The basalts of Yellowstone Valley, southwestern Montana
by John Harold Bush

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Applied Science
Montana State University

Abstract:
Remnants of the basalts of the Yellowstone Valley follow the general northeast trend of the valley for a distance of eleven miles from Point of Rocks to Emigrant, Montana. These basalts lie unconformably on gravels which in turn rest unconformably on late Miocene-early Pliocene sediments. Two flows can be distinguished and are designated as flow A (older) and flow B (younger). A K-Ar date of 8.4 m. y. for flow B indicates an early Pliocene age.

Flow A contains labradorite, augite, and olivine phenocrysts. In most places it is zoned, having light-gray basalt on top and bottom and dark-gray basalt in the center. The basalt is columnar: larger columns typify the outer zones, smaller columns the central zone. In places, inclined columns in the center indicate local movement of the flow after partial cooling.

Distinctive ophitic texture in the outer zones becomes less ophitic towards the center where the augite crystals are smaller and both augite and olivine more altered. Trappings of gases probably caused deuteric alteration, producing these changes in the central zone.

Flow B is columnar, black to dark-gray, commonly containing scattered plagioclase and olivine phenocrysts. The basalt exhibits non-ophitic texture characterized by a high content of magnetite and/or magnetite-rich glass.

Upstream, basalts cap a bench near the town of Gardiner. Five flows crop out at each end of the exposure. Comparisons suggest that six flows are represented. The upper two are similar to the basalts of flows A and B and may be erosional remnants of the same flows.

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ABSTRACT

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INTRODUCTION

Location

The basalts of the Yellowstone Valley are located 25 to 35 miles south of Livingston in Park County, Montana. Outcrops of basalt follow the general northeast trend of the valley, capping mesas, buttes, and benches on both sides of the Yellowstone River. The outcrops extend for a distance of eleven miles from east of Point of Rocks northward to Emigrant, Montana (Figure One). Many of the basalt outcrops can be seen along U.S. Highway 89 which connects Gardiner with Livingston. The most complete section is preserved on a seven square mile mesa, locally called "Hepburn's Mesa" (Plate I, Figure 1).

Regional Setting

The Yellowstone Valley is bounded on the west by the Gallatin Range which consists mainly of Eocene andesite flows and breccias. To the east the valley is bounded by the uplift Beartooth block, consisting primarily of Precambrian crystalline rocks with a sequence of volcanics covering the block on its southern end. These volcanics are believed to correlate with the early acid and early basic breccias in Yellowstone National Park (Pierce, 1963). The valley is on the downthrown side of the Deep Creek fault which bounds the western side of the Beartooth Range and passes within several hundred feet of Hepburn's Mesa. The displacement on this fault is at least 5000 feet near Elbow Creek north of Hepburn's Mesa (Horberg, 1940).

Southward from Hepburn's Mesa the width of the Yellowstone Valley decreases rapidly where the Yellowstone River cuts into Precambrian rocks, forming Yankee Jim Canyon. The canyon extends southward for approximately 3 miles and ends approximately 1 mile north of Cinnabar Mountain.

On the northwest side of Cinnabar Mountain, the Gardiner Thrust fault appears from under a cover of Tertiary volcanics. The fault is traceable southward for 13 miles before it again disappears under Tertiary volcanics 3 miles east of Mount Everts in Yellowstone National Park (Wilson, 1934). Near Gardiner, outcrops of basalt form a bench on the east side of the Yellowstone River. They are distributed in an elongate belt along the northwest trend of the Gardiner fault plane. At Cinnabar Mountain and at Mount Everts are outcrops of Paleozoic and Mesozoic basement rocks which occur on the southwest side of the trace of the Gardiner fault.

The Gardiner fault was delimited by Wilson (1934). He states that the fault dips 35 degrees northeast and in the vicinity of Gardiner the minimum throw is approximately a mile and the minimum heave is approximately a mile and a half (Wilson, 1934). "The Gardiner fault provides a common southern boundary for part or both the Beartooth and Gallatin ranges" (Foose, 1961, p. 1163).

Previous Work

Iddings and Weed (1884) studied the Yellowstone Valley as part of the Livingston 1-degree quadrangle. Although geologic work was general, they concluded that the basalts represented the most recent volcanic activity in that part of the Yellowstone Valley.

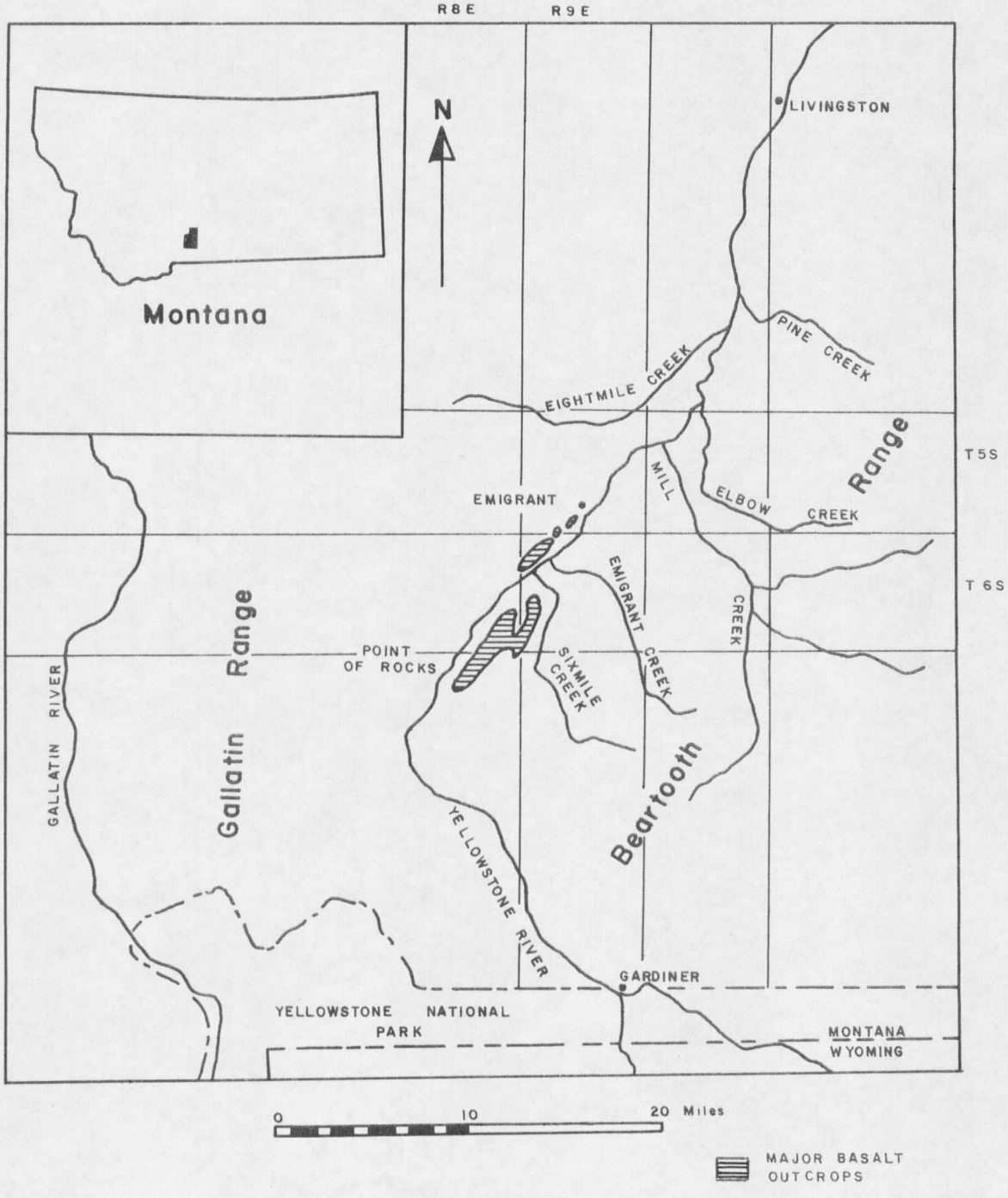

Figure 1 Index Map

Iddings (in Hague, 1899) described the basalts in Yellowstone National Park. His work includes both megascopic and petrographic descriptions.

Campbell (1916), in a guidebook of the Pacific Northwest, made passing mention of the basalt outcrops in the vicinity of Emigrant. He speculated that these were probably related to the basalts in Yellowstone Park.

Wilson (1934) cites "dike-like" structures in the basalts of the Gardiner exposure as evidence suggesting that basaltic lava came up the Gardiner Thrust plane. These "dike-like" structures are best exposed one mile east of Gardiner near the road to Jardine.

Howard (1937) made a detailed study in the area around the Yellowstone Canyon in Yellowstone National Park and distinguished six basalt groups: Jardine "basalt," Crescent Hill Basalt, Geode Creek Basalt, Elk Creek Basalt, Canyon Basalt and Oxbow Creek Basalt. On the basis of similar underlying gravels he suggested correlation of the basalt on Hepburn's Mesa to some of the older Canyon Basalts in Yellowstone Park. He also mapped the southern end of the basalts in the Gardiner area as belonging to the Canyon Basalts.

Horberg (1940), in a geomorphic study of Yellowstone Valley, discussed the basalts of the mapped area as "basalt flows" but did not separate the basalt sequence into individual flows. He suggested an early Pleistocene age for the basalts on the basis that an earlier date would present too many difficulties in explaining the geomorphic development of the valley.

Seager (1944) studied the Jardine Mining District which lies above the Yellowstone River about 12 miles southeast of Hepburn's Mesa. His report includes petrographic descriptions of the basalts exposed at