HYDROTHERMAL ALTERATION ZONES AND LANDSCAPE EVOLUTION IN THE CITY OF ROCKS NATIONAL RESERVE, IDAHO

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INTRODUCTION

The City of Rocks National Reserve is located in south-central Idaho near the town of Almo. The reserve occupies the center of the southern-most structural dome of the north-trending Albion Range, which is located in the Basin and Range geologic province. The City of Rocks consists of an Oligocene granite pluton which has been differentially eroded into spectacular fins, domes, and spires. This 29 ma granite, known as the Almo Pluton, intruded Archean and Proterozoic rocks which make up the oldest rocks exposed within the Raft River-Grouse Creek-Albion Range metamorphic core complex. The pluton was emplaced at a depth of 10 to 12 km (Miller and Bedford, 1999). Archean gneiss of the Green Creek Complex constitutes the oldest rocks in the National Reserve and is overlain by Neoproterozoic metasediments, most notably the Elba Quartzite, which forms hogbacks around the basin of the City of Rocks. The carapace of the core complex consists of deformed Paleozoic metasediments. The metamorphic core complex underwent drastic uplift and multiple episodes of extension in the Cenozoic that displaced much of the sequence and caused erosion and removal of material overlying the Almo Pluton. The two extensional events that affected the pluton occurred during the early and late Miocene. The first created a west-dipping low angle detachment fault, and the second created an east-dipping detachment fault (Miller and Bedford, 1999).

Recent geological studies of the area conducted by the USGS noted large-scale alteration zones within exposures of the Almo Pluton in the City of Rocks (D. Miller personal communication). While it was observed that several of the zones were north-trending, information regarding the distribution, age, and composition of the zones was not obtained. This study proposed to thoroughly investigate the zones and using this information, determine the timing and structural controls on their emplacement. A further goal of the study was to determine if these alteration zones have had significant effects on the geomorphology of the City of Rocks.

METHODS

Field data was gathered by hiking around the City of Rocks and Castle Rocks, and locating as many outcrops of sericitic and silicic alteration within the Almo Pluton as possible. Locating the zones involved identifying float rocks that exhibited alteration characteristics (red, orange, or silvery-gray colors, or quartz-rich) and then tracing them to their outcrop source. At each outcrop, orientation measurements were taken as well as notes on the degree and characteristics of alteration. All outcrops were plotted on aerial photographs and topographic maps using known landmarks, elevation, or GPS coordinates. Samples were collected from the Castle Rocks area in order to make thin sections to examine the mineralogy. Potassium-argon dates were obtained for two samples with a high mica content. Aerial photographs were used to find likely sites of alteration. Because alteration zones are more susceptible to erosion, many of the zones were found in narrow valleys between granite outcrops and presumably more lie concealed below colluvium or vegetation. The orientations of the zones were plotted on a rose diagram (fig. 1) to show the variation in strike direction. The zones were also plotted on an aerial photograph to show their geographical distribution.

RESULTS

The majority of the alteration zones are oriented between N0W and N20W (fig 1). Many of the zones that do not fall within this range occur as sets of small joints that exhibit minor alteration that consists only of iron staining with no significant secondary mineralization. The alteration zones were found either within the major vegetated valleys (known as "avenues") or at the edge of avenues where they crop out at the base of prominent fins or spires.

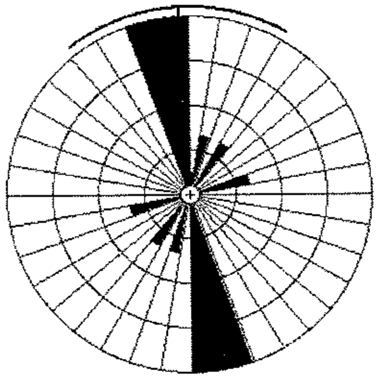

Figure 1

K-Ar radiometric ages obtained from the muscovite-bearing alteration zones are approximately the same as K-Ar ages determined in an earlier study by Armstrong and Hills (1967) for the main body of muscovite granite. The dates obtained from two different zones are 23.4 +/- 0.6 m.y. and 25.3 +/- 0.7 m.y. compared to the average date obtained by Armstrong and Hills (1967), which was 24.7 m.y. This data indicates that the mineralized joint planes formed simultaneously with the cooling of the pluton, and were not a result of a secondary post-cooling event.

The mineralogy of the alteration zones consists of fine-grained muscovite (sericite) on joint surfaces and more coarse-grained muscovite within heavily mineralized veins. Slickensides are common on sericitic joint planes indicating that small amounts of slip occurred parallel to the joint surfaces. The veins have a high silica content and minor sulfide content (generally oxidized). Large (up to 2 cm), euhedral hematite (after pyrite) pseudomorph crystals occur within heavily altered zones, some of which have pyrite cores. The thin sections show high amounts of coarse-grained muscovite sprays initiating at nucleation points as well as needle-like, interlocking crystals with random orientations. . Some lath-shaped euhedral muscovite crystals also occur. Quartz is the second most abundant mineral and it is generally anhedral and interstitial. Many of the quartz crystals contain inclusions of fine-grained muscovite and opaques, most likely sulphides and oxides. Deformation textures are absent from the thin sections. Veins with large amounts of silicification contain euhedral quartz crystals within vugs. The vugs indicate the potassium and silica-rich fluids that deposited these veins had a high volatile content. Minor amounts of orthoclase and plagioclase also occur within the alteration zones. The classification of the muscovite as sericite is somewhat misleading because sericite is generally classified as a fine-grained white mica, and is usually an alteration product of plagioclase. In the studied alteration zones the muscovite is very coarse and does not predominantly occur as small-scale alteration of plagioclase, instead it is more likely a primary muscovite deposited from potassium-rich hydrothermal fluids released by the cooling pluton. Preliminary microprobe analysis indicates that the muscovite contains higher amounts of magnesium than is typical for muscovite, and for this reason it may be better described as phengite.

CONCLUSIONS

The hydrothermal alteration zones found in the Almo Pluton are oriented perpendicular to the regional extension during the Cenozoic (Miller and Bedford, 1999) indicating that while the pluton was cooling, joints were forming perpendicular to the regional extension, which was a result of Basin and Range tectonics. As the pluton was unroofed, it depressurized, releasing volatile components. The low-angle normal faults contributed to the unroofing of the pluton while hydrothermal fluids were released causing mineralization and alteration along north-trending joints. The fluids traveling along the joints may have also facilitated small amounts of slip parallel to the joint planes.

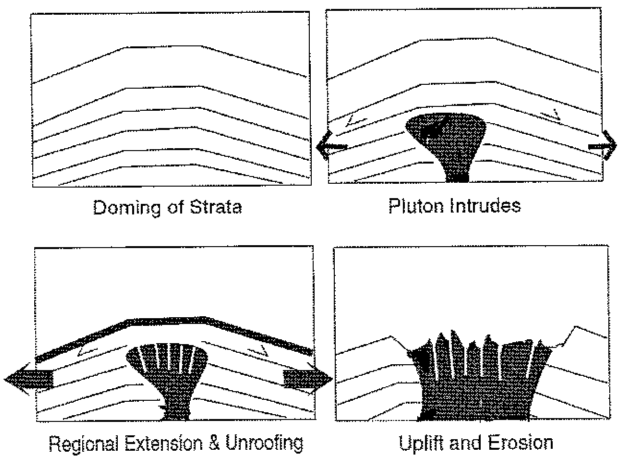

Figure 2

The hydrothermally altered zones in the Almo Pluton are more easily weathered than the unaltered granite due to the increased muscovite and sulfide content, as well as the occurrence of vuggy quartz (fig. 2). The increased weathering along these zones is responsible for the distribution and orientation of the large-scale fins and spires and "avenues" within the City of Rocks National Reserve (see fig. 3). Thus, the overall landscape evolution of the City of Rocks is a function of the pluton's history of unroofing due to uplift, tectonic extension, and differential erosion along north-trending hydrothermal alteration zones. The north-trending "avenues" that transect the City of Rocks are a direct result of this process.

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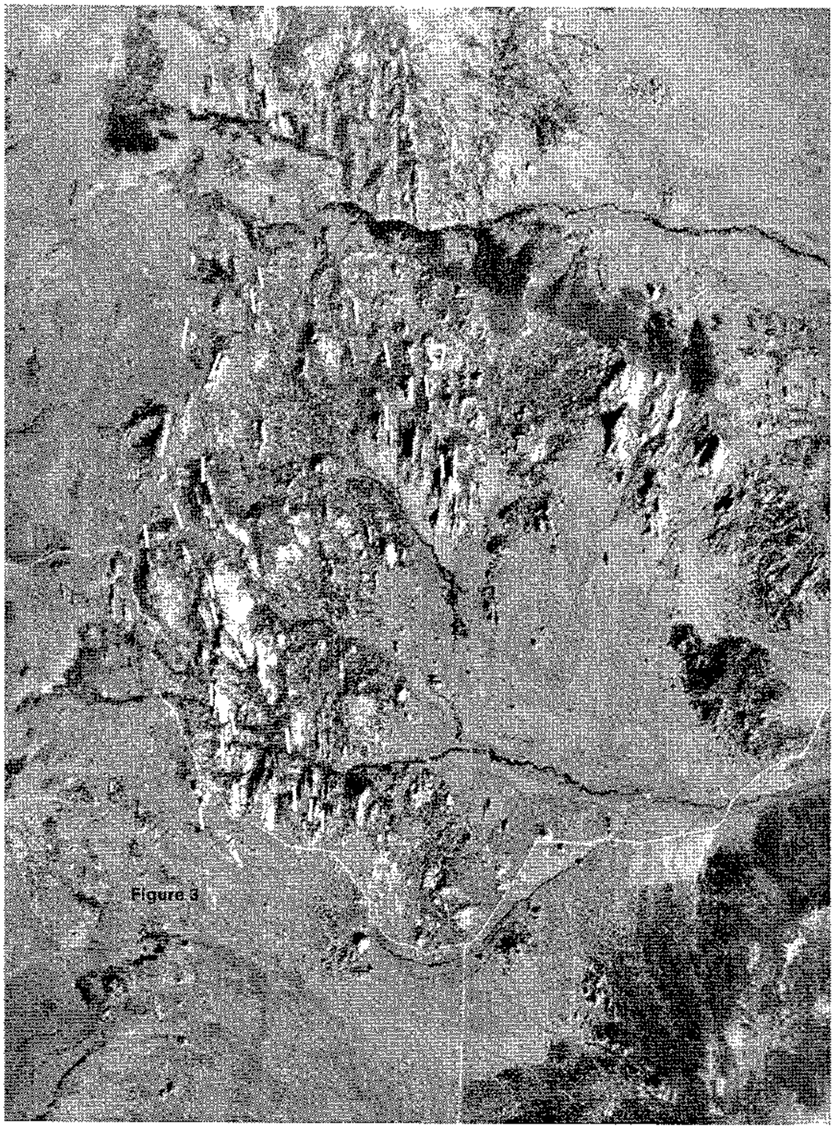

THE MARS 2000 PROJECT: USING MARS ORBITER LASER ALTIMETER DATA TO ASSESS GEOLOGICAL PROCESSES AND REGIONAL STRATIGRAPHY NEAR ORCUS PATERA AND MARTE VALLIS ON MARS

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