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DIABASIC AND GABBROIC INTRUSIONS IN THE FROST MOUNTAIN AREA, SOUTH-CENTRAL CASCADE MOUNTAINS, WASHINGTON

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ABSTRACT. Diabasic and gabbroic intrusions in the Frost Mountain area of the south-central Cascade Mountains of Washington, approximately 70 miles southeast of Seattle, represent at least in part feeders for two different sets of basalt flows. The older Naches basalt flows are probably Eocene in age, and the younger Yakima basalt flows are Mio-Pliocene. Field relations are of prime importance in distinguishing the two generations of intrusive bodies, but it is also generally possible to separate them by differences in degree of alteration.

INTRODUCTION

The Frost Mountain area is in the south-central Cascade Mountains of Washington, approximately 40 miles northeast of Mount Rainier and 70 miles southeast of Seattle (fig. 1). In this area, there are two sequences of basalt flows, the older probably Eocene in age and the younger Mio-Pliocene. Connections between the flows and intrusive bodies indicate that both sequences were fed locally. The two generations of intrusions are similar in texture and mineral composition, but usually can be distinguished by degree of alteration; the older are notably more altered than the younger.

Geologic setting.—Pre-Tertiary igneous and metamorphic rocks make up most of the northern and central Cascade Mountains in Washington, forming a "basement complex" in the Frost Mountain area. The basalt flows of the older generation are interbedded with the sedimentary and volcanic rocks of the Naches formation, generally considered to be Eocene in age (Smith and Calkins, 1906; Stout, 1959). The Naches formation is overlain unconformably by a thick pile of Oligo-Miocene (?) andesitic rocks probably correlative with the "Keechelus formation" as redefined by Foster (1960, p. 118-121). The younger basalt flows rest unconformably on the Keechelus andesites and are continuous to the east with the Yakima basalts, of probable Mio-Pliocene age (Waters, 1955). A description of the areal geology of the Frost Mountain area is currently being prepared for publication.

The term "Keechelus" is used here merely for convenience in referring to the entire stratigraphic section of Oligo-Miocene (?) andesitic rocks in the Frost Mountain area. At present, there is confusion as to exactly what the "Keechelus formation" represents because of the difficulty in correlating the volcanic units at the type locality with those elsewhere.

FIELD RELATIONS

Naches flows and intrusions.—The Naches basalt flows (1) are interbedded with arkosic sandstones and conglomerates and/or rhyolitic rocks; (2) usually have been deformed—some flows are now vertical or overturned; (3) are commonly amygdaloidal or megaporphyritic and/or highly vesicular; (4) are commonly altered.

Diabasic and gabbroic intrusions of the older generation are at least in part feeders for some of the Naches flows. Two intrusions near Mount Clifty

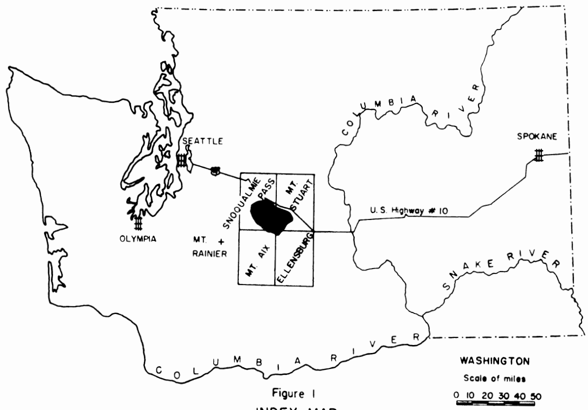


Figure 1
INDEX MAP

(fig. 2) can be traced almost continuously into basalt flows of the Naches formation.

Yakima basalt and intrusions.—The Yakima basalt (1) characteristically forms large talus slopes, sometimes more than a square mile in total area; (2) is found predominantly as ridge-cappings; (3) is usually very fresh; (4) commonly has columnar structure and blocky fractures; (5) rarely has amygdaloidal and megaporphyritic textures.

The younger diabasic and gabbroic intrusions commonly cut andesitic rocks tentatively correlated with the Keechelus formation. The intrusions range in size from small dikes less than 1 foot thick to large, pluglike bodies cropping out over more than a square mile. Most of the younger intrusions have a pronounced northwesterly trend, probably reflecting control by "basement" structures. They occur principally between the two belts of pre-Tertiary rocks (fig. 2).

In at least three places, diabasic and gabbroic intrusions of the younger generation can be traced into flows of Yakima basalt, but exposures are so poor that the actual connections of "dikes" and flows are rarely seen.

Just west of Frost Mountain a flow of Yakima basalt caps a small peak, and directly below it, to the north, are good exposures of a large diabasic body which partly intrudes Keechelus (?) rocks. A traverse on the northern ridge shows diabase grading into basalt in a distance of less than 100 feet.

Approximately 2½ miles northeast of Frost Mountain, a large, basic intrusion seems to connect with the lower flows of Yakima basalt, but talus and soil cover the contact. Approximately 1½ miles to the southeast, a smaller diabasic body is in contact with Yakima basalt, but again the contact is unexposed.

Smith (1904, p. 8) reported a diabase dike cutting the lower flows of Yakima basalt in the southeastern part of the Frost Mountain area. He stated:

> "The largest of these dikes occurs on the west side of North Fork of Manastash Creek and is unique in that it cuts the lower sheets of Yakima basalt. This occurrence, together with the general distribution of the diabase, justifies the conclusion that the diabase originated from the same magma as the Yakima basalt, the larger masses of diabase representing

> the intrusive bodies of molten rock which connected upward, through conduits now indicated by the dikes, with the lava flows at the surface".

The only dike that could be found near this locality intrudes Keechelus volcanic rocks and not Yakima basalt.

COMPARATIVE PETROLOGY

Basic intrusions of both generations are extremely friable, and exposures are rounded by weathering. Plagioclase laths and pyroxene can readily be identified in most specimens, and some rocks contain glomerophyric clusters of pyroxene that produce a spotted appearance.

Feeders of both generations have similar mineral compositions: plagioclase (45-60%), pyroxene (20-35%), and opaques (3-10%). The textures are usually ophitic to subophitic. No diktytaxitic textures were found. Zoned plagioclase is rare. The pyroxene is predominantly pigeonite, much of which is uniaxial or has a very small optic angle ($2V_z = < 15°$). Much of the pigeonite may be titaniferous, judging by its light-brown pleochroism.

Although the feeders of the two generations have similar textures and mineral compositions, the following petrographic characteristics, considered collectively, can generally be used to separate the younger from the older ones:

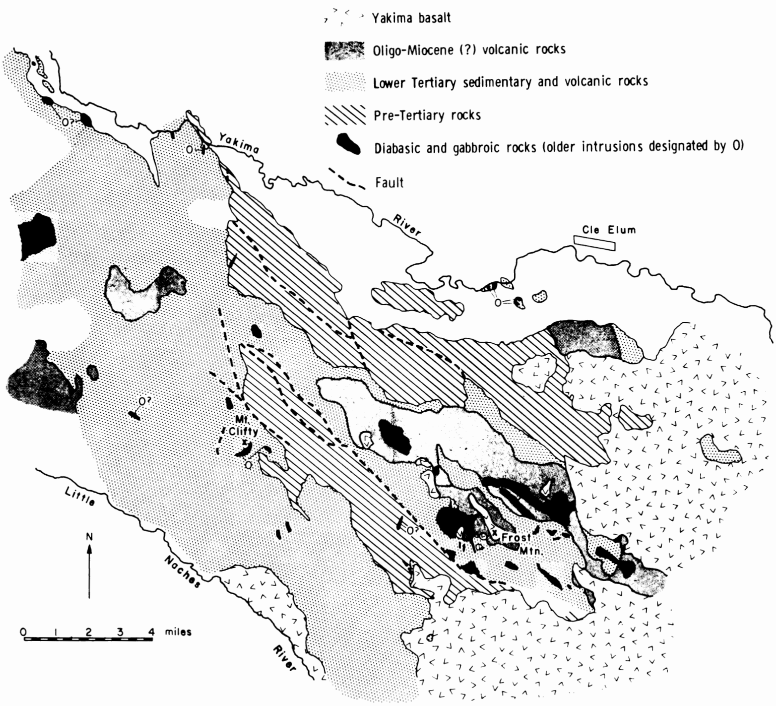
Younger rocks	*Older rocks*
Olivine is common and may be partly altered.	Olivine, if ever present, has been completely altered.
Glass may be present.	Glass is not present.
Quartz is rare.	Quartz is common.
Pyroxene is generally fresh.	Pyroxene is partly or completely altered.
Plagioclase may be fresh or altered and has a compositional range of An_{55} to An_{67}.	Plagioclase is commonly altered and may be more calcic (An_{60}-An_{76}).
No albitization.	May be partially albitized.

Alteration in the older intrusions is manifested by saussuritized and/or kaolinized plagioclase and chloritized pyroxene. Much of the plagioclase has been replaced by calcite. The groundmass consists of chloritic material, chlorophaeite, and other alteration products. In a few thin sections, the pyroxene is relatively fresh, although the plagioclase is altered. Quartz may form as much as 5 percent of the rock, and much of it is resorbed.

A striking property of some of the younger basic intrusions is kaolinization and/or saussuritization of the plagioclase with no or very little alteration of the pyroxene. Degree of alteration does not seem to be affected by grain size. Alteration may be localized, especially where the rocks have been fractured or faulted. Local alteration is also shown in almost vertical, light- and dark-colored flow layers in the relatively large, diabasic intrusion about 1½ miles west of Frost Mountain. The light-colored layers contain completely kaolinized plagioclase, some zeolites, and relatively unaltered pigeonite, but the dark layers contain relatively fresh plagioclase and unaltered pigeonite. Magnetite occurs as small, blocky crystals in the dark layers and as large, skeletal crystals in the light-colored layers. The dark layers are more typical of the average Yakima basalt feeder.

Figure 2

GENERALIZED GEOLOGIC MAP SHOWING DISTRIBUTION OF DIABASIC AND GABBROIC ROCKS



The highest olivine content in the younger intrusive rocks, up to 10 percent, is in the large, westernmost body (fig. 2). Smaller amounts of olivine are more common in the intrusions, and not all intrusive bodies contain olivine. The olivine is partly altered to iddingsite, saponite and/or other chloritic or clay materials.

The largest amount of olivine in the Yakima basalt flows in the Frost Mountain area, 5 to 8 percent, is in the flows on Frost Mountain. Smaller amounts are common in other flows of Yakima basalt. The large, olivine-rich intrusion to the west is a possible feeder for flows having a relatively high olivine content.

Olivine-rich basalts are not uncommon on the Columbia Plateau, although they seem to be confined to the upper part of the Yakima basalt. The writer examined about 50 thin sections from flows near Vantage, Washington, in the west-central part of the Columbia Plateau. The Roza porphyritic flow (Laval, 1956) contains up to 8 percent olivine, although the average olivine content in this and other flows, including the Priest Rapids flows (Laval, 1956), is generally less than 5 percent. The locations of the samples within the flows are not known, and this factor is critical before attempting correlation on this basis. The Wenas basalt exposed in the Ellensburg quadrangle and vicinity also has a rather high olivine content (Smith, 1903; Laval, 1956); it pinches out to the east (Waters, 1955, p. 673).

Detailed study of basalt stratigraphy between the Frost Mountain area and the Ellensburg and Yakima River districts to the east has not been undertaken, so that no definite correlations can yet be made. Exactly how many and what flows came from the west is not known.

TEANAWAY DIKE SWARM

A somewhat similar problem involving two different generations of intrusions is apparently presented by the Teanaway dike swarm which crops out in an elongate, east-west trending belt, approximately 15 miles north of Cle Elum. Chappell (1936a, p. 156; 1936b, p. 384) reported a multiple dike in the Wenatchee quadrangle, east of the main part of the Teanaway dike swarm, and explained the different stages of intrusion as representing feeders for both the Eocene Teanaway basalt and the Mio-Pliocene Yakima basalt. He noted that the older dike was coarser grained and more altered. Chappell also noted that foreset bedding in palagonitic breccias within the Yakima basalt in the Wenatchee area indicated that one or more flows came from the west or southwest.

Approximately 150 thin sections representing 46 different dikes in the Teanaway dike swarm were examined. The writer did not visit the individual localities, however, so that the field relations are unknown. Using the petrographic characteristics listed earlier to differentiate the two generations of intrusions in the Frost Mountain area, the thin sections of the Teanaway dikes can be divided into two groups: (1) those with pronounced alteration of plagioclase, groundmass material, and pyroxene, with no olivine, and (2) those which are relatively fresh and sometimes contain olivine. On this basis, it appears that the Teanaway swarm, especially in its easternmost part, includes dikes of two generations.

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