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SHORT COMMUNICATIONS

Analcite from the Neoproterozoic Peralkaline Dykes of Southern Karnataka

Analcite with the chemical formula close to $Na_{15}Al_{16}Si_{32}O_{96}$ occurs as one of the important groundmass minerals of some of the peralkaline Neoproterozoic dykes in Southern Karnataka. Observations suggest its formation upon emplacement, at low temperature, from a soda-enriched and silica deficient residual melt, after intratelluric preemplacement crystallization of K-feldspar and alkali pyroxene phenocrysts.

Introduction: Analcite tinguaites, solvsbergites, bostonites, latites-monzonites, monzodiorites-diorites and lamprophyres form dyke swarms in the southern part of Bangalore and adjoining areas of Mandya district (Fig.1). The dykes occur over a large area of 1120 km^2 and represent the last magmatic event of the Karnataka craton. They are much younger than the geographically closely associated unmetamorphosed dolerite dyke swarms of the region. Rb-Sr dating of some of these dykes has indicated that the alkaline dykes are about 819 Ma (Devaraju *et al.* 1995a) and the dolerites around 2400 Ma (Ikramuddin and Stueber, 1976). An account of the field relations, petrography, mineralogy and geochemistry of these dyke swarms has been given by Devaraju *et al.* (1989, 1995a, 1995b) and their pyroxenes have been discussed by Makkonen *et al.* (1993). The purpose of this paper is to highlight the fairly widespread distribution of analcite in the peralkaline dykes of the region. As far as the authors are aware, this is the first report of analcite in the Precambrian rocks of India, although the

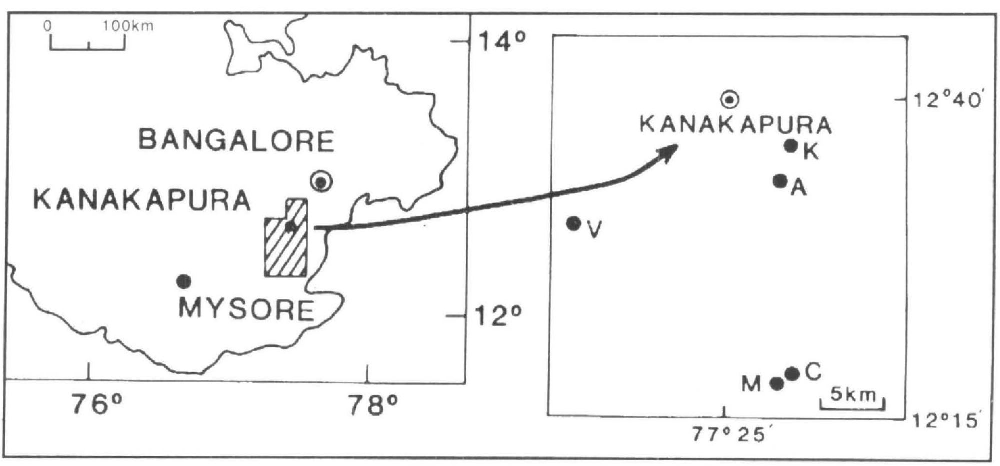

Fig.1. Sketch map of southern Karnataka with the shaded area enlarged showing the region of alkaline dyke swarms and locations of analcite-bearing tinguaite dykes. C: Chellipuradoddi, M: Madarhalli, A: Ankacharidoddi, K: Konasandra, V: Vaddaradoddi.

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report of Bowen (1927) on the occurrence of primary analcite restricted to the groundmass of some samples from the palaeocene Deccan traps is well known.

Distribution and Mode of Occurrence: Analcite occurs as an important mineral in all the peralkaline dykes classified as analcite tinguaites and as a minor or accessory mineral in some of the tinguaites and solvsbergites. It usually accounts for about 6-10 vol % in the analcite tinguaites, but in the analcite tinguaite dyke near Chellipuradoddi, it is estimated to constitute as much as 25% of the rock. Prominent outcrops of tinguaites containing analcite exist SE of Chellipuradoddi, south of Madarahalli, near Ankacharidoddi, Kona-sandra, and west of Vaddaradoddi (Fig.1), where the country rocks are Archaean charnockite, khondalite, Peninsular Gneiss and Closepet granite. These dykes often are multiple/composite intrusions with the later phases exhibiting pseudochilled margins against the older phases. Individual composite dyke intrusions contain analcite-rich and analcite-free types. The dykes are unmetamorphosed, relatively fresh and display chilled margins which may contain unaltered glass. These dyke varieties are distinguished by macro- to micro-porphyritic and tinguaitic textures. A flow orientation of early formed feldspars and pyroxene crystals parallel to the walls of the dykes is common.

Analcite is present only in the groundmass of the dykes, as anhedral interstitial patches. (Fig.2) which commonly include abundant randomly oriented fine needles of aegirine. The mineral is colourless and has a low refractive index of around 1.487. The smaller analcite patches are nearly isotropic, whereas the larger ones, as in DJK 14, show weak to moderate anisotropism and typical irregular polysynthetic twinning (Fig.3). The outlines of the mineral may be rectangular or squarish or polygonal depending upon the shape of the interspaces, and the analcite in samples DJK 14, DJK 11 can be as large as or even larger than feldspar crystals.

Being the last formed mineral, analcite forms incomplete rims over the feldspar with embayed contacts, suggesting replacement, and encloses early formed feldspar laths and aegirine crystals. Turbid patches, looking exactly like saussurite in feldspar, are not uncommon. The coexising phenocrysts are sanidine-orthoclase and aegirine-aegirineaugite, which commonly show zoning. Albitic plagioclase (Ab 97-99), K-feldspar and a very acmitic alkali pyroxene (Ac 80-87) are the main minerals in the groundmass.

Chemistry: Seventeen analyses of analcite from six different samples collected from three widely separated dykes are presented in Table I. They look strikingly similar in respect of

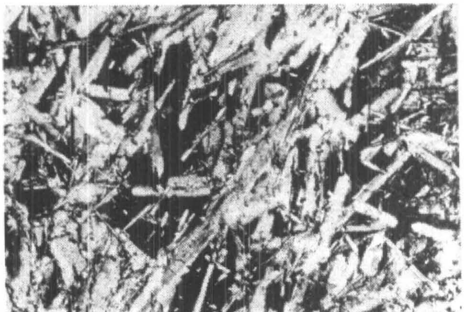

Fig. 2. Interstitial groundmass analcite in analcite tinguaite, Chellipura dyke. Sample DJK 5. X nicols, 73x.
Fig. 3. Patchy, weakly anistropic and polysynthetically twinned analcite with aegirine needles in analcite tinguaite, Chellipura dyke. Sample DJK 4. X nicols, 112x.

the main constituents, – silica, alumina and soda, but the concentrations of the chief minor constituents, – lime and potash, vary considerably and, as is usually the case, without any apparent correlation with the major constituents (*see* also Edger, 1984). Like the other igneous analcites, the Bangalore analcite is typically silica-deficient (Ferguson and Edger, 1978) with a formula calculated for the average composition on the basis of 96 oxygens (and on an anhydrous basis) being very close to $Na_{15}Al_{16}Si_{32}O_{96}$. In terms of its higher lime and potash values the Bangalore analcite compares with the P-type, but with respect to its low iron and higher alumina and soda, it is comparable to the H-type analcite of Luhr and Kyser (1989).

Table I. EPMA analyses of analcites from Southern Karnataka.

	1	2	3	4	5	6	7	P	L	H	S
No. of Anal.	(7)	(2)	(3)	(3)	(1)	(1)	(17)	(1)	(1)	(1)	(1)
SiO_2	54.24	53.86	54.34	55.56	54.73	53.32	54.34	55.28	56.37	54.06	57.10
Al_2O_3	23.46	23.92	23.26	24.41	23.50	23.85	23.73	21.04	22.12	22.49	19.41
TiO_2	—	—	0.01	0.01	0.01	—	0.01	ND	ND	ND	ND
FeO^t	0.04	0.02	0.05	0.03	0.08	—	0.04				
$Fe_2O_3^t$								0.98	0.27	0.03	0.10
MnO	—	—	—	0.02	—	—	0.01	ND	ND	ND	ND
MgO	—	—	—	0.01	0.01	—	—	ND	ND	ND	ND
CaO	0.66	0.09	0.67	0.67	0.04	0.11	0.37	0.26	0.09	0.18	0.02
Na_2O	12.28	13.61	12.80	12.38	13.35	13.74	13.03	11.58	11.46	13.20	11.47
K_2O	0.32	0.16	0.32	0.29	0.05	0.12	0.21	0.38	1.03	0.05	0.15
H_2O	8.14*										
Total	99.14	91.66	91.45	93.38	91.77	91.14	91.74	89.52	90.01	90.01	88.25

*Calculated. ND : not determined. FeO^t and $Fe_2O_3^t$: total iron determined as FeO and Fe_2O_3 respectively. 1: Ankacharidoddi dyke (DJK 22). 2: Madarhalli dyke (DJK 14). 3,4,5 and 6: Chellipuradoddi dyke (correspond to samples DJK 11, DJK 10, DJK 5, and DTK 4 respectively and collected over a strike length of about 1 km). 7: Average of 17 analcite analyses from S. Bangalore. P,L,H and S: Primary, leucite-derived, hydrothermal and sedimentary analcite compositions respectively (after Luhr and Kyser, 1989).

Genesis: Analcite has a very variable paragenesis (Deer *et al.* 1963) and is known to occur not only in peralkaline igneous rocks but also in a veriety of other igneous rocks. The genesis of analcite phenocrysts in alkaline and other igneous rocks has long been debated (*see* Pearce, 1970; Gupta and Fyfe,1975; Roux and Hamilton, 1976; Wilkinson, 1977; Ferguson and Edger, 1978; Church, 1978; Comin-Chiaramonti *et al.* 1979; Luhr and Kyser, 1989; Karlsson and Clayton, 1991) and the mineral has been interpreted as being either primary or secondary hydrothermal. Indeed analcite phenocrysts in the Crowsnest blairmorite (Pearce, 1967; Ferguson and Edger, 1978) and the Colima minette (Luhr and Kyser, 1989; Karlsson and Clayton, 1991) do pose a serious problem and cannot be explained as straight forward cases of primary crystallization from melts of deep-seated mantle origin. The complete absence of phenocrysts of analcite in the south Bangalore alkaline dykes however, makes the genetic interpretation simpler.

The striking freshness, the absence of evidence of derivation from leucite, nepheline, feldspar or other related minerals, the absence of veins and the silica deficient igneous chemistry all suggest primary magmatic formation of the Bangalore analcite. The overall sodic trend, indicated by both the whole rock (Devaraju *et al.* 1995b) and the feldspar and pyroxene chemistry (Makkonen *et al.* 1993) was also a favourable factor for the late-stage primary crystallization of analcite after emplacement of the dykes from a soda-rich melt with intratelluric K-feldspar and alkali pyroxene crystals. The post-emplacement reduction of silica coupled with a rapid fall in temperature and pressure may have developed a residual sodic melt from which analcite formed within its stability field (Roux and Hamilton, 1976).

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