Precambrian Talc-Associated Marbles of the Southern Ruby Range, Southwestern Montana

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Introduction

Large-scale, bedded dolomitic marbles of the Ruby Range in southwestern Montana have been preferentially replaced to form large talc bodies. The marbles are Archean in age and are associated with quartzofeldspathic gneiss (the Dillon Granite Gneiss), schists, quartzites, amphibolites, and banded iron formations. These rocks have undergone amphibolite- to granulite-grade metamorphism dated at approximately 2750 Ma (James & Hedge, 1980). The granulite-amphibolite-grade assemblages were then overprinted by a regional retrograde greenschist event in the Proterozoic. K-Ar dating of biotite and muscovite and Rb-Sr whole-rock dating of the quartzofeldspathic gneiss yielded dates of approximately 1.6 Ga for the retrograde greenschist event (Giletti, 1966). The dominant foliation and tight, isoclinal folds in the Ruby Range strike northeast and dip northwest. These structures are offset by a series of major northwest trending faults which have undergone recurrent movement during the Proterozoic. Loosely associated with these faults are several sets of diabase dikes which were intruded during the Proterozoic.

The overall purpose of our group project was to study the large talc bodies in the Ruby Range and try to determine their origin and timing of formation. While some students concentrated on the talc itself, the faults, or the dikes, I chose to focus my attention upon the marbles in which the talc formed. The composition of the marble in the Ruby Range varies in relation to its proximity to the large talc bodies. The purpose of my project was to characterize this variation in the hope that it would lead to some conclusions concerning the dolomitization of the talc-forming marble. Specifically, I wanted to determine if the dolomitization of the marble was syn-talc formation or simply a precursor stage to the formation of the talc.

Field Methods

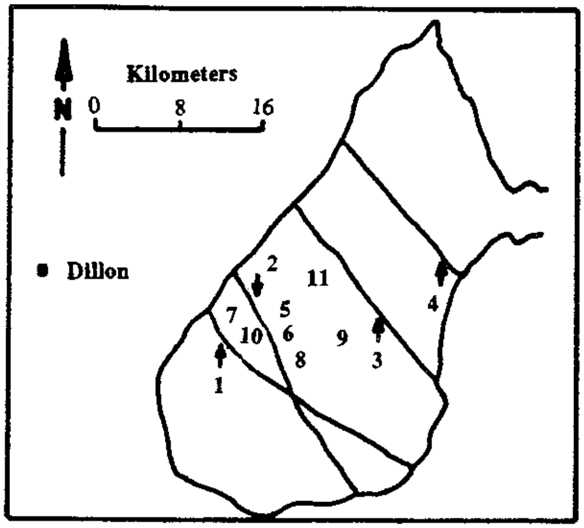
The field portion of my project was spent collecting samples at a variety of locations throughout the southern Ruby Range, along with one locality in the northern portion of the range. The northern part of the range was basically ignored because the Archean basement rocks there are covered by Phanerozoic sediments. Samples were collected from locations including the Regal-Keystone Mine, American Chemit-Pope Prospect, Smith Dillon Mine, Sweetwater Road Mine, MP Claims, and Ruby Peak in the northern part of the range. Samples were also collected from traverses made through Van Camp and Axes Canyons (Graphite Mine Traverse), and along the Stone Creek Road. Figure 1 shows the sampling localities and major faults in the southern Ruby Range.

An effort was made during field excursions to obtain a representative sampling of marble immediately adjacent to the large talc bodies, as well as of the unaltered or non-talcified marble several miles along strike of the talc bodies. The field (geometric) relationships of the talc and marble were especially noted for comparison to thin-section relationships and textures.

The Regal-Keystone Mine was chosen as a representative example of talc-marble relationships in the Ruby Range. A larger number of samples were collected at this mine than at the other localities in order to better document the talc-to-marble transition. A number of samples were taken from the actual pit itself, along with samples from the prospect trenches and samples along strike from the main talc body. The Regal-Keystone Mine lies within a structural synform of dolomitic marble, which was sampled randomly away from the mine. Figure 2 shows the Regal-Keystone mine, the marble body it lies within, and the locations of the samples collected within it.

Laboratory Investigations

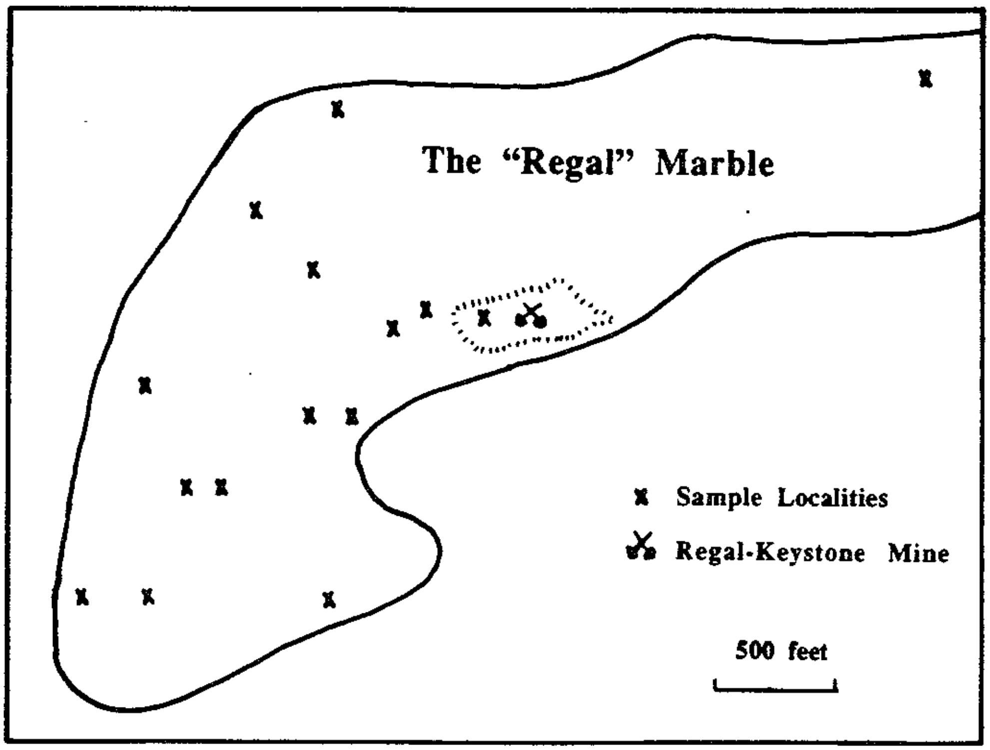
Laboratory investigation of the samples consisted mainly of standard petrographic analysis. Thirty-seven samples were cut and sent to Pioneer Thin Sections for production. All of the thin sections were stained for calcite and dolomite with a mixture of Alizarin Red S and potassium ferricyanide. After preliminary analysis of the thin sections, it became clear that X-ray diffraction analysis would be necessary



1. Sweetwater Fault
2. Carter Creek Fault
3. Stone Creek Fault
4. Cottonwood Creek Fault
5. Regal-Keystone Mine
6. American Chemit-Pope Prospect
7. Smith Dillon Mine
8. Sweetwater Mine
9. MP Claims
10. Graphite Mine Traverse
11. Stone Creek Traverse

Figure 1. General sketch map of the Ruby Range showing the location of major faults and sampling localities in the southern portion of the range. Modified from Anderson, et al. (1990).

Figure 2. General sketch map of the "Regal" marble showing the location of the Regal-Keystone Mine and the locations of the sample collecting sites in and around the mine.



to clarify much of the microcrystalline and altered minerals present within the thin sections. This work is currently in progress, but some clarification has already been achieved. Cathodoluminescent petrography was utilized on a reconnaissance scale in the hope that it would reveal primary textures that were not noticeable otherwise. This type of analysis proved most useful in accenting or highlighting features already revealed by the staining and standard petrographic analysis.

Discussion

Two broad distinctions have been noted so far in the composition of the marbles. In general, the marbles associated with the talc bodies are dominantly composed of dolomite, with minor calcite, talc, phlogopite, and graphite. The calcite which is observed in the dolomite occurs as tiny disseminated grains throughout the dolomite matrix. In many cases, the disseminated calcite is so fine that it ony manifests itself in the form of a pinkish stain in the otherwise clear or bluish-stained dolomite. The assumption that the pinkish stains represent finely dispersed calcite within large dolomite crystals has been initially verified with an EDAX-equipped scanning electron microscope at Amherst College. This type of texture has been interpreted as unmixing of dolomite with excess calcium at temperatures above the normal stability of dolomite. As the dolomite reformed, it incorporated this excess calcium in the fom of tiny disseminated calcite grains into its structure. Reaction rims of calcite around talc blebs in the dolomitic talc-marbles were also noted. This indicates that as the talc formed within the dolomite, the Mg^{++} was removed, leaving a reaction rim of calcite. This was also observed in the field at the Regal-Keystone Mine, where a talc body tens of meters across was separated from the surrounding dolomite by a calcitic, phlogopite-rich layer of marble approximately one meter thick.

The other general type of marble which was observed in thin-section was a calcite-rich marble with phlogopite, dolomite, forsterite, tremolite and apatite (distinguished by cathodoluminescence). Many examples of coarse exsolution lamellae of dolomite within the calcite crystals were observed, indicating unmixing from a higher grade mineral assemblage. This was also observed by Anderson, et al. (1990), who also noted that the higher grade calcite marbles were usually unaltered marbles not directly associated with the talc deposits. They interpreted these marbles to be the original Archean carbonate which was later dolomitized and selectively replaced by talc. However, most of the unaltered, non-talc-associated marble which I collected in the field proved to be mainly dolomite with only minor calcite scattered throughout it, as described previously. This was determined both by the staining of the thin sections, as well as by the X-ray diffraction analysis which has been performed so far.

Much of the mineralogy, particularly the silicates, within the marbles is so fine-grained that identification by petrographic means is difficult to impossible. This is particularly true in the differentiation of talc, serpentine, and chlorite. Thus, work is currently in progress to dissolve the carbonate out of some of these samples in order to identify the silicate minerals with X-ray diffraction. Until the precise silicate mineralogy is known, interpretation of the history of dolomitization will be uncertain at best. However, initial results indicate the likelihood of Archean dolomite, and thus a more complicated story than put forth by Anderson, et al. (1990).

References

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THE CHEMISTRY AND METASOMATIC ORIGIN OF THE TALC DEPOSITS OF THE RUBY RANGE, SOUTHWESTERN MONTANA

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INTRODUCTION

The Archean marbles of southwestern Montana have been the primary domestic source of steatite grade talc for many years(Berg, 1979). Many studies have been completed over the past several decades in order to better understand the geology and, more specifically, the talc mineralization of this area (Garihan, 1973;Berg, 1979; Anderson and others, 1990). Despite the considerable amount of work on these deposits, very little has been published about the chemistry of the talc and the subsequent metasomatic fluids. Therefore, my project centered on the collection and analysis of talc and marble specimens from seven mines and prospects in the Ruby Range (Figure 1). The primary goals of the chemical analyses were to characterize the chemical homogeneity of the talc deposits and the chemical make up of the metasomatic fluids.

OBSERVATIONS AND TECHNIQUES

Specimen Collection, Petrography and X-ray

Over one hundred specimens of talc and carbonate were collected from the Cresent Ranch Mine (1), the Smith-Dillon Mine (2), the Sweetwater Mine (3), the American Chemet Mine (4), the Regal-Keystone Mine (5), the Cottonwood Creek prospect (6), and the MP prospect (7)(Figure 1). The talc and unaltered carbonate specimens were collected in close association with each other to bracket the chemistry of the metasomatic fluids. Petrographic analysis of several talc and marble specimens was undertaken to effectively correlate collected chemical data with specific mineral assemblages. The thin sections studied were principally talc and carbonate. The majority of the carbonate is dolomite; however, the mineralogy varies from calcite to magnesite. Graphite is also common in both the talc and marble. Many of the specimens also contained sparse amounts of iron oxide and pyrite. X-ray diffraction of some of the samples was required to discern the individual mineral components of some cryptocrystalline talc specimens. Chlorite and a ten- angstrom mica, possibly phlogopite, were identified in the x-ray analysis.

Microprobe

Several different methods have been employed in the analysis of mine and prospect samples. The electron microprobe at Texas A+M University was used to obtain chemical traverses on several thin sections of talc and carbonate. The traverses across the microscopic boundary between the talc and carbonate indicated no consistent chemical patterns. The boundary was occasionally observed as a well defined, jagged segregation (Figure 2), but typically as a zone of gradation over a distance of fifteen microns. Many of the same relationships that were evident in petrographic thin section were also encountered during microprobe analysis. The chemistry of the talc was similar throughout the several thin sections sampled (Figure 3). The talc is relatively pure $Mg_3Si_4O_{10}(OH)_2$ with minor amounts of Al, Fe, and Mn. The talc also contained trace amounts of F but virtually no Cl. Anderson and others (1990) proposed sea water (saline solutions) as the source of the metasomatic fluids in the Ruby Range. Oxygen isotope data collected by Amy Larson and Angela Vasquez support this theory. However, the very low halide concentrations found in the talc contest the involvement of saline solutions.

A few dolomite remnants found in a talc matrix did exhibit slightly higher Ca/Mg ratios, evidence of a depletion of Mg in the marble during the talcification process. Back-scatter electron images of the carbonate also exhibited high concentrations of Fe, locally up to 3 wt.%. However, this observation was rare and the Fe concentration apparently did not alter the chemistry of the adjacent talc.

A series of reddish cryptocrystalline talc specimens collected at the Sweetwater Mine were found to contain significant amounts of K and Al with minor levels of Mn. Based on stoichiometry, the levels of K and Al indicated the presence of the mineral muscovite or sericite. Analysis of a blue cryptocrystalline mineral collected from the same location indicated the presence of Ca and P which stoichiometrically indicates the existence of apatite. The occurrence of the reddish mineral is common only to the Sweetwater Mine and might represent altered gneiss. Apatite is commonly found in several mines and prospects, in