The Geochemistry of Glaucophane Schists on Syros, Greece

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INTRODUCTION

Syros, an island in the central Aegean Sea, is located in the Attic- Cycladic metamorphic belt. The primary rock types on Syros are marbles and schists. In several areas of the island there are small, tectonically juxtaposed sections of rock that are believed to be mostly metamorphosed mafic rocks (Ridley and Dixon, 1984, 1987). These small sections are heterogeneous packages that typically include fine-grained blueschists, greenschists, and coarse-grained metabasites. The blueschists are thought to be metabasalts, and are indicative of high pressure, low temperature metamorphism that possibly occurred in conjunction with subduction.

Although the metamorphic history of these rocks has been studied extensively, there has been no geochemical investigation into the origin of glaucophane schists on Syros. The major and trace element chemistry of nineteen glaucophane schists is being studied extensively in several contexts within this project. The geochemistry of relatively fine-grained rocks reflecting blueschist facies metamorphism will be used to constrain the origin, possibly ophiolitic, of their protoliths. Chemical data on the blueschists will also be used for comparison with that of spatially associated coarse-grained metamorphosed mafic rocks in order to pinpoint possible reasons for their occurrence.

METHODS

Chosen samples of fine-grained blueschists were collected from four localities on Syros (figure 1). The four locations were chosen due to the presence of extensive and/or unusual sections of blueschists. Where exposed, the blueschists are commonly in contact with marble, metabasites of greenschist facies, metagabbros, and in some places, serpentinite. The extent and appearance of the blueschist sequence varies from location to location due to deformation following the metamorphism, which is common in metamorphic terrains (Lister and Raouzaios, 1996).

The focus of sampling in these areas was to pick rocks representative of the blueschists there, while avoiding rocks with hints of greenschist overprint. Heavily weathered rocks were also avoided to provide highest possible quality geochemical analyses. Thus, samples were chosen in the field based on overall appearance, and then re-evaluated for freshness and mineralogic homogeneity upon petrographic examination. Of the twenty-six rock samples collected on Syros, nineteen were ultimately chosen for chemical analyses.

PETROGRAPHIC DESCRIPTION

The blueschists from Syros can be characterized by the following mineral assemblage:
glaucophane + epidote + garnet + omphacite + white mica + quartz + rutile + chlorite + opaques.
These minerals combine in slightly varied ways, but do represent the standard blueschist. The glaucophane is in some samples compositionally Fe-rich. Garnets are euhedral porphyroblasts varying in size from 0.5mm to 3.0mm in diameter. All garnets analyzed under the SEM were found to be almandine. Micas in the blueschists include both paragonite and phengite; phengite is predominant. The epidote family is a dominant mineral in these blueschists, but varies in compostion from epdiote to zoisite and clinozoisite.

Textures observed in thin section vary due to differing local intensity of deformation, also noted by Ridley (1984). Many of the garnets exhibit features indicative of the metamorphism prevalent on Syros; such as sigmoidal tails of mica and small amounts of glaucophane, as well as the bowing of the matrix schistosity around the garnet. The glaucophane is typically elongate and aligned, but can also be found in foliated but non-lineated fabrics. The majority of samples collected exhibit strong foliation.

The mineralogy of the blueschists from Kini and Ermoupoli (figure 1) is almost identical, while the two other localitites have unusual features. Blueschists from southern Syros contain glaucophane that appears very Fe-rich, and clinozoisite rather than other epidote group minerals. Garnet and clinopyroxene are both rare in the samples from southern Syros. Similarly, blueschists collected from the northern area of Syros do not contain garnet.

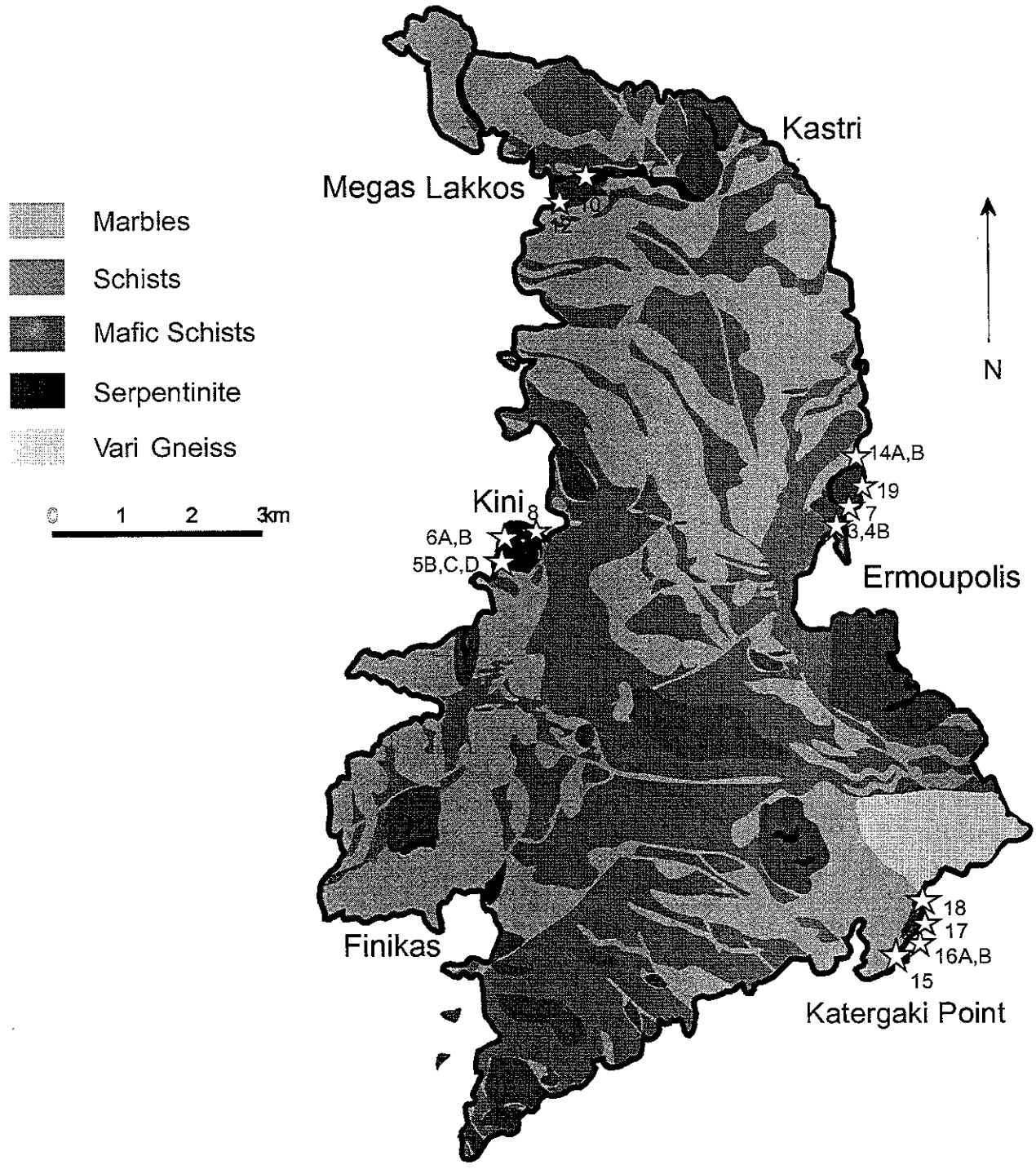


Figure 1. Sample locations on Syros for 19 geochemically analyzed glaucophane schists.

GEOCHEMICAL CHARACTERIZATION

Nineteen samples were selected for geochemical analyses on the basis of sample freshness and distribution from each of the four sampling localities. Major and trace elements in the samples were analyzed by X-ray fluorescence at Washington State University's GeoAnalytical Lab. Rare earth element analyses were also performed on an ICP-MS at the GeoAnalytical Lab.

Silica content of the samples ranges from 43.91% to 56.03%, making them basaltic. The TAS (Total Alkali vs.Silica) plot in figure 2 shows eight samples clearly plotting as basalts, along with a few basaltic andesites and basaltic trachy-andesites, and a single picrobasalt. When plotted on an AFM diagram (figure 3), the majority of samples plot as calc-alkaline basalts, favoring an interpretation as arc basaslts (Raymond, 1995). There are fewer tholeiites, which are typically characterized as MORB. However, Na and K are recognized as being extremely mobile during metamorphism, so these plots may not accurately reflect protolith character. The spider diagram in figure 4 shows the immobile elements U, La, Ce, Ti, and Y forming a fairly flat plot just over 10x chondrite. This is a strong indicator for MORB.

Figure 2. Total Alkali vs. Silica plot after LeBas et al, 1985. All samples plot as basalts of varying compositions. *Samples are plotted by location on all diagrams.

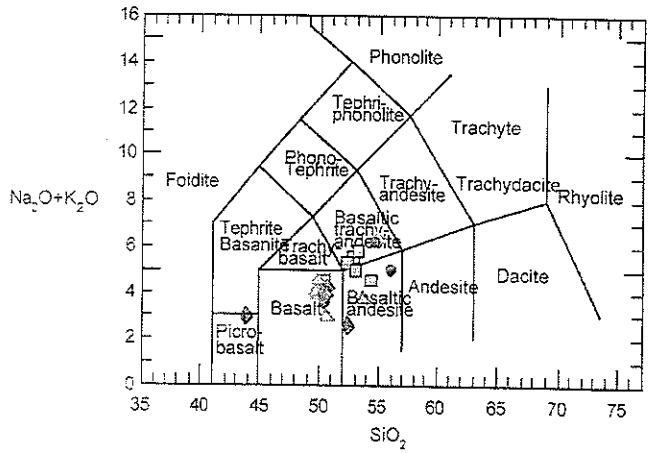
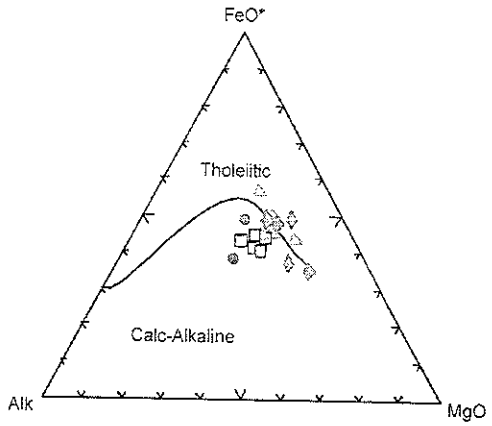
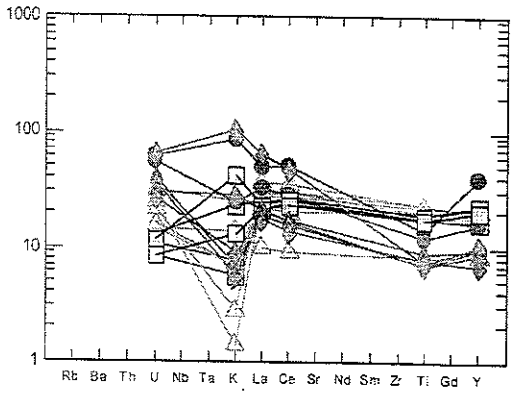


Figure 3. AFM diagram showing the division between samples with tholeiitic vs. calc-alkaline characteristics.





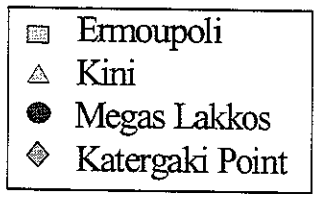


Figure 4. Spider plot of select trace and rare earth elements according to Sun, 1980.

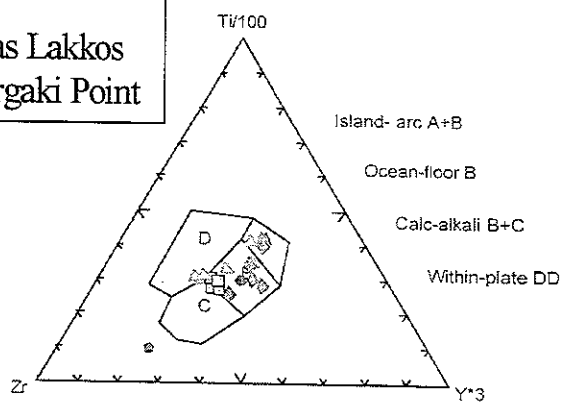


Figure 5. Tectonic discrimination diagram according to Pearce and Cann, 1973.

TECTONIC DISCRIMINATION

On a Ti/100 vs. Zr vs Y*3 diagram after Pearce and Cann (1973), samples plot within all fields (figure4). The majority plot within the region representative of ocean floor basaltic origin, with only a couple of samples in the within–plate basalt or arc region (figure 5). The samples from the Ermoupoli and Kini locales plot almost in clumps, but samples from the other two locales show greater variability in their possible tectonic origins. There are problems with relying solely on basaltic tectonic discrimination diagrams for tectonic interpretation due to ambiguity in trying to define tectonic origin in overlapping fields

CONCLUSIONS

The mineralogy of the majority of the examined samples confirms that they are of the blueschist facies. It is generally accepted that blueschist belts containing high-pressure minerals such as glaucophane, lawsonite, and jadeitic pyroxene mark the position of former suduction zones (Blake et al., 1981). Geochemical analyses of the nineteen glaucophane schists have shown that they were basaltic in composition prior to any subduction and related metamorphism. Their origin is suggested to be mostly MORB. A few samples do exhibit both Mid Ocean Ridge and Island-Arc characteristics, which can be produced in the same group of rocks if a spreading center occurs above descending lithosphere (Pearce, 1975). Though this suggestion is not definitive, Pearce's study was conducted on the island of Cyprus, which is located east of the Cycladic Islands in the Aegean Sea. Further geochemical interpretation, including additional spider diagrams reflecting the characteristics of trace and rare earth elements, will be used in order to constrain the basaltic origin of glaucophane schists on Syros.

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