in some, residual quartz is still preserved (Fig. 4). Albitites in Amba Dongar appear to have formed from two protoliths: sandstone and basement gneiss. K_2O in chemical analyses of albite from albitites varies from 0.00 % to 0.09% (Table 2; discussed later).

These albitite xenoliths show later feldspathization during K-metasomatism; however, at this stage of K-metasomatism of albitities, original albite is still preserved (Figs. 4–8).

4. Mineral Chemistry

Sodic plagioclase (albite) and K-feldspar (mainly orthoclase) are the only minerals which make up 99% of these rocks, along with some relict quartz. Both types of feldspars are analysed using the Electron microprobe, and the results are tabulated in Tables 1 and 2. In the albitites, the feldspar is exclusively albite, with K_2O content ranging from 0.01% to 0.05%.

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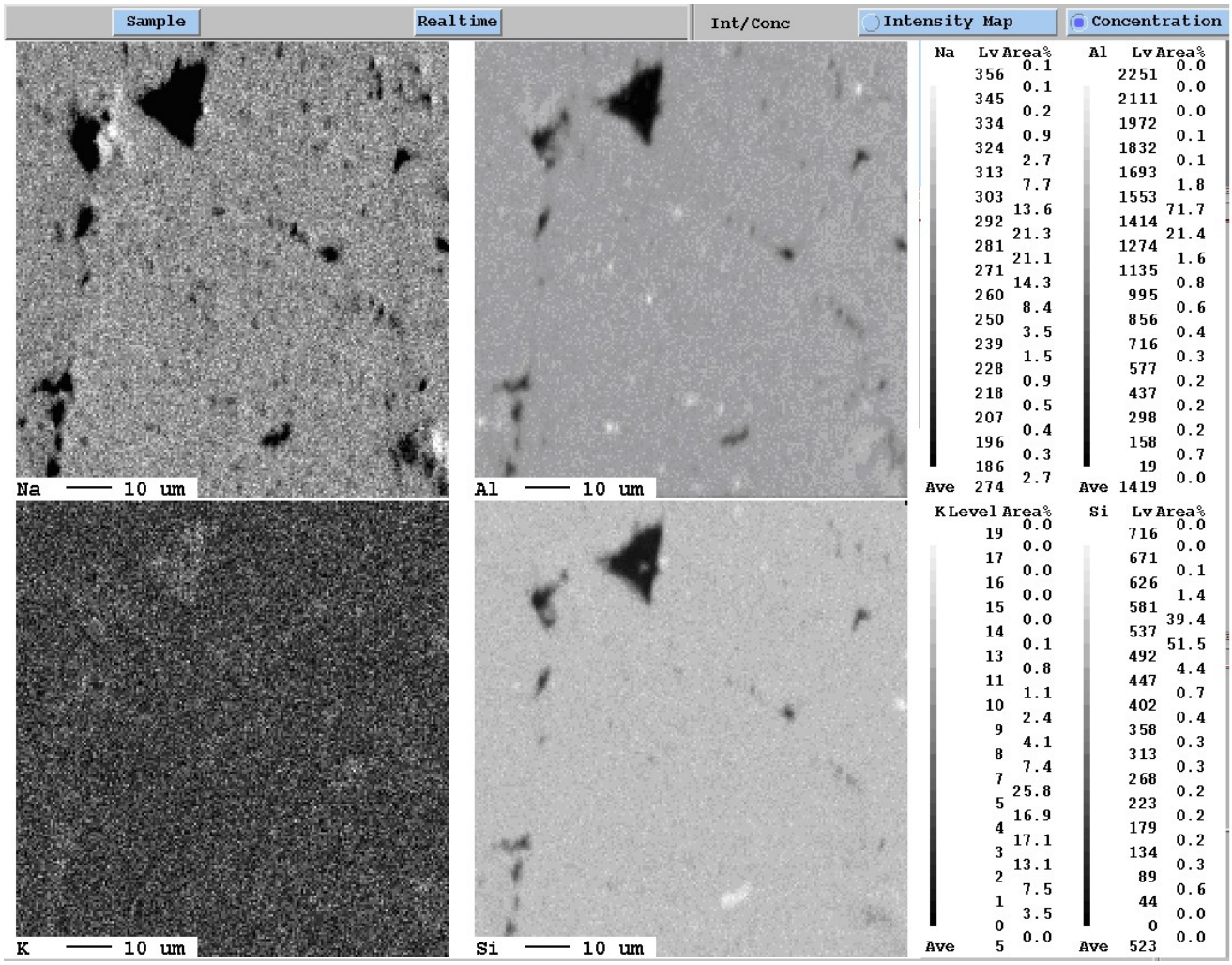

Fig. 3. BSE and elemental scans of Monomineralic albitite.

Table 1. Feldspar from albitite 328.

SiO_2	68.72	68.47	61.75	68.39	68.66	68.40	68.47	68.77	68.60
Al_2O_3	18.99	19.41	17.76	18.94	19.04	19.23	19.06	18.93	19.29
Na_2O	12.20	12.30	11.94	12.03	12.32	12.06	11.80	11.91	12.55
K_2O	0.02	0.02	0.02	0.03	0.01	0.00	0.05	0.01	0.02
BaO	0.02	0.05	0.00	0.04	0.09	0.02	0.05	0.00	0.00
Total	100.18	100.43	100.09	99.61	100.22	99.89	99.58	99.76	100.56
An	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ab	99.89	99.89	99.89	99.84	99.95	100.00	99.72	99.94	99.90
Or	0.11	0.11	0.11	0.16	0.05	0.00	0.28	0.06	0.10

Table 2. Representative analyses of K-feldspars from orthoclasites.

SiO_2	64.00	63.43	63.30	63.63	65.60
Al_2O_3	19.42	19.73	19.88	19.29	18.50
Na_2O	1.34	1.32	0.60	0.83	0.14
K_2O	14.62	15.28	15.92	15.50	15.99
Total	99.38	99.76	99.70	99.25	100.23
An	0.00	0.00	0.00	0.00	0.00
Ab	12.23	11.61	5.42	7.53	1.31
Or	87.77	88.39	94.58	92.47	98.69

On the other hand, in some orthoclasites, a small percentage of Na_2O (ranging from 0.06% to 1.32%) is observed. This is reflected in the composition of feldspar of orthoclasites in Fig. 9.

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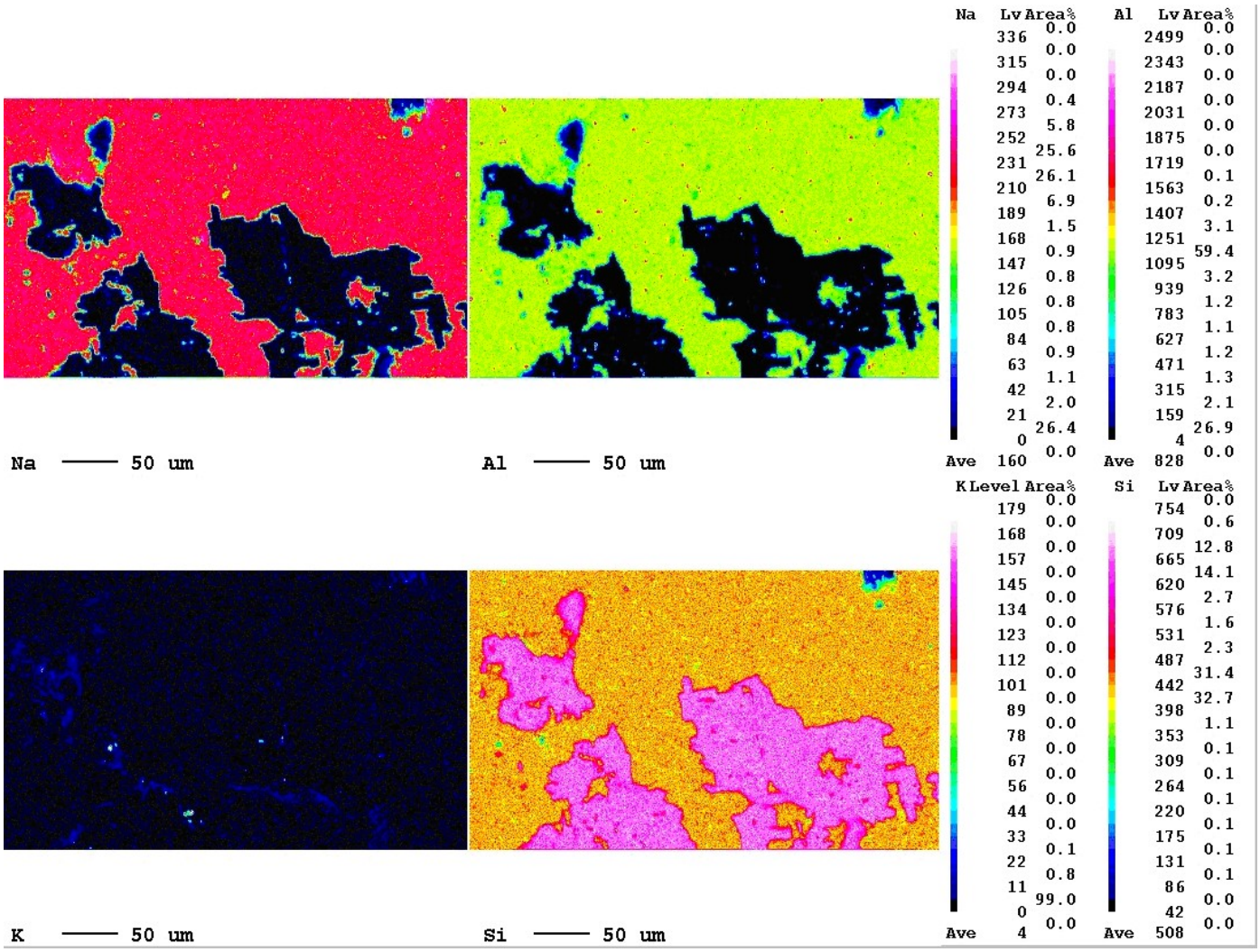

Fig. 4. Relict quartz in albitite.

5. Geochemistry

In the following tables, major oxide, trace, and REE data for albitites and Orthoclasites are presented, and these data are used to draft trace-element and REE diagrams for comparison.

Some of the key points observed in these trace and REE chondrite-normalized patterns are:

1. In Fig. 9, albitites show depletion in K and Rb, which is obvious in the fenitizing solutions that caused albitization; the Na/K ratio was higher.
2. Fig. 10 shows that the fenitizing solutions at the stage of K-metasomatism (later than Na-metasomatism) were distinctly richer in the REE. This also points to the fractionation of REE in the fenitizing fluids.

6. Discussion

Albitites and Orthoclasites are two extreme sodic and potassic fenitization products associated with the carbonatite metasomatism in Amba Dongar.

The albitites (under the group name sodic fenites) from the Amba Dongar carbonatite complex were first described by Sukheswala and Viladkar in 1981. Subsequently, Viladkar (1986, 1996) described these rocks in greater detail, naming them “ultrasodic fenites”, obviously because Na played a major role in this type of metasomatism in the Amba Dongar complex.

In a recent review of the fenites associated with carbonatites by Elliott and et al. (2018), albitites have not been included. However, much earlier, Sutherland (1965) described feldspathic fenitization resulting in the formation of albitites. Similarly, Woolley (1969) and Le Bas (1977) also described albitites in their study of fenitization. In fact, Le Bas

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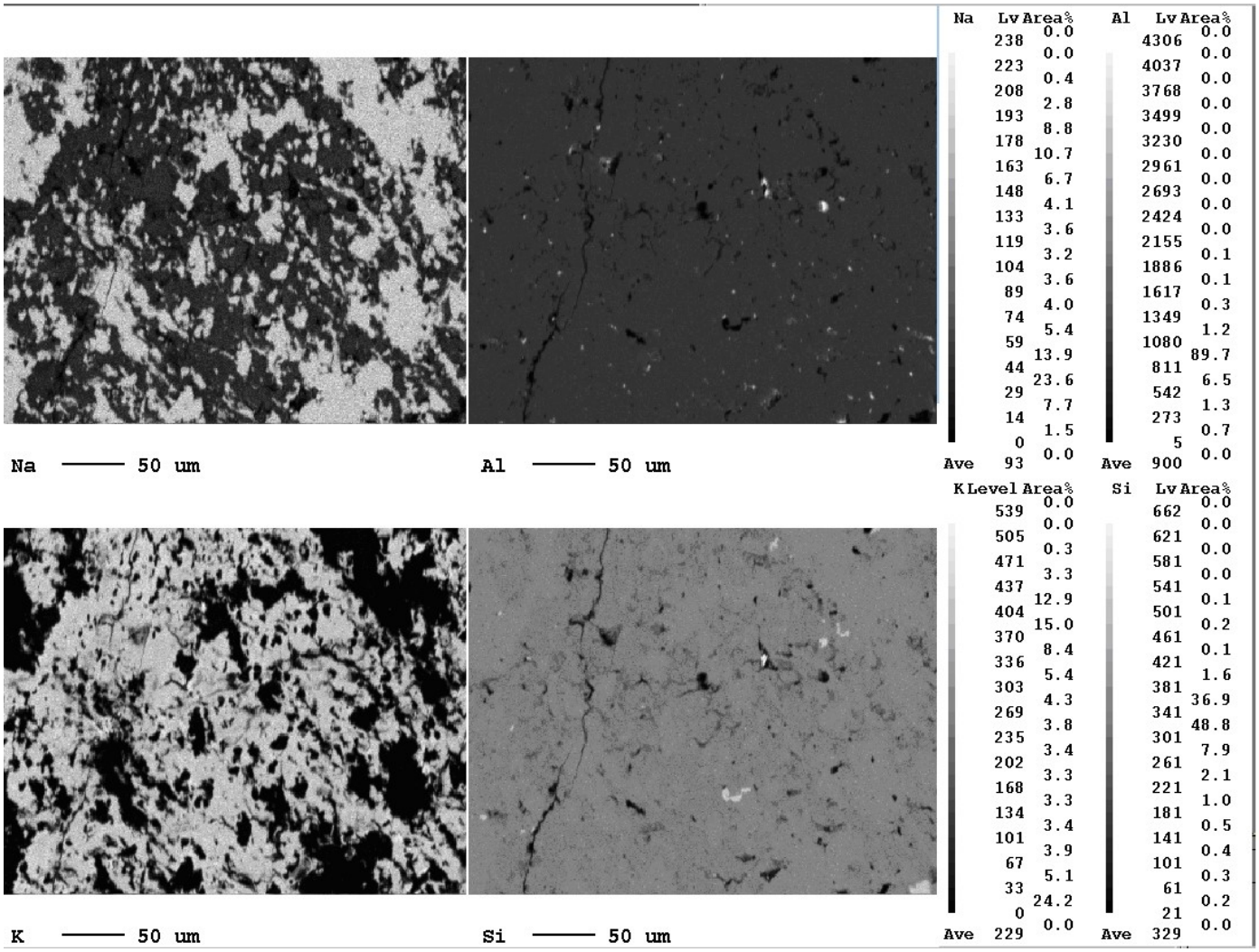

Fig. 5. Feldspathisation of Na-feldspar in Albitite.

(1981) concludes that albitites are undoubtedly of carbonatite parentage. Garson et al. (1984) described albitites associated with carbonatite veins from the Great Glen Fault Complex, Scotland. Heinrich (1966) reported albitites from the Ikomba carbonatite in Western Tanganyika; he also reported albitite from the Spitskop carbonatite in South Africa. One cannot overlook the many reported occurrences of albitite associated with carbonatites. Further, Rubie and Gunter (1983) attribute the formation of "albitites" and "orthoclasites" exclusively to the carbonatite magma.

The fenitizing fluids emanating from carbonatite magma (mainly calciocarbonatite) at Amba Dongar were rich in Na, K, Al, LREE, Ba, Sr, Th, and F. They were introduced into the protoliths, where the sandstone desilicated the country rock. This is described in detail by Sukheswala and Viladkar (1981) and Sukheswala and Viladkar (1981); Viladkar (1986, 1996). Detailed field, petrographic and geochemical studies of the different types of fenites reveal that fenitization in the Amba Dongar diatreme is depth-related; sodic fenites (albitites) formed at the deeper level and potassic fenites (orthoclasites) at the surface level (Fig. 11).

Le Bas (in Deans et al. (1973)) suggested that the composition of the fenitizing fluid, in terms of K/K + Na, varies with temperature. This is true in case of albitites and orthoclasites. Formation of albitite is certain at high temperature (composition of high albite) while feldspars of orthoclasite (orthoclase and microcline) were formed in the low temperature range.

The source of alkali-component-rich fenitizing fluids is undoubtedly carbonatite (mainly sövite) in the Amba Dongar diatreme. It should be emphasized here that at the stage of ankeritic intrusion, the magma totally lacks the alkali component, as no

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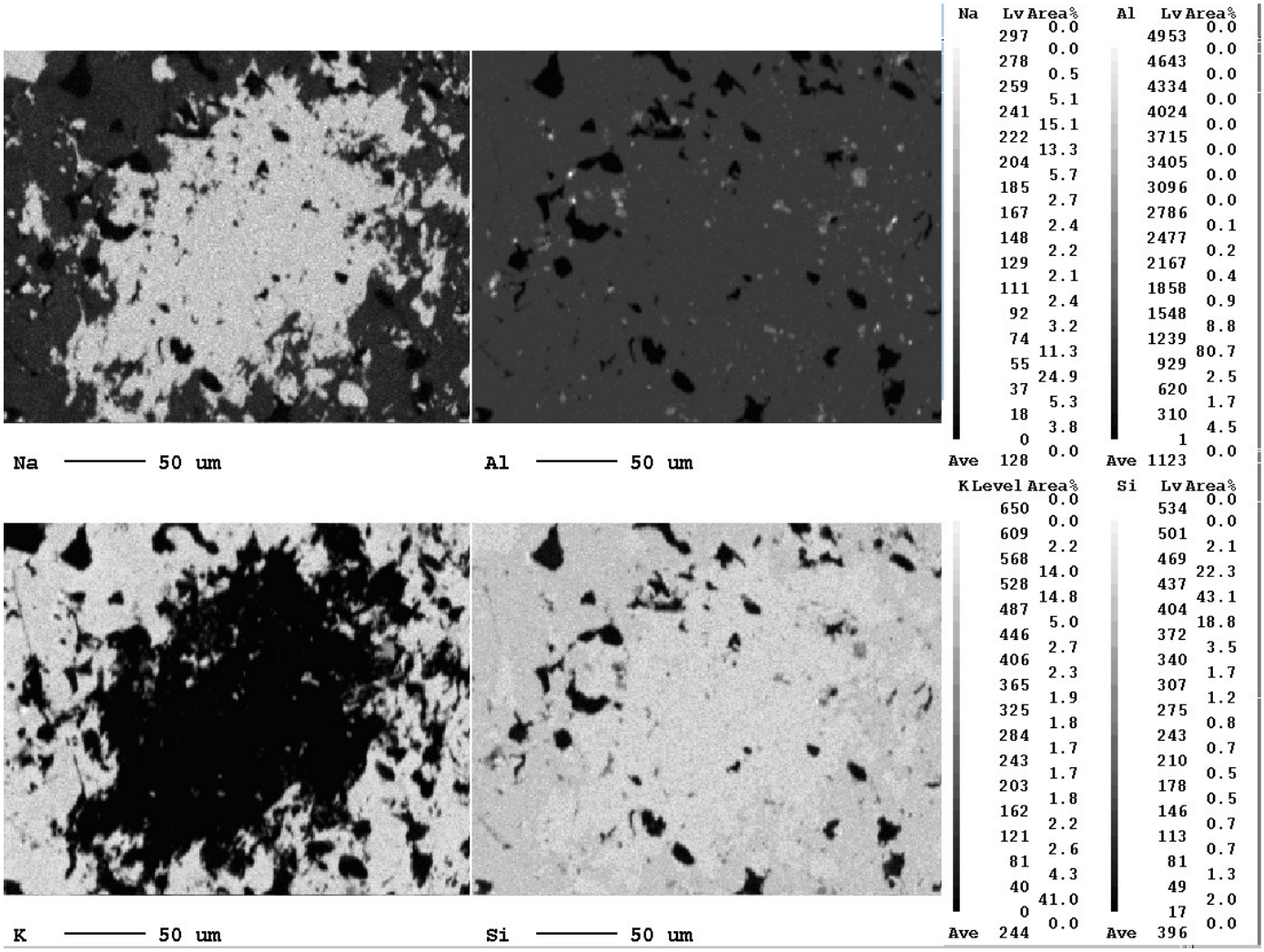

Fig. 6. Relict Na-feldspar during K-feldspathization of albitite.

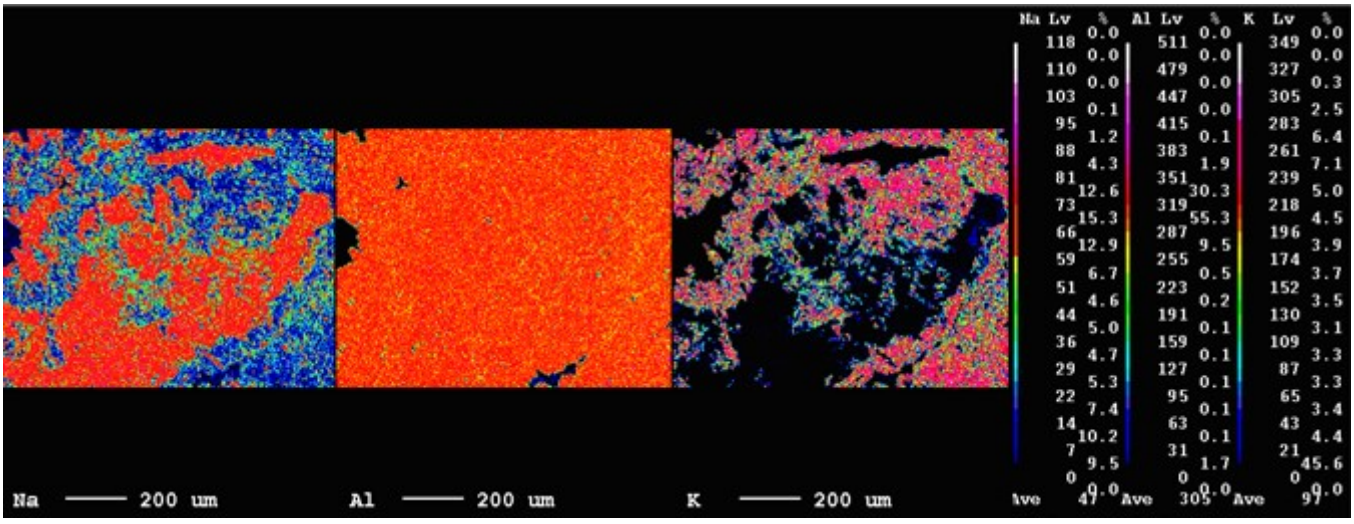

Fig. 7. Elemental mapping of Na, K, Al, Si and Ba of K-feldspathised albitite.

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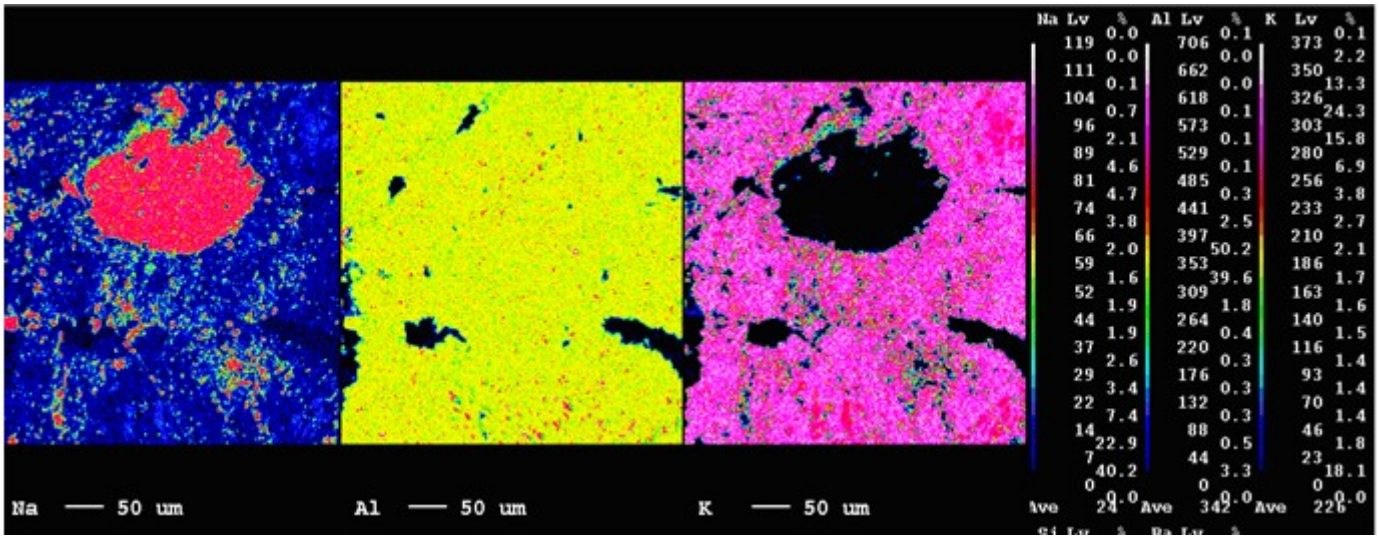

Fig. 8. Relict Na-feldspar in K-feldspathised albitite.

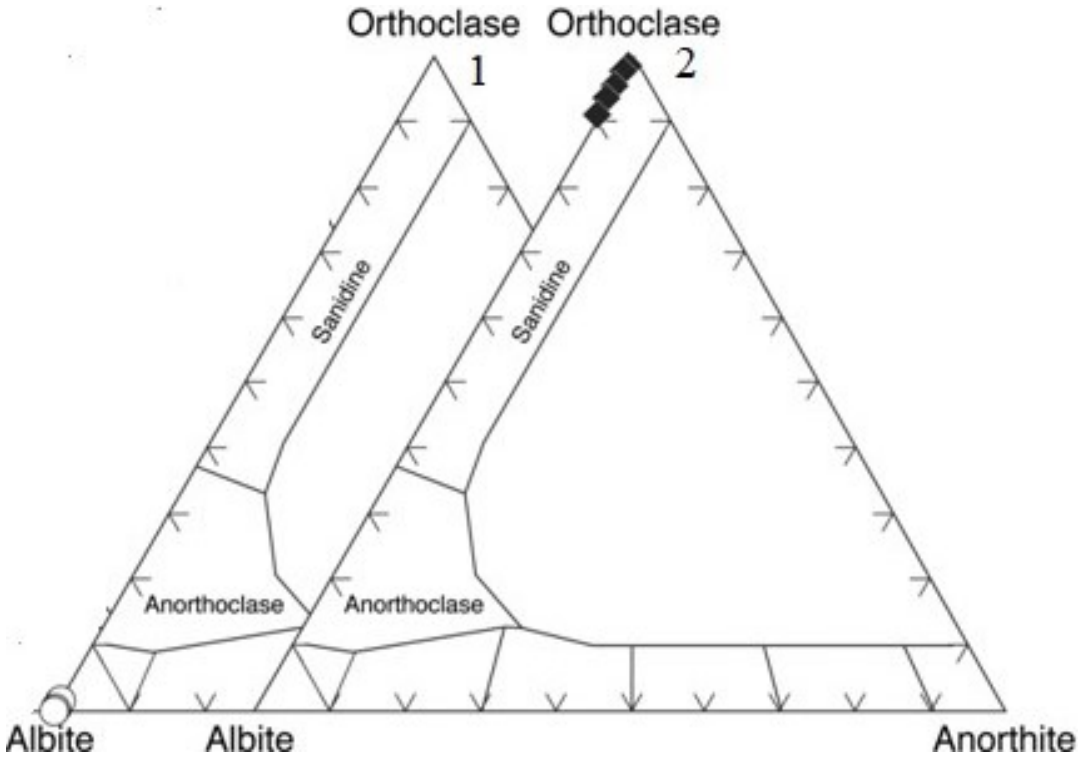

Fig. 9. Compositions of feldspar from: 1. albitite, 2 orthoclasite.

fenitization is observed around plugs and dikes of ankeritic carbonatite. Instead, it is commonly observed that abundant xenoliths of potassic fenites are engulfed in the ankeritic exposures. REE and other trace elements were mobile during the process of fenitization and were introduced to the country rock, Bagh sandstone (Figs. 9 and 10). Martin et al. (1978) investigated the mobility of REE during fenitization at the Borralan complex in Scotland, and this study supports the observation in the Amba Dongar diatreme. In Amba Dongar, too, REE were introduced into different types of fenites by the carbonatite magma (Viladkar and Dulski, 1986).

Doroshkevich et al. (2009) report Sr- and Ce-rich apatite and florencite (zoned, with the core richer in REE than the margin). This study shows that even fenites can be considered as a potential source of REE in Amba Dongar.

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Table 3. Analyses of Orthoclasites of Amba Dongar.

	1	2	3	4	5	6	7	8	9	10
SiO_2	59.88	59.08	67.52	67.06	61.34	63.44	56.76	60.48	57.49	61.32
TiO_2	0.51	0.12	0.09	0.10	0.28	0.56	0.16	0.21	1.50	0.08
Al_2O_3	15.00	15.49	13.58	12.78	13.44	14.52	13.11	14.36	14.21	13.58
Fe_2O_3	3.88	1.12	4.71	2.92	4.40	5.48	4.54	7.80	3.47	3.14
FeO	0.82	1.00	0.20	-	0.44	1.28	0.36	-	0.44	-
MnO	0.17	0.14	-	0.07	0.22	0.20	-	0.13	0.14	0.08
MgO	0.77	0.79	1.03	0.11	0.15	1.63	1.54	0.20	1.07	0.75
CaO	3.40	4.86	1.62	1.84	4.63	-	6.61	1.53	5.13	2.97
Na_2O	1.80	1.82	0.40	0.42	0.87	0.78	1.76	0.70	1.05	1.02
K_2O	11.75	11.49	10.00	10.81	10.44	10.07	10.40	11.46	10.94	12.20
P_2O_5	0.73	0.24	0.33	0.43	0.18	0.39	0.56	0.98	0.27	0.52
CO_2	-	0.19	0.20	0.97	3.50	-	2.50	-	3.30	-
LOI	1.29	2.63	1.04	2.00	2.90	1.60	2.50	1.46	1.60	0.30
Total	100.00	98.97	100.72	99.51	102.79	99.95	100.80	99.31	100.61	95.96
K	10.00	10.00	8.00	9.00	9.00	8.00	9.00	10.00	9.00	10.00
Ba	-	-	-	6854.00	4841.00	-	-	4389.00	4701.00	3891.00
Rb	-	152.00	192.00	190.00	199.00	192.00	190.00	491.00	240.00	256.00
Sr	-	2450.00	450.00	455.00	642.00	685.00	660.00	679.00	444.00	494.00
Ga	-	20.00	20.00	15.00	13.00	18.00	20.00	-	29.00	35.00
Nb	-	522.00	90.00	88.00	145.00	327.00	120.00	-	1129.00	386.00
Hf	-	-	-	-	11.00	-	10.00	-	27.00	-
Zr	-	660.00	90.00	86.00	145.00	291.00	100.00	604.00	447.00	28.00
Y	-	73.00	40.00	38.00	30.00	16.00	40.00	-	22.00	480.00
Th	-	23.00	40.00	36.00	46.00	10.00	20.00	-	8.00	10.00
U	-	-	10.00	5.00	12.00	10.00	10.00	-	12.00	-
Cu	-	-	10.00	13.00	13.00	25.00	10.00	-	11.00	19.00
Pb	-	17.00	20.00	224.00	63.00	105.00	20.00	-	33.00	27.00
Zn	-	190.00	130.00	138.00	109.00	202.00	80.00	-	138.00	208.00
La	-	260.00	124.00	135.00	230.00	100.00	90.00	-	162.00	42.00
Ce	-	560.00	224.00	-	-	198.00	200.00	-	-	50.00
Nd	-	105.00	60.50	-	-	60.00	50.00	-	-	20.00
Sm	-	-	22.00	-	-	-	-	-	-	5.00
Eu	-	-	6.40	-	-	-	-	-	-	1.00
Tb	-	-	2.10	-	-	-	-	-	-	0.36
Yb	-	-	2.20	-	-	-	-	-	-	1.50
Lu	-	-	0.39	-	-	-	-	-	-	0.44

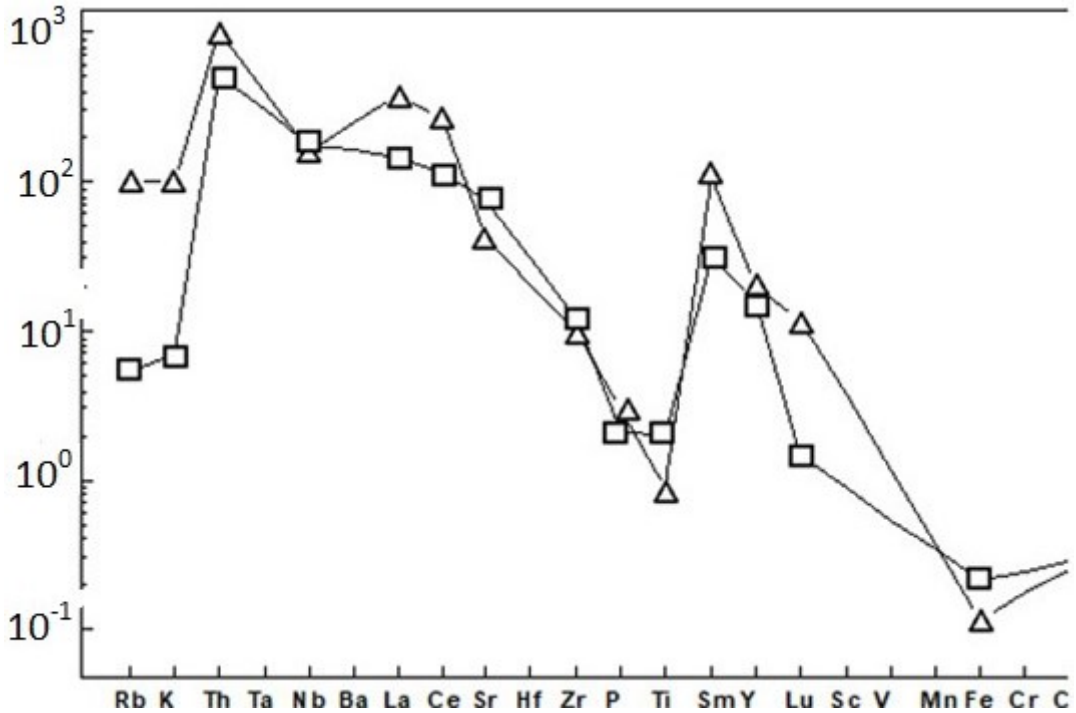

Fig. 10. Chondrite-normalized trace element spidergram patterns in Albitite (Open Square) and Orthoclasite (open triangle), The patterns are similar except depletion of K, Rb, Th, and Ce in albitites.

Table 4. Albitites from Amba Dongar.

	213*albitite	328*Albitite	329Albititi	87/A/31albi	87/A/94**a
SiO_2	60.00	65.86	69.12	57.35	66.42
TiO_2	0.20	0.15	0.15	0.16	0.16
Al_2O_3	8.97	15.87	18.85	13.80	14.40
Fe_2O_3	6.16	2.85	0.86	1.09	2.80
FeO	2.20	1.50	-	-	0.80
MnO	-	0.15	0.01	0.07	0.09
MgO	4.13	1.11	0.09	0.09	1.31
CaO	7.70	3.28	0.31	15.16	2.42
Na_2O	8.00	10.21	11.38	7.78	10.47
K_2O	0.70	0.04	0.03	0.29	0.29
P_2O_5	0.25	0.48	0.08	0.08	0.11
CO_2	-	-	-	4.66	-
LOI	1.50	-	-	0.64	0.50
Total	99.81	101.50	100.75	101.27	99.77
K	1.00	-	-	-	-
Ba	-	-	-	162.00	532.00
Rb	10.00	-	-	8.00	19.00
Sr	810.00	690.00	680.00	903.00	23.00
Ga	8.00	20.00	18.00	12.00	26.00
Nb	100.00	23.00	10.00	76.00	23.00
Hf	-	-	-	11.00	7.00
Zr	107.00	60.00	40.00	124.00	83.00
Y	30.00	10.00	5.00	50.00	8.00
Th	20.00	13.00	10.00	32.00	6.00
U	-	5.00	5.00	8.00	-
Cu	-	5.00	10.00	25.00	31.00
Pb	25.00	12.00	14.00	34.00	14.00
Zn	240.00	70.00	13.00	11.00	48.00
La	48.00	40.00	23.00	209.00	37.00
Ce	98.00	65.00	40.00	-	74.00
Nd	48.00	40.00	-	-	36.00
Sm	6.50	-	-	-	7.00
Eu	1.35	1.30	-	-	1.50
Tb	0.53	0.55	-	-	0.50
Yb	0.40	0.50	-	-	1.20
Lu	0.05	0.04	-	-	0.05
Mg*	52.80	36.42	-	-	45.28
La/Ybn	72.72	3.98	1.03	-	8.62
Total REE	220.85	142.34	180.00	209.00	177.85
Na_2O+K2	8.70	10.25	11.41	8.07	10.76

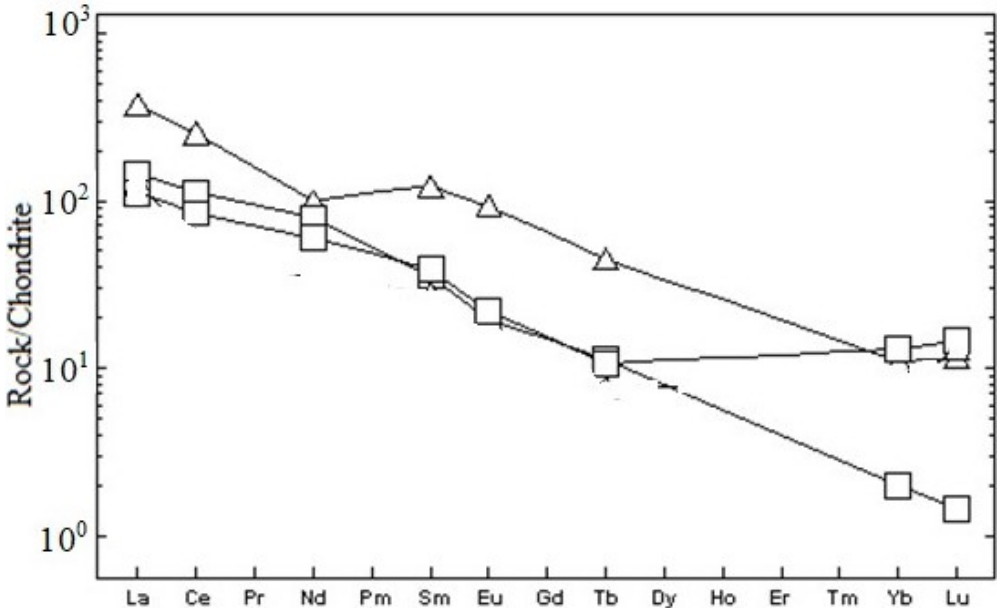

Fig. 11. Chondrite normalized REE patterns in albitites (open box) and orthoclasites (open triangle). Note that the high concentration of REE is seen in orthoclasites.

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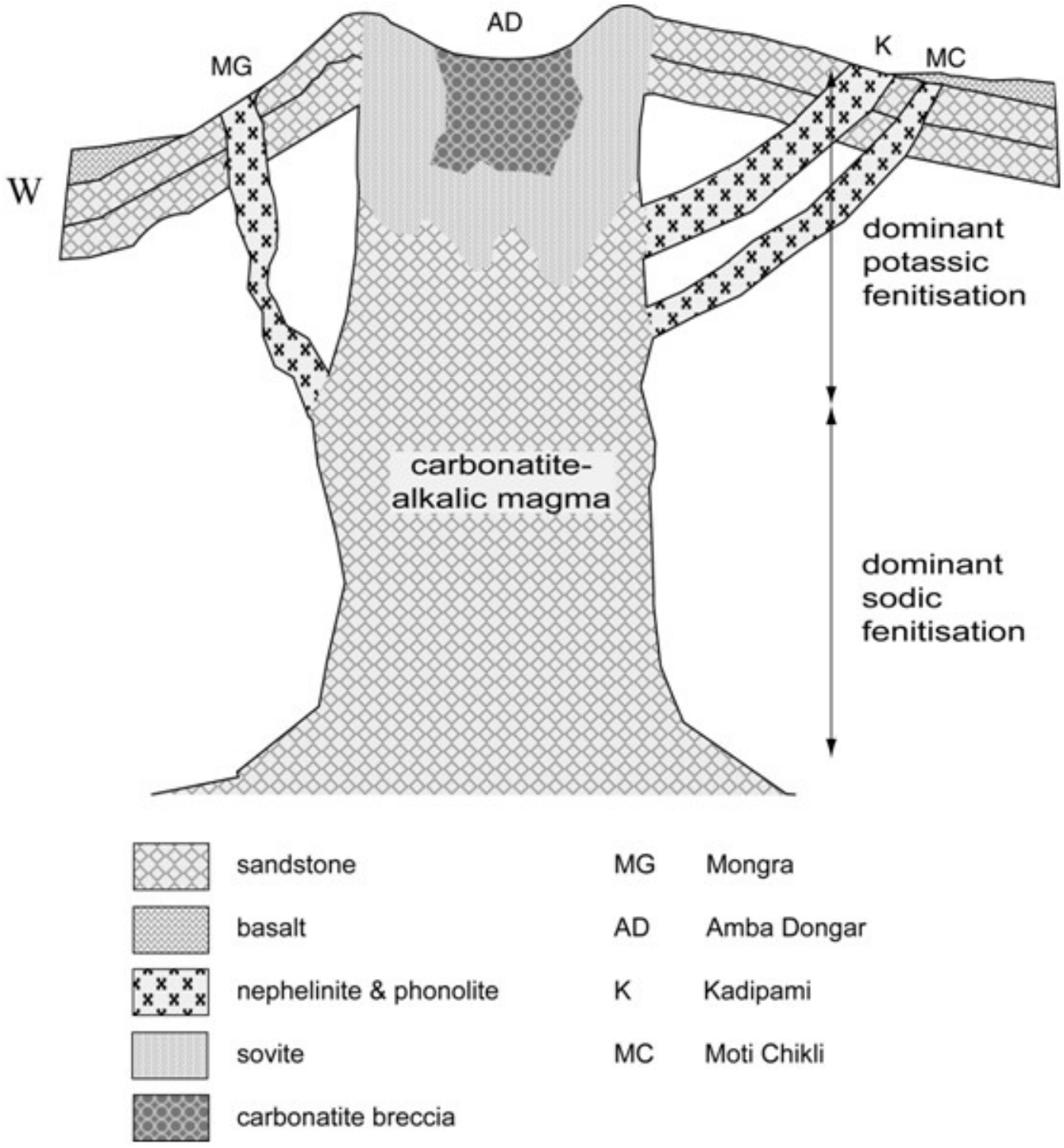

Fig. 12. Vertical zonation of fenitization in the Amba Dongar carbonatite diatreme.

References

Brögger, W.C., 1921. Die eruptiven Gesteine des Kristialingebietes, IV. Das Fengebiet in Telemark, Norwegen. Vit. Selsk. Skr., 1 Mat. Nat. Klasse 1920, 1 Kristiania, 408 p.

Deans, T., Sukheswala, R.N., Sethna, S.F., Viladkar, S.G., 1972. Metasomatic feldspar rocks (potash fenites) associated with the fluorite deposits and carbonatites of Amba Dongar, Gujarat, India. *Inst. Mining Metall. Trans.* 81, 1–9.

Deans, T., Sukheswala, R.N., Sethna, S.F., Viladkar, S.G., 1973. Discussions and contributions. *Inst. Mining Metall. Trans.* 82, 33–40.

Doroshkevich, A.G., Viladkar, Shrinivas, G., Ripp, G.S., Burtseva, M., 2009. Hydrothermal REE Mineralization in the Amba Dongar carbonatite complex, Gujarat, India. *Can. Mineral.* 44, 1105–1116. https://doi.org/10.3749/canmin.47.5.1105.

Elliott, H.A.L., et al., 2018. Fenites associated with carbonatite complexes: A review. *Ore Geology Reviews* 93, 38–59. https://doi.org/10.1016/j.oregeorev.2017.12.003.

Garson, M.S., 1965. Carbonatites in southern Malawi. *Geol. Surv. Dep., Bull.* 15.

Garson, M.S., Coats, J.S., Rock, N.M.S., Deans, T., 1984. Fenites, breccia dykes, albitites, and carbonatitic veins near the Great Glen Fault, Inverness, Scotland. *Jour. Geol. Society* 141, 711–732. https://doi.org/10.1144/gsjgs.141.4.0711.

Heinrich, E.Wm., 1966. *The geology of carbonatites.* Rand McNally and Co.

King, B.C., Sutherland, D.S., 1960. Alkaline rocks of Eastern and Southern Africa. *Science Progress* 48. 298-321, 504-524 and 700-720.

Le Bas, M.J., 1977. *Carbonatite-nephelinite volcanism.* John Wiley & Sons, London.

Le Bas, M.J., 1981. Carbonatite magmas. *Mineral. Mag.* 44, 133–140. https://doi.org/10.1180/minmag.1981.044.334.02.

Martin, R.F., Whitley, J.E., A.R., Woolley, 1978. An investigation of rare-earth mobility: Fenitized quartzites, Borralan complex, N.W.Scotland. *Contributions to Mineralogy and Petrology* 66, 69–73. https://doi.org/10.1007/BF00376086.

Rubie, D.C., Gunter, W.D., 1983. The role of speciation in alkaline igneous fluids during Fenite metasomatism. *Contr. Minera. Petrol.* 82, 165–175. https://doi.org/10.1007/BF01166611.

Saether, E., 1957. The Alkaline Rock Province of the Fen Area, Southern Norway. Kgl Norske Vidensk. Selsk. Skr No.1.

Sukheswala, R.N., Viladkar, S.G., 1981. Fenitized sandstones in Amba Dongar carbonatites, Gujarat, India. *Jour. Geol. Soc. India* 22, 368–374. https://doi.org/10.17491/jgsi/1981/220802.

Sutherland, D.S., 1965. Potassic trachytes and ultrapotassic rocks associated with the carbonatite complex of Tororo Hills, Uganda. *Mineral. Mag.* 35, 363–378. https://doi.org/10.1180/minmag.1965.035.270.10.

Verwoerd, W.J., 1966. South African Carbonatites and Their Probable Mode of Origin. *Annale/Universiteit van Stellenbosch* 41, 119–233.

Viladkar, S.G., 1986. Fenitization at the Amba Dongar carbonatite alkaline complex, India, in: Gabriel, M. (Ed.), Proceedings NEMIRAM Symposium, Czechoslovakia, p. 170–189.

Viladkar, S.G., 1996. Geology of the Carbonatite-Alkalic Diatreme of Amba Dongar, Gujarat. *GMDC Sci. and Research Centre* (medabad), 1–74.

Viladkar, S.G., Dulski, P., 1986. Rare earth element abundances in carbonatites, alkaline rocks and fenites of the Amba Dongar complex, Gujarat, India. *N. Jb. Mineral. Mh.* 1, 37–48.

Von Eckermann, H., 1948. The alkaline district of Alnö Island. *Sveriges Geologiska Undersökning. Avhandlingar och uppsatser* 14:0, N: O 36.

Woolley, A.R., 1969. Some aspects of fenitization with particular reference to Chilwa Island and Kangankunde, Malawi. *British Museum (Natural History), Mineralogy* 2, 189–219.

Woolley, A.R., 1982. A Discussion of Carbonatite Evolution and Nomenclature, and the Generation of Sodic and Potassic Fenites. *Min. Mag.* 43, 13–17. https://doi.org/10.1180/minmag.1982.046.338.03.

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