

# COEXISTING AEGIRINE AND MAGNESIORIEBECKITE FROM BABABUDAN HILLS MYSORE STATE

T. R. NARAYANAN KUTTY AND G. V. ANANTHA IYER

*Department of Inorganic and Physical Chemistry, Indian Institute of Science, Bangalore-12*

AND

M. RAMAKRISHNAN

*Geological Society, Jayanagar, Bangalore*

**T**HE 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

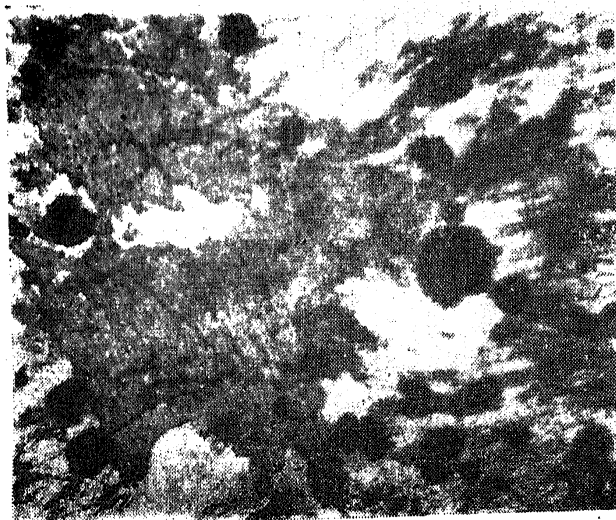


FIG. 1. Aegirine crystals growing across the magnesioriebeckite fibres. Black particles are magnetite,  $\times 40$ .

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<br>Basis 6 (0) atoms |                  |       | Wt. %                          | No. of ions<br>Basis 24 (0) atoms |                  |       |
| SiO <sub>2</sub>               | 52.55                            | Si               | 2.017 | SiO <sub>2</sub>               | 50.10                             | Si               | 7.394 |
| TiO <sub>2</sub>               | 0.00                             | Al <sup>4</sup>  | 0.000 | TiO <sub>2</sub>               | 0.00                              | Al <sup>4</sup>  | 0.563 |
|                                |                                  |                  | 2.017 |                                |                                   |                  | 7.957 |
| Al <sub>2</sub> O <sub>3</sub> | 0.26                             | Al <sup>6</sup>  | 0.012 | Al <sub>2</sub> O <sub>3</sub> | 4.08                              | Al <sup>6</sup>  | 0.000 |
| 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 |
|                                |                                  |                  | 1.006 |                                |                                   |                  | 5.214 |
| Na <sub>2</sub> O              | 12.10                            | Na               | 0.902 | Na <sub>2</sub> O              | 6.12                              | Na               | 1.752 |
| 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 |
|                                |                                  |                  | 0.945 |                                |                                   |                  | 1.912 |
| H <sub>2</sub> O <sup>-</sup>  | 0.19                             |                  |       | H <sub>2</sub> O <sup>-</sup>  | 0.23                              | OH               | 1.974 |
|                                |                                  |                  |       |                                |                                   |                  | 1.974 |
|                                | 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           | 213          | 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, carbonatites, glaucophanitic schists, green schists, meta-

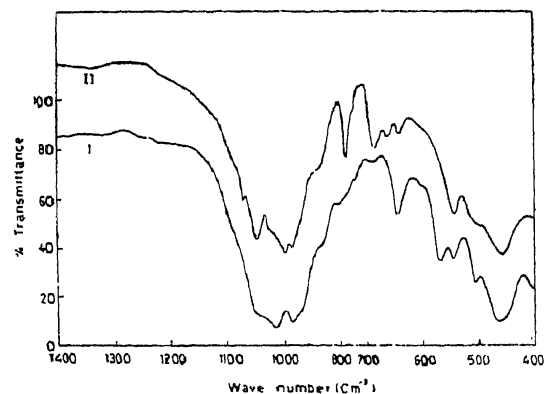


FIG. 2. Infrared spectra of I. Aegirine and II. Magnesioriebeckite.

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>, sodametasomatism<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 sodametasomatism<sup>12</sup>. Since the magnesioriebeckite-aegirine zones occur as distinct bands and are not spatially related to basic sills, soda metasomatism 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.

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