CHLORITOID AMPHIBOLITES FROM THE PAMUR AREA, ANDHRA PRADESH, SOUTHERN INDIA

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ABSTRACT

Chloritoid and tremolite–chloritoid amphibolites are reported from a metasedimentary sequence in southeastern India. From optical and X-ray data, chloritoid is identified as the monoclinic variety. These chloritoid-bearing rocks seem to have evolved, under greenschist-facies conditions, from marly sediments containing intercalated aluminous and ferruginous strata.

Keywords: chloritoid, amphibolite, marly sediments, greenschist facies, India, Andhra Pradesh.

INTRODUCTION

During the course of our geological investigation of the Pamur area in the Prakasam district, Andhra Pradesh, southern India (79°20′–79°25′E, 15°5′–15°10′N), four major rock-types were encountered: chlorite schist, granitic gneiss, amphibolite and quartzite (Fig. 1). The rare association chloritoid–hornblende was observed in samples from the amphibolitic map-unit. The object of this note is to describe some of the unusual assemblages in which this association was found.

PETROGRAPHY

The metasedimentary amphibolites are compact dark green rocks with a well-developed schistosity. They can be classified into four types, depending on the dominant mineral present in the rock in addition to hornblende: calcite amphibolite, epidote amphibolite, tremolite amphibolite and chloritoid amphibolite.

The chloritoid amphibolite occurs as lenses in a sequence of schistose amphibolite layers. It contains xenoblastic chloritoid grains that cut across the schistosity (Fig. 2), and that must therefore be postkinematic. Quartz, plagioclase, hornblende, opaque minerals (mostly oxides) and epidote also are present. The chloritoid is green, with the pleochroic scheme, X green, Y light blue, Z pale yellow; 2V 54–70°, Z:c 2–6°; nα – nγ 0.005–0.009, nβ 1.720–1.723. The optic axial plane is normal to (010). A single-crystal X-ray precession photograph gave the following cell-dimensions:

a 9.44(3), b 5.32(3), c 18.42(3) Å, α 90°, β 101°30′(5)′, γ 90°.

The optical and X-ray parameters identify the mineral as monoclinic chloritoid (Halferdahl 1961). Some of the grains are twinned, and some exhibit shadowy strained extinction. The green hornblende in the assemblage is the common type and has inclusions of quartz and opaque phases. Plagioclase is lath-shaped and shows polysynthetic twinning. Some of the quartz grains have relict clastic textures.

Chloritoid and hornblende are also observed in association with fibrous tremolitic–actinolitic amphibole, in assemblages that include quartz, epidote, chlorite and opaque phases. Chloritoid develops from chlorite (Fig. 3) and is similar in optical properties to that described in chloritoid amphibolite.

Chloritoid is green, with light green to light blue pleochroism, 2V 58–62°, Z:c 22–25°, nγ – nα = 0.025–0.028. Some of the tremolite grains are colorless, whereas a few others are light green, 2V 70–80°, Z:c 18–20°, nγ – nα 0.023–0.025.

CHEMISTRY

Two specimens of chloritoid, one from a chloritoid amphibolite and one from a tremolite–chloritoid amphibolite, have been chemically analyzed (Table 1). The chloritoid from the tremolite–chloritoid amphibolite was found to contain a few quartz inclusions, which could not be separated. These inclusions have probably given a high SiO2 value and corresponding low values of other constituents. The structural formulae agree with the general chloritoid formula, $X_2Y(OH)_4Al_2O_2(SiO_4)_2$, in which $X$ represents Fe$^{3+}$, Fe$^{2+}$, Mg, Mn, Ca, Na and K, and $Y$ represents Al, Fe$^{3+}$ and Ti (Snelling 1957). The
analytical results are recalculated to give 2 Si per unit cell, and the resultant formula is very close to the general formula. The calculated molar ratios MgO/(MgO + FeO) and MgO/(MgO + FeO + 2Fe₂O₃) are 15.1, 12.8 and 13.3, 11.3, respectively, which are within the values given by Chinner (1967) for chloritoid.

Two samples of chloritoid-bearing amphibolite and three of chloritoid-free amphibolite have been analyzed. Their chemical and modal compositions are given in Table 2. When plotted on Hoschek’s (1967) triangular diagrams (Fig. 4), a clear separation of chloritoid-bearing from chloritoid-free rocks.
is observed, with the former lying closer to the
Al₂O₃ apex than the latter. However, note that
some of these rocks lie outside Hoschek's chloritoid
field, a fact that may indicate that Hoschek's line
of separation does not apply to amphibolites, but
only to assemblages derived from metapelites.

PETROGENESIS

Chloritoid-bearing assemblages in aluminous
metapelites are relatively common (e.g., Milne 1949,
Williamson 1953, Hoschek 1967). They have also
been found in metamorphosed, hydrothermally
altered felsic volcanic rocks (e.g., Spitz & Darling
1973, Franklin et al. 1975). However, chloritoid-
amphibole assemblages appear to be rare. Descrip-
tions of such assemblages could only be found in
Thompson (1972) and Fox (1974), and in both cases,
the rocks are richer in Al₂O₃ and K₂O and poorer
in FeO + Fe₂O₃, CaO, MgO and Na₂O than those
at Pamur.

As described earlier, chloritoid-bearing am-
phibolites occur as lenses in the schistose am-
phibolites. The protoliths of the schistose am-
phibolites are considered to be marls. Aluminous and
ferruginous sediments admixed with marls as inter-
calations provided the suitable composition for the
formation of chloritoid amphibolites. The mineral
assemblages of these amphibolites are in the
greenschist facies.

Iron oxides and chlorite might have reacted to give
rise to chloritoid thus: 5 hematite + chlorite = 5
magnetite + 2 chloritoid + 2 quartz + 4H₂O, as
observed by Miyashiro (1973). The experimental
studies reveal that chloritoid would be stable over
the entire pressure range [P₈ = P(H₂O)] from near
zero to the highest value (above 20 kbar) and up to
500–700°C depending on P(O₂). With the participa-
tion of the full range of phases and components
available, the formation temperature of the
chloritoid is likely to be lower than that obtained in
experiments. In a reaction that involves the prior ex-
istence of dolomite in addition to the mineral
assemblages observed, chloritoid formation is like-
ly to have been influenced not only by T, P and
f(O₂), but also by X(CO₂).

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