GEOCHEMICAL ANALYSIS OF MAFIC AND FELSIC SCHISTS FROM SOUTH POINT AND KATERGAKI, SYROS, GREECE

DEBRA R. PRINKEY
GEOLOGY DEPARTMENT, THE COLLEGE OF WOOSTER
Faculty Sponsor: ALLEN DODSON, THE COLLEGE OF WOOSTER

BACKGROUND

Syros is an island located in the Cyclades Island chain, southeast of mainland Greece. The Cyclades are a subduction complex that has experienced several different episodes of metamorphism, including an Eocene blueschist facies metamorphism, Oligocene regional metamorphism which resulted in a partial greenschist facies overprinting, and a Miocene contact metamorphism due to the intrusion of an I-type granitoid (Schliestedt et al., 1987). Although the majority of the rocks exposed on Syros are marbles, mafic and felsic schists are found at several locations on the island, but their geochemistry has not been extensively studied. For this study samples were collected from two locations: Katergaki, in the southeast portion of the island, and South Point, the southernmost tip of Syros. At Katergaki, blueschists are found juxtaposed with quartzose micaceous schists; at South Point, similar felsic schists are found together with greenschists. Because of the complicated geologic history of Syros (Dixon and Ridley, 1987), choices for protoliths of these rocks include arc-type basalts and mid-ocean ridge basalts for the mafic rocks, and either silica-rich volcanics or sediments for the more felsic compositions. This study was undertaken in order to constrain the range of possible protoliths for these rocks.

METHODS

Samples of blueschsists and greenschists as well as quartzose schists were collected from Katergaki and South Point. Thin sections were made and analyzed to determine mineral assemblages. Major elements were analyzed by X-Ray Fluorescence (XRF) at Acme Analytical Labs Ltd., in Vancouver, B.C.; trace elements were measured by ICP-MS at Acme Labs. Some samples were also analyzed by SEM/EDS at Amherst College to confirm mineral assemblages and provide mineral composition data.

PETROGRAPHY

Katergaki blueschists contain glaucophane and omphacite; other minerals include epidote group minerals, garnet, chlorite, phengite, and paragonite. South Point greenschists predominantly are composed of quartz, chlorite, albite, garnet, epidote, and phengite. Felsic schists consist primarily of quartz, with minor amounts of chlorite, garnet, albite, epidote, glaucophane, paragonite and phengite. Alteration in all of these rocks seen in the field ranged from minor to extensive; veins in some samples contained calcite and quartz, in others rutile and epidote.

GEOCHEMICAL RESULTS AND DISCUSSION

sample no.	DRP00-4	DRP00-30	DRP00-35C	DRP00-46	DRP00-57	DRP00-17	DRP00-40A	DRO00-41	DRP00-53	DRP00-54	DRP00-31	DRP00-35A	DRP00-48	DRP00-49	DRP00-18	DRP00-40B
Location	SP	SP	SP	SP	SP	Kat	Kat	Kat	Kat	Kat	SP	SP	SP	SP	Kat	Kat
SiO2	50.27	49.5	49.9	48.6	48.25	47.5	45.09	49.93	46.13	44.65	76.54	73.77	84.59	75.38	72.02	78.69
TiO2	0.8	1.71	0.51	0.7	0.81	0.62	1.5	1.25	0.87	0.6	0.07	0.36	0.2	0.15	0.4	0.17
Al2O3	18.86	14.25	18	15.77	16.82	13.85	16.9	16.77	15.47	16.31	12.48	12.6	7.71	12.82	13.25	11.68
Fe2O3	10.46	11.14	9.81	12.52	9.43	10.44	11.81	8.43	10.75	7.34	1.2	3.85	1.36	1.33	4.4	2.2
MgO	3.05	5.82	4.55	4.32	7.05	10.77	2.63	6.94	8.31	9.75	0.15	0.81	0.3	0.61	1.13	0.23
CaO	7.43	9.31	7.63	8.94	8.36	10.97	14.78	9.09	8.39	15.93	0.1	0.62	0.66	0.5	4.51	0.18
Na2O	3.98	4.05	3.86	3.65	3.86	1.51	3.5	3.91	2.18	1.84	3.77	5.92	0.1	3.8	1.87	4.53
K2O	0.67	0.14	0.14	0.2	0.34	0.07	0.15	0.73	0.12	0.03	4.38	0.68	3.28	3.23	0.25	1.23
Ba	90	26	17	39	38	5	19	167	20	12	325	113	413	397	35	174
Nb	0.9	3.9	0.7	0.7	1	1.2	2.9	13.1	1.2	8.1	12.2	3.1	6.9	5.1	2.9	3.2
Sr	173.6	174.9	230.7	154.4	265.5	163.5	287	480.5	154.7	986.1	8.5	34.1	18.1	49.4	79.5	13
Zr	37.8	138.4	29.1	32.3	29.8	34.7	99.6	122.9	44.3	46.9	94.3	123.6	62.1	102.8	101.2	144.3
Y	19.1	40.6	14.7	18.8	13.9	13.8	31	20.8	15.5	14.9	24.5	27.6	17.8	14.1	38.3	36.7
La	3.3	10.2	2.4	2.8	4.3	20.6	4.6	15.2	7.3	26.9	9	9.3	39	28.6	8.9	7.8
Eu	0.78	1.85	0.59	0.72	0.86	1.08	1.42	1.58	0.85	1.43	0.1	0.87	0.67	0.63	1.37	1.23

Table 1. Selected geochemical data of mafic and felsic samples from South Point and Katergaki.

Table 1 shows selected geochemical data from Katergaki and South Point rocks. Some rocks in the field at South Point were initially classified as intermediate rocks due to their lighter color in hand sample, but are compositionally identical to darker rocks from the same area classified as mafic in the field. Both groups are therefore considered together for purposes of discussion.

Using major element data, Figure 1 shows a plot of $Si0_2$ vs. alkalis for mafic rocks (less than 52% silica) which is indicative of volcanic compositions. Most mafic rocks fall within the basalt field and are slightly tholeiitic; one sample plots in the picrobasalt field (DRP00-54). Assuming that these rocks have not experienced significant loss of alkalis, the results are compatible with the protoliths of these rocks being mid ocean-ridge basalt (MORB). South Point samples plot very tightly together, whereas Katergaki rocks are more diverse. This may reflect a more diverse protolith assemblage at Katergaki.

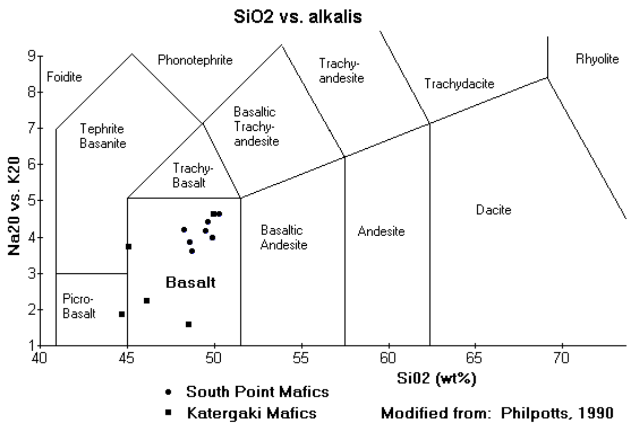

Figure 1. SiO_2 vs. alkalis for South Point and Katergaki mafic samples.

Rare earth element patterns normalized to chondrite compositions are shown below. The fairly flat patterns of the greenschists from South Point and Katergaki sample DRP00-40A suggest that they were derived from a MORB protolith (see Figure 2). Most Katergaki mafic rocks show a light REE enrichment. This could be due to addition of small amounts of continental-type sediment to a MORB source. Arc magmas also display this type of LREE enrichment. South Point felsic rocks (greater than 70% silica) have a REE pattern similar to shale which supports a sedimentary origin for the protoliths of these rocks. The other possible protoliths are felsic volcanics such as dacite or rhyolite, but the characteristic extreme europium anomaly of such lavas is not seen here. Katergaki felsic rocks appear to have sedimentary protoliths as well, but sediment sources may differ from the South Point felsic rocks since their REE patterns are different. The sample set of Katergaki felsic compositions is very limited, however.

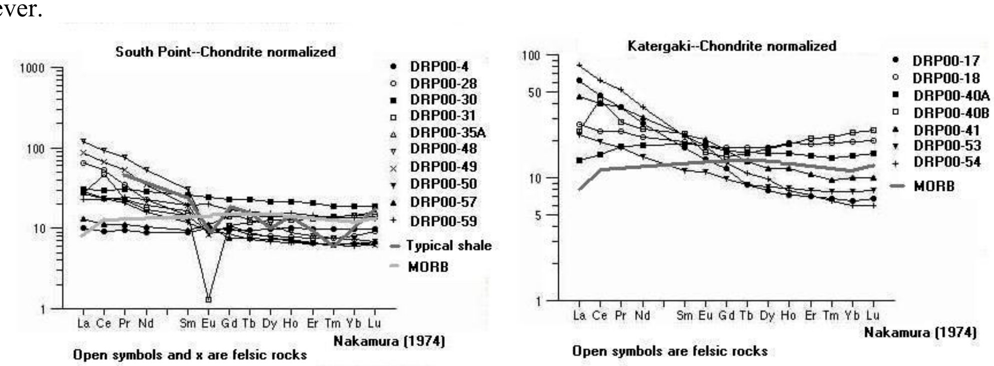

Figure 2. Chondrite-normalized REE plots for South Point and Katergaki; felsic samples are generally represented by open symbols and mafics by filled symbols. Typical shale and MORB patterns (Rollinson, 1993) plotted for reference.

MORB-normalized plots of selected trace elements (see Figure 3) illustrate that Katergaki sample DRP00-40A and South Point greenschists again have the signature of altered MORB protoliths because they have a rather flat signature. Some Katergaki mafic rocks, such as sample DRP00-17, show some deviance from the MORB signature, most likely due to sediment addition. Another possibility to be considered is that the protolith of the Katergaki blueschists is basalt from a volcanic arc. However, Ba/Nb ratios of these samples (Figure 4) are inconsistent with those found in arc basalt, suggesting that this origin is unlikely.

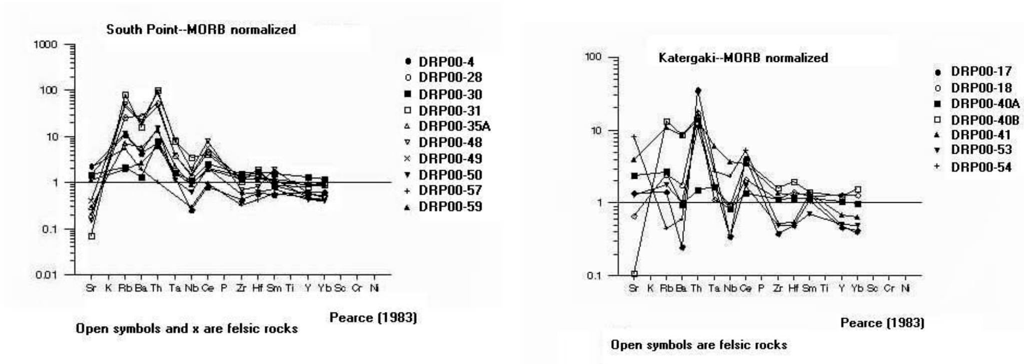

Figure 3. MORB-normalized trace element plots for South Point and Katergaki samples; felsics are open symbols and x s, mafics are filled symbols. More mobile elements (alkalis, alkaline earths) on the left of the diagram, more immobile elements on the right.

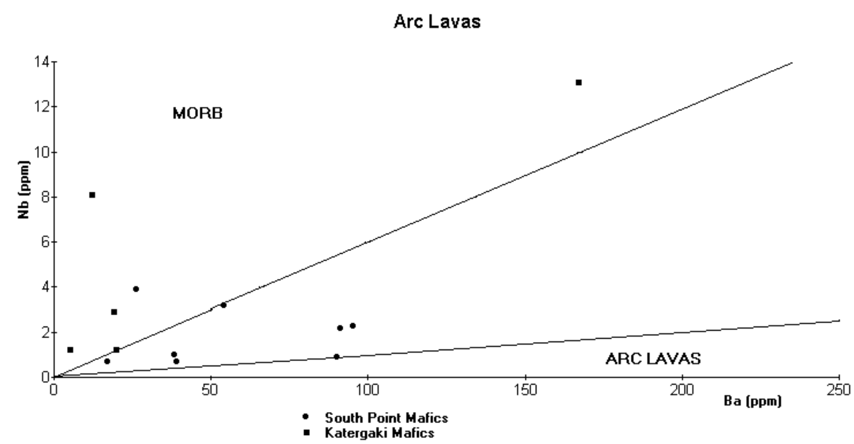

Figure 4. Barium vs. Niobium concentrations in Syros mafic samples; typical Ba/Nb ratios in arc basalts and MORB shown for reference (Gill, 1981).

The South Point felsic rocks are more enriched in elements such as Rb, Ba, and Th than the mafic rocks, indicative of a sedimentary protolith (Figure 3). Although the sample set for Katergaki felsic rocks is limited, a sedimentary origin for these rocks is suggested as well. Figure 5 shows alkali and silica concentrations for the felsic samples from both areas. Similar to Figure 1, which shows silica and alkali relationships for mafic samples, South Point rocks plot very tightly and Katergaki rocks are more diverse. The downward alkali trend with increasing silica is evidence for alteration due either to leaching by water after the sediments were metamorphosed leaving a silica-rich composition, or alteration by water before metamorphism. These sediments may have come from the same source because of the linear trend seen in the felsic rocks. The Katergaki sample that contains low alkalis and silica may have been a different type of sediment, but it is difficult to determine from the limited sample set.

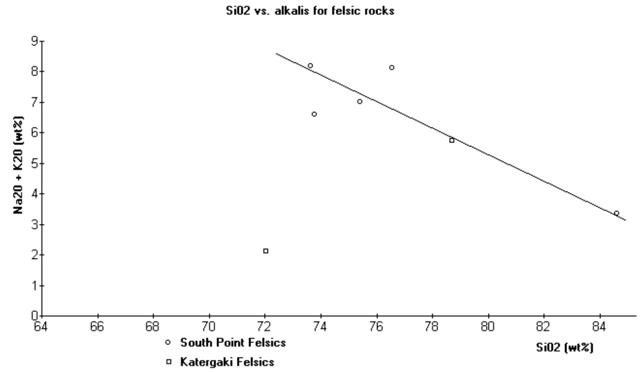

Figure 5. SiO_2 vs. alkalis for South Point and Katergaki felsic samples.

SUMMARY AND CONCLUSIONS

In summary, most mafic samples were originally MORB-type ocean floor basalts. Metamorphism of these basalts in a subduction zone, together with small amounts of sediment in some cases, has produced the metamorphic rocks we see today. The differences between the greenschists and blueschists, therefore, reflect differing metamorphic histories rather than different initial protoliths. The felsic schists found at both sample locations were once sediments; the sediment may have been similar in character and provenance, but the limited data set from Katergaki makes it difficult to determine this.

Some units in the field were in fault contact. These faults obviously occurred after metamorphic deformation, and therefore, could contribute to the juxtaposition of the mafic and felsic schists at South Point and Katergaki. Regardless, the diverse rock types testify to the heterogenous nature of material available for subduction, as shown by the involvement of terrigenous sediments and ocean-floor basalt at both locations.

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