



The petrogenesis of the alkaline rocks of the Judith Mountains, central Montana
by Paula Jean Barrick

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Earth Science

Montana State University

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Abstract:

The Judith Mountains are part of the central Montana alkaline province. Intrusive igneous activity began in the Judith Mountains about 68-69 m.y. ago with the emplacement of alkali-calcic plutons. Volume-triclyally minor but widespread alkaline igneous rocks were intruded 62-65 m.y. ago in the same terrane. This study focuses on the origin of the second (alkaline) intrusive event, which emplaced two different suites of alkaline igneous rocks.

The alkaline rocks are divided into two groups based on silica saturation: 1) a quartz-bearing assemblage consisting of syenite which contains xenoliths of alkali gabbro; and 2) a nepheline-bearing assemblage which includes tinguaitite (a textural variety of nepheline syenite) and xenoliths of nepheline pyroxenite or ijolite. The two assemblages may be termed "mildly" and "strongly" alkaline.

The parent magma may have been kimberlite, since carbonatite-kimberlite magmas are known elsewhere in the province and local alteration (fentization) suggests the presence of a buried carbonatite body. However, quartz-bearing alkaline rocks cannot be derived from an undersaturated kimberlitic magma except under certain special conditions. Therefore, the mildly and strongly alkaline rocks either formed from separate parent magmas, or formed from a single parent magma under two very different sets of conditions. The nearly contemporaneous emplacement of the two groups suggests a single parent magma pulse.

The early separation of the parent magma into two sub-magmas followed by physical separation of the magma chambers to two different levels in the crust could explain the formation of these two divergent alkaline assemblages.

Fractional crystallization of the strongly alkaline rocks is indicated by cumulate textures and by the formation of a residual melt, represented by tinguaitite. Fractional crystallization may have taken place relatively deep in the crust. At a shallower depth, quartzbearing syenite could have separated from alkali gabbro by the process of liquid immiscibility. Immiscibility is promoted by low-pressure environments and is known to produce bimodal felsic and mafic rocks, with the felsic fraction having a much higher degree of silica saturation. Syenite bodies containing xenoliths of alkali gabbro were the first alkaline rocks to be emplaced, tinguaitite dikes containing ijolite xenoliths were emplaced later, although in rare instances this sequence is reversed, suggesting nearly contemporaneous emplacement of the two groups.

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Date May 25, 1982

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by

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ABSTRACT

The Judith Mountains are part of the central Montana alkaline province. Intrusive igneous activity began in the Judith Mountains about 68-69 m.y. ago with the emplacement of alkali-calcic plutons. Volumetrically minor but widespread alkaline igneous rocks were intruded 62-65 m.y. ago in the same terrane. This study focuses on the origin of the second (alkaline) intrusive event, which emplaced two different suites of alkaline igneous rocks.

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INTRODUCTION

Purpose

The purpose of this investigation is to study the petrogenesis of the alkaline igneous rocks of the Judith Mountains. This study deals with two alkaline rock assemblages, one strongly alkaline and nepheline-bearing, and one mildly alkaline and quartz-bearing.

Previous investigations of the volumetrically subordinate alkaline rocks are of limited scope and only the felsic alkaline rocks were described. Origins proposed for the alkaline rocks, such as laccolithic differentiation (Weed and Pirsson, 1896) and limestone assimilation (Wallace, 1953) do not adequately explain the relationships and rock types observed. A more detailed examination of the alkaline rocks of the Judith Mountains was undertaken to help understand the origin of these rocks. The discovery of numerous mafic alkaline xenoliths in the felsic alkaline rocks shed much light on the origin of these alkaline rocks.

The first portion of this paper is a brief discussion of the geology and tectonic setting of central Montana and the Judith Mountains, followed by a detailed description of the alkaline rocks. The petrogenesis of the strongly and mildly alkaline assemblages is then discussed, and compared with other similar alkaline complexes. Finally, a petrogenetic model is proposed to explain the origin of the alkaline rocks of the Judith Mountains.

Location

The Judith Mountains are an isolated group of forested peaks in central Montana which rise 300 to 760 meters above the surrounding plains, reaching a maximum altitude of 1915 m (6,280 ft) at Judith Peak. Figure 1 shows the location of the Judith Mountains and the other ranges which make up the central Montana petrographic province. The study area for this thesis is limited to the northern portion of the range (Figure 2).

Topography in the study area varies from rugged cliffs and talus slopes to sparsely forested grassy hills. Several gravel roads and unimproved jeep trails pass through the area, which is easily traversed by foot. Poor rock exposures inhibit detailed mapping in some areas, but the more resistant rock units, notably the tinguaitite dikes, form resistant cliffs and walls.

Although much of this area is under the jurisdiction of the Bureau of Land Management, some of the surrounding land, especially in the eastern part of the study area, is privately owned. Excellent access to the Judith Peak-Red Mountain area is provided by a paved highway and an improved gravel road which leads to the abandoned Air Force radar base at the top of Judith Peak. Anyone wishing to visit the easternmost portions of the study area, however, should first contact the local landowners.

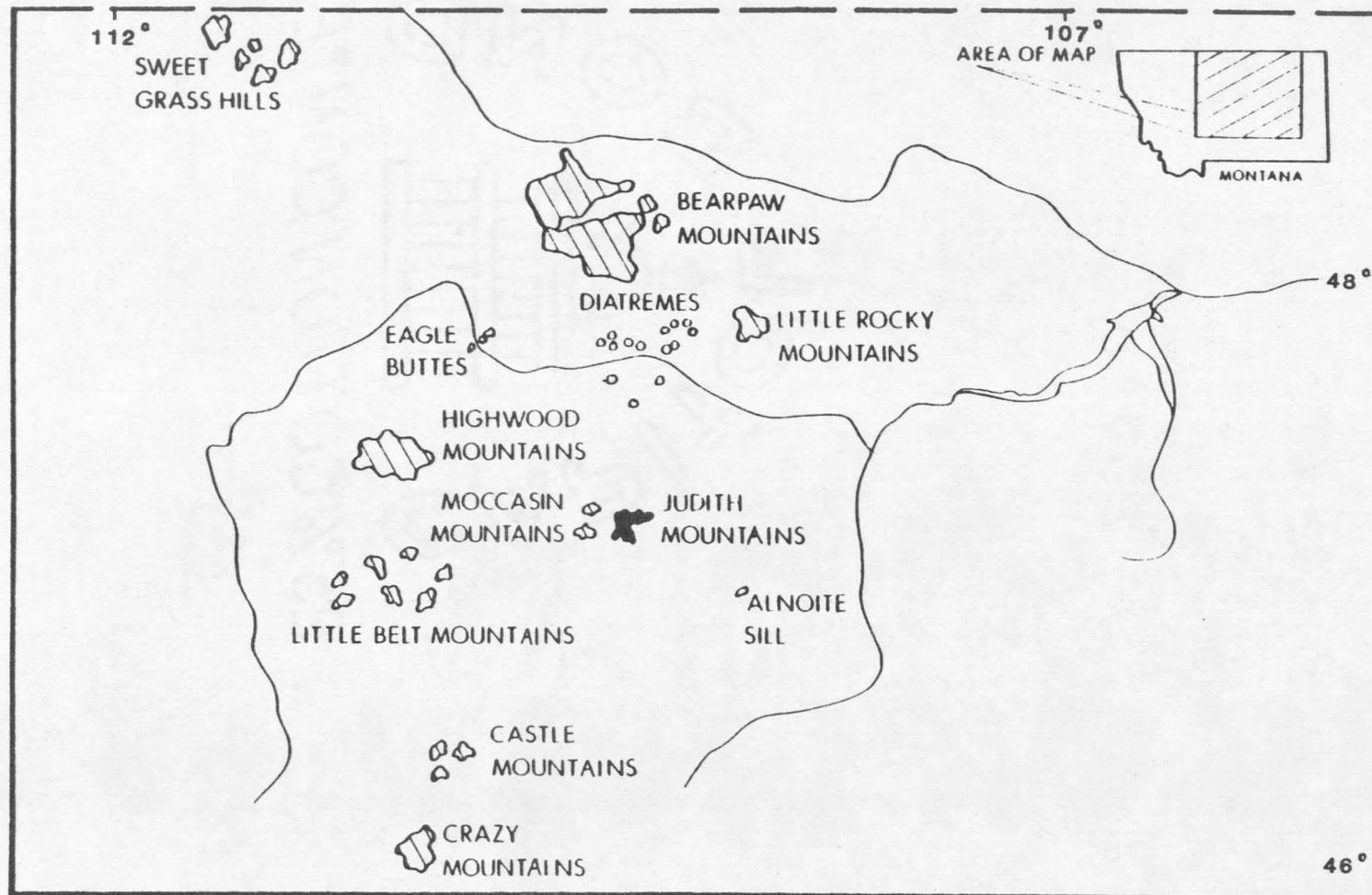


Figure 1. Location of the Judith Mountains, central Montana. Cretaceous-Tertiary igneous centers of the central Montana alkaline province are shaded in.

