GEOMORPHOLOGY AND EVOLUTION OF THE CIRCLE CREEK BASIN, SOUTH-CENTRAL IDAHO

MEREDITH BRISLEN
Department Of Geology, Beloit College
Faculty Sponsor: Carol Mankiewicz, Beloit College

INTRODUCTION

This study is an interpretation of drainage basin development in the Circle Creek Basin of the City of Rocks National Reserve. The basin currently exhibits two separate pediment surfaces: the existing basin floor and an historical erosion surface. This proposed erosion surface has been witness to regional geologic activity and portrays a record of previous events including activity related to the Yellowstone plume, which was situated north of the field area about 10 Ma. The increased heat and geothermal activity associated with the mantle plume influenced basin erosion and development due to uplift and crustal thickening.

The purpose of this study is to relate the deformation and erosion of the Circle Creek Basin to the migration of the Yellowstone Hot Spot, as well as present a topographic map of a proposed erosional surface that was present during the time that the hot spot was active in the Albion Mountain region.

REGIONAL GEOLOGY

The City of Rocks National Reserve is located in south-central Idaho, in the southern part of the Albion Mountain Range (Fig. 1). The north-south trending Albion Mountains are in the northern Basin and Range Province, east of the Antler orogenic belt, west of the Sevier orogenic belt, and south of and partially surrounded by the Snake River Plain (Armstrong, 1968). The Albion Mountains are a metamorphic core complex containing four northeast-trending mantled gneiss domes composed of 2.5 b.y. old Archean crystalline basement rocks (Armstrong, 1968; Miller, 1983). The City of Rocks dome is the largest of the four.

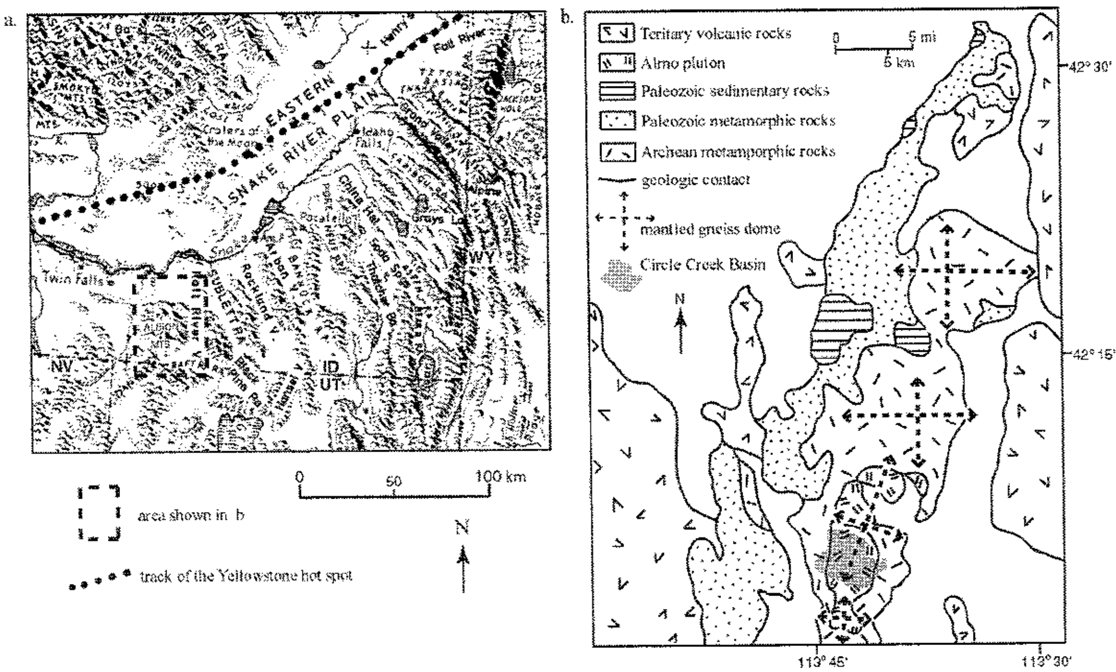

Figure 1. a. Regional map of southeastern Idaho (adapted from Pierce and Morgan, 1992).
b. Generalized geologic map of the Albion Mountains, showing shaded Circle Creek Basin area and mantled gneiss domes (adapted from Armstrong 1968; Miller, 1983).

and radiometric dating. His results describe the timing and type of mineralization and its affect on landscape evolution.

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About 30 Ma (Oligocene) the Almo Pluton intruded the City of Rocks area (Armstrong, 1968). This granitic pluton extends 15 km north to south and is 5 km across. The City of Rocks is a highly complex landscape of tall fins, towers, and spires all of which have been eroded from the Almo Pluton (Armstrong, 1968). Since the emplacement of the pluton the region has undergone different periods of uplift and erosion.

METHODS

This study is an interpretation of drainage basin patterns through the evolution and development of the Circle Creek Basin. Character, shape, and location of the proposed erosion surface are based on the location and elevation of the tops and shelves of the granite forms within the basin (Fig. 2). I used the USGS topographic map and aerial photographs of the Almo quadrangle, as base maps for plotting data. The photos were needed to plot the location of the rock forms, because many were too small to show up on the topographic map.

Figure 2. Schematic diagram presenting the method of projecting an erosion surface across the tops and shelves of the granitic rock forms. Existing basin floor in figures 2 and 5 based on the basin topography in the absence of the rock forms.

The smooth-surfaced nature and large planar character of the tops of most of the rock forms allows for the projection of a surface throughout the basin, at a topographically higher level than the existing basin floor. This surface is the proposed erosion surface in figure 3, which suggests a period of stability during uplift and erosion of the basin.

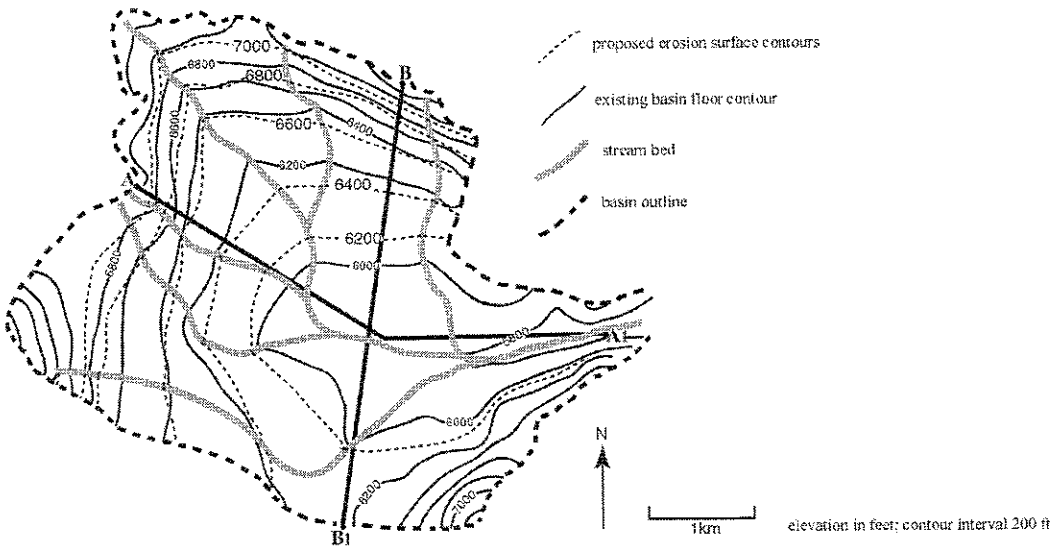


Figure 3. Topographic map of the Circle Creek Basin, showing existing basin floor contours and proposed erosion surface contours. (Surface profiles in figure 5 are located along A to A1 and B to B1).

DISCUSSION

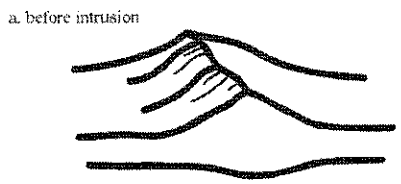
THE ROLE OF THE YELLOWSTONE HOT SPOT IN DRAINAGE DEVELOPMENT

The Yellowstone Hot Spot has migrated over 700 km in the last 16 m.y. (Pierce and Morgan, 1992), leaving a northeast trending scar from northern Nevada to western Wyoming. Migration is reflective of the west-southwest drift of the North American plate over a mantle plume (Rodgers et al., 1990). The plume associated with the Yellowstone Hot Spot was located north of the Albion Mountains and the City of Rocks about 10 m.y.a. (Fig. 1a). It was at this time that the previously mildly active narrow plume tail, which had been feeding the relatively stagnant head, rose through the upper mantle and came into contact with the base of the lithosphere (Pierce and Morgan, 1992).

The progression and migration of the hot spot can be identified by late Cenozoic faulting and uplift of nearby areas. This uplift and associated normal faulting may extend up to 200 km from the actual track of the hot spot (Pierce and Morgan, 1992). The Albion Range and the City of Rocks are within this limit and were probably affected by this regional doming.

BASIN EROSION PATTERNS

Landscape degradation and drainage-network development are primarily caused by fluvial erosion in response to changes in base-level of down-flow regions (Dohrenwend et al., 1987). Lowering base-level, as is the relative case with uplifting blocks, allows for headwall erosion on shallowly inclined surfaces (Dohernwend et al., 1987). This relationship of headwall migration overtime is due to the non-static characteristic of drainage basins on uplifting blocks (Harbor, 1997). Continual uplift may lead to the eventual migration of the drainage divide towards the middle of the range (Fig. 4). In the Circle Creek Basin, the headwall migrated westward towards the center of the Albion Mountains (Fig. 5).



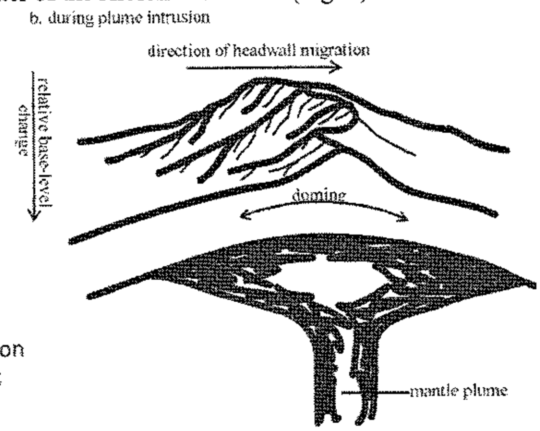


Figure 4. Schematic diagram of drainage basin evolution as an effect of mantle plume intrusion on headwall migration and relative base-level change (Pierce and Morgan, 1982; Cox, 1989; Harbor, 1997; Murphy et. al.,1998).

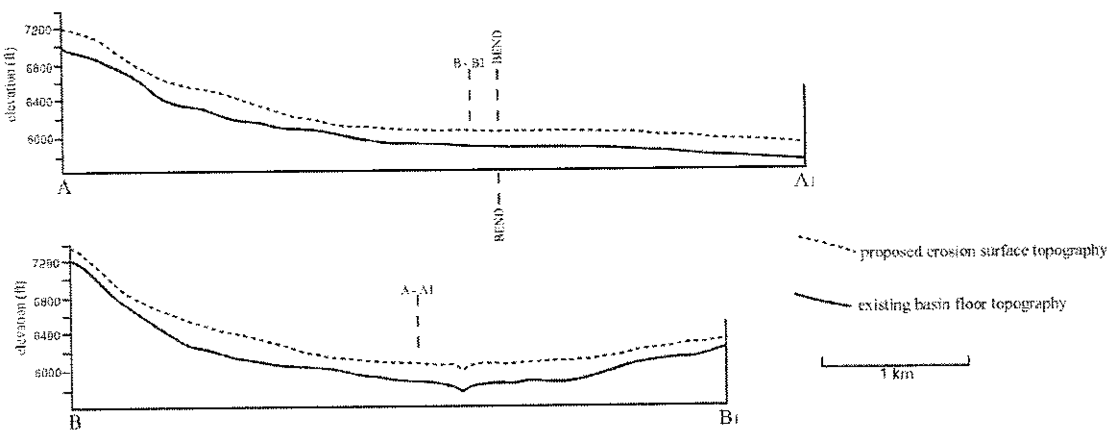


Figure 5. Surface profile from A to A1 and B to B1, Circle Creek Basin (see fig. 3).

The characteristic feature in the City of Rocks is the presence of large granite towers. These features are not unique to the City of Rocks and are preserved in other deeply weathered granite terrains such as the Needles in South Dakota. One possible explanation for the formation of these granite towers is from the rapid erosion of loosely consolidated saprolite from around the less-weathered granite. The distribution of saprolite in deeply weathered granites is probably controlled by the subsurface flow of ground water. This suggests that the north-south orientation of the granite fins in the City of Rocks might reflect the subsurface flow direction of groundwater during saprolite formation.

Uplift related to the migration of the Yellowstone plume caused eastward migration of the continental divide (Ore *in* Link et al., 1999). As a result of divide migration, previous eastward drainage systems were forced to shift drainage to the west. This major drainage pattern shift allowed for the capture of many smaller streams by the main draining rivers resulting in the rapid emptying of sediment filled basins. It is likely that the capture of Circle Creek allowed for the rapid erosion of the saprolite that developed in the Circle Creek Basin leaving the exposed rock features.

CONCLUSION

The Circle Creek Basin has two main pediment surfaces, the existing basin floor, as well as the proposed older erosion surface. The proposed erosion surface is approximately 200 ft (60 m) above the existing basin floor (Fig. 5). The headwall of the proposed erosion surface is located to the east of the current basin headwall, which is indicative of headwall migration westward towards the drainage divide.

The maximum amount of material eroded since the existence of the proposed erosion surface is 1.1 km3. This calculation is based on a crude estimate of the average height of the erosion surface above the existing basin floor and the basin area. This calculation does not account for the presence of the rock forms within the basin, and also does not account for westward migration of the headwall from its previous position to the current location. Other remnant pediments are not obvious between the levels of the two surfaces, which suggests that erosion rates were relatively constant between the stable period during the formation of the proposed erosion surface, and the present.

It seems likely that uplift as a result of the migration of the Yellowstone plume caused regional migration of the continental divide and a shift in general drainage direction. The characteristic landforms within the City of Rocks are probably due to the erosion of a saprolite from around less-weathered granite. The north-south oriented granite towers and fins formed in the subsurface and might reflect groundwater flow patterns before they were exposed due to rapid basin emptying and removal of saprolite associated with stream capture.

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