JOINT CONTROL OF LANDFORMS IN THE CITY OF ROCKS NATIONAL RESERVE: ALMO, IDAHO

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INTRODUCTION

The City of Rocks National Reserve, in southern central Idaho lies within the Northern Basin and Range province. The City of Rocks is part of a northeast trending mountain range, known as the Albion Range, which is comprised of 4 major gneiss-cored structural domes (Armstrong, 1968). The City of Rocks is characterized by large granitic landforms, surrounded by similar outlying gneissic landforms (Armstrong, 1968). The granite, which is 28 million years old, intruded the older gneissic country rock which is 2.5 billion years in age (Armstrong, 1968).

The landscape consists of large landforms that are up to 400-500 m in length and as much as 100-150 m high. These landforms take on a variety of different shapes, ranging from towers, to domes to fins. Intense jointing is prevalent in all landforms. There are 3 primary types of jointing, which include vertical, sub-horizontal and exfoliation, or sheeting, joints. The purpose of my study was to see whether there is any correlation between the overall shape of the landforms and the dominant type of jointing present in each landform.

Landforms of irregular shapes are found in a variety of landscapes all over the world (Brown and Waters, 1974; Ehlen, 1991, 1992, 1999; Segall and Pollard, 1983), but currently there is little known about what determines the shapes of the landforms at the Earth's surface; whether it is just weathering (Twidale and Bourne, 1998), lithology (King, 1975), joint control (Cunningham, 1971) or some unknown factor. Ehlen (1992) has looked at the influence of jointing as well as mineralogy, grain size and texture in the Dartmoor granite in England. She concludes that jointing patterns control landform shape but suggests that other factors may contribute to the shape as well (Ehlen, 1992). There have been a few studies in the City of Rocks (Miller, 2000; Cunningham, 1971) that have noted the importance of the joints in controlling the shapes of the landforms, but there have been no systematic studies done to date.

METHODS

In the field I measured strike and dip of 850 joints on 33 different landforms. In addition to recording strike and dip I also noted the type of joint. For each landform I sketched and photographed each side (usually 4). I also tried to insure that I took measurements on a variety of differently shaped landforms. In the lab I plotted all of the strike and dips on stereonets. I made separate stereonets for each type of joint found on a particular landform, as well as a composite stereonet for that landform. I did approximate counts of the number of each type of joint in each slide and sketch, so that I could determine which type of joint was the most prevalent for each landform. I also came up with a classification scheme for the shape of all of the landforms. I used aerial photos and data collected in the field to help determine the overall landform shapes.

RESULTS

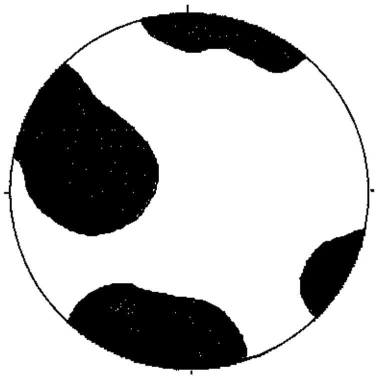
Landforms that have a dome or half-dome shape are dominated by exfoliation joints. Fins have an abundance of vertical joints perpendicular to the trend of the fin, but the short axis of the fin tends to be dominated by exfoliation joints. Towers are comprised of a combination of vertical and sub-horizontal joints. Towers that are more pyramidal (a wide base and small top) have more sub-horizontal joints. Spirelike or culumnar towers (constant area at the base as well as the top) are dominated by vertical joints. There are 4 out of 35 landforms that do not fit into this pattern.

DISCUSSION

To determine whether the joints actually have a major role in controlling the overall shape of the landforms, I compared the shape of each landform to its most prominent joint set. Most landforms are comprised of two if not all three major types of joints. Therefore, the determination of which is the most prominent joint does not suggest that it is the only type of joint, or even that there are few other joints.

All of the towers are dominated by vertical and/or sub-horizontal joints. Towers in general are comprised of relatively few joints. Pyramidal towers tend to be dominated by sub-horizontal joints, whereas spirelike, or culumnar towers are comprised almost entirely of vertical joints. In pyramidal towers the sub-horizontal joints determine the general appearance of the landform, whereas the vertical joints appear to be secondary in importance. Alternatively, in spires the vertical joints delineate the overall shape of the landform; the sub-horizontal joints only serve to subdivide it. Many of the stereonets of the towers show clumps of vertical joints at approximately 90 degrees to one another, defining the four sides of the rock (see Figure 1). Towers that tend to be more circular when viewed in aerial photos, have vertical joints dispersed around the stereonet, they do not have as many large clumps as the squarer ones (see Figure 2).

Figure 1: The contours of poles to the planes of all joints measured on Lost Arrow. There are 4 major contours suggesting that there are 4 major joint directions, as would be expected for a tower.



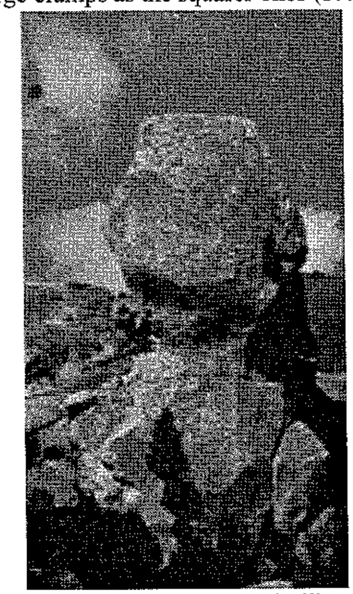


Figure 2: Lost Arrow – a spirelike tower.

Fins are dominated by vertical joints perpendicular to their long axis (see Figures 3 and 4) and frequently have exfoliation joints on their short axis. It would be expected that the vertical joints would be parallel to the trend of the overall fin. However, this does not appear to be the case in most circumstances. In 5 out of 13 cases the vertical joints are perfectly perpendicular to the long axis of the fin. In 4 out of 13 cases there is some correlation (see Figure 4) between the orientation of the fin and the joints, and in the other 4 there is no correlation. This suggests that there are other factors affecting the shape of the rock or its orientation. It is likely that the vertical joints perpendicular to the long axis existed before the landform was weathered into its current form. Thus, these perpendicular joints do not control the shape of the landform. Occasionally there are vertical joints parallel to the long axis and it is likely that these joints influenced the overall shape of the landform and the shorter vertical joints that are perpendicular or at some acute angle to the long axis, are secondary. Also, it is likely that the vertical joints parallel to the long axis cannot be seen because they border the fins, and are not exposed at the surface. Furthermore, Woodruff (this volume) found that North-South vertical joints are highly susceptible to weathering because they are likely to contain hydrothermal alteration. The fins have a general northerly trend, which correlates to many of the primary flow structures (Bandy, 1992) identified in the City of Rocks. Dimetrodon Rock (Figure 3) is parallel to the primary orientation of shear foliation in the City of Rocks (Bandy, 1992).

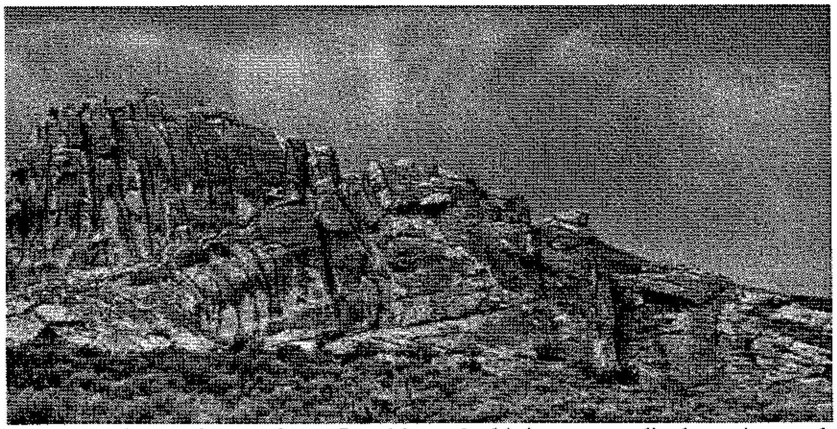


Figure 3: Dimetrodon Rock – a fin with vertical joints perpendicular to its trend.

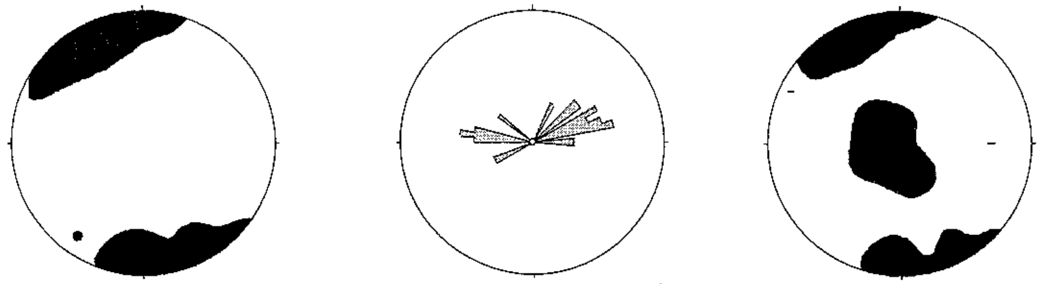


Figure 4: Stereonets from Dimetrodon Rock. A. Contours of the poles to the planes of vertical joints. The 2 clusters are illustrative of the dominant E-W joint set seen in Figure 3. B. Rose diagram of the vertical joints. The joints are primarily E-W and are nearly perpendicular to the trend of Dimetrodon Rock. C. Contours of the poles to the planes of all joints. The exfoliation and sub-horizontal joints are in a separate group from the vertical joints.

All of the landforms that are domes or half-domes are comprised primarily of exfoliation joints. The landforms that have domelike characteristics in addition to spirelike or finlike aspects have either purely exfoliation joints or exfoliation joints in addition to vertical or sub-horizontal joints. Domes are dominated by exfoliation joints but commonly have some vertical and sub-horizontal joints as well (see Figures 5 and 6). Steronet data show that domes are usually indicated by dispersed data points with a variety of orientations as well as a range of dips (see Figures 7 and 8). This is to be expected because domes are innately rounded. To form a rounded feature a wide variety of orientations are needed.

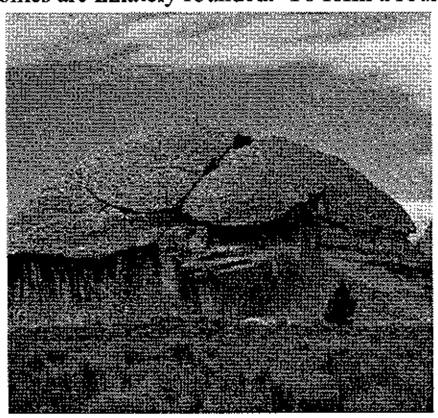


Figure 5: Kaiser's Helmet – a dome.

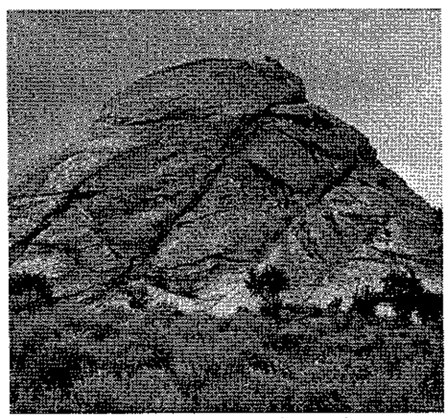


Figure 6: Treasure Rock – a dome.

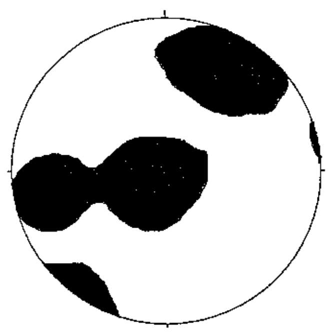


Figure 7: Contours of the poles to the planes of all joints measured on Kaiser's Helmet. There are a few groups that vary in strike as well as dip, which is expected, since the rock is dominated by exfoliation joints.

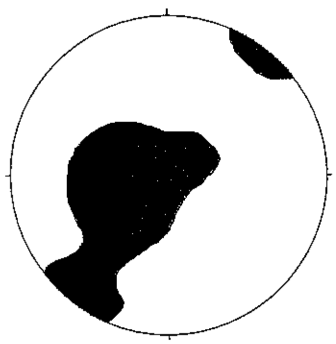


Figure 8: Contours of the poles to the planes of exfoliation joints measured on Treasure Rock. The dominant central group is indicative of exfoliation joints, which have a shallow dip.

CONCLUSION

The shape of the landforms found in the City of Rocks National Reserve are strongly influenced by their jointing patterns. However, there is not complete correlation between jointing and overall form in all landforms, which suggests that drainage patterns, texture, mineralogy, grain size or some other unexplored factor may additionally influence landform shape. The primary flow structure exhibited in the City of Rocks correlates strongly with the trends of the fins, which suggests that these flow structures may influence the shape and orientation of at least some of the landforms.

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