Geochemistry of the Spuhler Peak and Pony-Middle Mountain Metamorphic Suites, Tobacco Root Mountains, Montana

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INTRODUCTION

From the beginning of the Montana Project in 1993, it has been concerned with the relationships among three suites of rocks in the Tobacco Root Mountains in southwest Montana: the Spuhler Peak Metamorphic Suite (SPMS), the Indian Creek Metamorphic Suite (ICMS), and the Pony-Middle Mountain Metamorphic Suite (PMMMS). Although much information was gained from the first group of projects, some basic questions about their relationships still remain. What was the protolith of each suite, in particular the PMMMS and the SPMS? Are the ICMS and the PMMMS one continuous suite of rocks? The answers to these questions are the focus of this project and will provide information concerning the assemblage and metamorphic history of these rock groups.

Several of the projects undertaken by other members of the Montana group are directly related to the present study. Jason Cox (Washington & Lee University) is interested in the protolith for the massive amphibolite unit in the SPMS. Jennifer Martin (Franklin & Marshall College) is looking at a similar question for the ICMS.

PREVIOUS WORK

Models interpreting the Archean history of the mountains of southwestern Montana in terms of processes active at modern plate boundaries have been proposed by Mogk and Henry (1988) and Cummings and McCulloch (1992). They suggest that the terrane east of the North Snowy Block is underlain by older granitoids with blocks of supracrustal rocks which are the products of subduction along a continental margin. The terrane west of the North Snowy Block, which includes the Tobacco Root Mountains, represents high-grade metasedimentary rocks of a stable platform. Mogk and Henry envisage the development of a rift-bounded basin intruded by oceanic crust and buried by nappes as the sides of the basin collapsed, probably as the result of continental collision. Clark (1987), however, argues that a continental rift zone, possibly associated with a "retro-arc setting", could also be a feasible setting.

The purpose of the Montana Project has been to define the relationships among three suites of rocks in the western and southern Tobacco Root Mountains and characterize their protoliths, metamorphic and structural history, and tectonic setting.

The Spuhler Peak Metamorphic Suite (SPMS) has been interpreted as a distinct lithologic package in the southern Tobacco Root Mountains (Burger, 1967; Gillmeister, 1971). It consists primarily of amphibolites interspersed with sillimanite schist, quartzofeldspathic gneiss, quartzite and ultramafic pods and dikes. It lies structurally above the Indian Creek Metamorphic Suite (ICMS) and below the Pony-Middle Mountain Metamorphic Suite (PMMMS). Results from the previous Keck project suggest that the protolith was a tholeiitic basalt (oceanic crust) which has been altered by hydrothermal processes (Peck, 1994) and thrust as an allocthonous block on top of the ICMS (Burger, 1967; Cummings & McCulloch, 1992). The meta-ultramafic rocks may have been part of a komatiitic flow (Poulsen, 1994; Sincock, 1994).

The ICMS is an interlayered sequence of quartzofeldspathic gneiss with marble, aluminous schist, quartzite, and iron formation. Jacob (1994) questions the earlier suggestions (Cordua, 1973; Wilson, 1981) of a sedimentary origin for this package, and concludes that the quartzofeldspathic gneisses may be largely of magmatic (volcanic) origin. She agrees with Wilson and Hyndman (1990) that the ICMS represents accretionary-wedge volcanics and sediments with related basaltic intrusions of a fore-arc basin in an island arc setting.

The PMMMS consists of interbedded quartzofeldspathic gneiss and amphibolite with minor amounts of quartzite and marble. It is presumed to be of similar origin to the ICMS. The homogeneity of the gneisses and the presence of metamorphosed plutonic rocks of similar age in adjacent ranges suggest a possible intrusive protolith. The nature of the contact between the PMMMS and the ICMS is unclear although Gillmeister (1972) states that it may be an unconformity, as the ICMS is older and is structurally below below the PMMMS. However, initial results of Owen (this volume) seem to indicate that the ICMS and PMMMS are one unit with changing lithologic constituents.

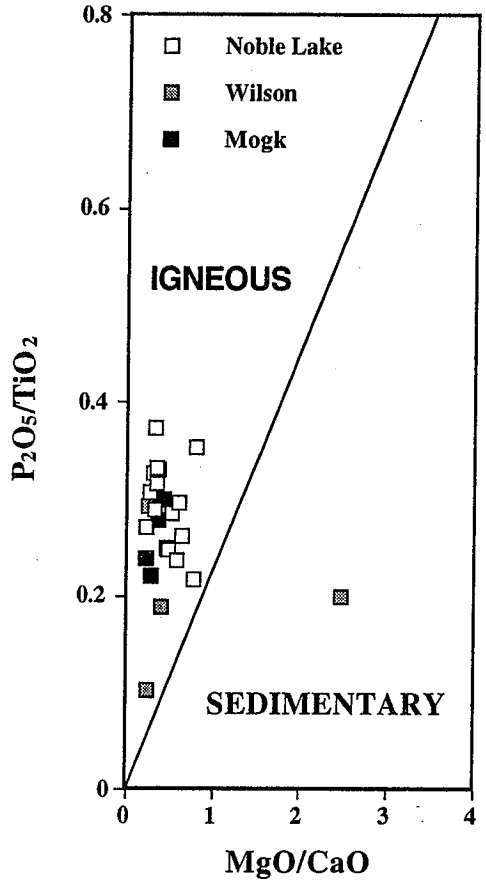

Figure 1. Major element discrimination diagram, after Werner (1987), suggests that quartzofeldspathic gneisses located structurally above the dominant marble horizon in the ICMS have an igneous parentage. Noble Lake and Branham Lakes analyses from this study; Copper Mountain analysis from Wilson (1981); Ramshorn Creek analyses from Mogk and others (1992).

Previous research focused on particular lithologies and sometimes particular expressions of the SPMS. The present study seeks to clarify the issue of protolith for the SPMS using an expanded database of all previous geochemical data plus additional sampling. Since little is known of the PMMMS, bulk chemistry analyses will provide information concerning its protolith and possible relation to the ICMS and SPMS.

METHODS

Twenty-three samples were collected from the SPMS: 7 quartzites, 2 garnet amphibolites, 14 quartzofeldspathic gneisses (four collected by Robert Burger) . Fifteen samples were collected from the PMMMS by John Brady: 7 amphibolites, 8 quartzofeldspathic gneisses. Sample preparation included removing weathering rind, crushing in a steel mortar and pestle, washing, drying and then powdering in a shatterbox. X-ray fluorescence was used to determine the concentration of major and trace elements.

DISCUSSION

Analysis of normative mineralogy, major element oxide ratios, and discriminant function values all indicate an igneous (volcanic) origin for the Tobacco Root quartzofeldspathic gneisses from the ICMS (Jacob, 1994). One major element discrimination technique after Werner (1987) is shown in Figure 1. Discriminant analyses after Shaw (1972) also indicate an igneous origin for these same gneisses. Initial information suggests that igneous (volcanic) rocks make up a larger proportion of the ICMS than originally believed.

A plot after Herzberg (1993) for the SPMS indicates tholeiitic basalt as a source for the amphibolites and komatiitic basalt or komatiites for the meta-ultramafics. This, however, does not explain the presence of the quartzites and aluminous schists within this unit.

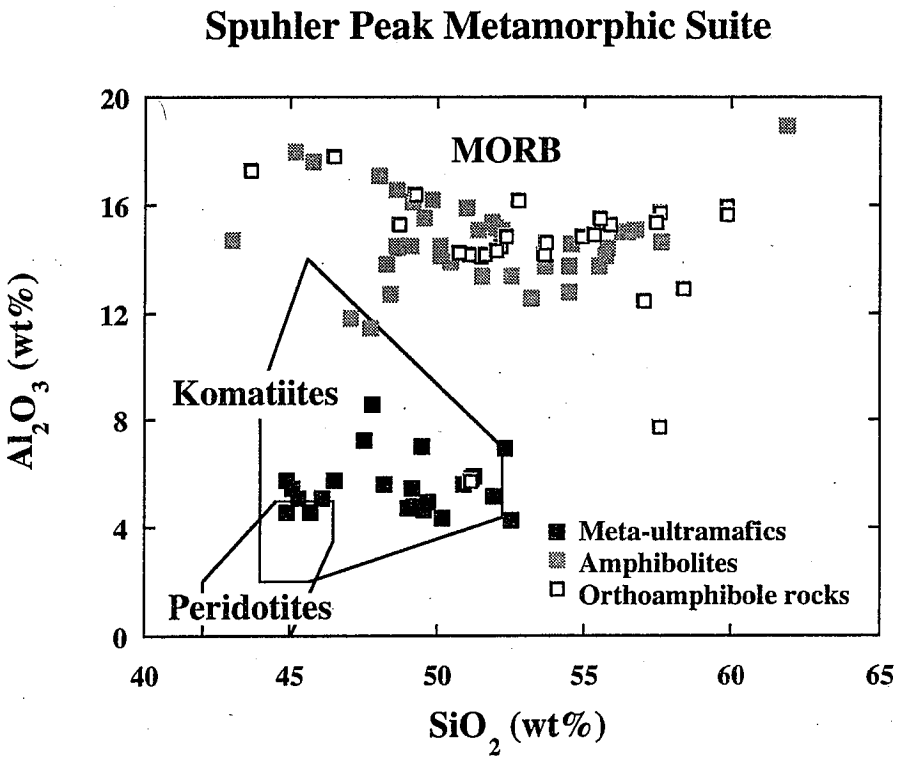

Figure 2. Plot after Herzberg (1993) for meta-ultramafics, amphibolites, and orthoamphibole-rich rocks from the SPMS which also support the contention that some SPMS rocks have komatiitic and basaltic komatiite affinities. Analyses: 64 this study, 20 from Cummings and McCullough (1992), and 6 from Friberg (1976).

Hopefully, if the results of analyses for the ICMS and PMMMS are consistent and demonstrate that the units are dominantly volcanic, then a similar tectonic and/or depositional environment (such as an island arc setting) can be inferred. Analyses confirming the SPMS as oceanic crust would suggest juxtaposition occurred during a collisional event and would make it less likely that these contacts represent an unconformity.

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