

# COEXISTING AEGIRINE AND MAGNESIORIEBECKITE FROM BABABUDAN HILLS MYSORE STATE

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THE occurrence of magnesioriebeckite (Bababudanite) in a few horizons of the banded iron formations of the Bababudan Hills has been reported by earlier workers<sup>1-3</sup>. The coexistence of aegirine along with magnesioriebeckite has now been found in one of the horizons at the base of the scarp between Kavikalgandi and Manikyadhara falls. These silicate minerals form distinct thin bands associated with magnetite and quartz bands of the iron formation. The chemistry and the physical properties of the aegirine have been studied and are reported in this communication.

## MINERALOGY

Aegirine occurs as a semiradial grass-green prismatic aggregate (2-4 cm long), growing from a few points along the bedding plane. It is feebly pleochroic and the lamellar twinning is conspicuous. Cleavage is perfect on [110] and the basal pyroxene cleavages are distinct. No zoning in one and the same crystal could be observed. Aegirine is found to be optically negative,  $\alpha : z = 8^\circ$  (max) and the refractive indices measured are  $\alpha = 1.765$ ,  $\gamma = 1.829$ . The textural relationships suggest that aegirine has grown from magnesioriebeckite. A number of crystals of aegirine are also seen growing across the magnesioriebeckite bands (Fig. 1), suggesting its later formation. In contrast to

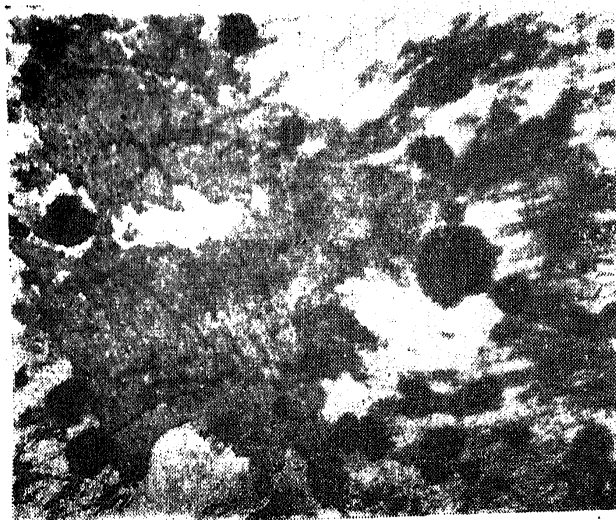


FIG. 1. Aegirine crystals growing across the magnesioriebeckite fibres. Black particles are magnetite,  $\times 40$ .

aegirine, the magnesioriebeckite forms distinct bands of slender acicular aggregates oriented parallel to each other. The colour of the latter is dark blue and has a pleochroic scheme: prussian blue to yellowish green to indigo and has a lower refractive index than that of aegirine.

Both aegirine and magnesioriebeckite were separated for chemical analysis. While the aegirine could be hand-picked, the isolation of magnesioriebeckite posed some problem, since the iron ore grains were found embedded in the mineral. The crushed sample is gravity separated with bromoform and the heavier fraction is boiled with concentrated hydrochloric acid. The insoluble fraction has been taken for chemical analysis. The analytical data are presented in Table I, along with the number of atoms per formula unit. The composition with more than 90 mole per cent of  $\text{NaFe}^{+3}\text{Si}_2\text{O}_6$  and low  $\text{H}_2\text{O}^+$  content clearly indicates that the mineral is aegirine. Besides, the percentage of  $\text{Na}_2\text{O}$  is higher than that of any of the known sodic amphiboles. The analysis shows that many of the major constituents have similar distribution in both the coexisting minerals. However, the amount of  $\text{MgO}$  and  $\text{H}_2\text{O}^+$  are undoubtedly partitioned in favour of the amphibole phase. The oxidation ratio,  $(\text{Fe}^{+3}/\text{Fe}^{+3} + \text{Fe}^{+2})$  in both the cases are high (0.94 and 0.81 for aegirine and magnesioriebeckite respectively). When the value of  $100 \text{Fe}^{+2} : (\text{Fe}^{+2} + \text{Mg} + \text{Mn})$  vs.  $100 \text{Fe}^{+3} : (\text{Fe}^{+3} + \text{Al}^6 + \text{Ti})$  is plotted for the amphibole, the point lies within the area of magnesioriebeckite. This excludes the possibility that the coexisting amphibole may be a crossite.

In order to confirm that the grass-green prismatic needles are aegirine, the X-ray powder diffraction pattern and also the infrared spectrum were taken. The observed reflections in the X-ray pattern could be indexed in the monoclinic system (Table II). The observed cell parameters are comparable to the reported values. Both  $a$ - and  $b$ -axes are shorter and the  $\beta$ -angle is also lower.

Figure 2 shows the infrared spectra of both aegirine and magnesioriebeckite. The difference in splitting and the number of distinguishable maxima in the silicate bands are very clear. In the region of  $600-800 \text{ cm}^{-1}$ , the characteristic peaks occur for

TABLE I  
Chemical composition of aegirine coexisting magnesioriebeckite

Aegirine				Magnesioriebeckite					
Wt. %	No. of ions Basis 6 (0) atoms			Wt. %	No. of ions Basis 24 (0) atoms				
SiO <sub>2</sub>	52.55	Si	2.017	} 2.017	SiO <sub>2</sub>	50.10	Si	7.394	} 7.957
TiO <sub>2</sub>	0.00	Al <sup>4</sup>	0.000		TiO <sub>2</sub>	0.00	Al <sup>4</sup>	0.563	
Al <sub>2</sub> O <sub>3</sub>	0.26	Al <sup>6</sup>	0.012	} 1.006	Al <sub>2</sub> O <sub>3</sub>	4.08	Al <sup>6</sup>	0.000	} 5.214
Fe <sub>2</sub> O <sub>3</sub>	31.47	Ti	0.000		Fe <sub>2</sub> O <sub>3</sub>	21.05	Ti	0.000	
FeO	1.84	Fe <sup>+3</sup>	0.911		FeO	4.60	Fe <sup>+3</sup>	2.428	
MnO	0.02	Mg	0.023		MnO	0.01	Mg	2.217	
MgO	0.40	Fe <sup>+2</sup>	0.059		MgO	10.08	Fe <sup>+2</sup>	0.568	
CaO	0.84	Mn	0.001		CaO	0.14	Mn	0.001	
Na <sub>2</sub> O	12.10	Na	0.902	} 0.945	Na <sub>2</sub> O	6.12	Na	1.752	} 1.912
K <sub>2</sub> O	0.17	Ca	0.035		K <sub>2</sub> O	0.74	K	0.139	
H <sub>2</sub> O <sup>+</sup>	0.28	K	0.008		H <sub>2</sub> O <sup>+</sup>	2.03	Ca	0.022	
H <sub>2</sub> O <sup>-</sup>	0.19								
	100.12				99.98				

TABLE II

## X-ray powder diffraction data of aegirine

Cr K $\alpha$  radiation 114.6 mm camera.  $a = 9.653 \text{ \AA}$ ,  
 $b = 8.655 \text{ \AA}$ ,  $c = 5.267 \text{ \AA}$ ,  $\beta = 105^\circ 54'$ .  $Z = 4$ , Space  
group  $C_{2h}^2$ ,  $D = 3.530$ .

$d(\text{\AA})$	$hkl$	Relative intensity	$d(\text{\AA})$	$hkl$	Relative intensity
6.328	110	25	1.583	440	20
4.332	020	20	1.560	113	5
3.290	021	30	1.526	610	15
3.042	201	5	1.463	203	10
2.948	22 $\bar{1}$	100	1.398	151	10
2.865	211	100	1.390	450	70
2.328	002	60	1.365	630	10
2.435	012	60	1.326	700	25
2.169	040	8	1.289	114	25
2.100	140	45	1.266	004	25
2.006	202	15	1.254	014	5
1.921	401	8	1.243	442	3
1.858	500	5	1.237	070	5
1.808	430	5	1.227	392	20
1.714	21 $\bar{3}$	25	1.215	024	8
1.648	042	3	1.203	413	10
1.626	250	5	1.160	800	3
1.606	60 $\bar{1}$	35	..	..	..

the glaucophane-riebeckite series. These are distinctly different in the case of aegirine, with the absence of bands around 790, 695 and 670 cm<sup>-1</sup> (Fig. 2—II).

## PETROGENETIC SIGNIFICANCE

The paragenesis of aegirine-riebeckite pair covers a wide range, such as alkali, igneous rocks, carbonates, glaucophanitic schists, green schists, meta-

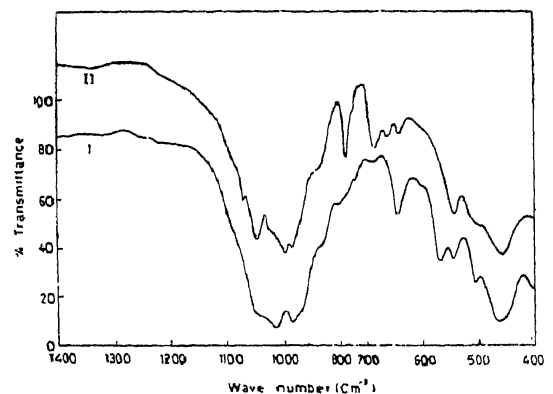


FIG. 2. Infrared spectra of I. Aegirine and II. Magnesioriebeckite.

cherts and alkalimetamorphic environments. Aegirine and riebeckite found in iron formations are explained to be due to the reaction of soda-rich water on haematite cherts<sup>4</sup>, by diagenesis<sup>5</sup>, sodametamorphism<sup>6</sup>. The soda for the formation of magnesioriebeckite in sediments of Bababudan Hills was thought to have been derived from the surrounding rocks of spilitic affinities<sup>6,11</sup>. Later the occurrence of acmite at the contact of intrusive quartz-albite-dolerites in the ferruginous quartzites of Kalhatti was attributed to sodametamorphism<sup>12</sup>. Since the magnesioriebeckite-aegirine zones occur as distinct bands and are not spatially related to basic sills, soda metamorphism need not be a factor in their genesis. The experimentally determined upper stability field of magnesioriebeckite in a silica deficient system by Ernst<sup>8</sup> show that at low vapour pressure (less than 200 atm.) and temperature

range of 800–950° C, the conversion to haematite, magnesioferrite, olivine, aegirine and vapour takes place. Above this pressure, magnesioriebeckite melts incongruently. Similarly, riebeckite breaks down around 750° C and below 1,500 atm. water vapour pressure to aegirine, fayalite, magnetite, quartz and vapour. The coexistence of magnesioriebeckite and aegirine can be explained on these lines; the vapour pressure built up in such a case may be due to the partial pressure of oxygen in the oxide facies rocks and carbon dioxide in carbonate facies rocks<sup>9</sup>. The formation of magnesioriebeckite, in turn, may be explained by the concept of Cilliers and Genis<sup>10</sup>; accordingly riebeckite is formed by lithification and diagenesis or under greenschist facies metamorphism of attapulgitic-rich clay admixtures containing precipitates of iron and silica along with alkali solutions.

1. Smeeth, W. F., *Rec. Mys. Geol. Dept.*, 1908, 9, 85.
2. Pichamuthu, C. S., *Ibid.*, 1952, 47, 1.
3. —, *Geol. Mag.*, 1936, 63, 41.
4. Suzuki, J. and Suzuki, Y., *J. Fac. Sci., Hokkaido Univ.*, 1959, 4, 183, 349.
5. Grout, F. F., *Amer. Min.*, 1948, 31, 125.
6. Trendall, A. F., *Bull. Geol. Soc. Amer.*, 1968, 79, 1527.
7. Chatterjee, A., *Quart. Jour. Geol. Min. Met. Soc. Ind.*, 1969, 51, 58.
8. Ernst, W. G., *Geochim. et Cosmochim. Acta*, 1960, 19, 10.
9. White, A. J. R., *J. Petrology*, 1962, 3, 38.
10. Cilliers, J. J. le R. and Genis, J. H., *Geology of Some Ore Deposits of Southern Africa*, Ed. Houghton, S. H., Geol. Soc., South Africa, Johannesburg, 1964.
11. Pichamuthu, C. S., *Half-yearly J., Mysore Univ.*, 1935, 8, 21.
12. —, *Quart. J. Min. and Met. Soc. Ind.*, 1952, 24, 19.

## AN OCCURRENCE OF GADOLINITE NEAR KARATTUPPATTI, MADURAI DISTRICT, TAMIL NADU

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### ABSTRACT

Chemical and spectrographic analyses of a greenish-black radioactive mineral from a zoned pegmatite near Karattuppatti showed 51.84%  ${}^{138}\text{Ce}_2\text{O}_3 + \text{La}_2\text{O}_3 + \text{Y}_2\text{O}_3$ , 9.0%  $\text{BeO}$ , 0.54%  $\text{U}_3\text{O}_8$ , 15.7%  $\text{Fe}_2\text{O}_3 + \text{FeO}$ , 22.04%  $\text{SiO}_2$ , and minor amounts of Er, Gd, Yb, Dy, Ho, Lu, Tm, B, Cr, Mg, Mn, and Zr. X-ray diffractometry confirmed it to be gadolinite—the second of its type to be reported from India. The presence of cerium as a major element in the mineral establishes it to be the variety cergadolinite.

### INTRODUCTION

**A**N *in situ* boulder weighing about 15 kg and consisting of two distinct minerals—a golden yellow beryl and a dark greenish-black mineral—was located in a zoned pegmatite about a km southwest of Karattuppatti village (10° 03'–77° 55') (Survey of India Toposheet No. 58 F/16) in Tirumangalam Taluk, Madurai District. X-ray diffractometric, chemical and spectrographic analyses of the greenish-black mineral have established it to be gadolinite—an uncommon rare-earth mineral ( $\text{Be}_2\text{FeY}_2\text{Si}_2\text{O}_{10}$ ), the occurrence of which has not been recorded since Holland's report<sup>1</sup> on gadolinite from Hosainpura (Banaskanta District, Gujarat). This paper presents a description of the geological setting, mineralogical and geochemical features of the Karattuppatti gadolinite occurrence.

### GEOLOGICAL SETTING

The area around Karattuppatti (Fig. 1) exposes Precambrian migmatitic gneiss composed of garnet, biotite, hornblende, magnetite, feldspar and quartz in varying proportions. This gneiss is flanked on the north by highly feldspathic garnetiferous

gneiss, and in the south by quartzite interbanded with the migmatitic gneiss. Distinct bands of calc- and pyroxene-granulite, too small to be represented separately on the map, occur interbanded with the gneissic rocks. Zoned discordant pegmatites carrying rare-earth minerals and beryl are confined to the gneissic rocks and are absent in the quartzite. Foliation in the rock formations trends about east-west with sub-vertical to steep southerly dips, generally conforming to the broad regional trends of the formations.

### MINERALOGICAL ASPECTS

The gadolinite-bearing pegmatite has a central zone of perthite surrounded by a perthite-quartz-plagioclase zone and a peripheral zone of quartz-feldspar-muscovite pegmatite (Fig. 1). Assemblages of radioactive rare-earth minerals consisting of allanite, polycrase and gadolinite, as also golden yellow, blue and green beryl, tourmaline and muscovite are associated with the two outer pegmatite zones. The rare-earth minerals and beryl occur as disseminations, small segregations and pods in the pegmatite, and appear as float in the debris around often ranging upto 15 cm in length,