MICROSTRUCTURAL AND GEOCHEMICAL IMPLICATIONS FOR DEEP-CRUSTAL SUBDUCTION DEFORMATION IN A BLUESCHIST BELT, SYROS, GREECE

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INTRODUCTION

Syros is part of the Cycladic blueschist belt in the Aegean Sea. From the Late Cretaceous to the middle Eocene this region experienced subduction zone metamorphism (Brocker and Enders, 2001; Schiestedt et al., 1987). Through microscopic and chemical analysis several phases of deformation have been distinguished including at least two during eclogite-blueschist facies conditions (Lister and Raouzaios, 1996). The eclogite-blueschist conditions experienced by rocks on Syros were 450°-500°C and roughly 14 kbars (Dixon, 1976). These temperatures are indicative of deep subduction. The purpose of this study is the analysis of fabric in garnet-bearing glaucophane schist. Through the mineralogy and microstructure of sampled blueschists from Syros indications of deformational events at deep subduction depths are interpreted. The conclusions reached and information gathered in this study are important contributions to the geologic understanding of subduction and associated deformation.

METHODS

Forty-eight samples of well-foliated blueschist facies rocks were collected from around the island (Figure 1). Thin sections of these samples were cut perpendicular to foliation and parallel to lineation as defined by glaucophane. The petrographic microscope was then used to characterize the microstructures present in each sample. Mineral analyses were collected using the Scanning Electron Microscope (SEM) with Energy Dispersive X-ray Spectrometry (EDS). Roughly eighty spot chemical analyses and two mineral maps were done on four key thin sections.

MINERALOGY

The typical mineral assemblage of the blueschists is epidote + glaucophane + garnet + white mica + quartz. Garnets compositions fit in the following ranges 60%-65% almandine, 16%-18% grossular, 3%-17% pyrope, and 0%-10% spessertine content. Glaucophane compositions were recalculated from the Scanning Electron Microscope results, that assume all measured iron is ferrous, to provide reasonable estimations of the ferric iron. The recalculated compositions of the glaucophanes plot as true glaucophanes with a relatively low ferric iron content (0-0.45 mole fractions) on a sodic amphibole diagram.

MICROSTRUCTURES

The blueschists of Syros are well foliated and lineated rocks (Dixon, 1976). Foliation is defined by the preferred orientation of micas and the lineation is defined by the preferred direction of glaucophane crystals. Garnet porphyroblasts (up to 2 cm in diameter) have pressure shadows composed of quartz + white mica with lesser components of gluacophane and plagioclase.

Three microstructures were characterized in this study. First, glaucophane crystals occur with a bimodal size distribution. In some thin sections a population of the glaucophane crystals are roughly twice as large as other crystals (Figure 2). These larger glaucophane crystals typically occur in proximity to garnet pressure shadows, and are located in bands parallel to foliation that contain garnet crystals (Figure 2). This bimodal size distribution was noticed in thirteen samples (10 from North Ermopoli, 1 from the airport, 2 from Charrasonis). Second, pressure shadows around garnets were categorized as asymmetrical, symmetrical, or undetermined (Figure 3). Categorizations are based on the parallel or non-parallel relation of a line between pressure shadow tips and foliation (Figure 4). The third microstructure is garnet inclusion trails. Inclusion trails within the garnet porphyroblasts are composed of any of the following three; quartz, mica, and glaucophane. Trails are both straight and curved (Figure 5). The trends of the inclusion trails are near perpendicular or parallel to current foliation. The various garnet inclusion trails exist within a single thin-section.

DISCUSSION AND CONCLUSIONS

The composition of large and small glaucophanes were plotted to determine if the different size glaucophanes had grown at different stages with different chemical conditions (Figure 6). There is no evidence that the two size populations of glaucophane grew under different chemical conditions.

Earlier studies have concluded that there were three deformational phases that occurred at blueschist facies conditions (Rosenbaum et al., 2002). The fabric (S1) from the earliest deformational event is preserved as inclusion trails in garnet porphyroblasts (Rosenbaum et al., 2002). Symmetric features such as pressure shadows, that indicate coaxial compression are associated with this fabric (Rosenbaum et al., 2002). The third phase of compression is related to shear bands not noted in my study. The second phase of deformation formed the foliation present in the matrix of the rock. Rosenbaum et al. (2002) found that the S1 fabric was nearly perpendicular to the foliation, indicating coaxial compression in the second phase that was perpendicular to the compression of the first phase.

What has been found with this study is inconsistent with previous models (Rosenbaum et al., 2002). Garnet inclusion trails exist at high and low angles to matrix foliation. This indicates that the inclusion trail fabric was either not consistently at a high angle to the matrix foliation, or that the garnet porphyroblasts have been rotated after over growing the earlier fabric. Asymmetric pressure shadows around garnets constitute a significant portion to the total pressure shadows observed (Figure 3). The presence of high and low angle inclusion trails in conjunction with asymmetric pressure shadows is indicative of non-coaxial deformation. (Passchier and Simpson, 1986). The implication is that the deep-crustal subduction zone deformation experienced by these rocks was not pure compression, but included significant shearing.

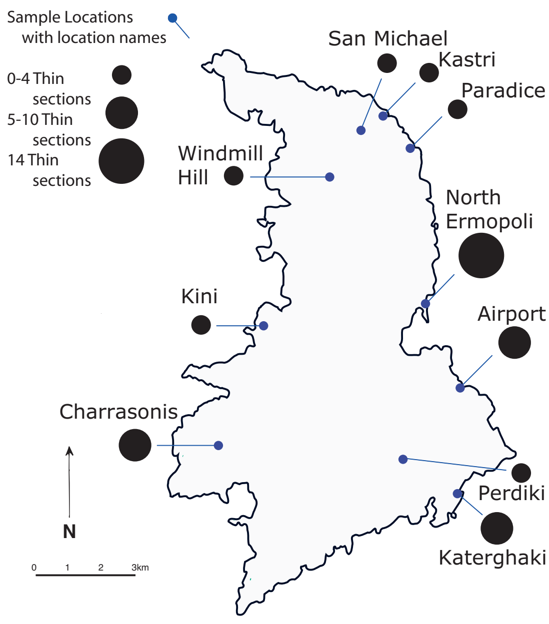

Figure 1: Names and locations of sampling on Syros. Dot size represents total number of thin-sections from a given location.

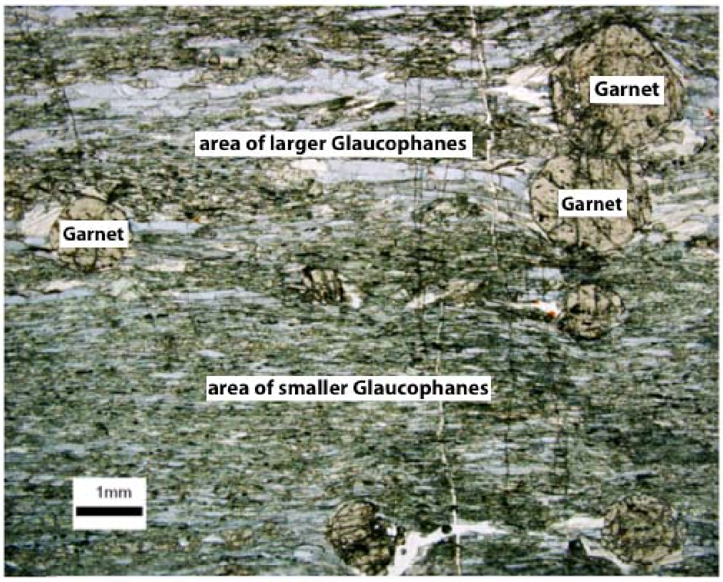

Figure 2: Bimodal size distribution of glaucophane in association with garnets. Sample 26121 from North Ermopoli.

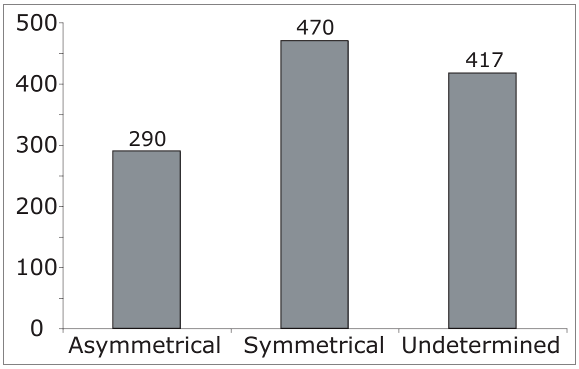

Figure 3: Symmetry of pressure shadows around garnets as determined in thin-section.

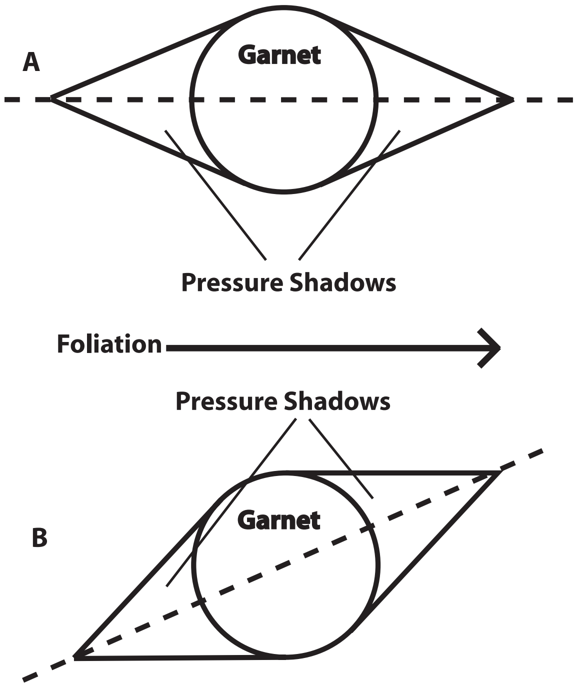

Figure 4: Schematic illustration of (A) symmetric and (B) asymmetric pressure shadows around garnet porphyroblasts. From Davis and Reynolds, (1996).

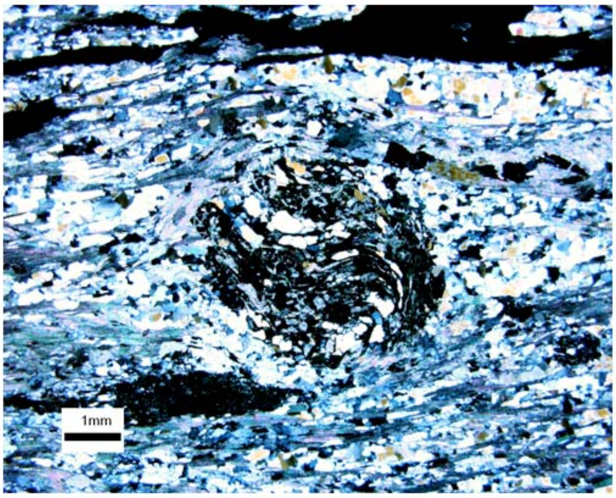

Figure 5. Curved inclusion trail in garnet. Sample 16191.

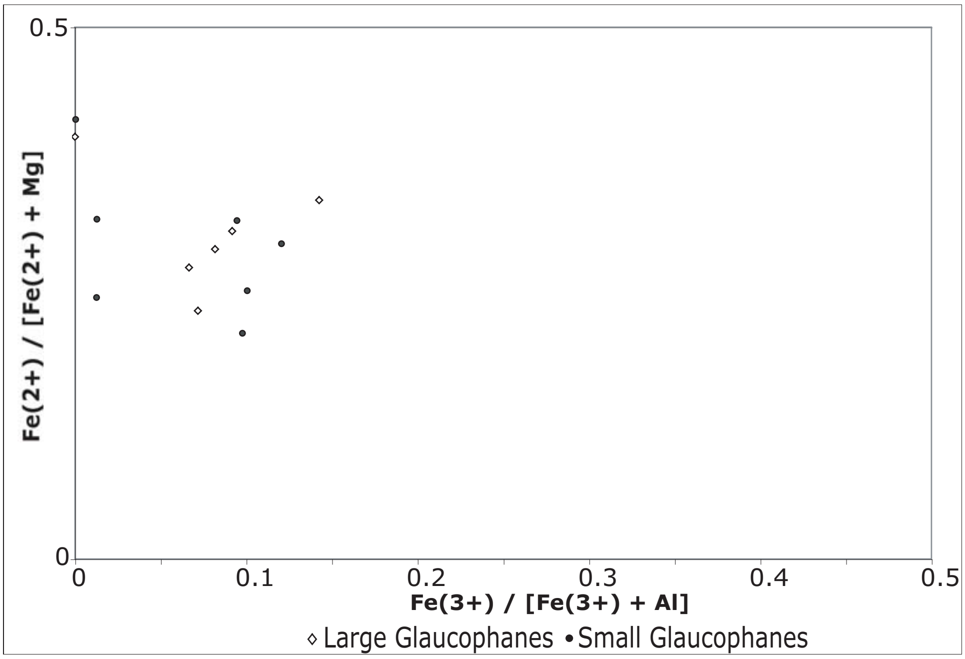

Figure 6: Composition plot of large and small glaucophane crystals on the glaucophane quadrant of a sodic amphibole plot.

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