Chemographic Relationships in Sapphirine-Bearing Rocks
From Sonapahar, Assam, India

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Abstract. Silica-deficient rocks in which sapphirine coexists with cordierite, gedrite, chondrodite, spinel, corundum and phlogopite in various parageneses, occur in association with cordierite-garnet-sillimanite-bearing granulite gneisses in a Precambrian metamorphic terrain displaying amphibolite-granulite transition facies. Brucite coexists with spinel and corundum and its unusual stability in this environment has been attributed to its significant fluoride content. Kornerupine occurs as armoured relics within cordierite in one sample of the sapphirine-spinel-cordierite-phlogopite-bearing rock. Sapphires (X Mg 0.77 to 0.92) plot near the 7 : 9 : 3 composition. X Mg varies in the order: chondrodite and brucite > gedrite > cordierite > phlogopite > sapphirine > spinel.

The consistent topology of the observed mineral assemblages with reference to the system MgO--FeO--Al₂O₃--SiO₂--H₂O, systematic partitioning of Mg and Fe in the coexisting phases, and textural relations are in accord with attainment of chemical equilibrium during the regional metamorphism. The sequence of metamorphic reactions has been deduced as a function of changing MgO/(MgO+FeO) ratio in the bulk composition and it has been shown that the topology in the SiO₂-(FeO+MgO)-Al₂O₃ diagram for more magnesian compositions is consistent with experimental data in the system MgO-SiO₂-Al₂O₃-H₂O. The stable occurrence of the spinel-cordierite and spinel-sillimanite joins in less magnesian bulk compositions suggests that these tie lines are stable to higher pressures and lower temperatures respectively as compared to the Fe-free synthetic system.

Using experimental and theoretical data on garnet-cordierite, garnet-biotite, garnet-plagioclase and orthopyroxene-clinoptyroxene equilibria, PT conditions have been estimated to be 750°±50°C/5±0.5 kbar for the thermal peak of metamorphism.

It is suggested that the unusual bulk composition of the sapphirine-bearing rocks viz. higher Al₂O₃, MgO and MgO/(MgO+FeO) and lower SiO₂, Na₂O and CaO compared to the parent cordierite-bearing granulite gneisses may be attributed to partial melting and removal of granitic melt. This is in agreement with the variation of oxides in the 'restites' and parent rock. The 'restites' consisted of the assemblage cordierite-spinel-corundum which then reacted to form sapphirine. This reaction, which in the synthetic Fe-free system is confined to extremely low-pressures (~300 bars), is likely to occur at higher pressures with MgFe substitution.

Introduction

Sapphirine-bearing rocks have attracted the attention of many geologists on account of the complex petrological problem they display. Experiments in the system MgO-SiO₂-Al₂O₃-H₂O, demonstrate that sapphirine is stable over a wide PT range from upper amphibolite to granulite facies conditions (e.g., Seifert, 1974; Ackerman et al., 1975) which is in agreement with the natural occurrence of sapphirine-bearing rocks. However, such rocks are relatively rare in nature presumably because of the restricted bulk composition in which sapphirine is able to form.

The area around Sonapahar, Assam, is well known for its classic sillimanite-corundum economic deposit. Although Dunn (1929) first mapped the area in detail, sapphirine bearing rocks have been recognised only in the last 25 years or so in this locality (Ghosh and Saha, 1954). However, to date, no detailed miner-
alogical and petrological investigations have been carried out on these rocks.

During these investigations of the rocks several new assemblages were found, some of which have not been hitherto reported. The purpose of this paper is to discuss the mineral chemistry, phase petrology, and genesis of sapphirine-bearing and associated silica-deficient rocks and to throw light on some of the current petrological problems displayed by them, viz. (1) the effect of Mg=Fe substitution on mineral stability in comparison to the synthetic Fe-free system; (2) the origin of the unusual bulk composition of these rocks which does not correspond to normal igneous or sedimentary rocks; (3) attainment of equilibrium; and (4) PT conditions of metamorphism with reference to various models of geothermometry and geobarometry.

Geological Setting

The area around Sonapahar constitutes a part of the Shillong Plateau which represents the northeastern wedge of the Peninsular Shield of India, uplifted and moved to the east over a distance of about 250 Km along the E-W trending transcurrent Dauki Fault during the Himalayan Orogeny (Evans, 1964). The Precambrian rocks of the Plateau have been variously interpreted as part of the Eastern Ghats charnockitic terrain (Crawford, 1974) or a continuation of the Satpura Belt of Bihar prior to the eastward movement. The Plateau consists essentially of rocks of upper amphibolite to granulite facies, flanked on the east by greenschist facies rocks belonging to the Shillong Series of pre cambrian age and to the south by sedimentary rocks and basic volcanics of cretaceous age (Fig. 1, Inset).

The metamorphic rocks of the area consist mainly of medium- to coarse-grained granite gneisses, cordierite-garnet-biotite-sillimanite granulitic gneisses (henceforth designated cordierite-bearing gneisses in the text), quartz-sillimanite schists, and pyroxene-hornblende granulites (Fig. 1). Quartzofeldspatic veins ramify these