PETROLOGIC AND TEXTURAL EXAMINATION OF BLUESCHIST-FACIES MICACEOUS SCHISTS OF SYROS, GREECE.

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INTRODUCTION

The island of Syros lies in the high pressure belt of the Attico -Cycladic crystalline massif. It is composed dominantly of metasedimentary and meta-igneous rocks with local areas of melange and serpentinite zones. These rocks preserve blueschist facies mineral assemblages, although an incomplete greenschist overprint exists locally across the island. This study focuses on the semi-pelitic and calcareous schists of Syros. The schist units are interlayered with marble across the island, and are laterally continuous parallel to the strike of the foliation, with beds generally dipping 25-45° to the NE (Hecht, 1985). The schists from the north end of the island were very consistent, laterally continuous units. Over the rest of the island, the schists tended to be much more locally variable in composition, Ideally, this project aims to integrate structural, petrographic, and compositional data to characterize the nature and timing of deformation relative to mineral growth, and to place constraints on the P/T conditions experienced by semi-pelitic rocks across the island.

PETROGRAPHY

The north end of the island contains calcareous schists with the relatively uniform mineral assemblages of quartz + phengite ± calcite ± minor amounts of sodic amphibole, garnet, epidote, rutile, titanite, and graphite. These rocks are divisible into two main groups based on the presence or absence of calcite, forming two fairly homogenous, mappable units (~1km scale). A greenschist overprint of albite + chlorite +/- epidote typically occurs in these rocks (Fig. 1), although the modal amounts of these minerals vary locally. Albite and chlorite are both are interpreted as retrograde on textural grounds. The chlorite grew perpendicular to the primary foliation of the rock, defined by an alignment of phengites, indicating that it grew late in the rock's history. The albite is also interpreted to be late, as it overprints the fabric; it is also appears to replace garnet in the rock, which has been preserved as multiple inclusions in the centers of some of the albites. Fig. 1 represents one of the more extensively overprinted rocks in the northern part of the island.

Schists from across the rest of the island have more varied mineral assemblages. Rocks completely transformed to greenschist facies are intercalated with assemblages similar to the calcareous schists of the north. Less common pelitic rocks occur locally and have quartz + phengite + paragonite. Typically these rocks contain titanite and/or rutile, and one or more of glaucophane, chloritoid, jadeite, lawsonite, garnet, and chlorite. The different mineral assemblages occur locally on outcrop scale, and are interpreted to be primarily the result of differences in bulk composition rather than metamorphic grade.

SHEAR SENSE INDICATORS

The schist units are all well foliated, expressed in an alignment of phengites. The original foliation in the rock is locally in the process of being overprinted in several areas by a second foliation which may be expressed as either crenulation cleavage or microfolds in the rock. Large scale folds are also plentiful at different orders of magnitude; in some cases parasitic folds can be seen, caused by interlayer slip.

In addition to these, at several localities shear-sense indicators can be found, both in hand sample and in thin section. Fig. 2 is a photomicrograph showing a well developed shear fabric. The rocks in which these are found tend to be well lineated parallel to the plane in which the sense of shear can be determined. In hand sample or at the outcrop, asymmetrical folds and shear bands (Which have a geometry identical to Fig. 2, but can be large enough to measure in the field.) can be measurable shear-sense indicators.

MINERAL COMPOSITION

Six thin sections were analyzed using a scanning electron probe to determine mineral compositions. They were chosen to a) characterize variation in mineral assemblages observed in the schist units, and b) attempt to place constraints on the pressures and temperatures experienced by the schists.

The thin sections that were analyzed contained zoned amphiboles that had glaucophane cores and became more enriched in iron towards the rims. Ferric iron corrections were applied to the analyses using different stoichiometric constraints. $\sum Mg = 13$ calculated ferric iron based on the assumption that the m4 site in the amphiboles contained only Na or Ca, and for most samples, resulted in no ferric iron at all. Given that many of the schists on Syros contained significant amounts of graphite, which would create a reducing environment, this is not necessarily surprising. The other correction, $\sum Na = 15$, assumes that the amphibole A-site is empty except for K. This resulted in higher (non-zero) amounts of ferric iron. Neither can be proved correct; Fig. 3 plots the two against each other to give a general idea of the trends. Most of the amphiboles plotted in the glaucophane quadrant of the sodic amphibole classification, some plotted as ferroglaucophane. The cores of the amphiboles were Mg - rich and increased in Fe content towards the rims. There were no riebeckite or magnesio-riebeckite amphiboles, the high ferric iron counterparts of the glaucophanes.

Fig. 4 shows the range of silica values from phengites in each of the six thin sections plotted against the (2+) cations. A coupled exchange reaction of $Al_{IV} + Al_{VI} >> Si + Mg$ is favored at higher pressures; it gives a rough estimate of the pressure experienced by the rocks. The phengite plot shows a fairly linear trend that supports this reaction in the Syros rocks, the upper values for each sample are consistent with high pressure metamorphism. Horizontal scatter on the plot is a result of the low temperature metamorphism, which creates a situation whereby it is easier for the rock to crystallize new grains of phengite in response to changing conditions than it is to keep existing grains at equilibrium through diffusion. The vertical scatter, particularly with sample 45B, is probably a result of ferric iron variation in the phengites which was not considered.

The mineral assemblages in the schists are not particularly well suited for ascertaining pressure and temperature of equilibration. However, preliminary calculation of pressure and temperature for one sample from the south of the island is shown in fig. 5, based on relationships between garnet-omphacite and omphacite-quartz. The garnet-omphacite geothermometer yielded a temperature of approximately 340 °C. It was not possible to calculate a pressure for the sample, which would have required albite, but a minimum pressure was calculated using omphacite ($Jd_{.50}Di_{.35}Ac_{.15}$) and quartz, which at 340° was roughly 8-9 kbars, using the pure Na-albite for the calculation. The actual pressure may be substantially higher; this should have little effect on the calculated temperature, as it is a nearly vertical curve in P/T space. (Thermobarometry carried out using a computer program, GTB 2.0, 1999; Spear, F.S. & Kohn, M. J.)

SUMMARY

The micaceous schists of Syros are found to be consistent with low-temperature high-pressure metamorphism. The Si content of the phengites is consistent with high pressure metamorphism, as is the range of composition of single minerals in equilibrium, and the existence of omphacite + qtz with the absence of albite.

Shear fabrics appear to be widespread, at least across the north of the island, where sampling for this project was concentrated; they may be prevalent in the southern part of the island as well, and provides what I believe is a worthwhile avenue for further study.

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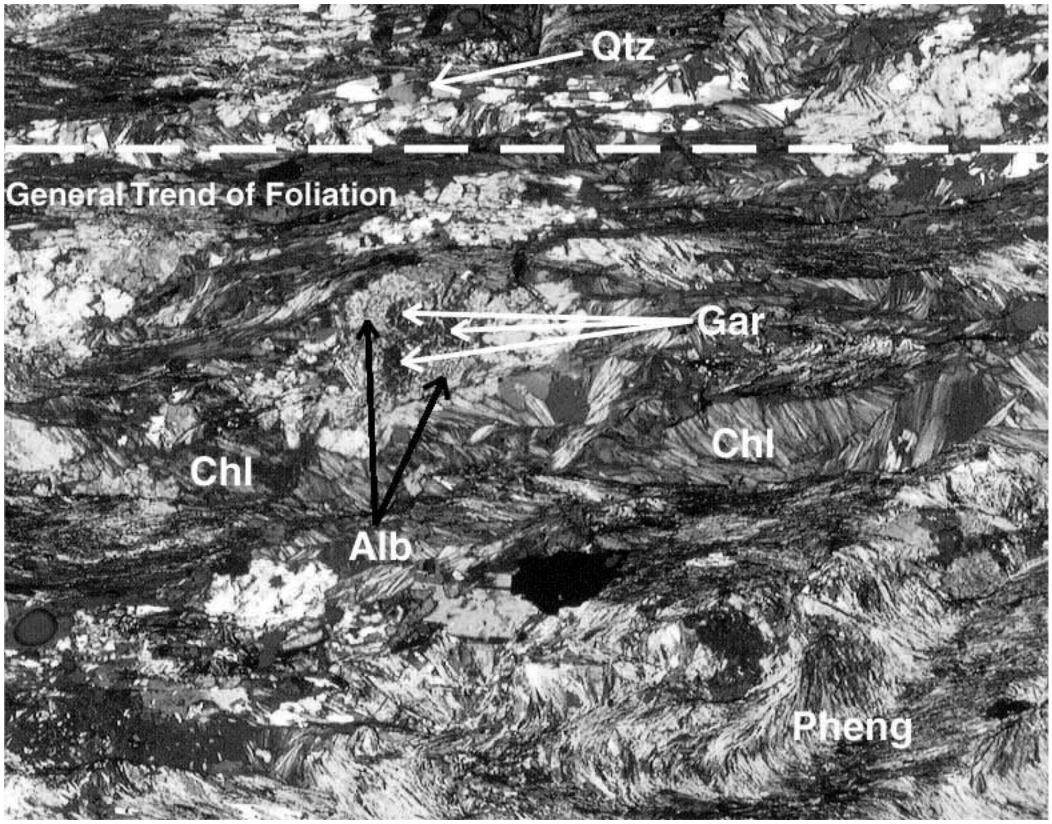


Fig. 2: Greenschist Overprint (photo explained in text)

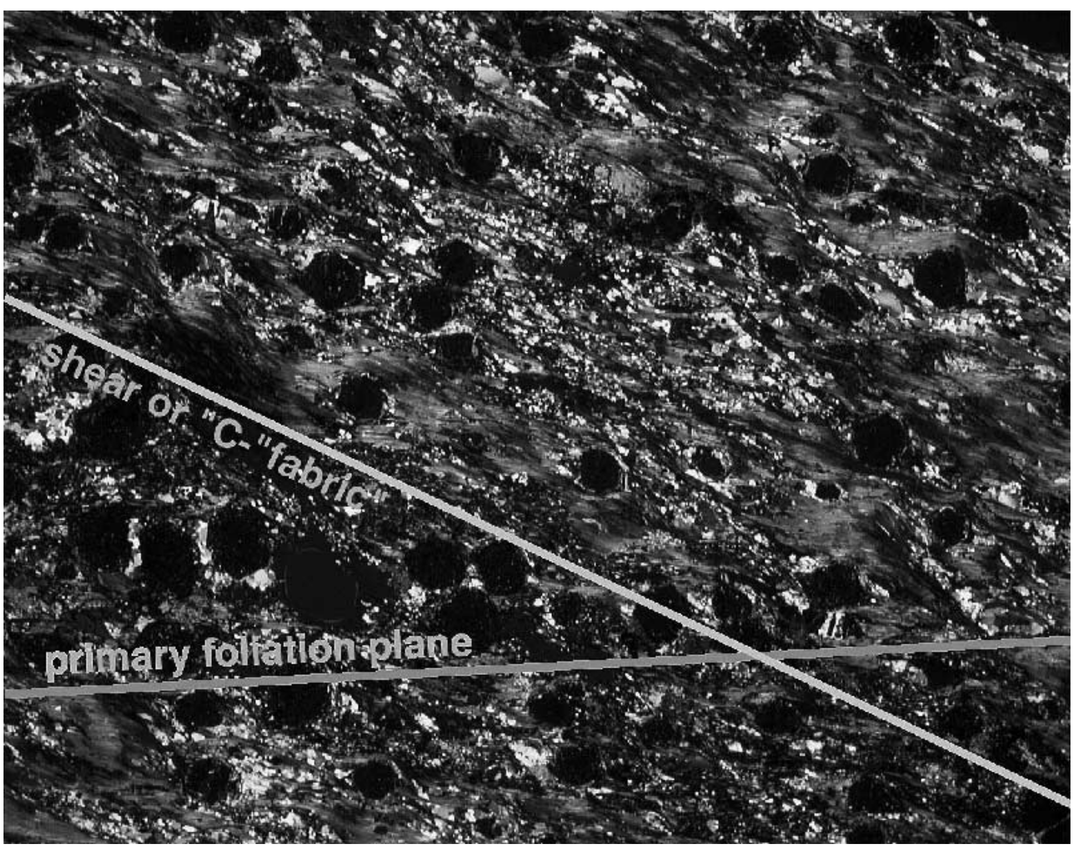
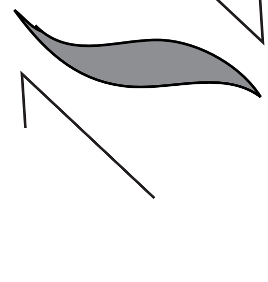


Fig. 2: Shear Bands

Note the consistent asymmetry in the foliation- down and to the right. This geometry gives a sense of shear that is top->right and down; bottom -> left and up.

Below: geometry of shear band with sense of shear that is indicated



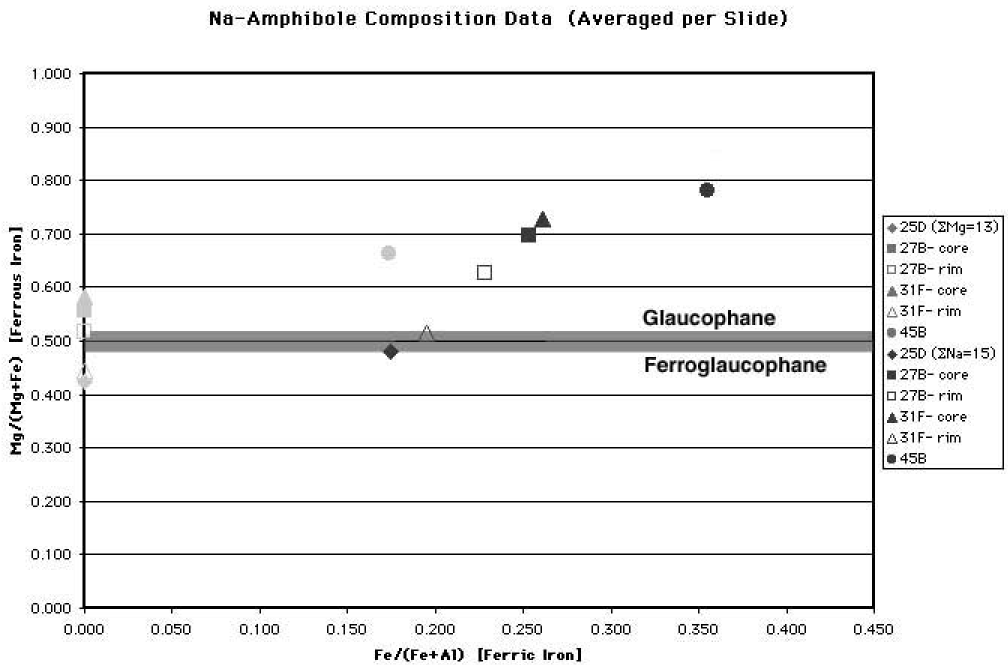


Fig. 3: Plot of sodic amphibole compostions

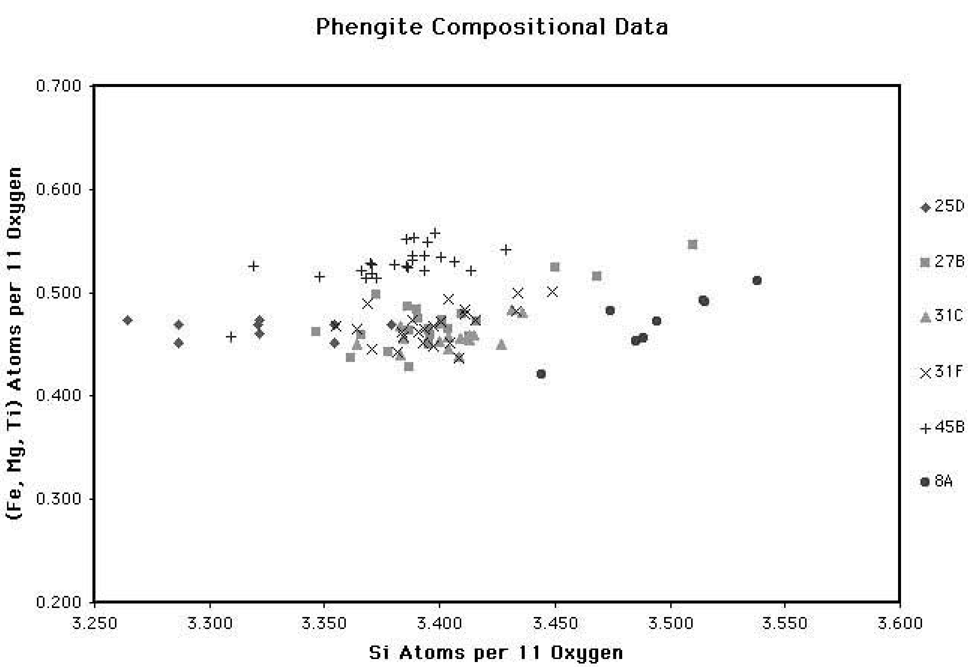


Fig 4: Plot of phengite (2+ cations)/(Si per 11 oxygen)

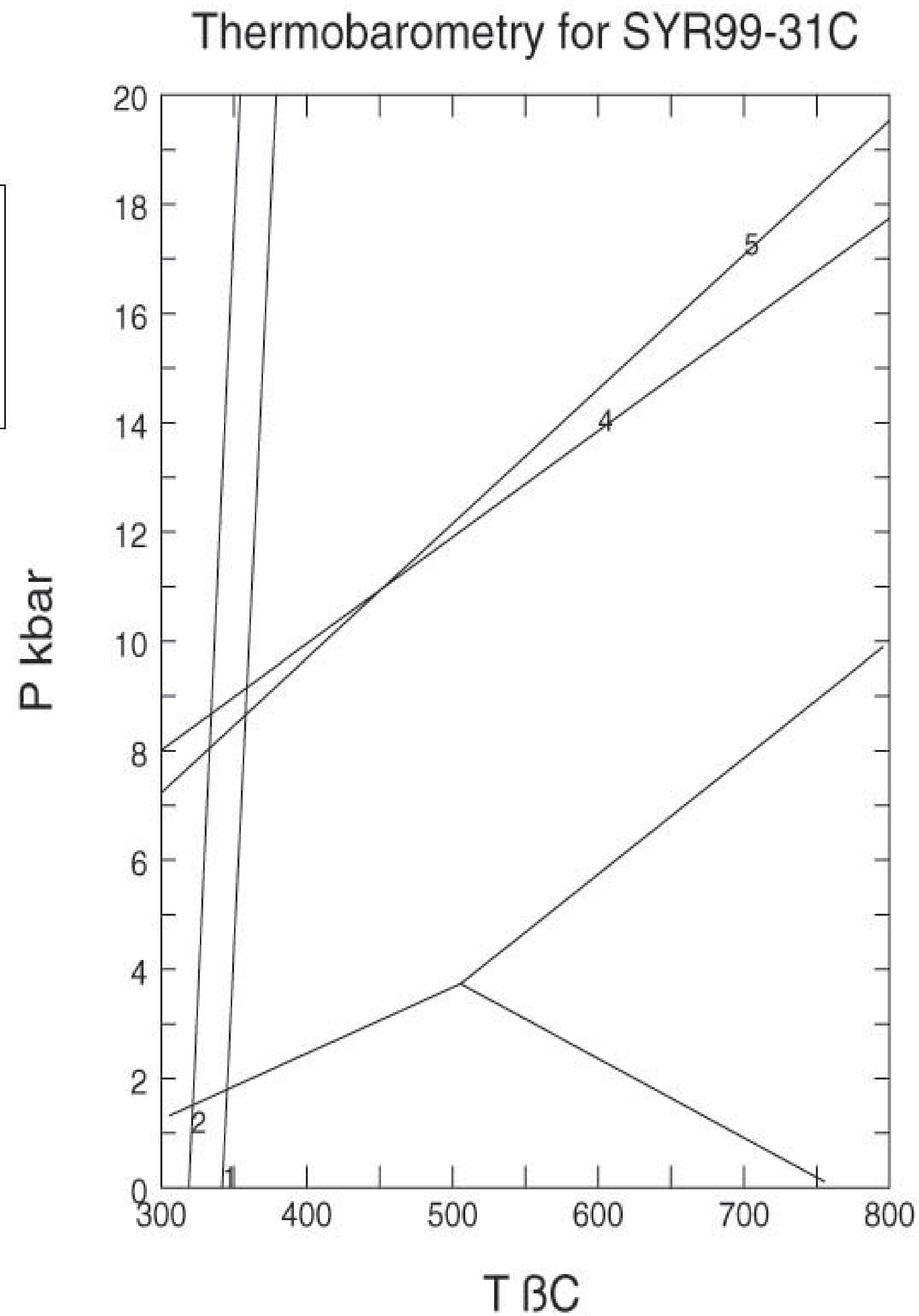


Fig. 5: GTB plot of pressure/temperature constraints