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AMPHIBOLITES FROM KUDERU AND ATMAKURU AREAS, ANANTAPUR DISTRICT, ANDHRA PRADESH, SOUTH INDIA

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ABSTRACT

Petrography, modal and chemical analyses of seven amphibolites from the Kuderu and Atmakuru areas are given. A basalt-carbonate mixture is considered to be the parent material of the amphibolites.

INTRODUCTION

During geological mapping of an area (14° 35′-14°45′; 77° 20′ 27″ - 77° 29′ 33″) of about 230 sq. km around Kuderu and Atmakuru, South India (Fig. 1), three major groups of rocks of Pre-Cambrian age were encountered. They are granitic rocks (180 sq. km) comprising adamellites, granodiorites, tonalites and granites; schistose formations (40 sq. km) constituting chlorite schists, quartzites, ferruginous quartzites and amphibolites; and dolerites. This paper describes and discusses the origin of the amphibolites.

FIELD RELATIONS

The schistose formations have a N-S trend with steep westerly dips (Fig. 1). Amphibolites occur as bands varying in thickness from about 100 to 350 meters. They do not exhibit features (discordant contacts, relict chilled margins, *etc.*) that give clues to their origin. Amphibolite with granite in the eastern portion, and quartzite with granite in the western portion have sharp contacts. The individual members of the amphibolites are indistinguishable from one another in the field. Chlorite schists and ferruginous quartzites are not in contact with the granite as they are shielded by amphibolite on the eastern side and quartzite on the western side. All the rocks of the schistose formations occur as xenoliths in granites, and the dolerites intrude both.

PETROGRAPHY

The amphibolites are hard, compact, massive, dark brown rocks with schistosity in some. They are classified into amphibolite (chiefly hornblende and plagioclase), augite amphibolite, augite-epidote amphibolite, tremolite amphibolite and epidote amphibolite. Modes are given in Table 1.

Amphibolite is schistose and is composed of hornblende and plagioclase with occasional quartz, sphene and iron ore. Hornblende is green, with light green to yellow pleochroism, $2V = -72°$, $\gamma:c = 17°$ and $n\gamma - n\alpha = 0.021$. Plagioclase ($An_{45}$) occupies the interstices between the hornblende grains and is generally altered. Quartz shows undulose extinction, and sphene is brown and spindle-shaped.

Augite amphibolite has allotriomorphic-granular texture with hornblende, plagioclase, augite and iron ore. Augite occurs as relicts in hornblende. Hornblende has $2V = -68°$, $\gamma:c = 16°$, $n\gamma - n\alpha = 0.020$ and strong pleochroism. Augite is green, feebly pleochroic, and has $2V$

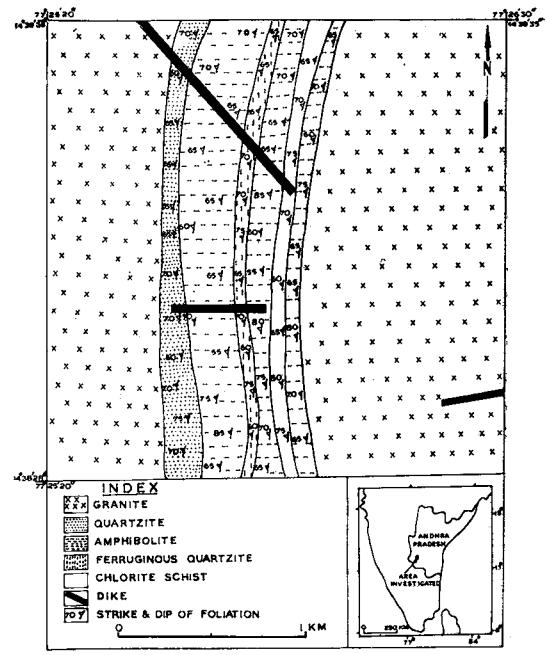

FIG. 1. A small portion of the geological sketch map of Kuderu and Atmakuru areas showing the distribution of the amphibolites and their associated rocks. A map of South India is also included showing the area discussed.

TABLE 1. CHEMICAL ANALYSES, NIGGLI VALUES AND MODAL ANALYSES OF AMPHIBOLITES

wt %	1	2	3	4	5	6	7
SiO_2	44.95	45.46	48.94	45.13	46.48	45.64	45.63
TiO_2	0.95	1.32	0.89	0.72	0.24	1.09	0.93
Al_2O_3	14.02	13.96	14.32	15.02	7.46	6.68	14.45
Fe_2O_3	7.62	7.68	4.93	6.85	4.06	4.20	6.70
FeO	10.40	10.67	12.28	8.79	7.60	8.65	10.10
MnO	0.08	0.12	0.09	0.20	0.13	0.16	0.15
MgO	7.04	5.26	5.48	7.90	16.23	15.48	5.64
CaO	12.70	11.63	10.39	12.62	13.68	14.78	12.46
Na_2O	0.82	1.96	2.46	1.73	2.16	0.80	2.18
K_2O	0.02	0.05	-	0.08	0.20	0.07	0.09
P_2O_5	0.21	0.25	0.25	0.17	0.03	0.20	0.14
H_2O	1.51	1.98	0.84	0.83	1.58	1.86	1.73
Total	100.32	100.34	100.87	100.04	99.85	99.61	100.20
Niggli values							
si	94.19	100.40	110.70	97.88	84.14	84.01	98.91
al	17.48	18.16	19.00	19.14	8.03	7.06	18.47
fm	52.37	50.02	50.34	47.94	61.34	62.26	47.85
c	28.52	27.44	25.23	29.28	26.61	29.14	29.00
alk	1.63	4.38	5.43	3.64	4.02	1.54	4.68
mg	0.42	0.35	0.37	0.54	0.72	0.69	0.38
Modal analysis							
quartz	1.7	0.9	5.1	1.0	-	0.6	0.7
plagio	15.6	28.8	38.4	28.1	3.0	4.0	34.4
hblde	80.7	65.7	47.2	54.6	19.7	18.2	60.8
augite	-	-	8.9	15.1	-	-	-
trem	-	-	-	-	76.1	75.1	-
epidote	-	-	-	1.2	-	-	2.5
iron ore	0.3	4.4	0.4	-	1.2	2.1	0.9
apatite	-	0.2	-	-	-	-	0.1
zircon	-	-	-	-	-	-	0.2
sphene	1.7	-	-	-	-	-	0.4
discriminant function values	+2.4177	+0.4843	+2.8466	+1.9474	-2.3660	-0.0902	+0.8235

1 & 2: amphibolites; 3: augite amphibolite; 4: augite-epidote amphibolite; 5 & 6: tremolite amphibolites; 7: epidote amphibolite

Analyst: G. Lakshmi Reddy

$= +48°$, $\gamma:c = 42°$, and $n\gamma - n\alpha = 0.023$. Plagioclase ($An_{43-48}$) is fresh, twinned on albite, Carlsbad and albite-Carlsbad laws. Quartz grains show strain effects.

Augite-epidote amphibolite is a variant of augite amphibolite. Epidote is secondary after hornblende and augite. The long prismatic grains of hornblende mantle fragmented grains of plagioclase, resulting in augen-like texture.

Tremolite amphibolite has a nematoblastic texture. Two types of amphiboles are present: (1) green-coloured hornblende with light green to yellow pleochroism, $2V = -70°$, $\gamma:c = 18°$, $n\gamma - n\alpha = 0.021$, and (2) fibrous tremolite with $2V = -86°$, $\gamma:c = 20°$ and $n\gamma - n\alpha = 0.025$. The tremolite is bent around coarse, incipiently altered, untwinned plagioclase (An_{40}). Iron ore is associated with hornblende.

Epidote amphibolite exhibits crystalloblastic texture and contains chiefly hornblende and plagioclase. Hornblende is green in colour and contains inclusions of quartz, iron ore, apatite, zircon and sphene. Granular epidote is developed along the crystal outlines and cleavages of hornblende. Plagioclase (An_{45}) is slightly altered and twinned. Quartz occurs in vague bands mostly crushed into medium- to fine-grained aggregates.

Chemical analyses and Niggli values of seven amphibolites representing all the above varieties are given in Table 1.

Petrogenesis

It has been tacitly assumed that banded amphibolites are metasedimentary rocks if they occur as thin layers within metasediments (Wilcox & Poldervaart 1958; Walker *et al.* 1960), or if they are associated with marble (Heier 1962). These observations group the Kuderu and Atmakuru amphibolites under para-amphibolites. The relict augite in hornblende, the dominance of hornblende and plagioclase, the Carlsbad and albite-Carlsbad twins in plagioclase, and paucity of quartz in most of the amphibolites are the petrographic features that militate against a metasedimentary origin.

The nature of the trends of chemical variation (using Niggli molecular values) and their relationship to known igneous and sedimentary trends have been utilized by Leake (1963, 1964) to distinguish two groups of amphibolites. The *mg-c* plot and the *c, al-alk* and 100 *mg* plot are considered to be more effective in distinguishing the two types of amphibolites, and are used in the present study. All the amphibolites follow the igneous trend on the *mg-c* plot (Fig 2) and cross the trend of metamorphosed decarbonated mixtures of clay with limestone or dolomite. It is clear from the plot that *c*-values are slightly higher than the trend of Karroo dolerites. Likewise on the *c, al-alk,* and 100 *mg* plot (Fig. 3), the amphibolites are close to the igneous trend, but deflected to the 100 *mg-c* side of the triangle. Although the amphibolites exhibit the general igneous trend, the deviations noted (higher *c* and lower *al-alk* values) can be explained by the admixture of limestone or dolomite with the basalt. Van de Kamp (1968) reported a mixed limestone-basalt association from the Grenville Province of Canada, and tuffs deposited with limestone have been noted in Finistère, France (Barrois 1889).

Shaw & Kudo (1965) have developed the discriminant function on the basis of the major elements (wt. %), for distinuishing amphibolites

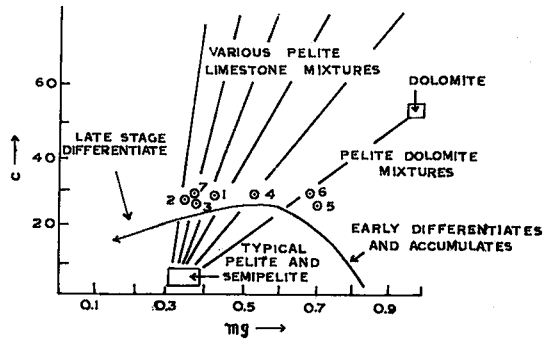

FIG. 2. Niggli *mg-c* plot for Karroo dolerites and the analyzed amphibolites (1 to 7, legend same as given in Table 1) (after Leake 1964).

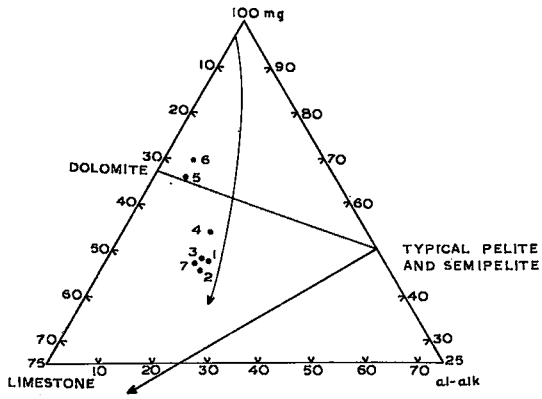

FIG. 3. Niggli, *c, al-alk* and 100 *mg* plot for Karroo dolerites and analyzed amphibolites (after Leake 1964).

derived by isochemical metamorphism of basic igneous intrusions or flows from those of sedimentary parentage, that gave positive values for ortho- and negative values for para-amphibolites. When the same function was applied to the amphibolites of the Kuderu and Atmakuru, five gave positive values and the other two gave negative values which are tremolite-rich, thereby indicating that the former have affinity to basic volcanics and the latter to the dolomitic sediments. Shaw & Kudo found that the probability of incorrect classification is 5.7%, and even if this cannot be directly applied to the results from other areas, it is an indication of the usefulness of this discriminant function.

A basalt-carbonte mixture is considered to be the parent material for the amphibolites of Kuderu and Atmakuru areas, as such a combination can best explain the observations.

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