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GeoRef Subject

clastic rocks igneous rocks Heart Mountain Fault United States sedimentary rocks Park County Wyoming volcanic rocks faults glasses volcanic glass Wyoming

First Page Preview

Volcanic fluidization and the Heart Mountain detachment, Wyoming

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ABSTRACT

The presence along the Heart Mountain detachment in Wyoming of microbreccia containing volcanic glass grains with primary shapes and accreted grains equivalent to accretionary and armored lapilli supports the concept that injection of volcanic gases along the fault produced fluidization. The probable source of the volcanic contribution was a fixed feeder pipe, now beneath the Crandall intrusive complex, which left a trail of intrusives akin to a hotspot trace in the moving allochthon. Volcanic gas carrying glass and fluidized microbreccia was injected in sill-like fashion along a bedding horizon near the base of the Ordovician Bighorn Dolomite, resulting in gravitative collapse and spreading, probably catastrophic, of the overlying carbonate and volcanic massif.

INTRODUCTION

The Heart Mountain fault in northwestern Wyoming has intrigued and perplexed geologists from around the world for more than 100 yr: no feature similar in character and scale is known. A sheet of rock some 1300 km^2 in area and a few kilometres in thickness detached from its substrate and spread to cover more than 3400 km^2 (Pierce, 1973), thinning at least locally (Hauge, 1993) to <1 km in the process. A gently inclined (1°–2°), rootless detachment separates upper plate Paleozoic carbonates and Eocene volcanic rocks from underlying lower Paleozoic through Eocene rocks (Fig. 1). The breakaway zone is exposed just west of Silver Gate, Montana, near the northeastern entrance to Yellowstone Park. South of the Clarks Fork of the Yellowstone River between the west flank of Dead Indian Hill and Silver Gate, the fault is remarkably planar, riding on a bedding surface ~2 m above the base of the Ordovician Bighorn Dolomite. The fault ramps up through the stratigraphic section of the underlying rocks as it climbs over Dead Indian Hill. Farther southeast is the "land surface" portion of the fault and its namesake, Heart Mountain, a klippe of Ordovician-Mississippian carbonates overlying the Eocene Willwood Formation. Frontal displacement required to emplace Heart Mountain was at least 30 km, and if McCulloch Peak is included, transport may have exceeded 50 km. Movement occurred during the Eocene, ca. 48 Ma, and was contemporaneous with volcanism in the overlapping Absaroka volcanic province.

Since the recognition by Bucher (1947) and confirmation by Pierce (1957) that extension and dispersion of blocks of Paleozoic carbonates in the upper plate preclude emplacement by compressional thrusting, movement of the allochthon has been attributed to a variety of mechanisms, as outlined in the excellent review of Hauge (1993): (1) tectonic denudation produced by gravity sliding of dispersing blocks aided by vertical accelerations due to earthquakes (Bucher, 1947; Pierce, 1957); (2) high fluid pressures (Rubey and Hubbert, 1959); (3) "hovercraft" flotation on volcanic gases (Hughes, 1970), with acceleration from a gaseous fluid wedge (Voight, 1973, 1974); (4) acoustic fluidization (Melosh, 1983); (5) a continuous expanding allochthon, produced by repeated Coulomb failure along a rootless, low-angle normal fault beneath an oversteepened, volcanically built wedge (Hauge, 1982, 1985; Sales, 1983).

Variations on the tectonic denudation (Pierce et al., 1991; Malone, 1993) and continuous expanding allochthon (Hauge, 1993; Templeton et al., 1995) hypotheses continue to be advocated, but disagreements remain. Are the bulk of volcanic rocks resting on the fault in spaces between carbonate blocks in depositional (or landslide) contact with the (tectonically denuded) fault (Pierce et al., 1991; Malone, 1993), or are they in tectonic contact, brought down onto the fault as the allochthon expanded (Hauge, 1993)? Is the fine-grained rock locally present along the Heart Mountain detachment a fault microbreccia (cataclasite) containing fault striae (Hauge, 1985, 1991), a lineated air-fall tuff (Pierce et al., 1991; Nelson, 1991), or neither? Beyond these questions, the fundamental problem remains: What caused this sheet of rock to move?

VOLCANICS IN THE UPPER PLATE

If the volcanic rocks between carbonate blocks are part of the upper plate, they could be expected to contain a kinematic signature indicating movement toward ~S60°E, the direction toward which the allochthon's movement is forced by the distribution of klippen and the bordering Clarks Fork and Black Mountain faults. We have plotted the large fault set measured by Hauge (1985, Fig. 12), which he described as being "diffuse," omitting faults without striae and those with striae raking <30° (i.e., those with dominant strike slip). Although Hauge

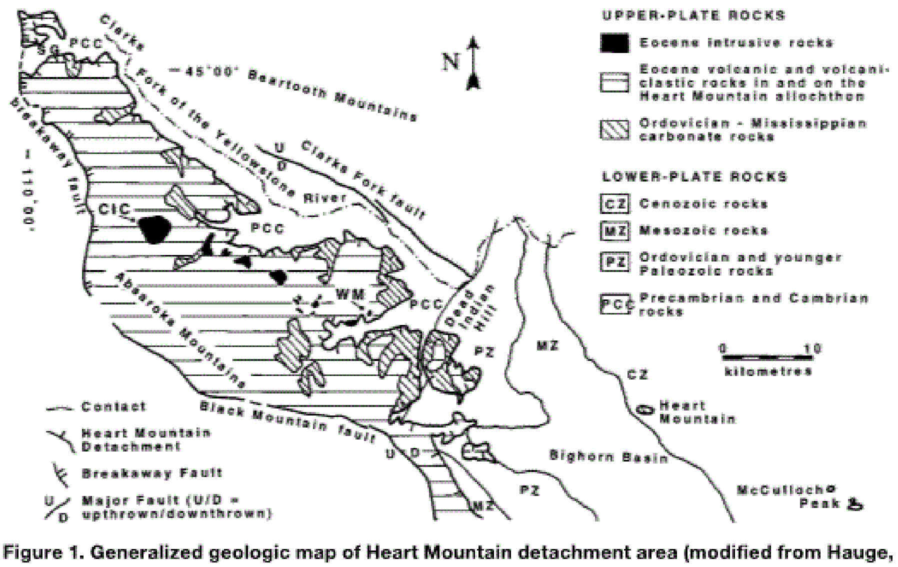

Figure 1. Generalized geologic map of Heart Mountain detachment area (modified from Hauge, 1993; Pierce and Nelson, 1971; Pierce et al., 1973). CIC = Crandall intrusive complex; SG = Silver Gate; WM = White Mountain.

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Index Terms/Descriptors

allochthons breccia clastic rocks decollement detachment faults

faults fluidization gases glasses Heart Mountain Fault

igneous rocks mechanics microbreccia Park County Wyoming

sedimentary rocks United States volcanic glass volcanic rocks

volcanism Wyoming northwestern Wyoming

Latitude & Longitude

N43°47'60" - N45°00'00", W111°02'60" - W108°34'60"

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