METASOMATISM OF BLACK-WALL REACTION ZONES OF SYROS, GREECE

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INTRODUCTION

Black-wall reaction zones are produced by metasomatism between an ultramafic body and another body of rock to produce a sequence of mineral zones. Syros is home to several occurrences of serpentinite matrix mélange. Here, serpentine has reacted with mafic exotic blocks located within the mélange to produce reaction zones rich in glaucophane, chlorite, actinolite and talc (Dixon and Ridley, 1987; Difilippo and Brady, 2000; Hernandez, 2001). Many of the exotic blocks are believed to have originated from an olistostrom and have been metamorphosed into ecologites. Others are ophiolitic metagabbros that have a greenschist overprint (Dixon and Ridley, 1987).

The purpose of this research is to study the minerals involved in these reaction zones and to better understand the nature of element mobility in a low-temperature/high-pressure environment.

METHODS

Sample Collection

Sample traverses across metasomatic reaction zones were collected from 7 areas around the island. Most samples were collected near the shoreline where the mélange outcrops were most accessible and visible. Some of the samples were collected inland and at a higher elevation. The exotic blocks of the mélange, along with some matrix, occur most notably in a linear array from the west shore to east shore in the northern part of the island, but mélange also occurs in the central and southern sectors as well. Obtaining a full black-wall sequence proved elusive because many of the reaction zone localities were well-weathered and difficult to sample.

An ideal sample traverse includes a full sequence from exotic block → serpentine. Six sample traverses through reaction zones have been studied in detail. These samples exhibit the best reaction zone boundaries and have the most complete sequences. Very few, if any of the samples collected are full sequences. The sample traverses range in length from 2 cm to 1 m, while areas of exposed melange ranged in size from 5 to 120 meters in width. The exotic blocks are roughly equant and about 5 to 20 meters across (Dixon and Ridley, 1987). Of the sample traverses studied, 4 of them contain exotic blocks in the black-wall sequence while the remaining contain just the reaction zone.

Laboratory methods

Thin-section petrography was conducted optically and with SEM/EDS at Beloit College. Electron microprobe analyses of mineral compositions were collected using the Cameca SX-50 at the University of Wisconsin – Madison.

FIELD DESCRIPTIONS

Traverse 10 is the largest of the sample traverses and came from the top of Mount Charissonas northwest of Finikas in southwest Syros. Mount Charissonas consists principally of alternating schists and marbles (Dixon and Ridley, 1987). Traverse 10 was located in a serpentine mélange zone that was about 15 – 20 m wide with exotic blocks ranging from 3 to 10 m across. The reaction zone traverse is about 40 - 50 cm in width from glaucophanitic eclogite through amphibole and chlorite schists to the serpentine matrix. A sample of eclogite was collected from the opposite side of the exotic block.

A thin, easily eroded, green rock is found at the end of the sequence following the talc/chlorite rock. The sample was too small and fragile to collect. There is uncertainty to whether or not the green rock is serpentinite or an intermediate reaction zone.

PETROGRAPY

Petrographic examination reveals variation in the development of reaction zones from the six studied localities. They all are different with the most common minerals being glaucophane and chlorite followed by phengite/paragonite and actinolite/tremolite. A breakdown sequence of ilmenite → rutile → titanite is found in varying amounts in almost all thin sections.

Traverse 10 is the most complete traverse and grades from glaucophanitic eclogite (glc + omp + grnt) to small, soft layers of talc and chlorite. The traverse consists of 6 rocks (10k, 10a, 10b, 10c, 10d and 10t). This traverse was chosen because it is the closest to an "ideal" reaction sequence and has gradual, but obvious transitions between zones, particularly with amphiboles and phyllosilicates (Figure 1).

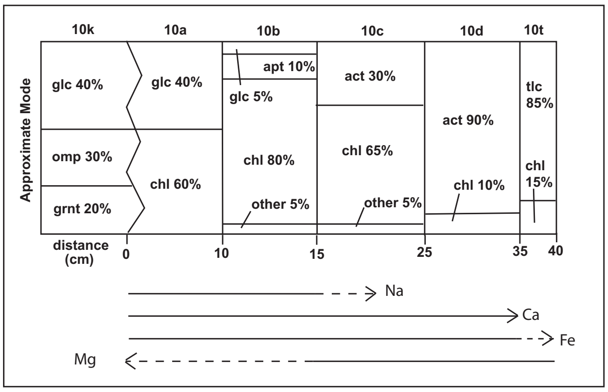

Figure 1: Approximate modes of black wall reaction Traverse 10 from eclogite (on the left) to serpentinite matrix (on the right). Distances approximated from eclogite to beginning of sample and are not necessarily all reaction zone. glc = glaucophane; omp = omphacite; chl = chlorite; act = actinolite; grnt = garnet; tlc = talc. Arrows point in direction of decreasing concentrations; dotted lines mean diminishing amounts.

The main orientation of foliation throughout the sequence is parallel to the zone boundaries and the eclogite contact. The main minerals that define foliation are chlorite, amphiboles and eventually talc.

The glaucophanitic eclogite contains glaucophane (40%), omphacite (30%), and garnet (20%). Minor chlorite, rutile, Fe-oxide, titanite, and traces of epidote are also present.

The first zone outwards from the eclogite is a chlorite amphibole schist about 10 cm in width. Chlorite (60%) and amphibole (40%) are most abundant with rutile and titanite found in trace amounts. The amphiboles exhibit complex chemical zonations in BSE images. Cores and some rims are more sub calcic actinolite (relatively Mg and Ca – rich) but patches and rims of other grains are more glaucophanitic (Na and Al – rich). Some of the amphibole grains have Na-rich rims compared to their cores (Figure 2). Upon observation of the microprobe data, the amphiboles are predominately sub-calcic actinolite but some zonations range in composition to reibeckite.

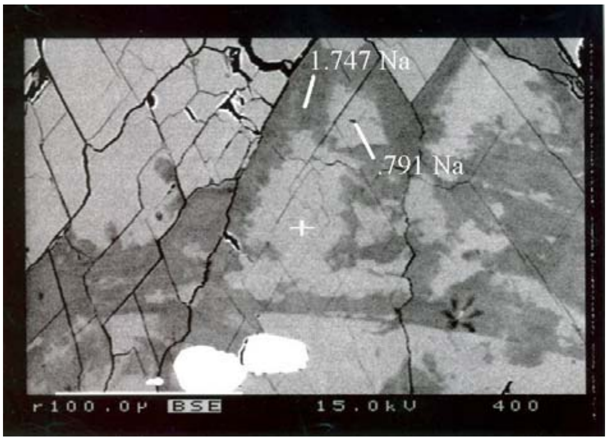

Figure 2: Chemical zonation in amphibole. Numbers show amount of Na cations per formula unit present in each zone.

The next zone is a chlorite schist about 5-10 cm in width. Chlorite (80%) is most abundant with minor amounts of apatite (5 - 10%) and glaucophane (<5%). Some of the apatites are 2-3 mm in size. Also present is rutile and titanite.

The next zone is a chlorite schist about 10 – 15 cm in width. Chlorite (65%) and actinolite

(30%) are most abundant with 5% rutile, titanite, and apatite. Actinolite in this sample shows some chemical zonation much similar to that of the glaucophanes in 10a. BSE images show a dark core and light rim (Figure 3). The dark core is more Mg and Ca – rich while the light rim is more Na, Al, and Fe-rich.

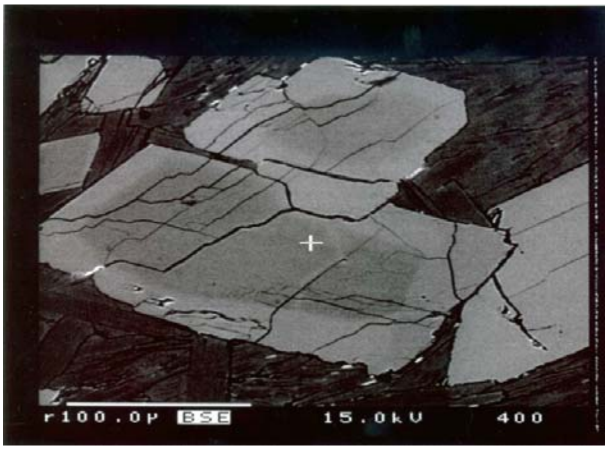

Figure 3: Back scatter electron image of compositional zoning in amphibole from sample 10c. The core contains more Mg and Ca and the rim is enriched in Fe, Na, and Al.

The boundary between 10c and 10d is marked by a line of Fe-oxide. This may mark the original reaction boundary between the serpentine and exotic block.

An actinolite schist about 5 – 10 cm in width follows. It contains actinolite (90%) and chlorite (10%) with traces of talc, apatite, and Fe-oxide. The chlorite is in pod-like form as if it has replaced a previous mineral. There is no rutile or titanite present.

The final zone sampled is about 3 – 5 cm in width. It contains talc (85%) and Mg – rich chlorite (15%). Chromite is present in trace amounts.

DISCUSSION

Several mineral trends are apparent in this traverse. Sodium-rich amphibole decreases in abundance in the first two zones. Actinolite increases in abundance until the appearance of talc. Chlorite is most abundant in the first 25 cm but then decreases toward the serpentinite. Chlorite shows a minor increase in abundance when talc appears.

From the glaucophanitic eclogite to talc the amphiboles show change in chemical composition which is apparent by the disappearance of glaucophane and the appearance of sub-calcic actinolite. Ca and Mg increase while Na, Fe, and Al all decrease (Figure 4). The increase in Mg is expected with the presence of talc at the end of the traverse.

The chlorites show an increase in Al_2O_3 for 10 cm but then decrease at 25 cm (Figure 5). They also show a very slight increase in MgO and a slight decrease in along the traverse.

These trends in mineral abundance and composition record decreasing rock concentrations of Na and Fe and increasing Mg concentration from the eclogite to mélange.

Other sample traverses collected displayed similar but not exact features as those in 10. A few contained zoned amphiboles with blue rims and green cores. Most samples had amphiboles with purple and blue zonation.

REFERENCES CITED

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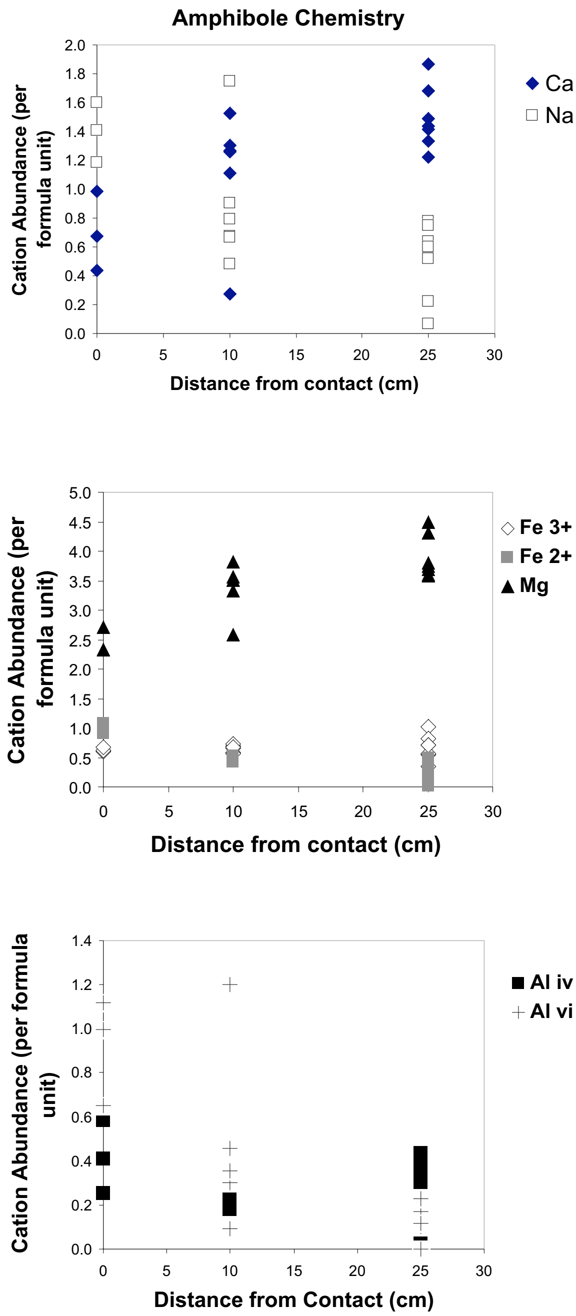

Figure 4: Cation abundance per formula unit for Na, Ca, Fe, Mg, and Al in amphiboles in traverse from eclogite (0 cm), through reaction zone samples 10a (10 cm)and 10c (25 cm). Distances are to the end of the sample in locality.

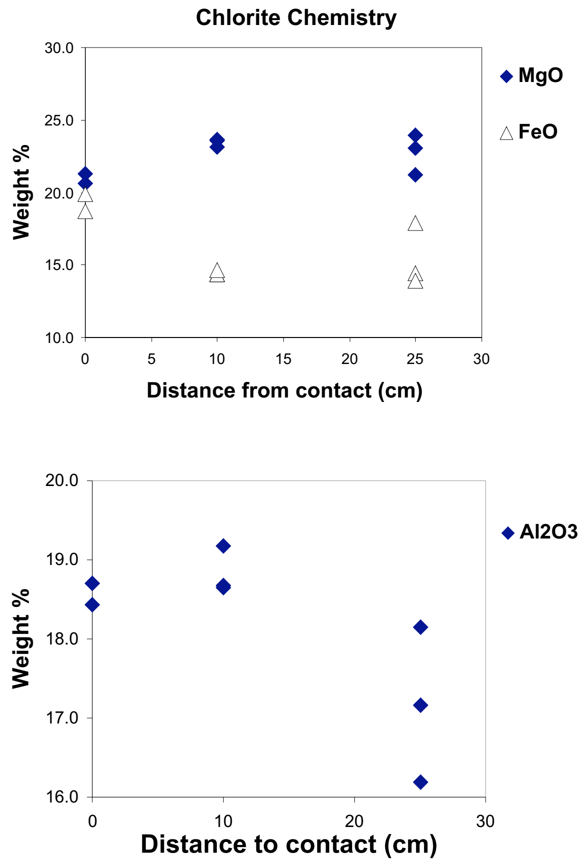

Figure 5: Variation in Wt. % oxides in chlorite in traverse from eclogite (0 cm) through reaction zone in three samples (10k, 10a, 10c).