PETROLOGY OF THE "AIRPORT OPHIOLITE", SYROS, GREECE.

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INTRODUCTION

Syros, one of the Cycladic Islands of Greece, is part of a high-pressure metamorphic belt in the Attico-Cycladic crystalline massif (Cheney et al., this volume). Beginning in the Cretaceous this region experienced eclogite and blueschist facies metamorphism. Metasediments including marble and meta-igneous rocks cover most of the island. Fragments of remnant ophiolitic rocks are well exposed on the island including a proposed ophiolitic sequence just south of Ermoupolis (Dixon and Ridley, 1987) These rocks, referred to as the Airport Ophiolite, contain blueschist and eclogite facies rocks with areas retrograded to greenschist. The purpose of this project includes mapping, determining the conditions of metamorphism, and constraining the origin of the protolith of the Airport Ophiolite.

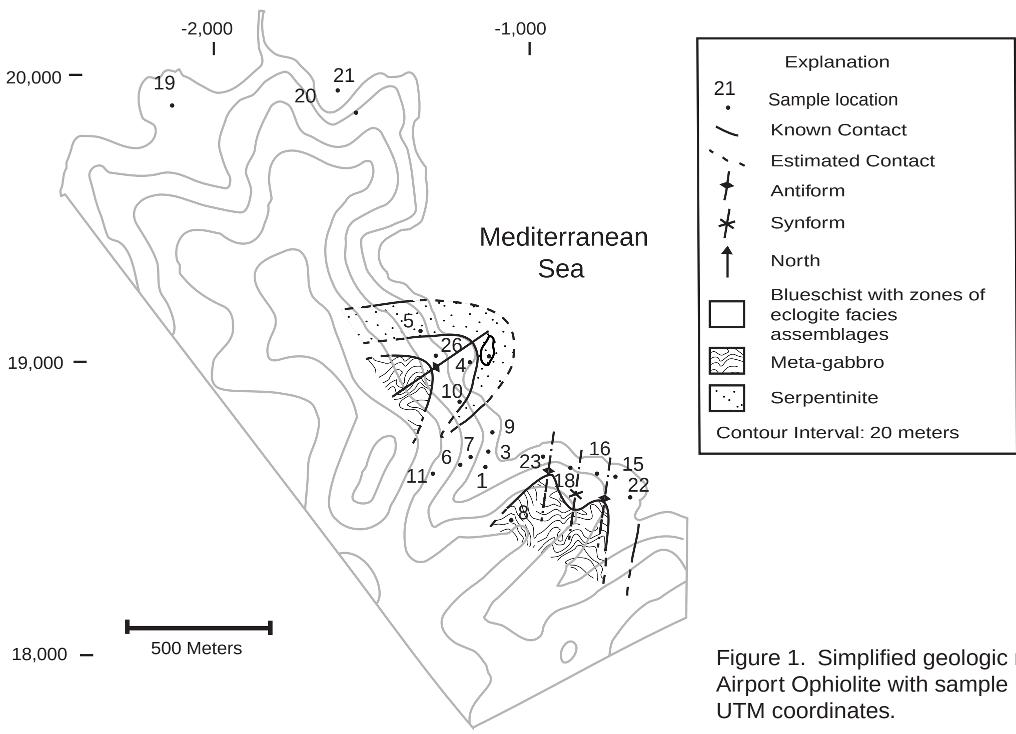


Figure 1. Simplified geologic map of the Airport Ophiolite with sample locations and UTM coordinates.

AIRPORT OPHIOLITE

The Airport Ophiolite was mapped at a 1:10,000 scale (Fig. 1). Blueschist, meta-gabbro, serpentinite, greenschist, and eclogite were identified in the field. The eclogite facies rocks have little to no internal deformation and occur as dikes and boudins in penetratively deformed blueschists. Similar to the blueschist, the greenschist and serpentinite facies rocks have well-developed foliation, with defined glaucophane lineations in some areas. The meta-gabbros are moderately foliated in areas closest to the blueschist rocks but have remained mostly unfoliated. Structural data show that the foliation is folded with near vertical NE to NNE striking axial planes. Serpentinite is folded within the blueschist (Fig. 1)

MINERAL ASSEMBLAGES

Eclogite: Medium to coarse grained (up to 1 cm), massive rock only found as a dike and as a few boudins within the blueschist at locality 4. It contains almost entirely omphacite and garnet.

Blueschist: Very fine to medium grained, well-foliated schist. All of these rocks contain glaucophane, epidote group mineral (mainly clinozoisite), phengite, titanite, rutile, and quartz. Other minerals appear in varying amounts such as garnet, clinopyroxene, and paragonite. Some of the samples contain retrograde greenschist minerals such as chlorite, albite, and actinolite.

Meta-Gabbro: Coarse grained, moderately foliated to massive rock. It contains the same mineral assemblages as the glaucophane schist, and includes omphacite porphroblasts, epidote, and phengite. It contains varying amounts of glaucophane, garnet, chlorite, and albite. Rutile, titanite, and quartz are accessory minerals. This lithology is classified as a meta-gabbro primarily due to its relatively coarse grain size (up to 3 cm) compared to the blueschists and greenschists, which presumably reflects the igneous protolith (Dixon and Ridley, 1987).

Greenschist: Very fine to fine grained, well-foliated rock. The most common assemblage is chlorite + albite + epidote ± actinolite. In some samples, corroded glaucophane is present.

Serpentinite: Very fine grained and very well foliated rock composed of serpentine. It also contains magnetite.

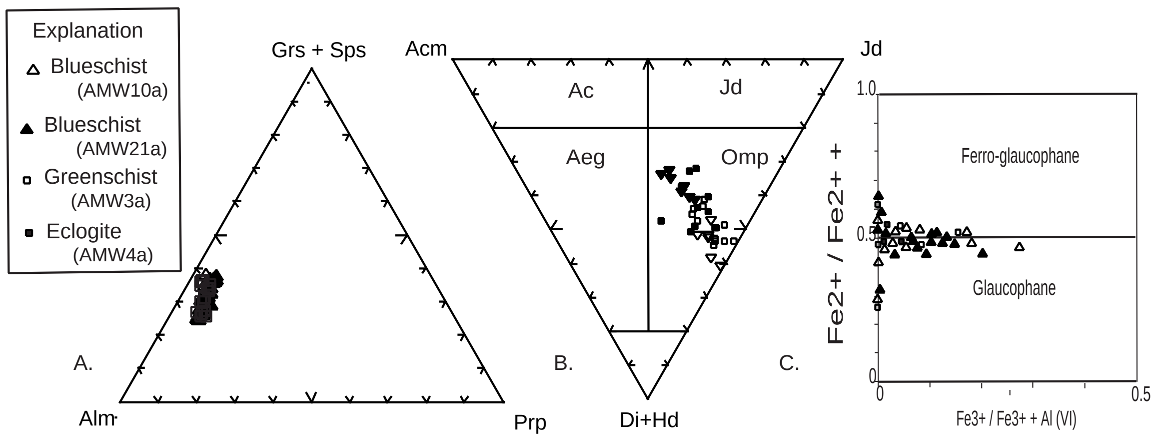


Figure 2. Mineral compositions from the airport ophiolite. A) Ternary diagram for garnet showing grossular, spessartine, pyrope, and almandine compositions. B) Ternary diagram for omphacite (Omp) showing jadeite (Jd), diopside (Di), hedenburgite (Hd), and acmite (Ac). C) Sodic amphibole compositions showing variations of Fe.

MINERAL CHEMISTRY

Four representative samples were analyzed on the Zeiss scanning electron microscope at Amherst College with an Oxford EXL microanalysis EDS system. Samples AMW10a and AMW21a are blueschist, AMW3a is an intermediate greenschist/blueschist, and AMW4c is an eclogite.

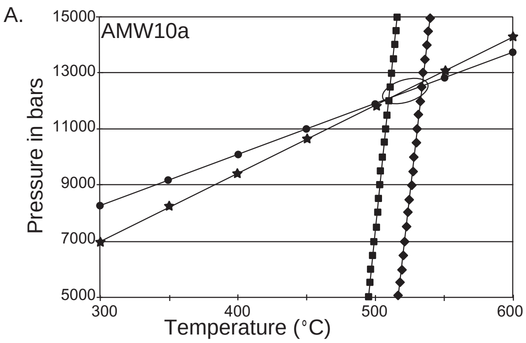
Garnet: Garnet is almandine rich with grossular contents ranging from 0.454 — 0.222 % (Fig. 2a). With the SEM/EDS, garnet traverses and maps were made on several garnets from all samples. The garnets are relatively unzoned with near-rim depletions of Mn and enrichments in Mg and Fe. Inclusions in garnet are mostly quartz, albite, and titanite. Chlorite has commonly replaced some garnets.

Sodic Amphibole: Ferric/ferrous ratios, assuming 13 cations and only Ca and Na in the M (4) site, were calculated to determine the variety of amphibole using an algorithm written by Prof. John Brady (1999). All compositions plotted in the glaucophane-ferroglaucophane range (Fig. 2b).

Omphacite: The diopside + hedenburgite content of the pyroxene ranges from 0.323 to 0.61%, jadeite from 0.364 — 0.463%, and acmite from 0 — 0.293%, which places all the samples in the omphacite range (Fig. 2c).

GEOTHERMOBAROMETRY

The garnet-clinopyroxene Fe-Mg exchange thermometer and albite-jadeite-quartz barometer were used to calculate the pressure and temperature of equilibration of an eclogite and blueschist sample (Fig. 3). Garnet, clinopyroxene, and albite compositions were used from AMW10a (blueschist) and AMW4c (eclogite) using thermometers from Ellis and Green (1979) and Powell (1980), and barometers from Holland (1980) and Gasparik and Lindsley (1980). Thermobarometry was calculated using GTB 2.0 (Kohn and Spear, 1999). Figure 3 shows that both the blueschist and eclogite give almost identical pressures and temperatures ranging from 500-520 ^{o}C and pressures from 12,000-12,500 bars.



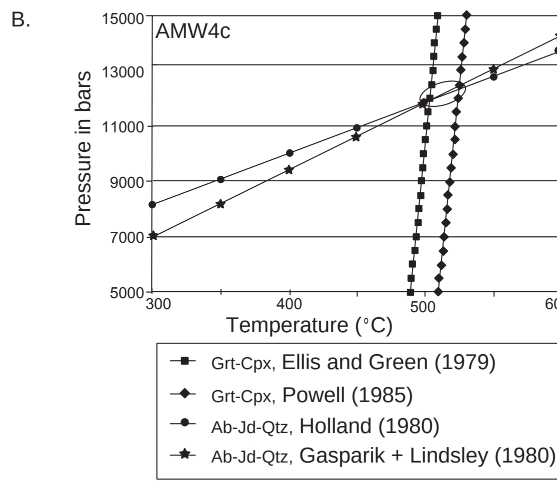
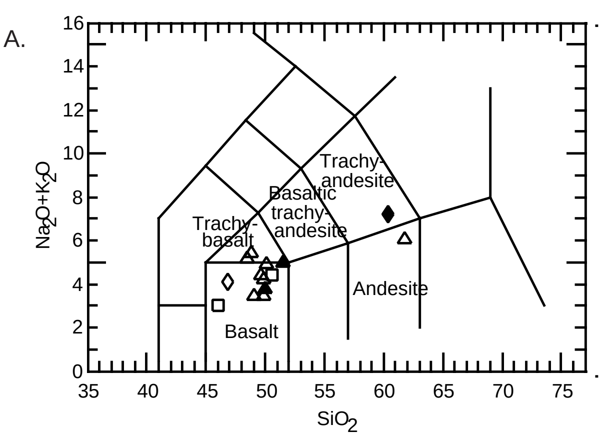
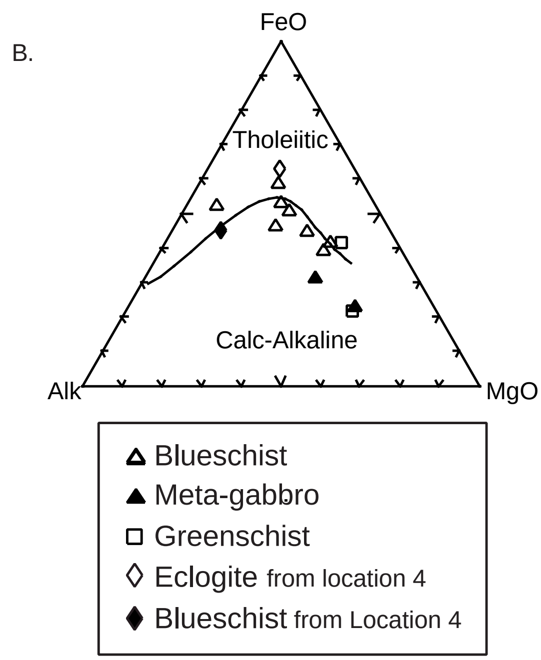


Figure 3. Calculated pressure - temperature for A) blueschist AMW10a and B) eclogite AMW4c. Ellipses show P-T fitted range for sample.

WHOLE ROCK GEOCHEMISTRY

Whole rock geochemical data were obtained from 14 samples from the Airport Ophiolite in order to help determine protoliths. On a total alkali vs SiO_2 plot (Fig. 4a) most samples plot in the basalt range. Two samples have a larger amount of silica, plotting in the andesite range. Figure 4b shows that most samples follow a Tholeiitic trend. Figure 4c shows the rare earth elements (REEs) compared to chondrites. All of the samples are enriched in the REEs and most have a larger enrichment of Eu.





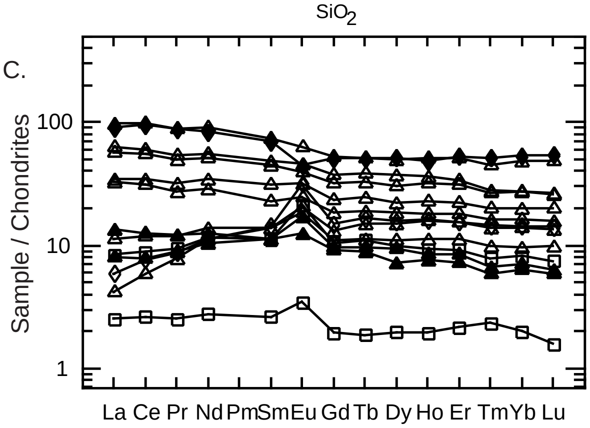


Figure 4. A) Total Alkali vs. Silica plot after LeBas et al, 1985. B) AFM diagram demonstrating the division between tholeiitic vs. calc-alkaline in samples. C) Spider plot of trace elements according to Sun & McDonough (1989).

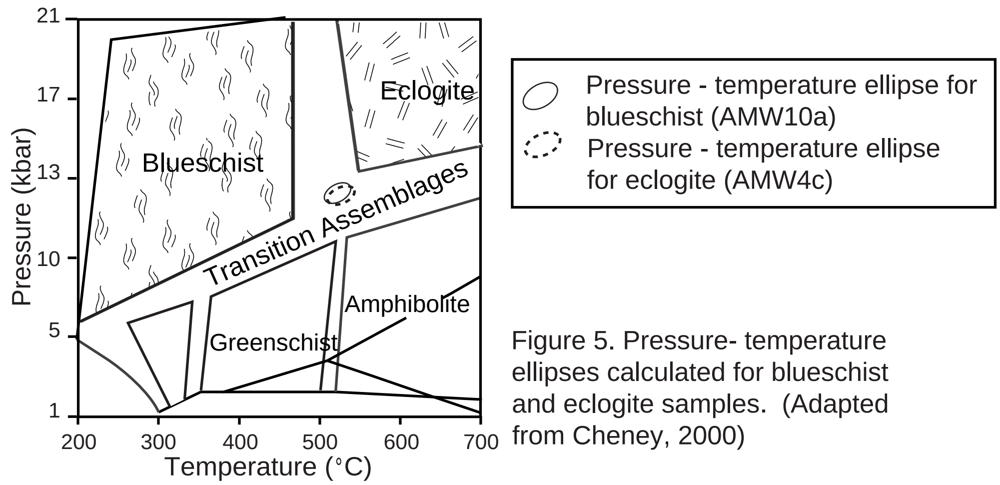


Figure 5. Pressure- temperature ellipses calculated for blueschist and eclogite samples. (Adapted from Cheney, 2000)

DISCUSSION AND CONCLUSIONS

Eclogite, blueschist, meta-gabbro, greenschist, and serpentinite units were mapped within the Airport Ophiolite based on field appearance and mineral assemblages. P-T ellipses, from in Figure 3, are shown on a facies diagram in Figure 5. Both samples plot in the transition zone between blueschist and eclogite facies. Geochemistry shows that the airport Ophiolite rocks are basaltic compositions and plot in the Tholeiitic region (Fig. 4b). In addition, the rare earth elements (REEs) do not show a depletion in the heavy REEs (Fig. 4c) suggesting that the basaltic protoliths of these rocks formed from shallow melting of the mantle, perhaps in a mid-ocean ridge environment (McBirney, 1984).

The blueschist and eclogite both equilibrated in the blueschist/eclogite transition zone giving the same P-T ranges (Fig. 5). However, they have different textures and modal mineralogy; the eclogite rock is coarse and massive with mostly omphacite and garnet with minor glaucophane, while the blueschist rocks are medium grained and well-foliated with high modal glaucophane. This suggests that the textures are a function of deformation and not metamorphic grade. That is, deformation was probably concentrated in the rocks mapped as blueschists, thus allowing fluids easier access to allow glaucophane growth. The greenschist facies rocks probably formed in areas where deformation and access to fluids continued during the exhumation of these rocks.

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