UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

VOLCANIC ROCKS OF THE MCDERMITT CALDERA, NEVADA-OREGON

By Robert C. Greene, U.S. Geological Survey

USGS Open-File Rept.
No. 76-753

This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards and nomenclature.

Contents

Page

Miocene volcanic rocks--Continued

Illustrations

Tables

Page

VOLCANIC ROCKS OF THE MCDERMITT

CALDERA, NEVADA-OREGON

By Robert C. Greene, U.S. Geological Survey

ABSTRACT

The McDermitt caldera, a major Miocene eruptive center, is located in the northernmost Great Basin directly west of McDermitt, Nev. The alkali rhyolite of Jordan Meadow was erupted from the caldera and covered an area of about 60,000 sq km; the volume of rhyolite is about 960 cubic km.

Paleozoic and Mesozoic sedimentary rocks and Mesozoic granodiorite form the pre-Tertiary basement in this area. Overlying these is a series of volcanic rocks, probably all of Miocene age. The lowest is a dacite welded tuff, a reddish-brown rock featuring abundant phenocrysts of plagioclase, hornblende, and biotite; next is a heterogeneous unit consisting of rocks ranging from basalt to dacite.

Overlying these is the basalt and andesite of Orevada View, over 700 m thick and consisting of a basal unit of cinder agglutinate overlain by basalt and andesite, much of which contains conspicuous large plagioclase phenocrysts.

Near Disaster Peak and Orevada View, the basalt and andesite are overlain by additional units of silicic volcanic rocks. The lower alkali rhyolite welded tuff contains abundant phenocrysts of alkali feldspar and has a vitric phase with obvious pumice and shard texture. The rhyolite of Little Peak consists of a wide variety of banded flows or welded tuffs and breccias, mostly containing abundant alkali feldspar phenocrysts. It extends south from Disaster Peak and apparently underlies the alkali rhyolite of Jordan Meadow. The quartz latite of Sage Creek lies north of Disaster Peak and consists mostly of finely mottled quartz latite with sparse minute plagioclase phenocrysts.

Volcanic rock units in the east part of the area near the Cordero mine include trachyandesite, quartz latite of McConnell Canyon, and rhyolite of McCormick Ranch. The trachyandesite is dark gray and contains less than 1 percent microphenocrysts plagioclase. It is the lowest unit exposed and may correlate with part of the basalt and andesite of Orevada View. The quartz latite of McConnell Canyon is olive gray and contains about 8 percent plagioclase phenocrysts. It has an upper phase of black vitrophyre which directly underlies the alkali rhyolite of Jordan Meadow. The rhyolite of McCormick Ranch is present farther north and consists of pinkish rhyolite with small amounts of phenocrysts of alkali feldspar, quartz, and plagioclase.

The alkali rhyolite of Jordan Meadow consists of interlayered aphyric, sparsely porphyritic, and abundantly porphyritic alkali rhyolites whose colors are predominantly light gray, greenish gray, and brown, respectively. Phenocrysts are alkali feldspar (to 15 percent) locally with quartz. Sections inside the caldera are as much as 360 m thick and consist of intimately interlayered gray, green, and brown alkali rhyolites commonly flow folded. Outside the caldera sections are equally thick to the south and southwest, but thinner to the north; in these places units of similar lithology are persistent for many kilometers, and flow folding is rare.

A basal green porphyritic unit north of the caldera contains definite shard texture, but elsewhere this feature is rare. Nevertheless, the great lateral extent and relative thinness of the alkali rhyolite of Jordan Meadow suggests that it is welded ash-flow tuff.

Overlying the alkali rhyolite of Jordan Meadow within the McDermitt caldera are four units of lavas. The rhyolite of Hoppin Peaks contains light-brownish-gray rhyolite and black vitrophyre, all with sparse phenocrysts of alkali feldspar, quartz, and plagioclase. The rhyolite of McDermitt Creek is greenish or brownish gray and contains abundant phenocrysts of plagioclase. It is in part structureless and in part flow banded. Alkali rhyolite of Washburn Creek is light gray and contains 0-5 percent phenocrysts alkali feldspar. Quartz latite of Black Mountain forms four isolated remnants of volcanoes in the south part of the caldera. It is brown where well crystallized and black where vitric and contains 5-15 percent plagioclase phenocrysts.

A unit of tuffaceous sedimentary rocks in part fills the caldera. A single occurrence of andesite is interbedded.

Analyses of 13 samples of the alkali rhyolite of Jordan Meadow and three of the overlying lavas show that these rocks contain 63 to 75 percent SiO_2. The alkali rhyolite of Jordan Meadow is distinctly lower in Al_2O_3 and higher in $FeO+Fe_2O_3$ at comparable values of SiO_2 than the overlying lavas. The Alk-F-M diagram shows a normal differentiation trend for the alkali rhyolites and a reverse trend for the overlying lavas. Norms show that most of the alkali rhyolites are peralkaline or meta-aluminous and the overlying lavas are per-aluminous. An obsidian sample from the alkali rhyolite of Jordan Meadow is exceptionally rich in Na_2O and suggests the other rocks lost this element on devitrification.

Calculated groundmass compositions for three porphyritic rhyolites show only minor differences from bulk composition, and indicate differentiation has taken place by settling of crystals to hidden depth. Interlayering of rhyolites of contrasting composition suggests a complex pattern of eruption. Laminar flowage modified the tuffs following eruption as ash flows, causing development of lineation and flow folds and destruction of shard and pumice textures.

The overlying lavas probably originated from residual magma left after eruption of the alkali rhyolites modified by the assimilation of sedimentary rocks.

The McDermitt caldera is well defined by fault and flexure zones on the north side, but the south margin is less clear and is apparently a passive downwarp.

K-Ar dates of the alkali rhyolite of Jordan Meadow and the overlying lavas are in the range 15 to 18 m.y.

INTRODUCTION

This report treats the stratigraphy, petrography, and petrology of a sequence of volcanic rocks of Miocene age in northernmost Nevada and adjacent Oregon. These center around the McDermitt caldera, the probable source area for the alkali rhyolite of Jordan Meadow, whose chemistry and origin will be considered in detail. Other units treated include the related overlying lavas and the probably unrelated underlying volcanic rocks including the basalt and andesite of Orevada View.

LOCATION

The McDermitt caldera is located directly west of the town of McDermitt, Nev., and is partly in Nevada and partly in Oregon (figs. 1, 2). The outcrop area of the alkali rhyolites erupted from the caldera includes parts of Double H Mountain and the Bilk Creek Mountains in Nevada and the Trout Creek Mountains in Oregon in addition to the unnamed range separating the Quinn River and Kings River valleys (fig. 2)

TOPOGRAPHIC AND GEOLOGIC SETTING

This area is located in the northernmost part of the Great Basin section of the Basin and Range province. The Great Basin is characterized by north-trending fault block mountains separated by alluviated valleys. Predominant types of rock in the northernmost Great Basin are volcanic and continental sedimentary rocks of Tertiary age. Pre-Tertiary rocks are less common in this area. Those present are Jurassic and Cretaceous granitic rocks and Paleozoic and Mesozoic sedimentary rocks.

PREVIOUS WORK

The southern part of the report area was mapped in reconnaissance by Willden, who included this mapping in the geologic map of Humboldt County, Nev. (Willden, 1961). The northern part was mapped in reconnaissance and appears on the geologic maps of the Adel and Jordan Valley quadrangles, Oregon (Walker and Repenning, 1965, 1966).

Yates (1942) studied the quicksilver deposits and general geology of the Opalite district. Curry (1960) and Fisk (1968) discussed geology and mineral deposits at the Cordero mine (figs. 2, 3). Curry mapped several square miles south and east of the mine.

PRESENT STUDY

Detailed mapping has been completed in the Jordan Meadow quadrangle (Greene, 1972), the north half of the Disaster Peak quadrangle, and small areas adjacent to the north in Oregon (fig. 3). In addition, reconnaissance work and measurement of sections has been done in the balance of the Disaster Peak quadrangle, and the Double H, Bilk Creek, and Trout Creek Mountains (fig. 2).

ACKNOWLEDGMENTS

Edwin H. McKee made potassium-argon age determinations on 27 samples from this area; some of these have been published by McKee and Marvin (1973). An interpretation of the dates appears in McKee, Greene, and Foord (1975). The writer benefited from discussions with Edward Speer and Eugene Foord, both of Placer Amex, Inc., who have done additional work in the vicinity of the Cordero and Bretz mines.

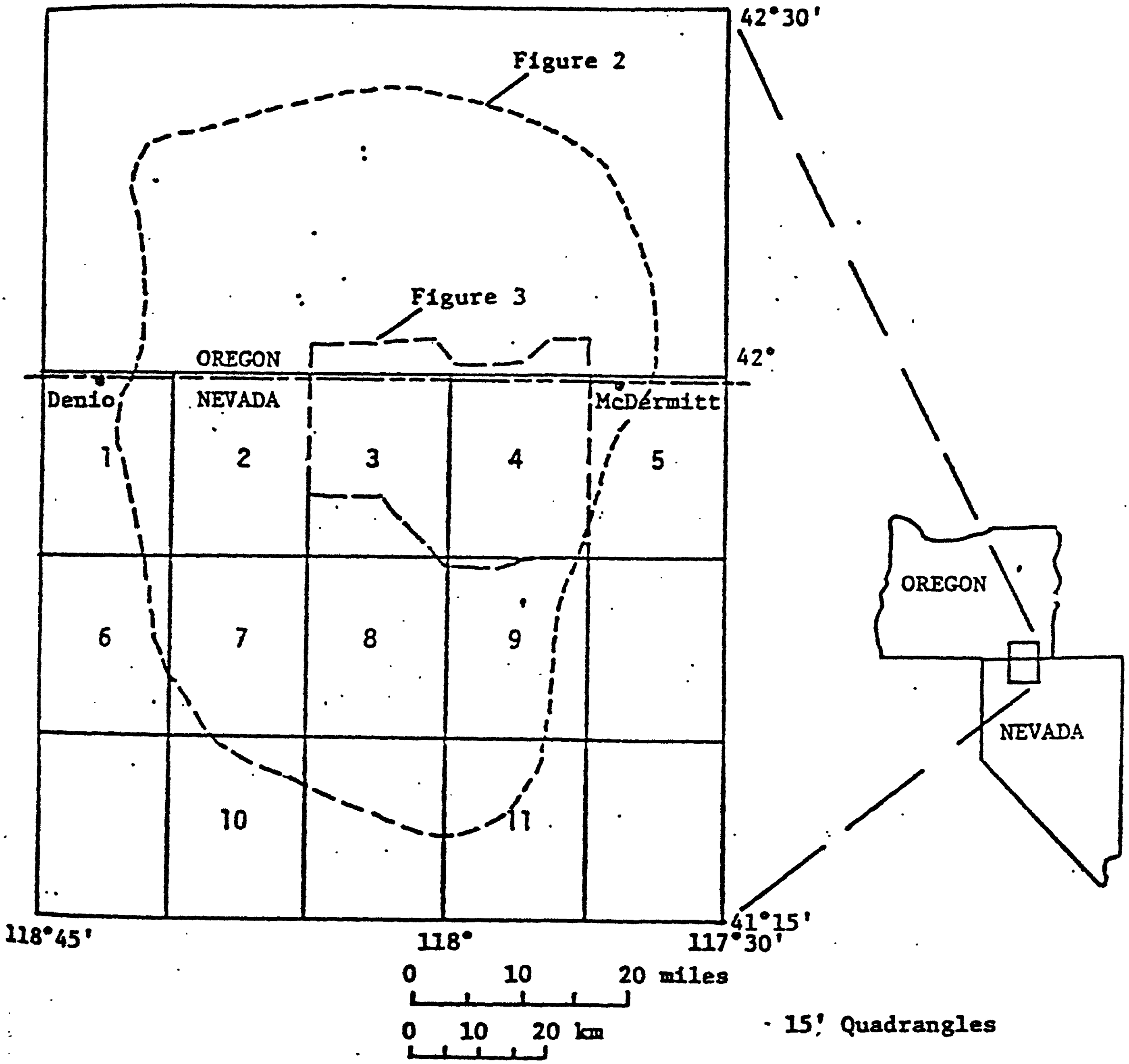


Figure 1. Index map

15' Quadrangles

1. Denio
2. Trident Peak
3. Disaster Peak
4. Jordan Meadow
5. McDermitt
6. Duffer Peak
7. Quinn River crossing
8. Thacker Pass
9. Orovada
10. Bottle Creek
11. Awakening Peak

8 follows

PALEOZOIC AND MESOZOIC SEDIMENTARY ROCKS

Exposures of these older rocks in the area are limited to the south part of the Bilk Creek range. They consist of limestone, shale, siliceous shale, chert, mudstone, and graywacke and were mapped and briefly described by Willden (1966) . The preliminary geologic map of Nevada (Stewart and Carlson, 1974) shows these rocks to be of Permian, Triassic, and Jurassic ages.

MESOZOIC PLUTONIC ROCKS

Exposures of Mesozoic plutonic rocks occur in the northern Bilk Creek range and south and west of Disaster Peak (fig. 3). None of these areas has been studied in detail.

The plutons exposed near Disaster Peak are eroded to a chaotic spire and pinnacle topography, designated as "The Granites" on the topographic maps (Disaster Peak and Trident Peak quadrangles). Similar spires mark the parts of the crest of the range (fig. 3) underlain by granitic rocks. Weathered surfaces are light gray to white, and commonly the rock is partially decomposed to depths of several centimeters. The few samples studied suggest that the plutonic rocks are of highly variable character. Near China Creek the rock is granodiorite and quartz monzonite with few dark minerals. It contains 5-30 percent microcline, 30-45 percent plagioclase, and 30-50 percent quartz, with trace amounts of biotite, magnetite, and locally, muscovite. Near Flat Creek the rock is diorite and quartz diorite containing abundant dark minerals. The more quartzose rocks contain hornblende and biotite as principal dark minerals, while those in which quartz is sparse or absent contain augite and hypersthene.

These plutons are part of the northwestern Nevada plutonic province (Smith and others, 1971). Potassium-argon dates from two localities in the Bilk Creek range are 94.2±3.7 and 90.6±3.2 m.y. These ages, along with 12 of the other 13 plutons dated by Smith and others (1971) are in the range of 105 to 85 m.y. b.p. This data suggests that most of the plutons in the province were emplaced during the Late Cretaceous Lovelock intrusive epoch of Smith and others (1971).

MIOCENE VOLCANIC ROCKS

INTRODUCTION

The area of this report (fig. 2) is underlain principally by volcanic and continental sedimentary rocks of Miocene age. Alluvium and gravels of Quaternary age drape the edges of the ranges and a few interior valleys such as Jordan Meadow Flat and Thacker Pass.

The most widespread rocks are the series of alkali rhyolites herein designated the alkali rhyolite of Jordan Meadow. These and the overlying intracaldera lavas form a closely related group and are the principal concern of this paper. Underlying volcanic rocks are also widely exposed, however, and will be considered first.

NOMENCLATURE OF THE VOLCANIC ROCKS

The chemical classification of Rittmann (1952) has been utilized for the volcanic rocks described in this report. For some units where no complete chemical analyses are available, it has been necessary to compare the SiO_2 contents, the phenocryst modes, and the groundmass appearance with analyzed rocks in which these properties are similar. In general, groundmass modes are not obtainable, so that Rittmann's modal classification cannot be applied.

The procedure for naming unanalyzed rocks is as follows: The SiO_2 content is determined by the refractive index of fused beads (fig. 4). (For discussion of fused bead method, see Huber and Rinehart, 1966.) Quite consistent results were obtained for most units (table 1-2, 6, 8-10, 13, 15-24). Since the silica contents of most of the rocks range between 61 and 76 percent, they are clearly oversaturated (Rittmann, 1952, fig. 4). Therefore, the names from Rittmann (1952, p. 95, table 3, part A) are appropriate, but the choice must be based on examination of a thin section.

Rocks in which the only feldspar phenocrysts are alkali feldspar are here identified as alkali rhyolites and those containing both alkali feldspar and plagioclase phenocrysts as rhyolites.

If the only feldspar phenocrysts are plagioclase, the rock is quartz latite or dacite, depending on the composition of the groundmass. A rough estimate of the proportion of plagioclase, alkali feldspar plus silica minerals, and glass can generally be made. If the groundmass contains any alkali feldspar plus silica minerals, the rock is a quartz latite. If the groundmass is all plagioclase and glass (perhaps also with some clinopyroxene and opaque oxides), then the rock is a dacite, provided that the glass amounts to not more than about 25 percent. Rocks with higher glass contents are indeterminate by this method, and better crystallized samples from the same unit must be utilized.

Rhyodacite, although occupying a small intermediate field on Rittmann's diagram (1952, fig. 5), cannot be used in this scheme and is combined with quartz latite.

The dacite welded tuff (p. 11) presents a special nomenclatural problem. It contains abundant phenocrysts of plagioclase (An_{40-48}), biotite, and hornblende and has 62.5-65 percent SiO_2. Groundmass is vitric or irresolvable devitrification products. Judging from the phenocryst content, the rock is almost certainly dacite.

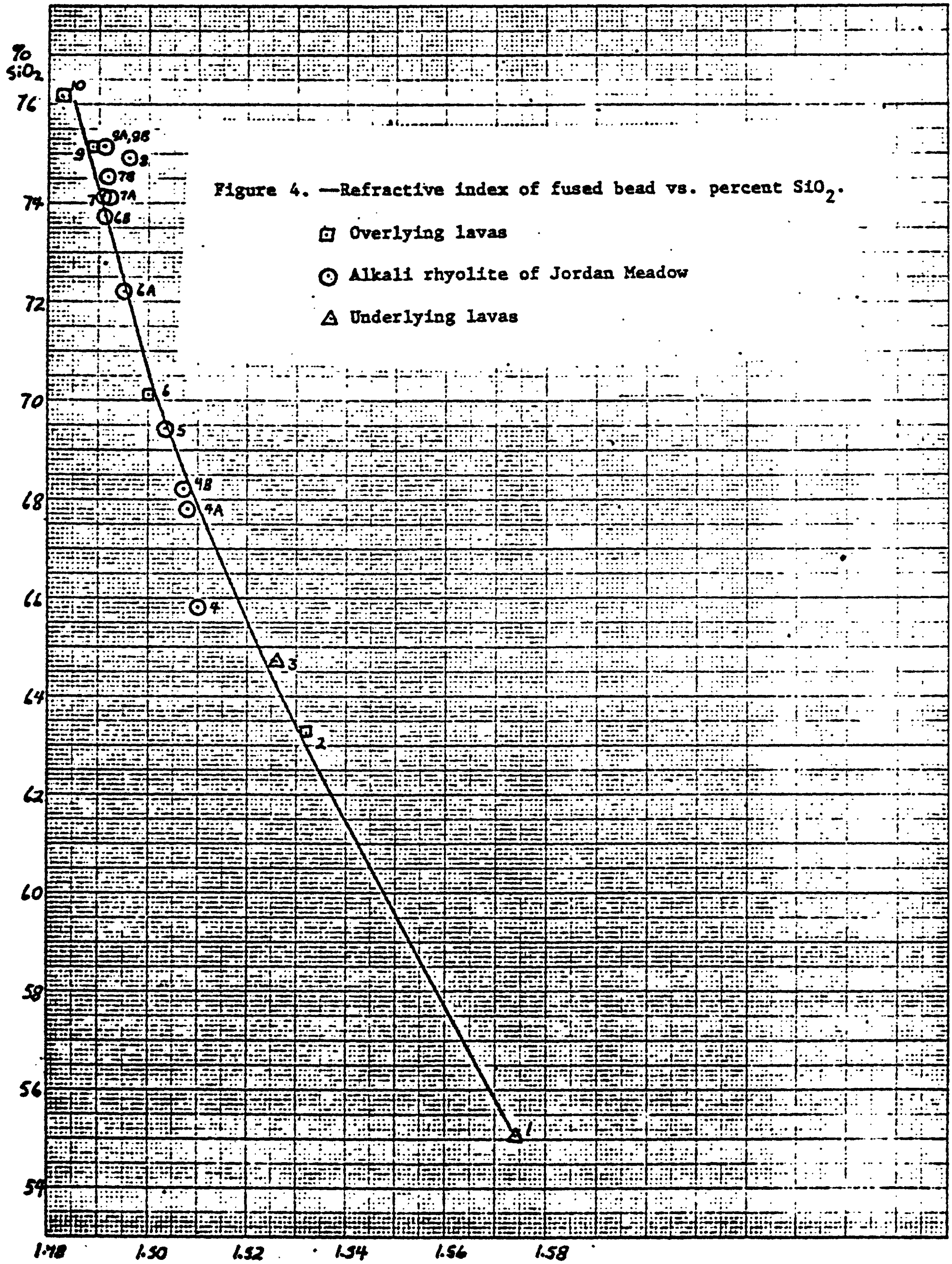


Figure 4. —Refractive index of fused bead vs. percent SiO_2.

Rocks with less than about 60 percent SiO_2 are named by the modal scheme of Rittmann (1952, p. 79). It is to be noted, however, that the modal scheme is far less satisfactory than the chemical one, especially for rocks containing more than 1 or 2 percent glass. For these rocks, there is no choice but to recalculate the crystallized phases to 100 percent and proceed from there using Rittmann's modal classification. Because the glass generally contains a higher proportion of SiO_2, Na_2O, and K_2O than the other phases, an unsatisfactory name may result. For example, no. 484, table 10, would be andesine basalt by the modal scheme, but is trachyandesite by the chemical scheme.

OLDER VOLCANIC ROCKS IN WEST PART OF AREA

Older volcanic rocks in the west part of the area consist of a thick sequence of basalt and andesite with smaller amounts of rhyolitic rocks both above and below in the section. These rocks were studied in some detail in the northwest part of the Disaster Peak quadrangle and the following discussion centers on this area.

Units Underlying the Basalt and Andesite of Orevada View

Dacite Welded Tuff

Dacite welded tuff underlies an area of about 2.5 sq km in the northwest part of the Disaster Peak quadrangle, about 4.8 km south of Disaster Peak (fig. 3). It lies on the crest of the range and directly overlies the Mesozoic plutonic rocks. It also occurs in a smaller area in the east-central Bilk Creek Range, about 27 km to the southwest.

The dacite welded tuff crops out abundantly on ridge crests and surfaces of gentle slope. It breaks down to slabs commonly 30-60 cm in maximum dimension, which strew the surface abundantly.

Most of the tuff is devitrified and has a dense brownish-gray to grayish-red (Goddard and others, 1948) aphanitic groundmass containing abundant phenocrysts of plagioclase and of dark minerals. Thin sections (table 1) reveal the following phenocryst proportions: 30-50 percent plagioclase, 5-10 percent hornblende, 2-10 percent biotite, and trace amounts of magnetite. These are set in an irregular, patchy groundmass. Both biotite and hornblende are strongly pleochroic and commonly have opaque rims.

The vitric tuff is medium dark to medium light gray in mottled pattern. Phenocryst mineralogy is as above, and the vitric groundmass is locally devitrified to spherulites, 0.5-1.5 cm in diameter. Shard structure is locally visible, as are uncollapsed pumice lapilli.

Table 1.--*Modes of dacite welded tuff*

Sample	864	884	891
Phenocrysts			
Plagioclase	25.5	26.9	28.3
(An) Albite-Carlsbad twins	39-47	36-52	---
Biotite	3.6	2.1	4.2
Hornblende	8.3	10.3	10.8
Magnetite	.4	.5	.7
Zircon	.1		
Groundmass			
Cryptocrystalline	62.0	60.1	
Glass			53.9
Pumice			1.9
Total	99.9	99.9	99.8
Points counted	1,045	1,094	1,078
Refractive index of fused bead	1.529	1.523	1.535
Silica content from fused bead	63-1/2	65	62-1/2

The tuff was erupted onto a distinctly irregular erosion surface developed on the Mesozoic plutonic rocks, as the elevation of the contact varies considerably, and spires of plutonic rocks locally rise above the dacite welded tuff.

Dacite, Quartz Latite, Andesite, and Basalt

Rocks of this heterogenous unit are present about 3 km directly south of Disaster Peak (fig. 3). Their outcrop area is about 1 sq km. They lie above the dacite welded tuff and probably beneath the cinder agglutinate (Tca) at the base of the basalt and andesite of Orevada View.

The most characteristic rock of this unit is a medium-dark-gray to medium-light-gray platy dacite with prominent phenocrysts. The phenocrysts include plagioclase, augite, and altered hornblende (table 2, nos. 870, 874) and are set in groundmass of plagioclase microlites and glass with intersertal-trachytic texture. The augite phenocrysts are clear, unaltered, and commonly euhedral. Nearly opaque patches of dark oxides and clays have the outline of former hornblende phenocrysts. This rock crops out well on several spurs in the west part of the area underlain by this unit. Quartz latite (table 2, no. 881) is found in the east part of the outcrop area. It is similar to the dacite but has a higher content of plagioclase phenocrysts and some alkali-feldspar plus silica minerals in the groundmass.

Andesite and basalt (table 2, nos. 865, 868) constitute the rest of this unit. They are present in the eastern part of the principal outcrop area and in patches farther west. A peak on the crest of the range is underlain by vesicular andesite, including some with elongate vesicles as much as 3 cm long.

Basalt and Andesite of Orevada View

Introduction

A thick sequence of basalt and andesite, some with large plagioclase phenocrysts, underlies many square kilometers in the central and northern Bilk Creek Range and the Trout Creek Range, extending discontinuously northeast to and beyond the valley of Oregon Canyon Creek (fig. 2). It is most commonly found directly underlying the alkali rhyolite of Jordan Meadow.

The basalt-andesite sequence is well exposed on Disaster Peak and the southern part of the east-facing scarp culminating in Orevada View (fig. 3). From this locality, the unit is given the informal name basalt and andesite of Orevada View. This section is tentatively divided into four units (table 3) which are readily distinguishable here; however, how far they extend is unknown.

Table 2.--*Modes of dacite, quartz latite, andesite, and basalt*

Sample	865 basalt	868 andesite	870 dacite	874 dacite	880 dacite	881 quartz latite
Phenocrysts						
Plagioclase	tr		2.7	2.6	---	18.8
(An)[1]	---		---	---	---	38-44
Olivine	9.7		---	---	.8	---
Augite	tr		.9	5.5	.5	2.0
Hypersthene	---		---	---	1.8	---
Altered hornblende	---		2.9	7.7	---	.5
Magnetite	---		---	----	---	1.4
Quartz	---		---	.7	---	---
Groundmass						
Plagioclase	21.5		93.5	83.6	41.4	77.3
Augite	55.4				9.4	
Magnetite	8.7				2.9	
Glass	4.7				43.3	
Total	100.0		100.0	100.1	100.1	100.0
Points counted						
Phenocrysts	526		2,033	1,014	1,062	1,043
Groundmass	269		---	---	300	---
Refractive index of fused bead	1.618	1.550	1.537	1.542	1.535	1.520
Silica content from fused bead	[2]46	59-1/2	62	61	62-1/2	65-1/2

[1] Albite-Carlsbad twins.

[2] From "average" curve of Huber and Rinehart (1966, fig. 7).

The Disaster Peak-Orevada View scarp is a striking feature. It rises as much as 850 m from the base of unit Tba to the top of Orevada View. The more resistant flows form bold cliffs that may be continuous for more than a kilometer, but other parts of the slope are covered with debris. The most nearly continuous exposures of units Tbn and Tbs are found on spurs, while unit Tba, crops out best in gulleys in the lower parts of the scarp.

The petrography of the basalt and andesite of Orevada View was not studied in detail, therefore it is difficult to properly name the rocks. There is a tendency among geologists to call most black holocrystalline rocks in thin extensive flows "basalt." However, most of the rocks in this unit have a color index less than 40, and the writer prefers to call such rocks "andesite." Rittmann's (1952) names, given for the analyzed rocks in table 4, are awkward and not suitable for descriptive purposes. The names point out that the rocks range into the oversaturated category, however (no. 1237). For the general description of this unit, the name "basalt and andesite" seems most suitable.

Table 3.--*Thickness, in meters, of basalt and andesite of Orevada View*

Location of section	Unit Tbn	Unit Tbs	Unit Tba	Unit Tca
South of Little Peak				60
Northeast side Disaster Peak		330+	184+	
Orevada View - southeast and east spurs	256+	310	137+	
Orevada View - northeast spur	137+	274	128+	
State line Peak - 8264	420+	194+		
Spur between Sage and West Branch McDermitt Creeks	408+	38+		

Description of units:

Tbn, andesite-aphyric or small plagioclase phenocrysts.
Tbs, basalt and andesite - some with large plagioclase phenocrysts.
Tba, basalt and andesite - in part amygdaloidal.
Tca, cinder agglutinate.

Description of Units

Unit Tca.--Unit Tca is the lowest in the basalt-andesite sequence. It is shown on the map (fig. 3) as underlying unit Tba but may in part interfinger with it. South of Little Peak it clearly overlies the dacite welded tuff and underlies the rhyolite of Little Peak.

Unit Tca consists of andesite or basalt cinder agglutinate. Exposures are nearly continuous on a spur about 2 km south of Little Peak; elsewhere they are poor. The cinder agglutinate is mostly gray with minor local reddish coloration. Cinders are mostly 2-5 cm in maximum dimension with abundant matrix. Locally, larger blocks and bombs of highly vesicular rock, commonly 15-50 cm long, but reaching a maximum of 2 m long, are found. Bedding is generally poor; one thin vesicular flow was observed.

The refractive index of fused bead of one sample from this unit is 1.572, suggesting a silica content of 55-1/2 percent.

Unit Tba.--Unit Tba contains basalt and andesite similar to that described below for Tbs and in addition contains amygdaloidal flow rocks. The top of unit Tba is placed at the top of the highest amygdaloidal flow; however, the filling of the vesicles to form amydules is a secondary process and may reach a higher stratigraphic level at one place than another.

The amygdules are composed chiefly of zeolite; they range in size from about 1 mm to 1 cm as do the vesicles in unit Tbs above, however, most of the amygdaloidal rock contains amygdules no larger than about 3 mm. Some of the amygdaloidal rocks have the medium dark gray of fresh rocks, others are brownish and altered. The amygdaloidal rocks generally contain plagioclase phenocrysts, locally as large as those in unit Tbs, described below. Groundmass is plagioclase, clinopyroxene, magnetite, and glass. In the brownish rocks much of the glass and some of the groundmass plagioclase is altered to clays.

Unit Tbs.--Unit Tbs consists of basalt and andesite. Some is aphyric or contains small plagioclase phenocrysts and is similar to that of unit Tbn, described below. The rock which characterizes unit Tbs, however, is basalt or andesite porphyry containing large plagioclase phenocrysts. These rocks are medium to dark gray or brownish gray, with fine-grained to aphanitic groundmass. The phenocrysts are characteristically tabular and have maximum dimensions commonly from 1/2 to 2 cm, more rarely to 3 cm or more. Thicknesses of the crystals are 1-5 mm. Such phenocrysts commonly constitute from 5-25 percent of the rock, more rarely as much as 35 percent. Trace amounts of olivine and, more rarely, magnetite phenocrysts are locally present. Groundmass consists of plagioclase, augite, magnetite, and glass, locally tachylyte. Some of the rocks contain groundmass olivine. This porphyry constitutes 50-75 percent of unit Tbs.

Some of these rocks, including those containing the large plagiocase phenocrysts, are strikingly vesicular. Vesicles are mostly near spherical and range in size from 1 mm to about 1 cm in diameter. Rocks containing as much as 10-25 percent void space in the form of vesicles are common.

About 27 subhorizontal flows of basalt or andesite of unit Tbs were counted on the upper part of Disaster Peak in about 130 m of elevation. This gives an average thickness of 4.8 m. The probable thickness range is 1.5-7.5 m.

The top of unit Tbs is placed at the top of the highest lava flow with large plagioclase phenocrysts. In the sections traversed, this is a distinct contact and one that may be expected to extend for many more kilometers.

Unit Tbn.--Unit Tbn overlies unit Tbs and caps Orevada View (fig. 3). Unit Tbn consists mostly of andesite, but the rock compositions range to rhyodacite (table 4). The andesites are medium gray to grayish black with fine-grained to aphanitic groundmasses. Light-gray to yellowish-gray fine mottle is common in some flows. Plagioclase phenocrysts, commonly 1/2-3 mm long, are inconspicuous but generally present. Percentages range from trace amounts to about 10 percent. Trace amounts of olivine phenocrysts are present in most of the rocks. Phenocrysts of clinopyroxene and magnetite are less common. Groundmass consists of plagioclase microlites, clinopyroxene, magnetite, and glass. Glass may be light-brown or a black tachylyte that is nearly opaque.

Some of the andesite is highly vesicular, and some black cinder agglutinate is present. These types of rocks may be present in higher proportions under covered parts of the section. In general, the proportion of plagioclase phenocrysts increases downward in the section, so that the unit is somewhat transitional with unit Tbs.

Analyses

Rapid rock analyses (table 4) of the dated samples from units Tbn, Tbs, and Tba show a considerable range in composition. No. 1237, from the top of Orevada View, is petrographically an andesite with sparse phenocrysts of plagioclase, clinopyroxene, and magnetite but contains 59.2 percent SiO_2 and belongs in the oversaturated family according to Rittmann (1952, fig. 4). No. 1238 is an andesite or basalt from near the top of unit Tbs directly east of Orevada View. It contains about 10 percent large plagioclase phenocrysts and sparse phenocrysts of olivine. No. 1236 is an altered andesite or basalt from low in unit Tba further to the east. It contains about 30 percent large plagioclase phenocrysts and 1 percent phenocrysts of olivine.

Radiometric Ages

The basalt and andesite of Orevada View was erupted over a rather long period of time, considering that it is a conformable sequence of

Table 4.--*Rapid rock analyses and CIPW norms of samples of the basalt and andesite of Orevada View*

[Analyses by Lowell Artis using method described in Shapiro (1967)]

	1237	1238	1236
Rittmann's name	dark quartz latite or dark rhyodacite	olivine-andesine trachybasalt	pigeonite-labradorite andesite
Unit	Tbn	Tbs	Tba
SiO_2	59.2	52.2	46.8
Al_2O_3	14.2	15.9	16.7
Fe_2O_3	4.2	5.3	4.6
FeO	5.1	6.2	6.2
MgO	2.1	4.0	6.9
CaO	4.5	7.2	8.2
Na_2O	3.7	3.6	2.8
K_2O	2.9	1.9	1.3
H_2O+	1.2	.89	2.3
H_2O^-	.51	.31	1.8
TiO_2	1.9	2.2	1.8
P_2O_5	.43	.36	.28
MnO	.12	.14	.11
CO_2	.02	.02	.02
	CIPW norms		
Q	14.96	4.51	---
Or	17.18	11.20	7.69
Ab	31.29	30.40	23.74
An	13.56	21.57	29.22
Wo	2.43	4.84	4.00
En	5.27	9.94	12.8
Fs	2.98	3.67	3.59
Fo	---	---	3.10
Fa	---	---	.96
M+	6.09	7.69	6.68
Il	3.61	4.17	3.43
Ap	1.01	.85	.66
Cc	.05	.05	.05

flows (table 5). Units Tba and Tbs, with their large plagioclase phenocrysts, are lithologically identical to much of the basalt underlying Steens Mountain, which lies 40-100 km to the west and north. The Steens basalt has been dated at 15.1 m.y. (Gunn and Watkins, 1970) and 15.3 m.y. (Greene and others, 1972). It is thus apparent that basalt of this type was erupted during several periods over a time span of about 8 m.y.

Table 5.--*K/Ar dates on plagioclase separates from the basalt and andesite of Orevada View*

Unit	No.	Age, m.y.	Most probable age m.y.	Reference
Tbn	1237	16.5±1.5	18	McKee and Marvin, 1973
	1105	17.5±2.0		
	1101	21.8±3.0		
Tbs	1238	20.1±5	20	
	1031	19.6±1.3		
Tba	1236	24.6±2.0	23	McKee and Marvin, 1973
	1038	23.3±10.0		

Units Overlying the Basalt and Andesite of Orevada View

Volcanic rock units in this interval include the lower alkali rhyolite welded tuff, the rhyolite of Little Peak, and the quartz latite of Sage Creek, all in the west part of the area mapped in detail (fig. 3). Also in this interval, but not described here, are a thick section of rhyolitic rocks forming a high scarp overlooking the Kings River valley from the south part of the Disaster Peak quad to Thacker Pass and an assortment of silicic rocks in the south part of the Bilk Creek Range.

Lower Alkali Rhyolite Welded Tuff

The lower alkali rhyolite welded tuff underlies a small area (less than 1 sq km) along the crest of the range in the Disaster Peak quadrangle (fig. 3).

Devitrified tuff of this unit (table 6) has medium-light-gray to light-brownish-gray or greenish-gray groundmass with characteristic light-gray lenticles. Lenticles are commonly 5-30 mm long and 1/2-2 mm wide; many have voids in their centers. The principal phenocryst is alkali feldspar, about 10 percent. Additional phenocrysts include trace amounts of magnetite and of an altered ferromagnesian mineral. The light-gray lenticles are comby-textured tridymite and quartz, probably former pumice lumps. The aphanitic groundmass shows a very fine striping, which probably reflects shards that have been extremely flattened and stretched.

The vitric tuff is dark gray with dull vitreous luster. Lenticles (medium gray to yellowish gray) are of similar dimensions to those in the devitrified tuff. The vitric tuff contains about 1 percent alkali feldspar phenocrysts, and trace amounts of fresh augite and fresh magnetite phenocrysts in addition to patches of bright-green clay which appear to be altered augite phenocrysts. Devitrified lenticular streaks show the loci of former pumice, and shard texture is obvious.

Table 6.--*Modes of lower alkali rhyolite welded tuff*

Sample	974	976
Phenocrysts		
Alkali feldspar	10.1	8.7
Altered dark mineral	.2	.1
Magnetite		.6
Crptocrystalline groundmass	89.7	90.6
Total	100.0	100.0
Points counted	1,179	1,100
Refractive index of fused bead	1.485	1.492
Silica content from fused bead	76	73

This unit also contains a breccia phase. The breccia consists of brownish-gray fragments, 1-10 mm long, which are identical to the main body of the rock and are enclosed in a light-gray matrix of granulated rock with broken feldspar phenocrysts.

Rhyolite of Little Peak

The rhyolite of Little Peak forms a north-south band across the Disaster Peak quadrangle from the north boundary of the quad to the limit of detailed mapping at Little Reiser Creek (fig. 3).

This unit consists of rhyolite and alkali rhyolite. The rocks are flows, breccias, and probable welded tuffs. They are composed of 0-15 percent alkali feldspar phenocrysts, 0-3 percent augite (commonly altered), and 0-2 percent magnetite in a groundmass of cryptocrystalline alkali-feldspar and silica minerals (table 7). Despite this overall similarity in composition, they have a bewildering variety of colors and textures.

Banded porphyritic rhyolite is the most characteristic type of rock in the rhyolite of Little Peak and locally can be separately mapped. The most distinctive banded porphyritic rhyolite has alternating bands of reddish and greenish colors. Elsewhere the rhyolites consist of alternating pale-brown and medium- to light-gray bands so that the rock resembles parts of the alkali rhyolite of Jordan Meadow. Bands are mostly 1/2-2 mm wide and are commonly somewhat wavy but mostly continuous for several centimeters. The banded rocks crop out moderately well on ridges and spurs, shedding platy debris.

The banded rhyolites generally contain 3-15 percent alkali feldspar phenocrysts (table 7). Other phenocrysts include a few percent augite, commonly altered, trace amounts of magnetite, and, locally, quartz. The altered augite appears as dark oxides and (or) greenish clays, some with crystal outlines. Groundmass is a cryptocrystalline mass of alkali feldspar and silica minerals, with coarser bands commonly defining the greenish or lighter gray bands of the hand specimen, while finer grained more oxide-charged bands define the reddish or brownish bands. Lenticular blebs of secondary quartz are common.

Interlayered with the distinctly banded rhyolites are an assortment of other rhyolites and alkali rhyolites. Faintly banded to nonbanded porphyritic rhyolites, mostly of darker browns, grays, and greenish grays are similar to, and grade into, the banded rhyolites. Some rocks, probably alkali rhyolites, are medium to light gray or light greenish gray, sparsely prophyritic, and generally somewhat vesicular. They resemble parts of the alkali rhyolite of Jordan Meadow.

In thin section the greenish alkali rhyolites are seen to contain 0 to a few percent alkali-feldspar phenocrysts and 0 to trace amounts of altered dark minerals. Cryptocrystalline groundmass of alkali feldspar and silica minerals commonly has granophyric texture. Secondary quartz is common.

This type of rock is particularly abundant near Line Canyon, where the rhyolite of Little Peak and the alkali rhyolite of Jordan Meadow come close together, and suggests that the former grades upward into the latter through increase in the proportion of greenish alkali rhyolites. In this area, much of the greenish alkali rhyolite and some banded porphyritic rhyolite is brecciated. Some outcrops are composed of breccia with fragments in the size range of a few centimeters, and others have fragments several tens of centimeters across.

Table 7.--*Modes of the rhyolite of Little Peak*

Sample	730	734	836	849	853	857	859-1	898
Phenocrysts								7.0
Alkali feldspar	14.4	7.3	9.9	12.5	11.7	12.7	---	
Quartz		.3					---	
Augite and clays after augite	2.7	1.1	.6		1.1	1.0	---	
Magnetite	.1	.1		1.8	1.2	.3	---	
Rock fragments	1.5			.5	.3	.1	---	
Groundmass								
Cryptocrystalline	81.3	91.2	89.5	85.3	85.8	17.6	---	92.6
Glass						68.2	---	
Total	100.0	100.0	100.0	100.1	100.1	99.9		100.0
Points counted	1,475	1,000	1,152	1,091	1,180	1,102	---	1,163
Refractive index of fused bead	1.507	1.508	1.501	1.503	1.504	1.505	1.500	1.506
Silica content from fused bead	68-1/2	68	70	69-1/2	69	69	70-1/2	69

Description of samples:

- 730 Banded greenish-gray and pale-red.
- 734 Strongly banded pale-brown to white.
- 836 Fine banding and mottled pale-brown, pinkish, greenish.
- 849 Strongly banded grayish-red and brownish-gray.
- 853 Breccia yellowish-brown to greenish-gray.
- 857 Black lustrous vitrophyre.
- 859-1 Black lustrous vitrophyre.
- 898 Prominent banding grayish-red to reddish-brown.

Flow breccia of brown porphyritic rhyolite is also characteristic of this unit and locally can be separately mapped. It is best developed on Little Peak and on the hill 2-1/2 km to the south (fig. 3), where it forms bold cliffs facing westward.

The breccia is composed of pale-brown to grayish-red fragments in somewhat lighter colored matrix. Both fragments and matrix are mostly porphyritic, but locally either may be aphyric rhyolite. On Little Peak, nonbrecciated brown porphyritic rhyolite is found near the base of the section, then grades upward into breccia by increase in percentage and size of fragments. Fragments are mostly 1-5 cm in maximum dimension, but locally, especially near the top of the section, are as large as 15 cm.

In thin section, breccia fragments are commonly less distinct from matrix than in hand specimen. Mineralogy (for example, table 7, no. 853) is similar to that of the other types of rock in this unit; phenocrysts consist of 5-15 percent alkali feldspar, trace amounts of augite, mostly altered, and trace amounts of magnetite. These are set in a groundmass of alkali feldspar and silica minerals.

On the northeast side of Little Peak, some of the breccia contains a considerable proportion of andesite or basalt fragments. In one outcrop of brown porphyritic breccia are two very large (about 3 m) boulders of basalt containing large plagioclase phenocrysts, similar to that of unit Tbs.

Vitrophyres constitute only a small part of the rhyolite of Little Peak but are locally prominent. Vitrophyres are black with faint banding and are lustrous on fresh broken surfaces. They are tough where fresh, but most outcrops are weathered and hence crumbly. Phenocrysts of alkali feldspar show prominently, as do devitrified bands and occasional rock fragments. Alkali feldspar phenocrysts constitute 5-15 percent of the vitrophyres. About 1 percent fresh augite and trace amounts of fresh magnetite are present in most of the vitrophyre. Banding in the groundmass may be folded and swirled, evidence of flowage. No shard structure is seen.

The relationship between the rhyolite of Little Peak and the alkali rhyolite of Jordan Meadow remains uncertain as their contact is overlain by a band of younger sediments (unit Tsa). However, the rhyolite of Little Peak appears to dip gently eastward below the alkali rhyolite of Jordan Meadow.

Two K/Ar dates on alkali feldspar separates from the rhyolite of Little Peak were obtained by McKee and Marvin (1973): no. 734, 16.1±5 m.y. and no. 1042-2, 15.8±5 m.y. These are within the range of the dates obtained on the alkali rhyolite of Jordan Meadow (table 31). The dates may be correct, but the wide range of dates obtained for the latter unit renders their significance uncertain.

Quartz Latite of Sage Creek

The quartz latite of Sage Creek crops out in the upper canyons of Sage and McDermitt Creeks and tributaries thereto, immediately northeast of Orevada View but entirely in Oregon. Mapped area of outcrop is about 8 km^2. Rocks of this unit reappear in Little Whitehorse Creek, 8 km to the north.

This unit is composed primarily of quartz latite (table 8), with a small amount of interbedded andesite and basalt (table 9). It crops out abundantly; it is exposed in canyon walls and underlies high rounded knobs which are covered with slabby debris through which frequent outcrops are seen. Soil is sparse, and little vegetation covers the slabs.

The quartz latite is of various colors--greenish gray, light brownish gray, and pale brown to pale red. It is characteristically spotty or mottled to weakly banded, and sparse phenocrysts are visible. Thin sections reveal that the phenocrysts are plagioclase, augite, magnetite, and, rarely, quartz. Plagioclase phenocrysts (trace to 2 percent, rarely to 5 percent) are mostly tiny (<1 mm) and euhedral; augite and magnetite are present in trace amounts. Groundmass consists of plagioclase microlites, fine granular alkali feldspar and silica minerals and glass. The relative proportion of these components ranges widely.

A small proportion of quartz latite vitrophyre is also present. It is black, has perlitic fracture, and breaks down readily upon weathering. Phenocryst content is similar to that of the crystallized quartz latite, and the groundmass is glass, locally devitrified adjacent to phenocrysts. Shard structure is absent.

Andesite and basalt (table 9) are locally interbedded with the quartz latite in this unit, and these rocks are the dominant ones in a small area between the headwaters of Sage and West Branch of McDermitt Creeks.

Andesite and basalt are pale brown to brownish gray and dark gray and may be solid or vesicular with local cinder agglutinate. Like the quartz latite, these rocks contain sparse phenocrysts of plagioclase, augite, and magnetite. The groundmass, however, consists of plagioclase microlites, augite, magnetite, and glass.

OLDER VOLCANIC ROCKS NEAR THE CORDERO MINE

A structurally high area directly east, south, and southwest of the Cordero mine exposes a sequence of three mappable units which underlie the alkali rhyolite of Jordan Meadow (fig. 3). These are the trachyandesite and the lower and upper parts of the quartz latite of McConnell Canyon. Thirteen km north of the Cordero mine an additional unit, the rhyolite of McCormick Ranch, directly underlies the alkali rhyolite of Jordan Meadow.

Table 8.--*Modes of quartz latites from the quartz latite of Sage Creek*

Sample	678	1066	1085	1094	1109
Phenocrysts					
Plagioclase	1.8	3.4	1.5	1.7	3.6
(An) β RI	---	28-33	---	---	40-41
Augite	.15	.4	.4	.5	.6
Magnetite	.1	.2	.3	.3	.2
Altered mafic mineral				tr	.05
Groundmass					
Cryptocrystalline and glass	98.0		97.8	97.6	95.6
Glass		96.0			
Total	100.05	100.0	100.0	100.1	100.05
Points counted	2,058	---	1,540	2,356	2,137
Refractive index of fused bead	1.497	1.497	1.503	1.511	1.509
Silica content from fused bead	71-1/2	71-1/2	69-1/2	67-1/2	68

Table 9.--*Modes of andesites and basalts from the quartz latite of Sage Creek*

Sample	686	688-2	1075	1077	1081
Phenocrysts					
Plagioclase	tr	.24	.08	.5	.11
Augite		tr	.06	.2	.06
Magnetite		.04	.007	.2	.04
Groundmass					
Plagioclase	51.1	44.4	50	50	50
Augite	19.4	23.8	20	25	20
Magnetite	17.5	14.9	10	15	10
Glass	11.1	9.7	20	10	20
Clays	.9	7.0			
Total	100.0	100.08	100	100	100
Points counted					
Phenocrysts	---	direct measurement[1]	direct measurement	1,555	direct measurement
Groundmass	325	330	estimate	estimate	estimate
Refractive index of fused bead	1.563	1.560	1.562	1.555	1.560
Silica content from fused bead	57	57-1/2	57	58-1/2	57-1/2

[1]Measured area of phenocrysts in thin section divided by total area of thin section.

Trachyandesite

The trachyandesite (andesite in Greene, 1972) is the lowest unit exposed in this area. The main area of occurrence is on the lower slopes of the north part of the ridge east of the Cordero mine, another is about 8 km to the southwest.

The trachyandesite flows (table 10) are exposed in a few low rounded outcrops, but the rock is seen mostly as float. Much of it is vesicular. It is dark gray, commonly streaked and speckled yellowish brown to pale red. The rock is microgranular and contains 0.1 to 1 or more percent microphenocrysts of plagioclase. Groundmass is plagioclase, clinopyroxene, magnetite, and glass; texture is intergranular-intersertal, more rarely subophitic.

Although the base is not exposed, a thickness of over 60 m is suggested by local topographic relief.

An analyzed sample of the trachyandesite (table 11) contains only 55.1 percent SiO_2. Al_2O_3 and total iron are high at 14.6 and 12.1 percent respectively. Although total alkalis are low at 5.3 percent the K_2O content of 1.8 percent is high for andesite, leading to the name trachyandesite in Rittmann's nomenclature.

Table 10.--*Modes of trachyandesite*

Sample	61	318	484 (analyzed rock)
Phenocrysts			
Plagioclase	0.12	0.2	1.3
(An) β RI	--	--	56-59
Amygdules	--	.5	--
Groundmass			
Plagioclase	49.2	35.5	42.3
Augite	34.1	20.6	24.2
Magnetite	8.4	8.2	10.0
Clays	--	6.3	.8
Glass	8.4	28.8	21.5
Total	100.22	100.1	100.1
Color index	46.4	44.7	43.9
Points counted:			
Phenocrysts	Direct meas.	Est.	1,226
Groundmass	334	300	376
Refractive index of fused bead	1.568	1.572	1.574
Silica content from fused bead	56	55-1/2	55

Table 11.--*Rapid rock analyses of samples of trachyandesite, quartz latite of McConnell Canyon, and alkali rhyolite of Washburn Creek*

[Analyzed by Lowell Artis using method described in Shapiro (1967)]

Unit	MC-484 Trachyandesite	MC-58 Quartz latite of McConnell Canyon	MC-285 Alkali rhyolite Washburn Creek
SiO_2	55.1	64.7	76.1
Al_2O_3	14.6	13.8	12.2
Fe_2O_3	8.2	4.3	.77
FeO	3.9	3.0	.08
MgO	2.3	1.0	.03
CaO	5.9	2.9	.00
Na_2O	3.5	3.5	3.3
K_2O	1.8	3.7	5.3
H_2O^+	.87	.40	.58
H_2O^-	.93	1.2	.33
TiO_2	2.3	1.1	.29
P_2O_5	.62	.35	.04
MnO	.19	.12	.03
CO_2	.02	.02	.02
Total	100.23	100.09	99.07

Table 12.--*Norms of samples of trachyandesite, quartz latite of McConnell Canyon, and alkali rhyolite of Washburn Creek*

Unit	MC-484 Trachyandesite	MC-58 Quartz latite of McDonnell Canyon	MC-285 Alkali rhyolite Washburn Creek
Q	14.9	23.5	37.0
C	-	-	1.05
Or	10.6	21.8	31.6
Ab	29.5	29.6	28.2
An	18.8	11.0	-
Wo	2.6	.40	-
En	5.72	2.49	.03
Fs	-	.36	-
Mt	6.51	6.23	-
Hm	3.69	-	.78
Il	4.36	2.09	.24
Ru	-	-	.17
Ap	1.47	.83	(1)
Cc	.05	.05	-
Mg	-	-	.039

[1]P_2O_5 set = to zero to make norm computable.

Quartz Latite of McConnell Canyon

The quartz latite (dacite in Greene, 1972) of McConnell Canyon occurs only on the ridge east of the Cordero mine, extending south to McConnell Canyon.

The unit consists of quartz latite flows, mostly with microcrystalline groundmass, but is vitric in its upper portion, which is separately mapped. Upper and main parts are 0-15 and 0-45 m thick, respectively.

The microcrystalline quartz latite has light-olive-gray to medium-gray groundmass and weathers yellowish brown. Outcrops are rare, but areas covered with platy slabs are common. The overlying vitrophyre is dark gray and weathers black. Outcrops are abundant and show a dense basal portion grading upward to a vesicular top with elongate vesicles.

The quartz latite contains small phenocrysts of plagioclase, augite, and magnetite (table 13). Microcrystalline groundmass consists of plagioclase, alkali feldspar, and silica minerals, with some clinopyroxene, opaque minerals, and glass. Vitric groundmass is mostly glass but also contains a portion of plagioclase microlites, augite and opaque minerals.

Table 13.--*Modes of quartz latite of McConnell Canyon*

Sample	58 (analyzed rock)	59	319	325
Phenocrysts				
Plagioclase	8.9	7.6	8.7	--
(An) Albite-Carlsbad twins	36-43	35	--	--
Augite	3.3	3.0	2.5	--
Magnetite	.3	.7	.9	--
Groundmass				
Cryptocrystalline	87.5		88.0	--
Glass, partially devitrified		87.6		
Clays		1.3		
Total	100.0	100.2	100.1	--
Points counted	1,733	1,629	1,462	--
Refractive index of fused bead.	1.526	1.531	1.514	1.528
Silica content from fused bead	64	63	67	64

An analyzed sample of the quartz latite of McConnell Canyon (table 11) contains 64.7 percent SiO_2, nearly 10 percent more than the underlying trachyandesite. Other elements are also different, Al_2O_3 is slightly lower and total iron is much lower; total alkalis are greater and CaO and MgO less. The quartz latite is chemically somewhat similar to the quartz latite of Black Mountain (table 26).

Rhyolite of McCormick Ranch

The rhyolite of McCormick Ranch is found low on the east-facing scarp overlooking the broad valley of Oregon Canyon Creek, northwest of McDermitt.

This unit is composed of porphyritic rhyolite and alkali rhyolite of varied appearance. Colors are pinkish to light brownish gray and pale to grayish red, commonly mottled or splotched, more rarely banded.

Light-colored phenocrysts consist of 2-15 percent alkali feldspar and trace to 2 percent quartz in the alkali rhyolites, with trace to 1 percent plagioclase also in the rhyolites. Dark-colored phenocrysts include trace amounts of magnetite and, locally, augite or sphene. Groundmass is mainly alkali-feldspar and silica minerals, locally with admixed plagioclase microlites. Areas with abundant secondary quartz account for the lighter streaks and splotches of the hand specimen.

Vitrophyres account for a small portion of the unit. Some are dark gray and porous, others are banded light brownish gray and grayish black. Phenocrysts are as in the crystallized rhyolites, and flow banding is prominent.

The rhyolite of McCormick Ranch is overlain by the alkali rhyolite of Jordan Meadow, but no underlying formations are exposed in the area studied.

Radiometric Ages

K/Ar dates on plagioclase separates from older volcanic rocks near the Cordero mine have been determined from one sample each of the trachyandesite and the quartz latite of McConnell Canyon. The date on the trachyandesite, 18.8±2.5 m.y., is in the same range as that of unit Tbn of the Orevada View sequence; this also is a good correlation on geologic grounds. The date on the quartz latite of McConnell Canyon, 17.5±2.0 m.y., is in the same range as those on the overlying alkali rhyolite of Jordan Meadow (table 29) so it seems likely that the former is only slightly older than the latter.

ALKALI RHYOLITE OF JORDAN MEADOW

Introduction

The alkali rhyolite of Jordan Meadow is a widespread unit, which occurs both within the McDermitt caldera and without (fig. 2). It extends south to the southern end of Double H Mountain, west to the central and southern parts of the Bilk Creek Range, north to the westernmost part of the Trout Creek Mountains, and to the end of the range west of Blue Mountain. On the east, its area of occurrence is mostly bounded by the Quinn River and Oregon Canyon Creek valleys, but outliers occur on Blue and High Mountains (fig. 2).

The name alkali rhyolite of Jordan Meadow is herein informally assigned to the entire sequence of rhyolitic rocks overlying the older units previously described and underlying the intracaldera lavas. It includes several units informally named on the preliminary geologic map of the Jordan Meadow quadrangle (Greene, 1972): the alkali rhyolites of Long Ridge and Reiser Creek and the rhyolite of McConnell Canyon.

The alkali rhyolite of Jordan Meadow consists of interlayered aphyric, sparsely porphyritic and abundantly porphyritic alkali rhyolites, of various gray, green, and brown colors. The rocks will be described in detail in the following sections. It will be convenient to consider the intracaldera alkali-rhyolites first, followed by the southern, western, and northern occurrences.

Intracaldera Alkali Rhyolite

Central and Southern Parts

General description

In the central and southern parts of the caldera, aphyric alkali rhyolite constitutes perhaps as much as 70 percent of this unit. It is mostly light gray, but may be medium gray or light brownish gray to pale brown or pale red.

Phenocrysts are absent; the rock consists of an aphanitic groundmass which commonly has a very fine faint mottle or beady texture. It weathers to slabs generally one to several centimeters thick which commonly show a pronounced grooving or lineation on their surfaces. Weathered slabs are gray through brown to brownish black on their surfaces; the darker talus is presumably older. Steep dips and minor folds are common in this area (fig. 5).

In thin section, the aphyric rhyolite is seen to consist of an aggregate of alkali feldspar and silica minerals, commonly in a patch or granophyric texture. Secondary quartz in seams and blebs is common. Dark minerals consist of fine dark oxides, commonly slightly concentrated between patches of light minerals and very fine needles of alkali amphibole (table 14).

Table 14.—*Silica contents and densities of alkali rhyolite of Jordan Meadow, intracaldera, south part; gray aphyric phase*

Sample	[1]51	53	64	340	[1,2]343	386	397-1	419	[1]464-2
Refractive index of fused bead	1.496	1.492	1.491	1.496	1.492	1.490	1.490	1.491	1.491
Silica content from fused bead	72	73	74	72	74	74	74	74	75
Density, gms/cc	2.45	2.38	2.31	2.30	2.33	2.35	2.36	2.60	2.29

[1]Analyzed rock.

[2]Obsidian.

Table 27.--*CIPW norms of samples of the alkali rhyolite of Jordan Meadow*

	4	4A	4B	5	6A	6B	7	7A	7B	7C	8	9A	9B
Q	19.0	22.4	23.0	25.3	28.6	31.7	34.2	32.4	31.2	32.4	35.4	33.3	34.5
C	---	---	---	---	---	---	.54	---	---	---	---	---	---
Or	33.0	29.7	28.9	30.7	34.3	27.2	31.3	30.2	27.8	30.7	30.7	27.8	28.4
Ab	32.0	35.7	35.5	33.0	29.6	32.5	27.9	30.3	34.0	31.2	26.2	33.8	31.3
An	4.1	3.24	2.69	.97	1.27	---	.26	---	---	---	1.29	.09	.05
Ac	---	---	---	---	---	1.18	---	.19	2.09	.81	---	---	---
Wo	1.38	.79	.90	1.02	.35	2.39	---	1.86	1.07	.50	1.33	.56	1.20
En	1.19	.33	.64	.95	.42	.32	.47	.65	---	.10	.40	---	.20
Fs	---	---	---	---	---	---	---	---	.65	---	---	---	---
Mt	.85	4.83	.63	1.35	---	1.44	---	.26	2.00	1.33	---	1.23	.65
Hm	4.90	.79	4.86	3.57	3.6	1.30	3.60	2.66	---	1.30	3.10	1.85	2.46
Il	1.14	1.09	1.01	.89	.51	.49	.49	.57	.61	.82	.28	.59	.57
Tn	---	---	---	---	.20	---	---	---	---	---	.21	---	---
Ru	---	---	---	---	---	---	.004	---	---	---	---	---	---
Ap	.38	.26	.24	.21	.10	.095	.095	.05	.02	.05	.07	.05	.05
Cc	.18	---	---	.05	---	---	.05	---	---	---	.18	.05	.05
Q+Or+Ab	84.0	87.8	87.4	89.0	92.5	91.4	93.4	92.9	93.0	94.3	92.3	95.1	94.2

Slightly porphyritic alkali rhyolites are entirely similar to aphyric ones, except that they contain trace amounts of alkali feldspar phenocrysts, rarely detected in hand specimen but seen in thin section.

Abundantly porphyritic alkali rhyolite is interlayered in irregular fashion with the other rhyolites. It is most commonly brownish gray and grayish to pale brown or grayish red; generally streaked and banded with slightly lighter and darker values of the same hue. It tends to weather to small pieces rather than forming slabby talus.

The porphyritic rhyolite consists primarily of phenocrysts of alkali feldspar in an aphanitic groundmass of alkali feldspar plus silica minerals (table 15). Some of the rock contains a few plagioclase phenocrysts, which may be rimmed with alkali feldspar. Augite is the principal mafic mineral; in general it is unaltered but may be reduced to clays and iron oxides. Magnetite phenocrysts are sparse to common but generally partly altered to brown oxides. Sparse rock fragments are mostly andesite.

The groundmass has alternating micro- and crypto-crystalline bands, which corresponds, respectively, to lighter and darker bands in the hand specimen. The lighter bands may have some void space, commonly in part filled with secondary quartz. Poorly developed granophyric texture is common, especially in the lighter bands.

All the rhyolites crop out well on ridge crests and spurs. Outcrop surfaces are commonly fairly smooth and parallel to the general land surface, despite steeply dipping planar structures. Cliffs occur locally, generally rimming the tops of canyons, more rarely down near stream level.

Localities with special features

On a pinnacle 2½ km east of the Cordero mine (loc. 22A, fig. 2), a section showing the base of the alkali rhyolite of Jordan Meadow is exposed. The section is about 6 m thick and consists of a pumice lapilli tuff (devitrified) at the base, which grades upward into gray aphyric rhyolite. The pumiceous tuff is white and porous at the base, though well consolidated. Pumice lumps retain their original shape. A meter upward, the pumice is noticeably flattened and the rock less porous. Considerable swirling and irregularity characterize the next few meters of section, as pumice becomes completely collapsed and pinkish spherulites with dark rims appear. A few lenses of black glass appear in this zone, but distinctive shard structure does not appear either in the glass or in the matrix of the pumiceous tuff. This rock grades upward through loss of distinct pumice lumps and spherulites into normal platy, light-gray alkali rhyolite with distinct lineation on the slabs.

To the south 2.2 km (loc. 22B, fig. 2) is another ridge crest exposure which shows some of the same features. About 1 m of pumiceous sediments forms the base of the section. Above is some medium-gray nonporous lapilli tuff, only partly devitrified, which shows both pumice lumps and shards distinctly in thin section. Platy, light-gray alkali rhyolite overlies tuff.

Table 15.--*Modes of alkali rhyolite of Jordan Meadow, intracaldera, south part; brown porphyritic phase*

Sample	[1]279	384-5	[1]465	505	[1]1139	486	487	493
Phenocrysts								
Alkali feldspar	9.4	6.3	6.4	7.7	8.1	7.6	7.1	---
Plagioclase	---	---	.13	tr	tr	1.3	.8	---
Augite	1.6	.8	1.6	.6	1.0	---	---	---
Olivine	---	---	---	---	.3	---	---	---
Magnetite	.3		1.1	.7		.4	1.1	---
		2.0			.7			
Brown oxides	.75		.8	.7		---	---	---
Rock fragments	.4	.2	---	1.1	.2	---	---	---
Secondary quartz	---	---	---	13.8	---	---	---	---
Groundmass	87.4	90.8	90.0	75.5	89.8	90.7	91.0	---
Total	99.85	100.1	100.03	100.1	100.1	100.0	100.0	---
Points counted	1,204	1,328	1,508	1,284	1,597	1,552	1,312	---
Refractive index of fused bead	1.503	---	1.507	1.501	1.508	1.495	1.499	1.493
Silica content from fused bead	69-1/2	---	68-1/2	70	68	72	71	73
Density, gms/cc	2.49	2.49	2.47	2.47	2.50	---	---	---

[1]Analyzed rock.

On one of the ridges between Long Canyon and Jordan Meadow Flat (loc. 23, fig. 2), a 7-m-thick section of the basal part of this unit is exposed. The bottom 3½ m is compressed, lenticular, reddish and greenish pumice fragments in fine gray matrix, mostly devitrified, but with some lenses of hackly glass with nodules of coherent obsidian. Obsidian nodules, concentrated on the ground surface here and, locally, elsewhere, probably have their source in this basal zone. The upper 3½ m of the exposed section consists of gray aphyric rhyolite with abundant lenticular cavities. The cavities are commonly bordered by a light-brownish to pinkish-gray halo, a common feature near the base of a section of gray aphyric rhyolite. A thin section of this rock reveals a faint fine streaking which is suggestive of shard structure.

The middle part of the canyon of Crowley Creek (fig. 2; no. 7, fig. 3) exposes a section which may be near the base of the alkali rhyolite of Jordan Meadow. Here there are several types of rock characteristic of the unit and some uncommon ones. Common types include gray and brownish-gray aphyric and slightly porphyritic rhyolites and abundantly porphyritic brown-banded rhyolites. Uncommon ones include rhyolite breccias, lithophysal rhyolite, and rhyolites with unequivocal groundmass shard structure.

Northern Part

General description

In the canyons of McDermitt and Reiser Creeks and tributaries in the northern parts of the Jordan Meadow and Disaster Peak quadrangles, the dominant type of rock is aphyric to slightly porphyritic alkali rhyolite (the alkali rhyolite of Reiser Creek in Greene, 1972), which is distinguished by its greenish color (fig. 6, secs. 1, 2, and 3, lower parts). The most common colors are light olive gray to grayish olive and light to medium greenish gray to grayish green. Less common are grays and browns similar to exposures elsewhere. These colors are most commonly uniform in the aphyric to slightly porphyritic rocks, but rocks of higher phenocryst content are banded or mottled.

The outcrop appearance of these greenish rocks is very similar to that of the gray aphyric rhyolite. Smooth-surfaced outcrops on ridge crests yield platy debris, much of it with prominent lineation in the form of grooving of the surface. Flow layering is commonly steeply dipping, and fold axes are locally seen (fig. 5).

Much of the outcrop of the greenish rocks is on canyon walls, most commonly high along the rims, but also near stream level. Crude columnar jointing is common, and the aphyric to slightly porphyritic rhyolites are characteristically more severely darkened with iron oxide stains than the gray rocks.

These alkali rhyolites contain 0-5 percent phenocrysts of alkali feldspar and may contain trace amounts of clinopyroxene, altered mafic minerals, and magnetite (table 16). Groundmass is a crypto- to micro-crystalline aggregate of alkali feldspar and silica minerals in granophyric texture, with dark oxides concentrated between patches. Also present, especially in the greenish alkali rhyolites, are minute needles of bluish-green alkali-amphibole, which may impart the green color to the rocks.

Interlayered abundantly porphyritic rhyolite is brownish gray to grayish brown and grayish green. It is mostly distinctly color banded in alternating lighter and darker browns or alternating browns and greens, locally with grays, reds, and pinks. Banding is commonly even and continuous with bands only 2-5 mm wide but may be lenticular. Contacts between abundantly porphyritic and slightly to nonporphyritic rock are locally exposed. They are sharp to transitional over 2 cm or less. Abundantly porphyritic rhyolite is less resistant, forming recesses in the outcrops and weathering to small bits.

Abundantly porphyritic alkali rhyolite contains 5-15 percent alkali feldspar phenocrysts (table 16). This rhyolite also contains 0-2 percent each phenocrysts of augite, altered mafic minerals, and magnetite plus brown oxides. A very few samples contain a few phenocrysts of plagioclase, generally mantled with alkali feldspar. Groundmass is cryptocrystalline alkali feldspar and silica minerals with dark oxides. The banding seen in hand specimen is caused by an alternation of fine oxide-charged bands and slightly coarser clearer bands. Secondary quartz is common and may partially or completely fill former voids, especially in the lighter colored bands.

Localities with special features

Several uncommon varieties of rhyolite are locally present in the north part of the caldera. Some of the rhyolite is porous to spongy, containing 1-10 percent void space, either as small round vesicles or as larger (2-8 cm long) lenticular voids. Color variations commonly occur near these, with brown areas rimming the voids in otherwise green or gray rocks. Some is lithophysal. Vitrophyre is rare, but there is an occurrence (loc. 24, fig. 2) on Reiser Creek. The vitrophyre here is greenish black and perlitic with sparse alkali feldspar phenocrysts.

Breccias are present at scattered localities and are locally abundant. In the lower canyon of Sage Creek (loc. 25, fig. 2), there is a considerable mass of breccia. Most of the breccia has brown abundantly porphyritic matrix, in some the fragments are brown porphyritic rhyolite also; in other places they are gray aphyric rhyolite. Much of the rock is porous and contains fragments in the 2 mm to 1 cm range; elsewhere it is denser with larger fragments, commonly as much as 7 cm. Strongly banded brown porphyritic rhyolite may locally be seen grading laterally into breccia, as fractures appear and fragments separate, commonly at fold axes, showing that brecciation occurred simultaneously with flow folding.

Table 16.--*Modes of alkali rhyolite of Jordan Meadow, intracaldera, north part*

Sample	[1]123	133-1	[1]134	296	309-1	535	[1]541	[1]618	[1]782	[1]790-2	1014	1088
Phenocrysts												
Alkali feldspar	1.5	1.7	10.1	6.6	11.6	---	2.3	---	---	4.6	---	---
Alkali amphibole	.1	---	---	---	---	---	---	---	---	.5	---	---
Augite	---	---	.8	.1	---	---	---	---	---	---	---	---
Altered mafic minerals	---	---	---	.2	---	---	---	---	---	---	---	---
Magnetite and brown oxides	---	---	2.0	1.0	1.8	---	.5	---	---	.4	---	---
Secondary calcite	---	---	1.3	---	---	---	---	---	---	---	---	---
Rock fragments	---	---	---	---	---	---	---	---	---	.9	---	---
Groundmass	98.4	98.3	85.7	92.0	86.5	100	97.1	100	100	93.7	---	---
Total	100.0	100.0	99.9	99.9	99.9	100	99.9	100	100	100.1	---	---
Points counted	1,887	2,262	1,437	1,474	1,613	---	1,542	---	---	1,330	---	---
Refractive index of fused bead	1.491	1.490	1.510	1.498	1.496	1.488	1.491	---	1.492	1.495	1.501	1.489
Silica content from fused bead	74	74	68	71	72	75	74	---	73	72	70	75
Density, gms/cc	2.42	2.47	2.45	2.50	2.37	2.41	2.38	2.49	2.56	2.50	2.45	2.46

[1]Analyzed rock.

Description of samples:

123	Green, slightly porphyritic.
133-1	Green, slightly porphyritic.
134	Brown, banded, porphyritic.
296	Brown and green, banded, porphyritic.
309-1	Pale-red to dark-gray, porphyritic breccia.
535	Gray, aphyric.
541	Light-brownish-gray, slightly porphyritic.
618	Green, aphyric.
782	Green, aphyric.
790-2	Banded, brownish-gray to medium-dark-gray.
1014	Brown and green, banded, porphyritic.
1088	Green, slightly porphyritic.

On an unnamed tributary to Sage Creek (loc. 26, fig. 2), 2½-3 km east of the above-described locality, there is exposed a mass of brecciated breccia. Here porous and lithophysal brown-banded porphyritic rhyolite grades into breccia. Fragments are mostly 2 mm to 1 cm and strongly welded. This breccia is in turn broken into a megabreccia with fragments as much as 50 cm across.

Near the junction of McDermitt and Cherokee Creeks (loc. 27, several tens of meters north of lat 44°), there is a section that contains definitely recognizable poorly to strongly welded pumiceous tuff interlayered with the normal green, slightly porphyritic and brown abundantly porphyritic rhyolites.

Columnar Sections

Some representative sections of the alkali rhyolite of Jordan Meadow within the caldera are shown in figure 6. In general, the sections illustrate the lithologic content of discontinuous outcrops on ridges or canyon walls over distances of as much as 2 km. They are mostly partial sections, that is, the base is not exposed, and the top is not preserved. Nevertheless, they serve to illustrate the proportion of lithologic types present and the minimum thickness, which may be close to the full thickness.

Sections (1, 2, 3, 7, fig. 6) show that in the central part of the caldera, the rocks are probably over 300 m thick and consist dominantly of gray (south part) or green (north part) aphyric to slightly porphyritic rhyolites. Brown porphyritic rhyolite is sparsely interlayered. Near the edges of the caldera (secs. 5 and 8), the sections are thinner and contain a higher porportion of brown porphyritic rocks. Near the Cordero mine (secs. 9, 10, 11), the section is still thinner, and brown porphyritic and gray aphyric units are in part separately mappable (Greene, 1972). The considerable thickness of gray aphyric without admixed brown porphyritic rhyolite in the top part of section 7 is evidently continuous with that of sections 6 and 12 (fig. 7) to the south.

ALKALI RHYOLITES OUTSIDE THE CALDERA

Double H Mountain

South of the caldera, the alkali rhyolite of Jordan Meadow is continuous across Thacker Pass and down Double H Mountain (fig. 2). It is well exposed on the west-facing escarpment adjacent Kings River Valley. Here the section consists of three units (fig. 2; fig. 7, sec. 12): about 137 m of brown porphyritic rhyolite at the base, 228 m of gray aphyric rhyolite in the middle, capped by about 4.5 m of brown porphyritic rhyolite at the top. Thus brown porphyritic and gray aphyric rhyolites are distinctly separated, not interlayered as they are farther north within the caldera. However, sections 7 and 9 (fig. 6) and 6 and 12 (fig. 7) show a measure of continuity between intra- and extra-caldera rocks.

Figure 6.--Generalized columnar sections of alkali rhyolite of Jordan Meadow, intracaldera. Locality numbers shown on plate 2.

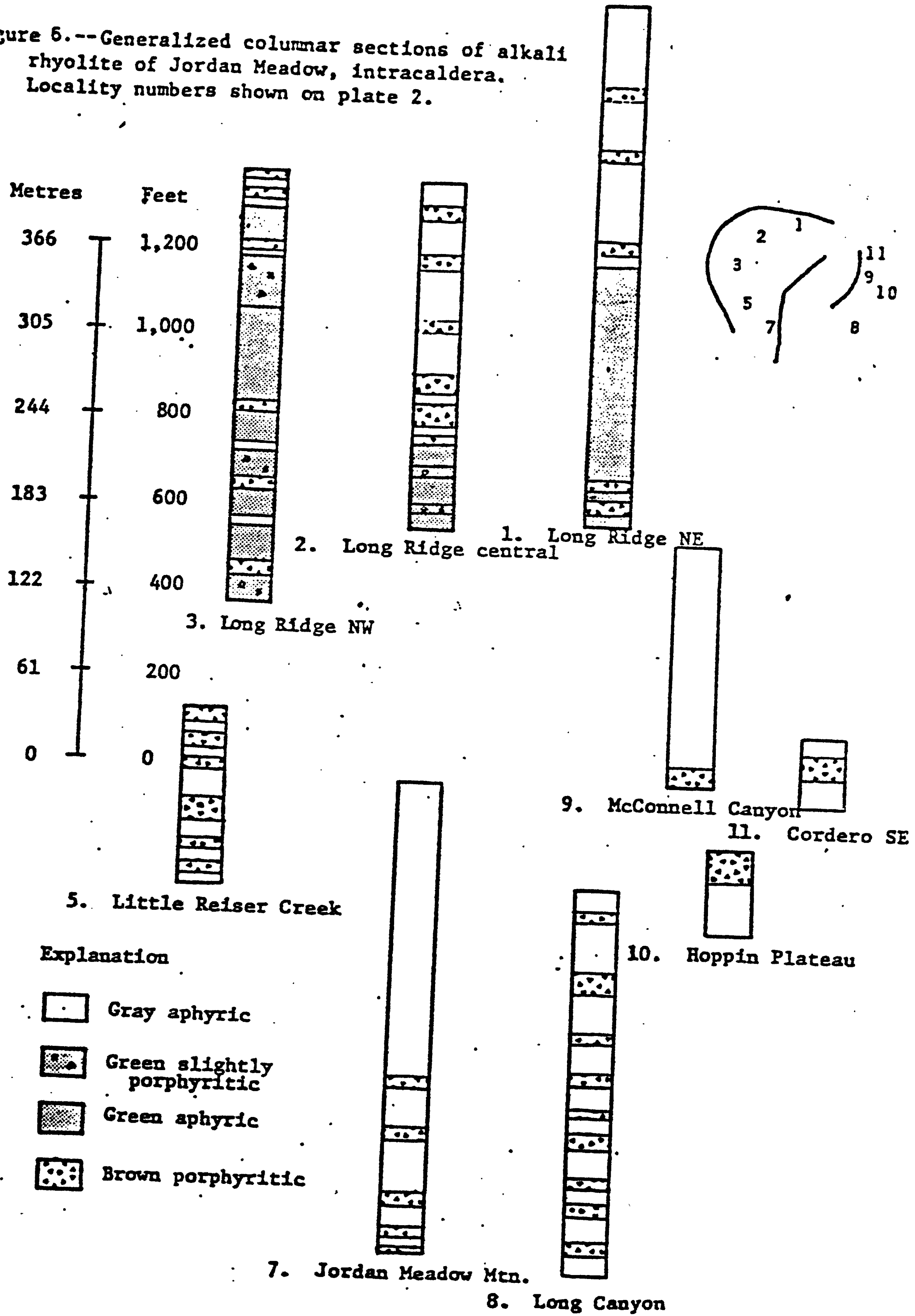
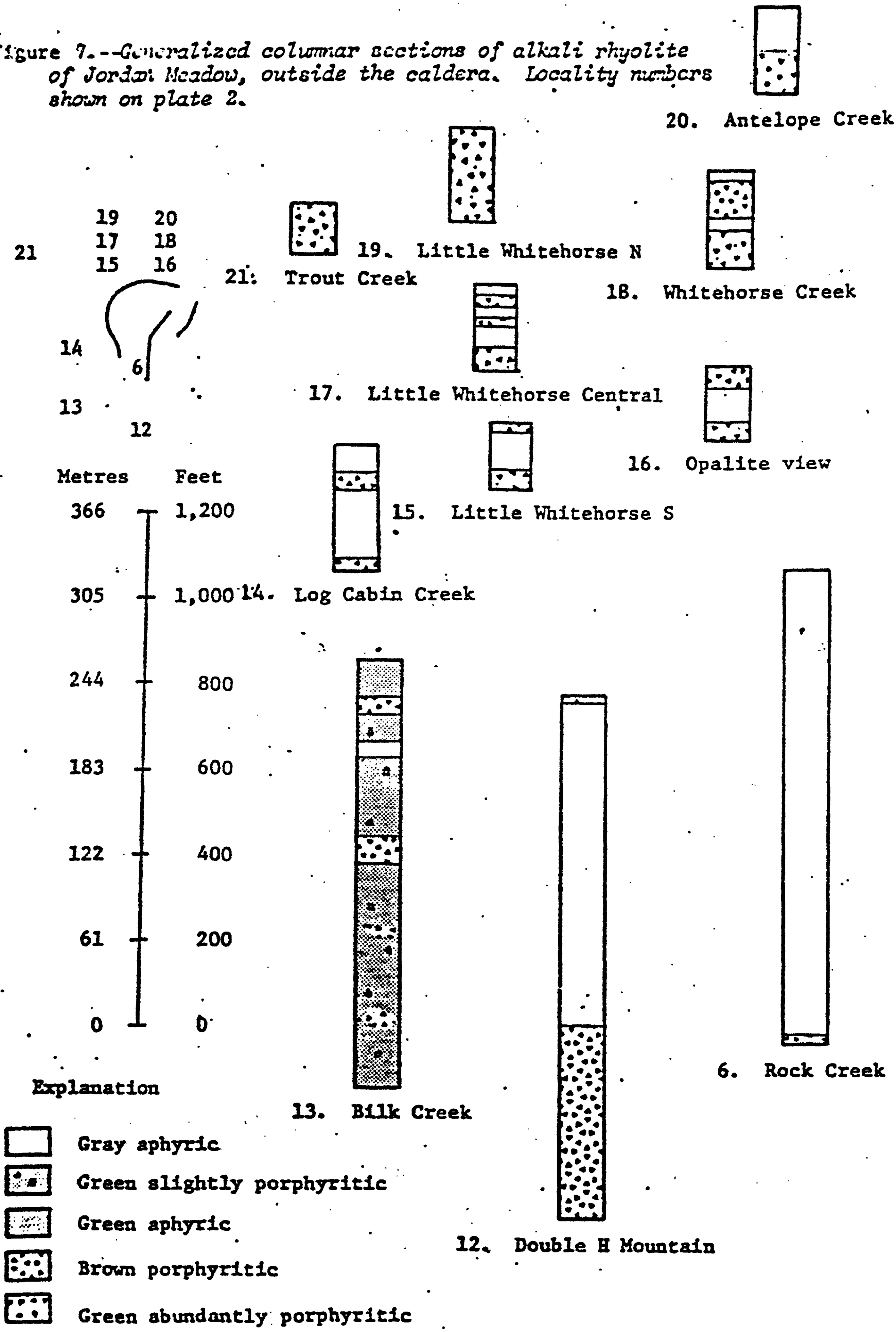


Figure 7.--Generalized columnar sections of alkali rhyolite of Jordan Meadow, outside the caldera. Locality numbers shown on plate 2.



The lithology of the rocks on Double H Mountain is similar to that of their counterparts to the north (table 17). Brown porphyritic rhyolite of the lower unit has a vitric top. Almost all of the unit is flat lying and unfolded (fig. 5), however, some steep dips and minor folds are present near the top, suggesting laminar flowage of a thick mass with folding of the cooler, more viscous upper part.

Rhyolite of the middle unit is similar to gray aphyric rhyolite elsewhere. However, part is slightly greenish and has a faint breccia texture (table 17, nos. 1659-1660), rather than the more common platy jointing with lineation. This part is extremely tough and resistant and outcrops have columnar joints of exceptional uniformity and continuity. Farther up, the rhyolite is flow banded with local steep dips; obsidian nodules and perlitic vitrophyre blocks make their appearance near the top of this unit.

At the top of the section, a 4.5-m layer of brown porphyritic rhyolite (table 17, no. 1666) is present; this rock is noticeably less silicic than that of the lower unit. A well-exposed contact shows this rock to be transitional over a few centimeters with the underlying gray aphyric rhyolite. This is similar to many exposures in the Trout Creek Mountains north of the caldera.

A similar section of rhyolites continues to the south end of Double H Mountain, where decreasing structural elevation causes its eventual disappearance beneath alluvium.

Bilk Creek Mountains

West of the Kings River valley, the alkali rhyolite of Jordan Meadow reappears in the Bilk Creek Mountains (fig. 2; fig. 7, secs. 13 and 14). A section near Bilk Creek (table 18) contains mostly rocks of greenish colors, which thus most nearly resemble the rhyolites in the north part of the caldera.

Greenish-gray slightly porphyritic (trace to 5 percent alkali feldspar phenocrysts) alkali rhyolites are the predominant rocks in the Bilk Creek section. Most have granophyric texture in the groundmass. Some have lenses of brown porphyritic rhyolite a few centimeters to a few decimeters in length, with phenocrysts equally common in lenses and the remainder of the groundmass. These brown and green rocks are unique to this area. Other rhyolites include gray aphyric to slightly porphyritic and brown porphyritic types similar to those found elsewhere.

The rhyolites in the Bilk Creek section mostly dip steeply east. The section is homoclinal and apparently over 915 m thick. However, parts are repeated by normal faults and the probable stratigraphic thickness is 305-457 m.

Table 17.--*Modes of alkali rhyolite of Jordan Meadow, Double H Mountain section*

Sample	1655	1657	1658	1659	1660	1666
Phenocrysts						
Alkali feldspar	7.6	7.3	5	---	---	7.7
Clinopyroxene	---	---	1	---	---	.2
Altered mafic mineral	tr	---	---	---	---	1.8
Alkali amphibole	---	---	---	tr	tr	---
Magnetite	.2	.2	tr	---	---	.1
Groundmass	92.1	92.4	95	100	100	90.5
Total	99.9	99.9				99.9
Points counted	1,319	1,204	estimate	---	---	1,103
Refractive index of fused bead	1.495	1.494	1.499	1.492	1.490	1.503
Silica content from fused bead	72	73	71	74-5	74-5	69-1/2

Description of samples:

1655, lower unit	Grayish-red, porphyritic.
1657, lower unit	Mottled, grayish-red and dark-gray, porphyritic, rosette texture.
1658, top of lower unit	Dark-gray, vitrophyre-incipient devitrification.
1659, middle unit	Greenish-gray, aphyric, exceptional columnar joints.
1660, middle unit	Greenish-gray, aphyric, exceptional columnar joints.
1666, upper unit	Medium-grayish-red, porphyritic.

Table 18.--*Modes of alkali rhyolite of Jordan Meadow from the Bilk Creek section*

Sample	1615	1618	1619	1620	1623	1624	1626	1627
Phenocrysts								
Alkali feldspar	tr	tr	1.5	3.1	2	3.7	4.4	10.8
Quartz			tr	tr		---	---	2.5
Clinopyroxene			.2	.2		1.1	.4	---
Altered mafic mineral			---	.2		---	.6	---
Alkali amphibole		tr	---	---		tr	tr	.3
Magnetite			tr	tr		.1	tr	---
Rock fragments		tr	.7	2.4		.1	---	1.6
Groundmass	100	100	97.6	94.1		95.0	94.6	84.8
Total			100.0	100.0		100.0	100.0	100.0
Points counted	---	---	1,128	1,252	estimate	1,204	1,137	1,234
Refractive index of fused bead	1.493	1.494	1.493	1.497	1.495	1.494	1,495	1.491
Silica content from fused bead	73	73	73	71-1/2	72	73	72	74-75

Description of samples:

1615 Greenish-gray platy lineate.
1618 Greenish- to dark-greenish-gray granophyric texture.
1619 Mottled grayish-red, slightly porphyritic pumice and shard texture.
1620 Mottled pale-brown, porphyritic, shard texture.
1623 Gray, slightly porphyritic, granophyric texture; shard(?).
1624 Light-brownish and light-olive-gray, granophyric texture.
1626 Even mottled medium-gray and light-greenish-gray granophyric with brown lenses, phenocrysts equally common in each.
1627 Greenish-gray, porphyritic, very porous.

At the southern end of the Bilk Creek Range and in the Coyote Hills (fig. 2, locs. 28 and 29) are additional occurrences of brown porphyritic and gray aphyric rhyolites of indeterminate thickness but similar lithology to those on Double H Mountain, directly to the east.

In the north part of the Bilk Creek Range, there are additional occurrences of gray aphyric and brown porphyritic rhyolite (fig. 2; fig. 7, sec. 14). These are of unknown thickness but are similar in all respects to the intracaldera rhyolites lying to the east.

Trout Creek Mountains

North of the McDermitt Caldera, the alkali rhyolite of Jordan Meadow caps a plateau dipping gently northward. Several canyons are deeply incised into the plateau and reveal sections of the rhyolite and underlying basalt and andesite.

The rhyolites in this area are distinctly separated into two units, each 30-60 m thick but rarely exceeding 60 m total exposure (fig. 2; fig. 7, secs. 15-21).

Lower Unit

The lower unit consists of gray and greenish crystal-rich alkali rhyolite. It forms a lower cliff line rimming canyons and thus appears to be resistant, though exposed rocks are commonly porous and crumbly. At the Whitehorse Creek section (fig. 7, no. 18) a basal nonwelded crystal-rich pumiceous ash-flow tuff about 10 feet thick is exposed. Lenses of dense glass appear near the top, but there is a sharp contact with the overlying vitric rhyolite (table 19, no. 1674). The basal 2 m of the rhyolite is vitric; above the devitrified rhyolite is generally very crystal rich (table 19, no. 1676), but some layers contain fewer crystals (table 19, no. 1674A) and are likewise less porous and more coherent.

In thin section the rhyolite is seen to contain 10 to over 20 percent alkali feldspar and 2-6 percent quartz phenocrysts and small amounts of ferromagnesian minerals; shard and pumice textures are prominent in the groundmass. Thus this rock is distinguished from others in the alkali rhyolite of Jordan Meadow by being rich in alkali feldspar and quartz phenocrysts and by containing distinct shard texture in the groundmass throughout.

This unit is present throughout the plateau north of the caldera (see fig. 7, nos. 15-21) and locally is the only one preserved. Maximum thickness is about 60 m at Little Whitehorse Creek North, no. 19. About a meter of the rhyolite of this unit also occurs in the caldera bounding fault zone near the headwaters of Sage and McDermitt Creeks (fig. 2, locs. 30 and 31; table 19, nos. 1072A, 1089). Here the rhyolite overlies the quartz latite of Sage Creek and underlies intracaldera alkali rhyolites of the dominantly greenish type characteristic of the north part of the caldera.

Upper Units

Overlying the greenish crystal-rich rhyolite described above are gray aphyric and brown porphyritic alkali rhyolites similar to those within the caldera (fig. 7, secs. 15-18, 20). Only 30-60 m of section are preserved. In general, gray aphyric and brown porphyritic rhyolites form distinct units separately mappable in this area, in contrast to the intimately interlayered rhyolites within the caldera.

Well-exposed sections at canyon rims are common. These generally reveal a section of typical platy-weathering gray aphyric rhyolite with strong lineation, overlying the lower unit. Higher in the section is brown porphyritic rhyolite, in transitional contact with the gray aphyric. In places the transition zone is as little as 2 cm thick, elsewhere it may be as much as 4 m thick. Some of the brown porphyritic rhyolite of this area is characterized by the presence of darker brown lenses (table 19, nos. 1679, 1642). These lenses are a few centimeters to a few decimeters long and contain phenocrysts in about the same proportion as the remainder of the rock. The rocks with brown lenses are similar to those found at Bilk Creek, except that there the remainder of the rock is green instead of brown. In some sections there are additional layers of gray aphyric and (or) brown porphyritic rhyolite towards the top.

In general, the rocks are not flow folded north of the caldera (fig. 5), however, the transition zones and the brown lenses suggest mixing of lavas or tuffs undergoing laminar flowage at the contacts between contrasting types.

Peripheral Areas

The northernmost outliers of the alkali rhyolite of Jordan Meadow consist of green crystal-rich rhyolite overlain by gray aphyric rhyolite, or only one of these. Brown porphyritic rhyolite does not extend this far north. Thus at the mouth of Trout Creek (fig. 2; fig. 7, sec. 21) and Fish Creek (loc. 33) only green crystal-rich rhyolite is present while at Antelope Creek (sec. 20) and west of the Blue Mountain (loc. 34) gray aphyric rhyolite overlies green crystal-rich rhyolite. At High Mountain (loc. 35) only platy gray aphyric rhyolite is present.

INTERPRETATION

The vast extent--105 km north-south by 60 km east-west--and relative thinness--maximum 365 m--of the alkali rhyolite of Jordan Meadow are the primary factors leading the writer to conclude that this rhyolite is welded tuff. Several subunits within it are also very continuous. The brown and gray upper unit north of the caldera persists for at least 30 km, but is only 30-50 m thick. Likewise, the two thicker units on Double H Mountain appear to persist for about 30 km, but are only in the range of 100-250 m thick.

Table 19.--*Modes of alkali rhyolite of Jordan Meadow, north of the caldera*

Samples	Lower units			Upper units			
	1674	1674A	1676	1679	1642	1072A	1089
Phenocrysts							
Alkali feldspar	21.0	10	21.9	4.8	3.6	25.1	18.1
Plagioclase	---	---	---	tr	---		
Quartz	5.7	2	4.5	---	tr	.4	2.0
Clinopyroxene	.4	tr	.8	.6	.3	.5	.2
Fayalite	---	tr	.5	.1	.1	---	---
Altered mafic mineral	---	---	---	---	---	---	.3
Magnetite	.1	tr	.9	.6	.3	.15	.1
Rock fragments	.1	tr	1.3	---	.2	---	.3
Groundmass	72.7	88	70.0	94.0	95.4	73.8 (glass)	79.0 (glass)
Total	100.0		99.9	100.1	99.9	100.0	100.0
Points counted	1,067	estimate	1,112	1,084	1,198	1,343	1,201
Refractive index of fused bead	1.495	1.495	1.497	1.509	---	1.492	1.501
Silica content from fused bead	72	72	71-1/2	68	---	73	70

Description of samples:

1674	Greenish-gray vitric crystal-rich shard and pumice.
1674A	Medium-dark-gray, porphyritic.
1676	Medium-dark-gray, crystal-rich.
1679	Streak and mottle gray-brownish-gray with grayish-red lenses.
1642	Light-brownish-gray with grayish-red lenses, light areas granophric texture.
1072A	Dark-greenish-gray, vitric with prominent shard texture.
1089	Grayish-olive-green vitric shard and perlitic texture.

Shard texture in the lower, green crystal-rich unit in the Trout Creek Mountains shows that that unit is definitely welded tuff, however, shard texture is mostly lacking elsewhere. Pumice lapilli tuffs at the base of the section south and west of the Cordero mine (fig. 2, nos. 22A, 22B, 27) grade upwards into normal gray and green alkali rhyolites, and shard texture is found at localities on Crowley Creek (fig. 2, no. 7) and Bilk Creek (fig. 2, no. 13). If the bulk of the alkali rhyolite is indeed welded tuff, shard texture must have been destroyed by welding, crystallization, and laminar flowage.

Many units of welded tuff, including, for example, the welded tuffs of Double O Ranch and Prater Creek mapped by the writer (in Greene and others, 1972) contain parts that show no shard texture. In these cases, dense welding and crystallization alone have destroyed the shard outlines.

Extremely stretched pumice, folding, mixed rocks at transitional contacts and abundant rocks featuring narrow lenticular bands of contrasting color, all point to extensive laminar flowage in the alkali rhyolite of Jordan Meadow. This also served to destroy shard texture.

INTRACALDERA LAVAS

Introduction

Lavas overlying the alkali rhyolite of Jordan Meadow are confined to the caldera and its marginal fault and flexure zones. They are mostly located in the Jordan Meadow and Disaster Peak quadrangles and have been mapped in detail (fig. 3; see also Greene, 1972).

The three principal units are, from oldest to youngest, rhyolite of Hoppin Peaks, the rhyolite of McDermitt Creek, and the quartz latite of Black Mountain. Their relative ages are well shown by structural and physiographic evidence. The alkali rhyolite of Washburn Creek occurs only in fault-bounded blocks but is most likely the same age as the rhyolite of McDermitt Creek.

Rhyolite of Hoppin Peaks

Rhyolite of Hoppin Peaks underlies about 30 sq km between Long Canyon and the Quinn River Valley (fig. 3).

Rhyolite of Hoppin Peaks consists of rhyolite flows with some mappable units of vitrophyre. Maximum thickness is over 365 m. The rhyolite is resistant and forms a bold scarp with several prominent cliff lines, overlooking the Quinn River Valley. A plateau above the highest cliff line is surmounted by the Hoppin Peaks and Salient Peak, containing the highest parts of the section.

The rhyolite of this unit is medium light to light gray and light brownish or pinkish gray to pale red. Finely banded rhyolite, with gray and brownish-gray colors appearing in alternate bands, is characteristic of this unit, but probably a larger proportion is evenly colored or mottled.

Well-banded rhyolite forms the upper prominent cliff line on the east-facing scarp beneath the Hoppin Peaks. Banding, while normally planar, is locally folded and swirled by flowage. Amplitude of folds is only a few centimeters, however, unlike the large-scale folding of the alkali rhyolite of Jordan Meadow. The banded rhyolites have platy flow jointing and shed slabby debris.

Nonbanded rhyolite crops out less well but is seen on numerous spurs and in some washes. It is commonly columnar jointed and sheds blocky debris. Locally, the rock adjacent joints is bleached to light gray, while that in the center of joint blocks remains pinkish.

The rhyolite forming the summit of the southernmost Hoppin Peak is somewhat vesicular. This peak is an erosional remnant rather than constructional cone; however, the rhyolite forming its summit is the highest part of the sequence and may represent material not far from a vent.

Phenocrysts are inconspicuous in the rhyolite of Hoppin Peaks, but alkali feldspar, plagioclase, and quartz are almost universally present. Thin sections reveal that alkali feldspar ranges from 1 to 5 percent while plagioclase and quartz range from trace to 3 percent (table 20). Most grains of these minerals are rounded or embayed. Trace amounts of magnetite and (or) altered ferromagnesian minerals complete the list of phenocrysts.

Groundmass is a cryptocrystalline aggregate of alkali feldspar and silica minerals with interstitial dark material concentrated in the darker bands of banded rocks. Some lighter bands exhibit rosette or patch texture.

Flows of rhyolite vitrophyre appear at certain stratigraphic levels, where they form mappable units. Vitrophyre is present at the base of the unit near both the northwest and southwest corners of the outcrop area, but the main vitrophyre unit is high on the plateau, forming the lower portions of the Hoppin Peaks and Salient Peak (fig. 6). A yet higher vitrophyre is present on the southernmost Hoppin Peak.

Vitrophyre of this unit is unusually varied in color, ranging from light gray to black. It crops out well on surfaces of low to moderate slope. Light-colored phenocrysts are more conspicuous than in the crystallized rhyolites, but consist of the same minerals in about the same proportions (table 20). Sparse phenocrysts of fresh augite and magnetite are also present. Vitric groundmass contains minute flow-alined crystallites; shard structure is absent. Fracture is largely perlitic. Accumulations of small bits blanket the outcrop area.

The rhyolite of Hoppin Peaks forms an exceptionally thick pile considering its limited areal extent. It cannot ever have extended much farther to the west, north or south, or more would be preserved. It is faulted off on the east side right where it is thickest, hence a buried extension to the east must be assumed. It is likely that the source also lies to the east.

Table 20.--*Modes of rhyolite of Hoppin Peaks*

Sample	67	350	362-1	[1]367-1	373	467	472
Phenocrysts							
Alkali feldspar	2.4	1.1	4.4	1.4	---	3.1	---
Plagioclase	.1	1.5	1.4	1.2	---	.3	---
(An)	---	23-25	23-29	---	---	---	---
Quartz	.8	.9	1.9	1.3	---	1.3	---
Magnetite	.1	.1	.1	---	---	---	---
Altered mafic minerals	.1	---	---	tr	---	---	---
Groundmass							
Cryptocrystalline			92.2	96.2	---	95.3	---
Glass	96.5	96.5					
Total	100.0	100.1	100.0	100.1		100.0	
Points counted	1,272	1,721	1,570	1,569	---	1,876	---
Refractive index of fused bead	1.487	1.491	1.491	1.489	1.492	1.487	1.491
Silica content from fused bead	75	74	74	75	73	75	74

[1]Analyzed rock.

Rhyolite of McDermitt Creek

The rhyolite of McDermitt Creek occurs in a band 5-8 km wide that runs north-south across the east part of the caldera for a total length of about 29 km (fig. 3). It consists of porphyritic rhyolite flows with conspicuous and abundant feldspar phenocrysts.

Much of the area underlain by this unit is covered with gravels derived from Long Ridge and Jordan Meadow Mountain; however, where not so covered, the rhyolite crops out well. Especially good outcrops occur in the lower canyons of McDermitt and Washburn Creeks (fig. 3) and in the part of Crowley Creek directly south of Jordan Meadow.

The rhyolite of McDermitt Creek contains two distinct types of porphyritic rhyolite--structureless and flow banded.

Structureless porphyritic rhyolite is present in the north part of the outcrop belt near McDermitt Creek and in the south part near Crowley Creek. The typical rock is porphyritic rhyolite with no banding or alinement of phenocrysts. Groundmass color is most commonly light to medium greenish gray or brownish gray, more rarely light to medium gray. Flecks of a bright-greenish color are common, especially near minute vugs. Feldspar phenocrysts are a dull light gray. The color of a weathered surface is medium brown to brownish black (rusty).

Where exposed in canyon walls (Crowley, lowermost McDermitt Creeks), vertical joints spaced 1-3 m apart are common and locally form a crude columnar pattern. At outcrops on moderate slopes, however, the rock breaks on horizontal joints into large slabs with tapering edges. Coherent slabs are commonly 1-2 m across and 5-15 cm thick. They have very characteristic shiny surfaces.

Flow-banded rhyolite with flow-alined phenocrysts is present near Washburn Creek and tributaries. Brownish-gray to pale-brown and grayish-red colors predominate in the groundmass of this rock. Platy flow jointing is common, and the rock breaks to small slabs. Structureless and flow-banded rhyolites are locally interlayered, so that the two types are not separately mappable.

Both types of rhyolite consist of phenocrysts of feldspar, magnetite, and an altered mafic mineral in a cryptocrystalline groundmass (table 21). The feldspar is mostly sodic plagioclase, but alkali feldspar occurs locally as overgrowths on plagioclase and as independent grains. Some of the plagioclase is albite-twinned, particularly in the inner zones; most is not. Most of the plagioclase is somewhat altered--the grains are cloudy, embayed, and many are pockmarked throughout. Thin sections of the freshest gray rhyolites contain a few clear euhedral well-twinned feldspar grains. Patches of birefringent clay are probably derived from clinopyroxene phenocrysts and account for the green flecks of the hand specimen. Irregular grains of magnetite are in part altered to brown oxides.

The groundmass is a cryptocrystalline aggregate of alkali feldspar and silica minerals, commonly in patch texture with darker borders between patches. Streaks of brown iron oxides are common.

The basal part of this unit is well exposed in the lower canyon of McDermitt Creek (fig. 2, loc. 36). Here, in addition to the normal lithology of the unit, are an assortment of flow breccias, vesicular and vuggy rocks, bleached zones, and some vitrophyre (table 21, no. 6). The vitrophyre is grayish black and has local devitrified streaks and spherulites; outcrops are rounded and disintegrate to hackly bits. Phenocryst content is similar to the normal rhyolite.

Maximum exposed thickness of the structureless rhyolite, measured near McDermitt Creek, is about 152 m. Maximum for the flow-banded rhyolite is about 91 m (Washburn Creek).

Rhyolite of McDermitt Creek overlies the alkali rhyolite of Jordan Meadow and occupies a structural and topographic low. This position indicates it is most probably younger than the rhyolite of Hoppin Peaks. It apparently came from local vents, filling an area of collapse following the eruption of the underlying rhyolite and alkali rhyolite.

Alkali Rhyolite of Washburn Creek

The alkali rhyolite of Washburn Creek is present in several fault blocks and isolated erosional remanents 1½ to 6½ km northeast of the Cordero mine. There are no stratigraphic contacts with other units in the area of outcrop; therefore, the relative age of the unit is indeterminate. However, it appears most likely that it is similar to that of the rhyolite of McDermitt Creek.

The most typical alkali rhyolite in this unit (table 22) is light gray with faint fine mottle or with faint banding. Other rocks are pinkish to light brownish gray and medium to dark gray and brownish gray. The alkali rhyolites crop out well on low cliffs and spurs, despite the small relief in the outcrop areas.

Phenocrysts are sparse and indistinct in the hand specimen. In thin section they are seen to consist of trace amounts to 5 percent alkali feldspar, trace amounts of an altered ferromagnesian mineral, and trace amounts of magnetite with brown oxides (table 22). Groundmass is aphanitic; it consists of alkali feldspar and silica minerals, commonly in granophyric texture.

An analyzed sample of the alkali rhyolite of Washburn Creek (MC-285) (table 11) is the most silica-rich rock of those analyzed. Refractive indices of fused beads (table 22) prepared from several samples of this rock are correspondingly low, indicating very high silica content.

Table 21.--*Modes of rhyolite of McDermitt Creek*

Location	McDermitt Creek			Washburn Creek		Crowley Creek		Washburn Creek
Sample	2-1	3	6	30	40	74-1	[1]439	552
Phenocrysts								
Plagioclase	16.1	12.65	14.4	15.2	---	---	21.7	---
(An) β RI	---	12-20	---	---	---	---	---	---
Altered mafic mineral	.4	.4	1.6	.3	---	---	.7	---
Magnetite	.3	1.1	.4	2.5	---	---	2.4	---
Groundmass								
Cryptocrystalline	83.2	85.8		82.0	---	---	75.2	---
Glass			83.6					
Total	100.0	99.95	100.0	100.0			100.0	
Points counted	1,605	1,415	1,290	1,529	---	---	1,401	---
Refractive index of fused bead	1.497	1.499	1.502	1.499	1.500	1.500	1.500	1.502
Silica content from fused bead	71-1/2	71	70	71	70-1/2	70-1/2	70-1/2	70

[1]Analyzed rock.

Description of samples:

2-1 Grayish-olive.
3 Greenish to brownish-gray.
6 Vitrophyre, grayish-black.
30 Brownish-gray, fresh.
40 Strongly banded, brownish-gray to dark-red.
74-1 Pale-to grayish-red.
439 Medium-gray, fresh.
552 Banded, brownish-gray with white flecks.

Table 22.--*Modes of alkali rhyolite of Washburn Creek*

Sample	[1]285	322	330
Phenocrysts			
Alkali feldspar	4.9	4.1	2.7
Altered mafic mineral	---	.6	.7
Magnetite and brown oxides	.2	.2	---
Secondary quartz	---	4.3	.8
Clays and altered glass	.4	.4	---
Groundmass	94.5	90.4	95.7
Total	100.0	100.0	99.9
Points counted	1,760	1,407	766
Refractive index of fused bead	1.483	1.484	1.485
Silica content from fused bead	76	76	76

[1]Analyzed rock.

Quartz Latite of Black Mountain

The quartz latite of Black Mountain is present on Black, Jordan Meadow, and Round Mountains (fig. 3). Rocks of this unit form only a thin capping on Jordan Meadow Mountain but form the bulk of Black and Round Mountains.

The quartz latite of Black Mountain consists of porphyritic quartz latite. The rock is mostly crystalline but is in part vitric, especially near the base. Typical crystalline quartz latite on Jordan Meadow and Black Mountains is brownish gray to grayish brown, grayish red, and reddish brown. Banding is rare. Vitric quartz latite is dark gray to black with vitreous luster.

The quartz latite crops out well along the edge of the body capping Jordan Meadow Mountain and on the spurs of Black Mountain. The rock breaks into large slabs generally several centimeters thick. A uniform dark-brown to brownish-black weathering color is distinctive.

Black Mountain culminates in a breached crater but little modified despite its age (Miocene). A small amount of vesicular quartz latite and reddish cinder is found on the crater rim.

Round Mountain is underlain mostly by vesicular reddish quartz latite; much of it cinder agglutinate. Some denser vitrophyre is interlayered; all contains small quantities of minute plagioclase phenocrysts. Round Mountain also has the form of a volcanic cone with a breached crater at the top. At 2,148 m, it is one of the highest points south of Disaster Peak.

The quartz latite contains 5-15 percent plagioclase phenocrysts (table 23). Some of these are euhedral and clear, but many are partially to nearly completely resorbed. Two to 8 percent clinopyroxene and 2-3 percent magnetite constitute the mafic phenocrysts. Clinopyroxene is commonly unaltered but is locally bleached or altered to clays at the grain margins. Magnetite is mostly fresh in the centers of grains but rimmed with brown oxides.

The groundmass of these quartz latites consists of plagioclase microlites with interstitial alkali feldspar, silica minerals, clinopyroxene, and glass. There is a continuous gradation from holocrystalline to vitric groundmasses corresponding to the color change of the hand specimen from brown to black. Where the groundmass is all glass, it is an opaque black tachylyte.

The quartz latites are flows originating from local vents. The distribution of the lavas and the topography suggest four such vents--the summits of Round, Jordan Meadow, and Black Mountains, plus the hill northeast of Black Mountain.

A K/Ar date on this unit (13.7±2.0 m.y., table 31) is substantially younger than the others for the overlying lavas; however, when the standard errors for all the ages are taken into consideration, the difference becomes small. Though the relationship is not certain, the unit of tuffaceous sedimentary rocks appears to overlie the quartz latite of Black Mountain.

INTRACALDERA SEDIMENTARY ROCKS AND ANDESITE

Tuffaceous sedimentary rocks cover much of the north and west sides of the caldera floor and occur in patches on the east side (fig. 3). The sedimentary rocks are well exposed in the vicinity of the Opalite mine (fig. 3). Here, they are largely white, yellowish, and light-gray tuffaceous sediments, weakly consolidated. Much of the rock is claystone; the rest is sandstone and conglomeratic sandstone, mostly composed of glass shards, pumice fragments, and plagioclase grains. Much of the vitric material is unaltered. Although mostly soft, the sediments are locally silicified to hard, flinty rocks, mostly gray but locally in the varied colors prized by rock hounds.

Sandstones, fine conglomerates, and breccias composed of fragments of andesitic and rhyolitic rocks are also present in this unit, particularly near the west edge of the band of sedimentary rocks between Little Peak and the Oregon State line. Here, there are several occurrences of silicified sandstones and conglomeratic rocks that form bold outcrops. The rocks are composed of angular fragments, well sorted in the finer rocks and poorly sorted in the coarser ones. Fragments are volcanic rocks

Table 23.--*Modes of quartz latite of Black Mountain*

Sample	391	391	404	502	507	510	515-1[1]	555
Phenocrysts								
Plagioclase	11.7	11.2	---	---	11.5	14.0	7.9	6.3
(An) β RI	---	---	---	---	---	49-50	45-46	---
Augite	5.4	5.9	---	---	4.7	8.1	3.6	2.9
Magnetite	1.8	2.3	---	---	2.9	3.3	1.9	1.9
Groundmass								
Cryptocrystalline	81.3	80.6	---	---	80.9		86.6	89.1
Glass			---	---		74.7		
Total	100.2	100.0	---	---	100.0	100.1	100.0	100.2
Points counted	1,530	1,320			1,118	1,460	1,464	1,496
Refractive index of fused bead	1.537	1.531	1.528	1.528	1.537	1.568	1.532	1.530
Silica content from fused bead	62	63	64	64	62	56	63	63

[1]Analyzed rock.

Location of samples:

391	Jordan Meadow Mountain
393	Jordan Meadow Mountain
404	Jordan Meadow Mountain
502	Washburn Creek
507	Black Mountain
510	Black Mountain
515-1	Peak 6046 northeast of Black Mountain
555	Washburn Creek

and plagioclase grains. A particularly coarse breccia is exposed 2½ km directly east of Disaster Peak. It includes fragments and blocks of brown and green porphyritic rhyolite as much as 2 m across. It also contains rounded cobbles of basalt, as large as 1 m in diameter, some scoriaceous and some containing large plagioclase phenocrysts.

A single occurrence of andesite with cinder agglutinate is located in the north-south band of sedimentary rocks very near lat 41°-55° (fig. 3). The andesite is dark gray with aphanitic groundmass and small amounts of tiny phenocrysts; some is solid but most vesicular. The two samples studied (table 24) are remarkably different in phenocryst mineralogy and in silica content.

A K/Ar date on the above described andesite is 16.4 m.y. (table 31). Because the sedimentary rocks overlie the alkali rhyolite of Jordan Meadow, they are younger. Yates (1942) reports that diatoms collected in rocks of this unit indicate a late Miocene age; also fresh-water gastropods and leaves each indicate a Miocene age.

Irene Gregory (written commun., 1976) reports the following fossil woods from the area directly east of Disaster Peak: Osmanthus, Drimys, Bumelia, Mahonia, Actinidia, Picea, Prunus, Tetracertion, Cedrela, Rosa, Ginko, Chestnut, Sequoia, Ash, Beech, various oaks, elms, and maples.

Table 24.--*Modes of andesite*

Sample		902	1234
Phenocrysts			
Plagioclase		5.6	3.9
Olivine		.6	
Augite			.6
Hypersthene			.8
Magnetite			.8
Groundmass			93.8
Plagioclase		13.1	
Augite		3.9	
Glass		73.9	
Void		3.1	
	Total	100.2	99.9
Points counted		1,495	1,590
Points counted for groundmass		305	
Refractive index of fused bead		1.576	1.530
Silica content from fused bead		54	63

CHEMISTRY OF THE ALKALI RHYOLITE OF JORDAN MEADOW AND THE OVERLYING LAVAS

ANALYSES

Rapid rock analyses were obtained for 13 rocks from the alkali rhyolite of Jordan Meadow, and for one each of the three principal units of overlying lavas. All the analyzed alkali rhyolites are from within the caldera, but represent a broad spectrum of the rock types present--brown porphyritic, green porphyritic, aphyric, and gray aphyric (table 25).

In general, the major element contents of the alkali rhyolites follow closely their color and phenocryst content--the darkest brown rocks with the most feldspar phenocrysts contain the least SiO_2 and the most Al_2O_3, Fe_2O_3+FeO, and CaO. The light-brown and green rhyolites with few phenocrysts and the gray aphyric rhyolite are higher in SiO_2 and lower in Al_2O_3, Fe_2O_3+FeO, and CaO. The silica contents from fused beads of the alkali rhyolites which appear in tables 14-19 further affirm this.

The analyses show that the rocks of the alkali rhyolite of Jordan Meadow are alkali rhyolites and dark alkali rhyolites according to the chemical classification of Rittmann (1952). They range in SiO_2 content from about 65-75 percent (table 25). The lavas of the overlying units are quartz latite and rhyolite and range from 63 to 75 percent in SiO_2 content (table 26).

A series of SiO_2 variation diagrams (fig. 8) illustrates some of the characteristics of these rocks. Nos. 2, 6, and 9 are from the overlying lavas; the others are from the alkali rhyolite of Jordan Meadow. The oxide which distinguishes these families of rocks most strikingly is Al_2O_3. Nos. 2, 6, and 9 are high in Al_2O_3 (13.6-14.2 percent), and there is a slight decrease only toward the more silicic compositions. In the alkali rhyolites, however, the range is 11.2 to 13.8 percent, with a marked decrease in the higher SiO_2 rocks.

Na_2O and K_2O are characterized by irregular slightly decreasing trends, including all samples but no. 2. When combined, the alkalis give a regular decreasing trend, albeit over a small range (8.3 to 9.4 percent Na_2O+K_2O), and excepting no. 2. Because the alkalis exhibit a regular trend in contrast to the diverging Al_2O_3 trends, the alkali-alumina ratios follow the same pattern as the Al_2O_3 contents. Likewise, the more complex ratio Al-Alk/Al+Alk used for Rittmann's nomenclature scheme clearly distinguishes the alkali rhyolites from the other rocks (Rittmann, 1952).

As with most series of silicic volcanic rocks, FeO and Fe_2O_3 are best treated together, as total iron content is low and the oxidation state varies irregularly. FeO+Fe_2O_3 content ranges from 1.3 to 7.6 percent and decreases markedly with increasing SiO_2 content (fig. 8).

Table 25.--*Rapid-rock analyses of samples of the alkali rhyolite of Jordan Meadow*

[Nos. 4, 5, 7, and 8 analyzed by Lowell Artis (in Shapiro, 1967); nos. 4A, 4B, 6A, 6B, 7A, 7B, 7C, 9A, and 9B analyzed by Paul Elmore (in Shapiro and Brannock, 1962) supplemented by atomic absorption]

Number[1]	4	4A	4B	5	6A	6B	7	7A	7B	7C	8	9A	9B
Field no.	MC-134	MC-1139	MC-465	MC-279	MC-790-2	MC-64	MC-123	MC-782	MC-343	MC-618	MC-51	MC-464-2	MC-541
Description	Brown porphyritic	Dark-brown banded porphyritic	Light-brown porphyritic	Brown porphyritic	Dark-brown porphyritic	Gray aphyric	Green slightly porphyritic	Green aphyric	Obsidian	Green aphyric	Green aphyric	Gray aphyric	Light brownish-gray slightly porphyritic
SiO_2	65.8	67.8	68.2	69.4	72.2	73.7	74.1	74.1	74.5	74.5	74.9	75.1	75.1
Al_2O_3	13.8	13.5	13.2	12.4	12.5	11.3	11.8	11.4	11.7	11.7	11.2	11.7	11.3
Fe_2O_3	5.5	4.1	5.3	4.5	3.6	2.7	3.6	2.9	2.1	2.5	3.1	2.7	2.9
FeO	.56	1.8	.44	.76	.20	.64	.20	.32	1.2	.76	.08	.60	.40
Fe_2O_3+FeO	6.06	5.9	5.74	5.26	3.8	3.34	3.8	3.22	3.3	3.26	3.2	3.3	3.3
MgO	.48	.13	.26	.38	.17	.13	.19	.26	.00	.04	.16	.00	.08
CaO	1.8	1.2	1.2	.83	.56	1.6	.13	1.0	.54	.28	1.1	.34	.64
Na_2O	3.8	4.2	4.2	3.9	3.5	4.0	3.3	3.6	4.3	3.8	3.1	4.0	3.7
K_2O	5.6	5.0	4.9	5.2	5.8	4.6	5.3	5.1	4.7	5.2	5.2	4.7	4.8
Na_2+K_2O	9.4	9.2	9.1	9.1	9.3	8.6	8.6	8.7	9.0	9.0	8.3	8.7	8.5
H_2O^+	1.1	.60	.65	1.0	.63	.49	.83	.62	.53	.41	.50	.37	.50
H_2O^-	.68	.20	.75	.97	.37	.09	.27	.21	.05	.27	.25	.07	.09
TiO_2	.60	.57	.53	.47	.35	.26	.26	.30	.32	.43	.23	.31	.30
P_2O_5	.16	.11	.10	.09	.04	.04	.04	.02	.01	.02	.03	.02	.02
MnO	.24	.20	.23	.08	.04	.04	.03	.03	.06	.04	.05	.06	.07
CO_2	.08	.02	.07	.02	.02	.31	.02	.06	.01	.01	.08	.02	.02
Total	100	99	100	100	100	100	100	100	100	100	100	100	100

[1]Numbered in order of increasing SiO_2 content. These numbers identify the points on succeeding diagrams.

Table 26.--*Rapid-rock analyses and norms of samples from the overlying lavas*

[Analyzed by Lowell Artis (in Shapiro, 1967)]

Number	2	6	9		2	6	9
Field no.	MC-515-1	MC-439	MC-367-1		MC-515-1	MC-439	MC-367-1
	Rapid-rock analyses				CIPW norms		
SiO_2	63.3	70.1	75.1	Q	20.6	27.0	34.8
Al_2O_3	14.2	13.8	13.6	C	.20	1.05	1.60
Fe_2O_3	5.5	4.4	.61	Or	24.2	31.9	32.4
FeO	2.1	.08	.72	Ab	30.4	30.5	25.3
Fe_2O_3+FeO	7.6	4.5	1.3	An	9.9	2.70	3.01
MgO	1.2	.22	.09	Wo	---	---	---
CaO	2.7	.74	.70	En	2.99	.55	.22
Na_2O	3.6	3.6	3.0	Fs	---	---	.60
K_2O	4.1	5.4	5.5	Mt	3.91	---	.88
Na_2O+K_2O	7.7	9.0	8.5	Hm	2.80	4.41	---
H_2O^+	.78	.53	.64	Il	2.77	.23	.25
H_2O^-	.72	.36	.14	Tn	---	---	---
TiO_2	1.2	.48	.13	Ru	---	.36	---
P_2O_5	.51	.13	.05	Ap	1.21	.31	.21
MnO	.19	.03	.00	Cc	.05	.05	.05
CO_2	.02	.02	.02	Q+Or+Ab	75.2	89.4	99.16
Total	100	100	100				

Units: 2, Dacite of Black Mountain; 6, Rhyolite of McDermitt Creek; 9, Rhyolite of Hoppin Peaks.

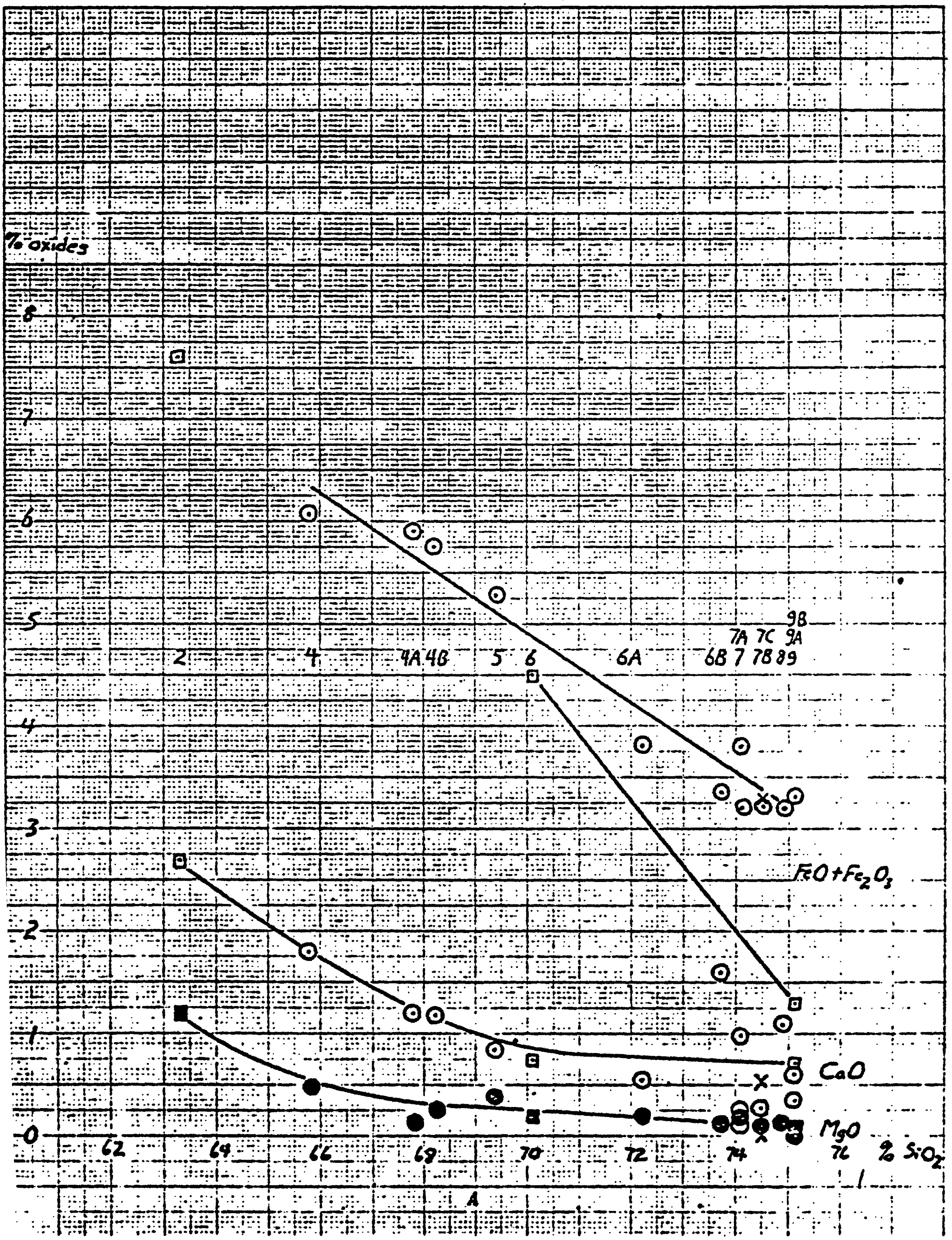
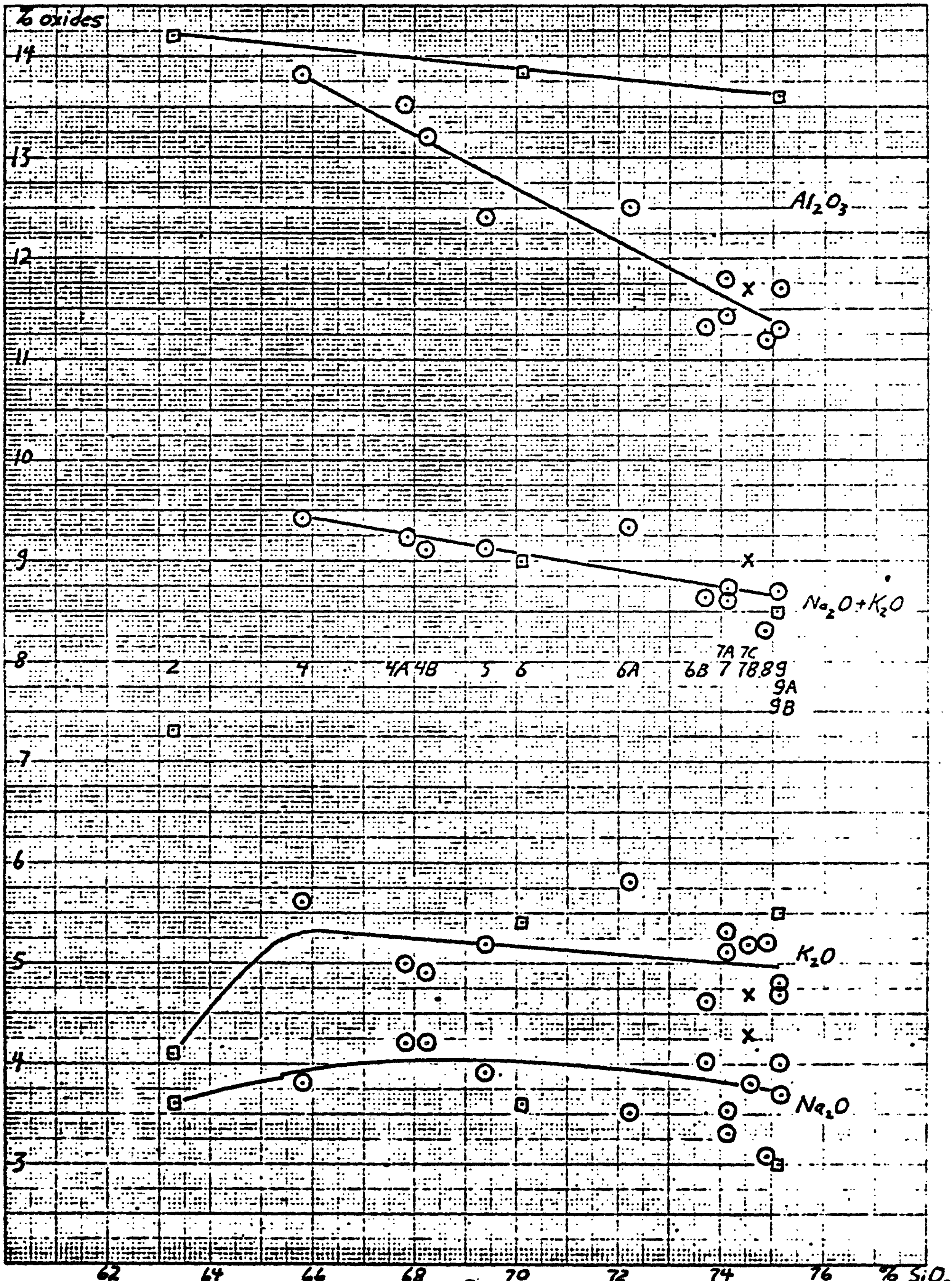


Figure 8.--*A* and *B*, Silica variation diagrams for analyzed samples of alkali rhyolite of Jordan Meadow and overlying lavas. Explanation: ⊙ Alkali rhyolite of Jordan Meadow; ✕ Obsidian; ⊡ Overlying lavas; MgO symbols filled for clarity.


% oxides
14
13
12
11
10
9
8
7
6
5
4
3
Al_2O_3
$Na_2O + K_2O$
K_2O
Na_2O
2 4 4A 4B 5 6 6A 6B 7 7A 7B 7C 8 9 9A 9B
62 64 66 68 70 72 74 76
% SiO_2

B

Two of the samples from the younger lavas have lower iron contents at given SiO_2 levels than the alkali rhyolites. CaO, MgO, and TiO_2 show a smooth decrease with increasing SiO_2 from no. 2 to no. 6A; in the more silicic rocks, these elements vary irregularly.

An additional plot (fig. 9) illustrates the difference between the two families of rocks. On figure 9, Al_2O_3 vs K_2O+NaO, a line of small curvature can be drawn through the field of the alkali rhyolites, showing a nearly constant alumina/alkali ratio for these rocks, while the younger lavas have higher Al_2O_3 contents and differing alumina/alkali ratios.

The Alk-F-M plot (fig. 10, Alk = K_2O+Na_2O; F = $FeO+Fe_2O_3$+MnO; M = MgO) shows a small portion of the normal differentiation trend toward higher F/M ratios and towards the Alk corner. For the interlayered alkali rhyolites, this trend is probably in normal order, but for the overlying lavas, it is reversed; that is, the trend is away from the Alk corner with time.

NORMS

Computer calculated CIPW norms for the alkali rhyolites and younger lavas (tables 26 and 27) show that Q, Or, and Ab are the major constituents. Some of the alkali rhyolites contain normative Ac and thus are peralkaline; others contain normative Wo and thus are meta-aluminous; one contains, instead, normative C and is slightly peraluminous. The overlying lavas all contain normative C and thus are peraluminous.

Since Fe_2O_3/FeO ratios are rather high in these rocks, most contain Hm (hematite), and the FeO all goes into Mt (magnetite) or Il (ilmenite). The obsidian sample and no. 9, a younger lava with very low iron content are exceptions and, therefore, contain some Fs.

The plot of the normative feldspar components Ab-Or-An (fig. 11) has all points but one clustered in the area $Or_{43-54}Ab_{42-55}An_{0-6}$. Most of the samples have an Ab-Or ratio close to 1, though the available data show a much higher albite content in the contained phenocrysts (table 28).

The best picture of the compositional relationships of these rocks is given by the Q-Ab-Or plot (fig. 12), as these components form the bulk of the rocks (84 to 95.1 percent, except no. 2, 75.2 percent). The light-colored phenocryst-poor alkali rhyolites cluster closely in the middle near the isobaric equilibrium curves for 3,000 to 1,000 bars (Tuttle and Bowen, 1958), while the darker rhyolites are closer to the Ab-Or base. The overlying lavas show a trend toward more Q and Or-rich compositions, but this trend is in the reverse time order, that is, the older units are richer in Q and Or. A similar result was shown by the Alk-F-M diagram.

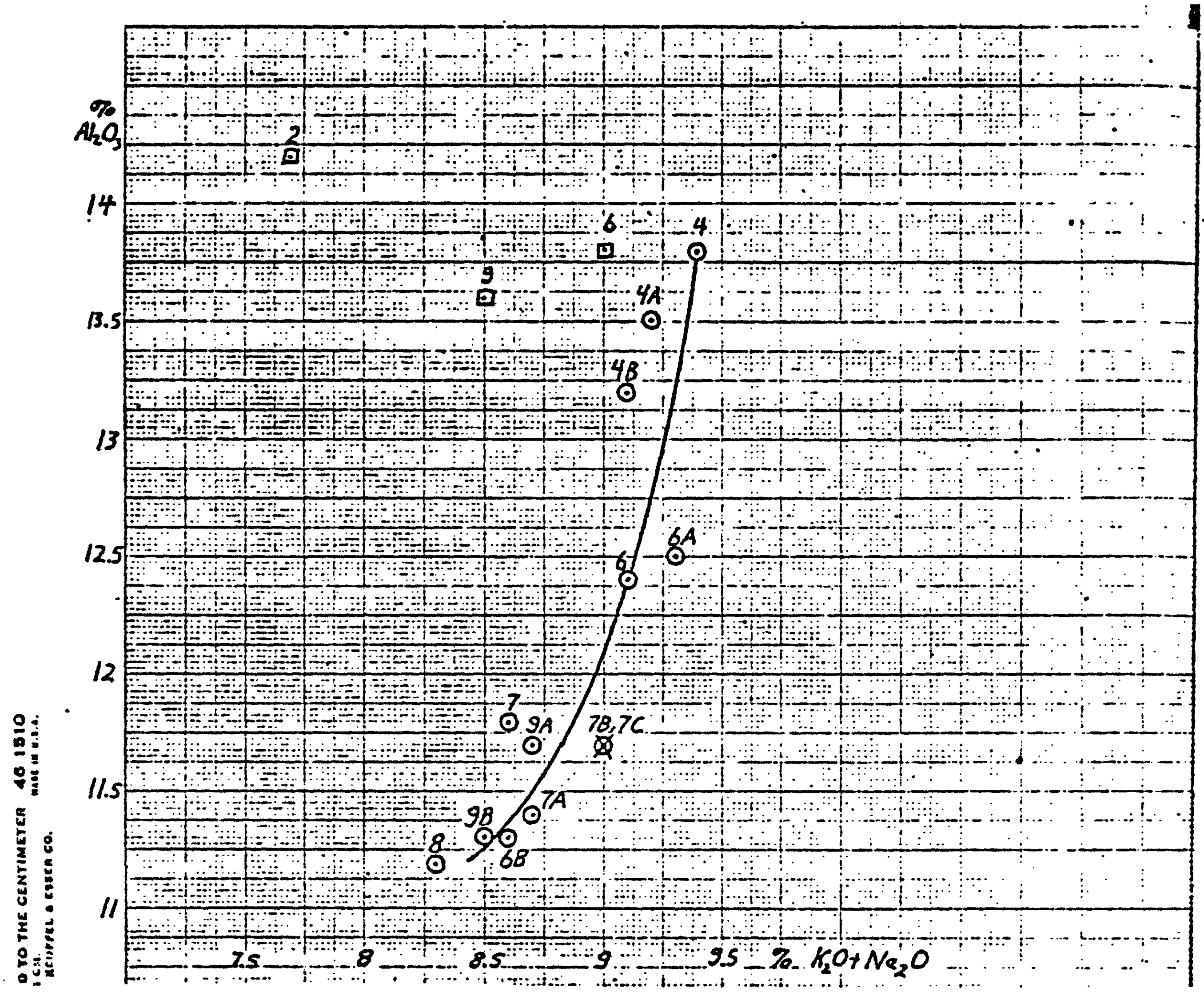


Figure 9.—Al_2O_3 vs. K_2O+Na_2O for analyzed samples of alkali rhyolite of Jordan Meadow and overlying lavas.

Explanation

⊙ Alkali rhyolite of Jordan Meadow

X Obsidian

⊡ Overlying lavas

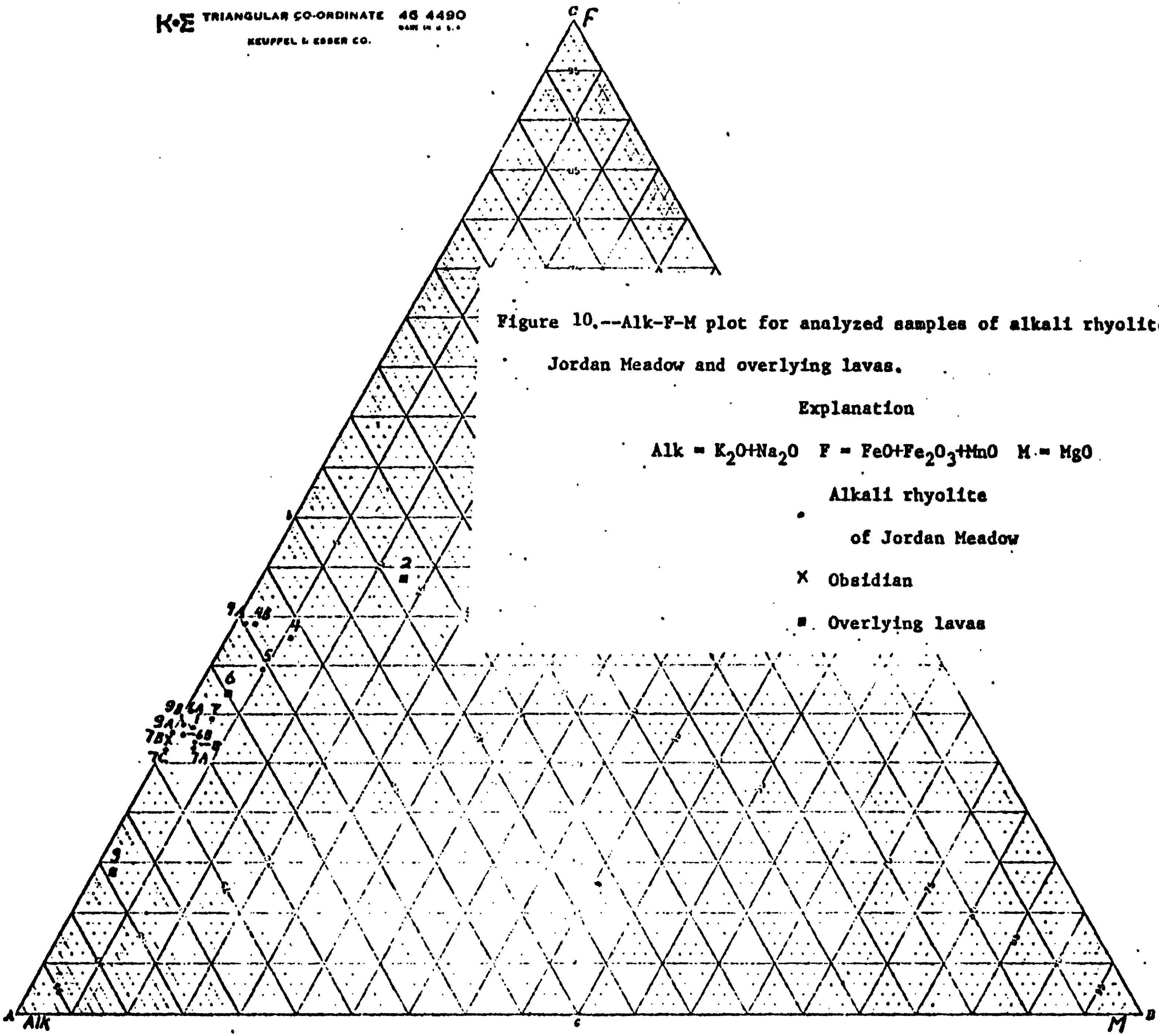


Figure 10.--Alk-F-M plot for analyzed samples of alkali rhyolite of Jordan Meadow and overlying lavas.

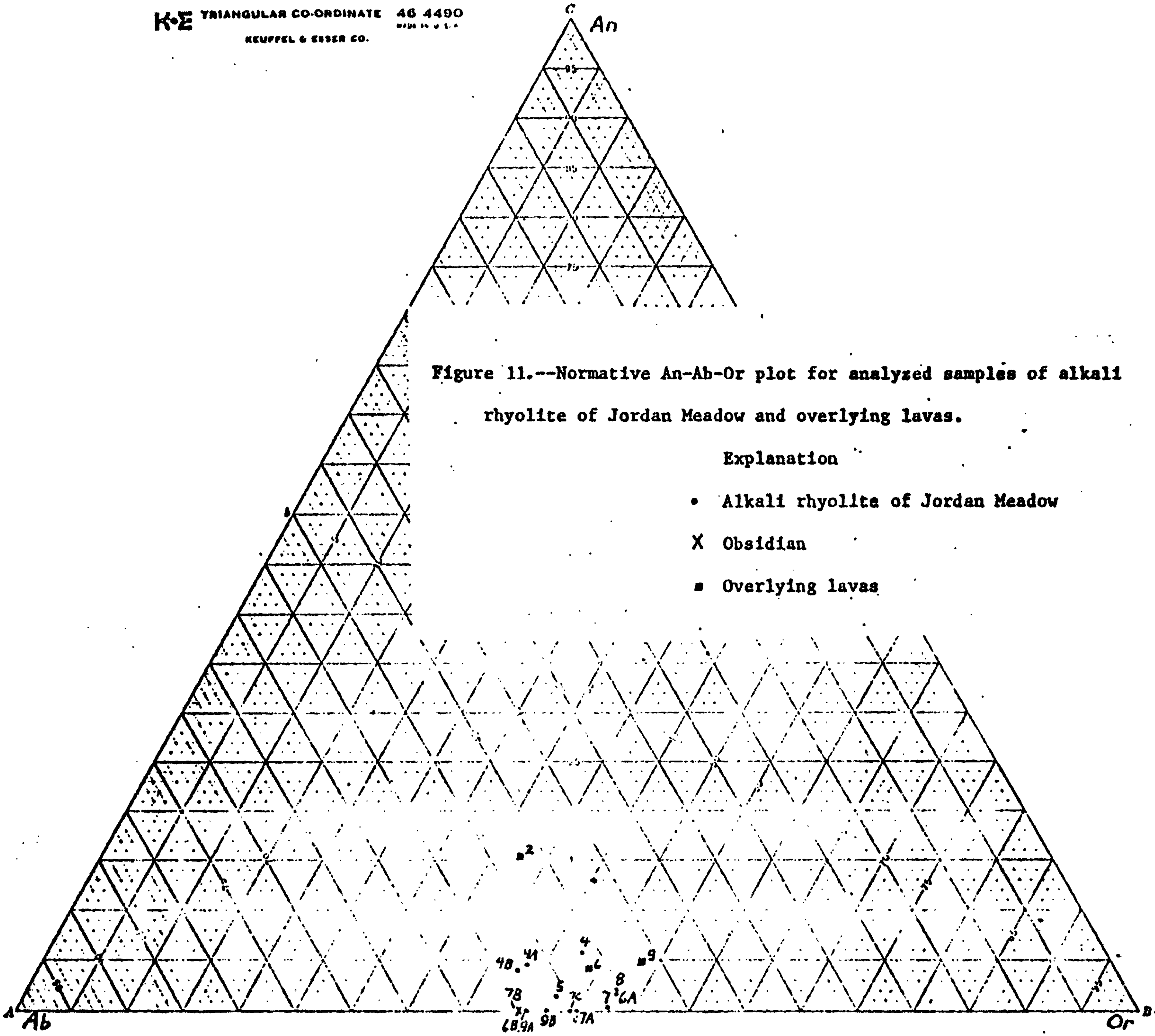


Figure 11.--Normative An-Ab-Or plot for analyzed samples of alkali rhyolite of Jordan Meadow and overlying lavas.

Explanation

• Alkali rhyolite of Jordan Meadow

X Obsidian

▪ Overlying lavas

K•E TRIANGULAR CO-ORDINATE 46 4490
KEUFFEL & ESSER CO.

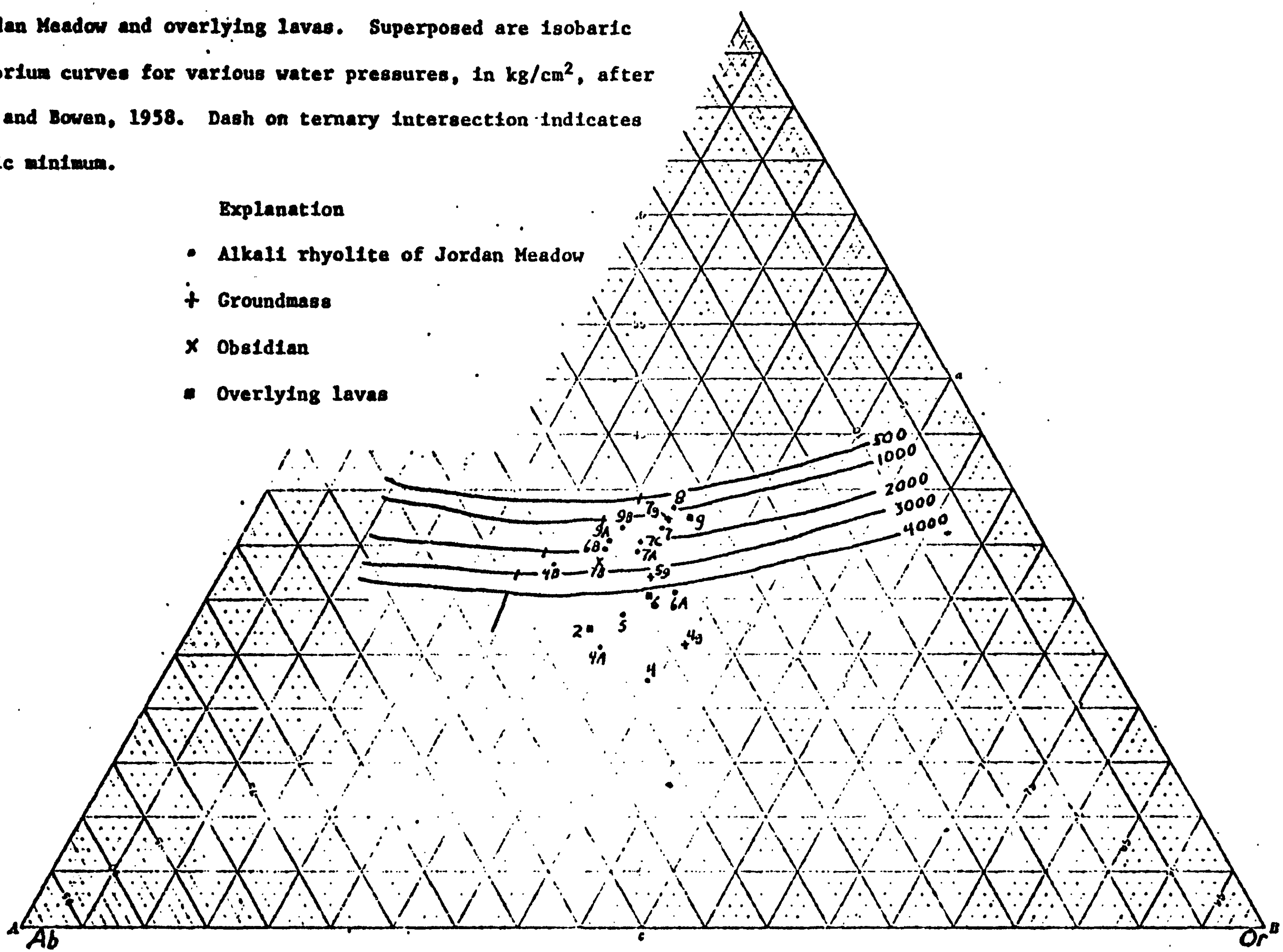


Figure 12.--Normative Q-Or-Ab plot for analyzed samples of alkali rhyolite of Jordan Meadow and overlying lavas. Superposed are isobaric equilibrium curves for various water pressures, in kg/cm^2, after Tuttle and Bowen, 1958. Dash on ternary intersection indicates isobaric minimum.

Explanation

- • Alkali rhyolite of Jordan Meadow
- + Groundmass
- × Obsidian
- ▪ Overlying lavas

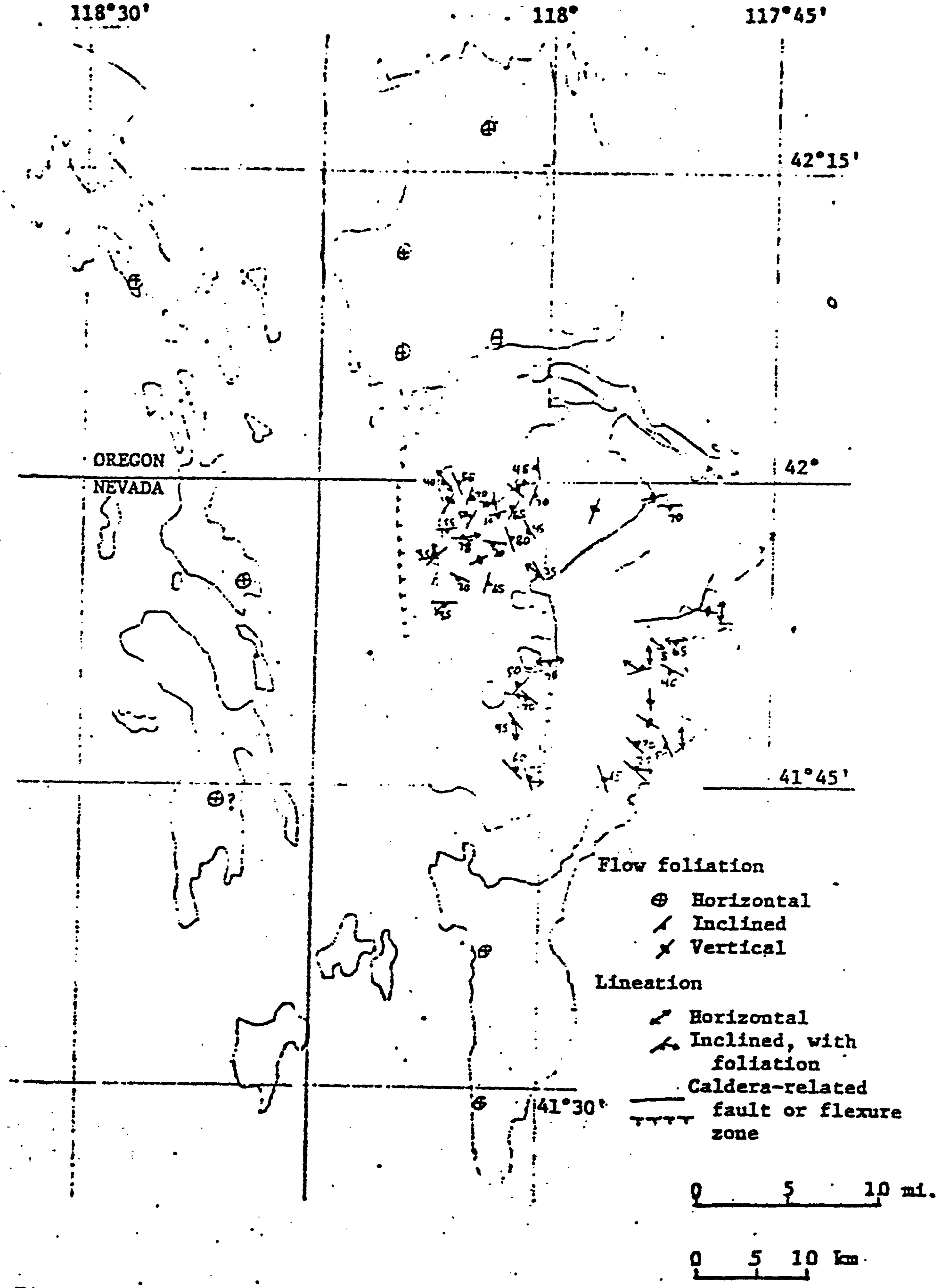


Figure 5.--Flow structure in the alkali rhyolite of Jordan Meadow. Tilt of fault blocks removed.

Table 28.--*Analyses of some feldspar phenocrysts from the alkali rhyolite of Jordan Meadow, the rhyolite of Little Peak, and the rhyolite of Hoppin Peaks*

[Analyses by Lois B. Schlocker by flame photometry]

Sample	734	1131	1135	1139
Unit	Little Peak	Hoppin Peaks	Jordan Meadow	Jordan Meadow
Na_2O	6.40	6.07	8.24	7.13
K_2O	5.95	8.22	5.43	5.34
CaO	1.32	---	---	1.60
Normative feldspar components				
Ab	54.1	48.6	69.7	60.3
Or	35.1	51.4	32.1	31.6
An	6.5	---	---	8.0
Total	95.7	100.0	101.8	99.9

PETROLOGIC AFFINITY

The alkali rhyolite of Jordan Meadow is only in part peralkaline. Na_2O contents (3.1-4.3) (table 25) are not unusually high, nor are K_2O contents (4.6-5.8). Combined Na_2O and K_2O have a very small range (8.3-9.4) (fig. 8).

Alkali-alumina ratios are such that a few of the samples contain normative acmite, but most do not. The obsidian sample (table 27, no. 7B) is acmite normative. This nonhydrated glass is the richest in Na_2O of all the analyzed rocks, which suggests that the devitrified rocks may have lost Na_2O (McDonald and Bailey, 1973; Noble, 1965). Therefore, it is likely that the more silicic members of this series of rocks were erupted from peralkaline magma. According to McDonald and Bailey's (1973) classification, the acmite normative rocks are commendites; the others are meta-aluminous rhyolites. However, in order to emphasize the unity of the series, Rittmann's term "alkali rhyolite" (commonly abbreviated to "rhyolite") is retained throughout this paper.

MINOR ELEMENTS

Noble and Haffty (1969) suggest that certain minor elements are enriched in commendites and pantellerites, and, likewise, certain elements are impoverished. Among the enriched elements are B, Y, and Zr; Ba is impoverished. Accordingly, quantitative spectrographic analyses of these elements were obtained for some specimens of the alkali rhyolite of Jordan Meadow (table 29). Comparing these with Noble and Haffty's (1969, table 1, p. 503) analyses of pantellerites and commendites, mostly from the Mediterranean, it is seen that Y and Zr values are much lower in the Jordan Meadow rocks, and Ba much higher. B is noticeably enriched in some, however. This minor element data does not particularly support a peralkaline affinity for the alkali rhyolite of Jordan Meadow.

Table 29.--*Quantitative spectrographic analyses for B, Ba, Y, and Zr in some samples from the alkali rhyolite of Jordan Meadow*

[N, not detected at value shown. Analyst, R. E. Mays]

Field no.	B ppm	Ba ppm	Y ppm	Zr ppm
MC-64	N20	60	90	250
MC-343	80	20	100	250
MC-464-2	N20	48	85	250
MC-465	34	2200	50	220
MC-547	N20	180	60	200
MC-618	42	80	40	300
MC-782	N20	100	46	320
MC-790-2	80	280	60	340
MC-1139	N20	1400	40	250

MAGMATIC HISTORY

The writer believes that the alkali rhyolite of Jordan Meadow is welded tuff. As has been seen, it consists predominately of light-colored (gray or greenish) aphyric to slightly porphyritic alkali rhyolite, with interlayered darker rocks showing a complete gradation to brown porphyritic rhyolite.

These rocks probably originated in a differentiated magma. However, the case is rather more complex than those where compositional zonation is continuous from base to top of a single cooling unit, as in the Topapah Spring Member of the Paintbrush Tuff and others in southern Nevada (Lipman and others, 1966).

DIFFERENTIATION

The magma erupted to form the alkali rhyolite of Jordan Meadow was probably differentiated by a crystal-settling process. As in many other silicic volcanic rocks, the principal crystals settling out were alkali feldspar. Thus, the more phenocryst-rich rocks erupted from lower in the column may be expected to be more feldspathic (less silicic) than the less phenocrystic rocks,

To detail the differentiation process, it is necessary to examine the groundmass compositions of the phenocryst-bearing rocks. Calculated partial normative groundmass compositions of three of the analyzed rocks are given in table 30. These are obtained by subtracting the proper portion of feldspar from the analyzed rocks after converting modal data to weight percent and assuming the feldspar has the composition $Or_{31.5}Ab_{68.5}$ (MC-1135, table 28). Other phenocrysts are ignored, as these are small in amount and have little effect on the normative mineral composition in the Q-Or-Ab system.

Table 30.--*Calculated partial groundmass composition of some rocks from the alkali rhyolite of Jordan Meadow*

No.	4	5	7
Field no.	MC-134	MC-279	MC-123
Volume percent Feldspar phenocrysts	10.1	9.4	1.5
Weight percent Feldspar phenocrysts	10.7	9.8	1.6
Bulk density	2.45	2.49	2.42
Percent phenocrystic Ab	7.3	6.7	1.1
Percent phenocrystic Or	3.4	3.1	.5
Normative groundmass composition, resumed to 100 percent Q+Or+Ab			
Q	25.9	31.9	37.3
Ab	33.7	33.2	29.3
Or	40.4	34.8	33.6

The normative groundmass compositions of samples 4, 5, and 7 in the system Q-Or-Ab are plotted on figure 12. It is at once apparent that these compositions are only slightly more silicic than the whole-rock compositions from which they are derived; thus the compositional differences are not due merely to crystal accumulation in the less silicic rocks. It is, therefore, necessary to hypothesize substantial removal of crystals from all parts of the magma column to hidden depth. Greater removal from the higher, presumably cooler, portions of the magma results in a substantially more silicic magma than that at greater depth. This is essentially the situation described for the Topapah Spring Member of the Paintbrush Tuff (Lipman and others, 1966).

In the case of the alkali rhyolite of Jordan Meadow, rhyolites of different compositions are interlayered. Locally, as at Payne Creek headwaters (fig. 2, loc. 37), the normal sequence of silica-rich, phenocryst-poor rhyolite (gray aphyric) grading upward to a less silicic phenocryst-rich caprock, as in the Topapah Spring Member, is well exposed. Only 3 km away, however (southeast branch of Little Whitehorse Creek (fig. 2, loc. 38)), the reverse sequence--brown porphyritic grading upward into gray-aphyric rhyolite is exposed. More commonly, porphyritic and aphyric rhyolites are in sharp contact, or gradational over a few centimeters only.

It is apparent from the foregoing that a complex pattern of eruption has ensued; one involving an number of magma taps at different times and at different levels, with eruption through a number of local vents within the caldera. Transition zones only a few centimeters thick at the contacts between contrasting types of rhyolite are probably owing to mixing at the contacts during laminar flowage. Such zones show that the eruption of magmas of contrasting compositions took place in rapid succession.

LAMINAR FLOWAGE AND FLOW FOLDING

Many of the alkali rhyolites, particularly the gray and green aphyric or slightly porphyritic types, show laminar flowage features, particularly gas cavities very elongate in one dimension. These produce a pronounced lineation in the parting planes of the rock, which were evidently planes of maximum slip during flowage.

The gas cavities probably originated at the locus of pumice fragments; the spaces are locally partially filled with vapor phase minerals. The rocks resemble those discussed by Schminke and Swanson (1967) from Gran Canaria and by Noble (1968) who named an alkali rhyolite from Double H Mountain as an example.

A particular feature of the intracaldera alkali rhyolites is the steep dips and local minor folds (fig. 5), all in a unit which is essentially flat lying. This, along with the lineation, suggests flow folding as an accompaniment to the laminar flowage. Outside the caldera, the flowage generally did not result in folding. Local exceptions are found near the tops of some units on Double H and Trout Creek Mountains.

Schminke and Swanson (1967) and Walker and Swanson (1968) discuss the probable causes of laminar flowage. In their views, high alkali/alumina and iron/alumina ratios such as are present in the alkali rhyolite of Jordan Meadow increase the fluidity of the collapsing mass of shards and thus enhance flowage. The rhyolite was probably not erupted onto steep slopes but rather onto a flat plain, judging from its considerable areal extent. It seems likely that a considerable pile-up of ash-flow material relatively near the vents caused retention of heat and contributed to laminar flowage, flow folding, and destruction of shard texture.

AREA AND VOLUME

Assuming that the alkali rhyolite of Jordan Meadow pinches out under the alluvial valleys on the east, south, and west side of its outcrop area, an original areal extent of about 7,000 km^2 is obtained (fig. 2). Measured sections show much of the central and southern parts to be about 300 m thick and the north part about 65 m thick (figs. 6, 7). Based on these data, the total volume would be about 960 km^3. This places the unit in order 7 of Smith (1960) comparable to other tuffs which originate in a subsidence structure.

ORIGIN OF THE OVERLYING LAVAS

The position of the overlying lavas within the caldera clearly indicates that they must be closely related to the alkali rhyolite of Jordan Meadow. The time relationships shown by K/Ar dates are less clear (see below), but certainly suggest that at least the older two units, rhyolites of Hoppin Peaks and McDermitt Creek, were erupted soon after the alkali rhyolites. Quartz latite of Black Mountain may be considerably younger.

Representative samples of each of the three major units of overlying lavas have been analyzed (table 29), and their normative Q-Or-Ab ratios appear on the triangular diagram (fig. 12). Their order is from more silicic to more feldspathic from oldest to youngest. The specimen (no. 2) of quartz latite of Black Mountain is the most feldspathic in this trend and has the highest Ab-Or ratio. The younger lavas are richer in Al_2O_3 than the alkali rhyolites and the samples from the rhyolites of McDermitt Creek (no. 6) and Hoppin Peaks (no. 9) are poor in total iron.

These chemical differences require a more complex origin for the lavas than mere differentiation from the residual magma following eruption of the welded tuffs. If this residual magma is indeed the source of the younger lavas, it must have lost alkalis, or, more likely, gained Al_2O_3 through the assimilation of crustal rocks richer in this oxide. Jurassic and Cretaceous sedimentary rocks, now exposed in the Santa Rosa Range to the east and the Slumbering Hills to the south, may be present at depth under the caldera and may have supplied the Al_2O_3.

The progression from acidic to more basic shown by the sequence Hoppin Peaks→McDermitt Creek→Black Mountain requires either a separate batch of magma for each or a differentiated magma column much like that postulated for the sequence of alkali rhyolites. In the latter case, the magma would have to have been tapped at successively lower levels, as a continuous gradation in lava compositions is not found.

STRUCTURE OF THE CALDERA

Fault and flexure zones clearly define segments of the McDermitt caldera (fig. 2), but it is not a completely enclosed structure.

North of the State line the margin is well defined by faults with the south side downdropped, and a topographic scarp is also present (Walker and Repenning, 1965, 1966). Near the State line, these faults terminate on the west side and the affected rocks are concealed by alluvium on the east side. On the west side, however, the zone of downwarping to the east continues to the south past Disaster Peak, giving the caldera some definition there.

Near the Cordero mine (figs. 2, 3) are several faults downdropped to the northwest, which define another segment of the caldera margin. To the northeast, they too are concealed by alluvium, and to the southwest, buried by the intracaldera lavas.

Another caldera-related fault zone is that defining the west edge of Jordan Meadow, with its associated semicircular fractures surrounding Jordan Meadow Mountain. Their close relationship to the rhyolite of McDermitt Creek and the quartz latite of Black Mountain suggest that they are later collapse features.

There is no field evidence for caldera boundaries other than those segments described above. It is apparent that while eruption and collapse was taking place, the south side of the caldera was relatively passive and merely downwarped along a hinge line whose position is no longer apparent.

RADIOMETRIC AGES
OF THE ALKALI RHYOLITE OF THE JORDAN MEADOW
AND THE OVERLYING LAVAS

K/Ar dates for the alkali rhyolite of Jordan Meadow and the overlying lavas are presented in table 31. Unfortunately, these data are inconsistent with some of the observed field relationships. The alkali rhyolite of Jordan Meadow appears to be of two different ages, and the part outside the caldera is younger.. The overlying lavas are nearly the same age as the older alkali rhyolite inside the caldera. The lower unit from Little Whitehorse Creek (fig. 7, secs. 15-21) is relatively young, even though it appears to extend into the caldera and underlie the older rhyolites there.

McKee believes (McKee, Greene, and Foord, 1975) that most of the dates are correct and that the parts of the alkali rhyolite of Jordan Meadow outside the caldera are indeed younger, younger even than the overlying lavas within the caldera. I find this unreasonable on geologic grounds--a complete change of chemistry is recorded by the appearance of

Table 31.--*K/Ar dates on the alkali rhyolite of Jordan Meadow and the overlying lavas*

No.	Loc. no. fig. 2	Unit	Mineral	Age, m.y.	Reference
		Overlying lavas			
1234	39	Andesite in sediments	Plagioclase	16.4±1.2	
RdM	40	Quartz latite of Black Mountain	Plagioclase	13.7±2.0	
Tlm	41	Rhyolite of McDermitt Creek	Plagioclase	16.9±0.6	
1140	42	Rhyolite of McDermitt Creek	Plagioclase	17.6±0.5	McKee and Marvin, 1973
Trh	43	Rhyolite of Hoppin Peaks	Alkali feldspar	16.5±0.4	
1131	44	Rhyolite of Hoppin Peaks	Alkali feldspar	17.8±0.5	McKee and Marvin, 1973
		Alkali rhyolite of Jordan Meadow			
167	45	Little Whitehorse Creek (north of caldera)	Alkali feldspar	15.8±0.3	
1179	46	Bilk Creek Mountains	Alkali feldspar	15.6±0.3	
1139	47	Crowley Creek (in caldera)	Alkali feldspar	17.5±0.5	McKee and Marvin, 1973
1135	27	McDermitt Creek (in caldera)	Alkali feldspar	17.9±0.5	McKee and Marvin, 1973
1649	19	Little Whitehorse Creek, lower unit	Alkali feldspar	15.9±0.3	

the overlying lavas, and no remnants of the younger alkali rhyolite sequence are found within the caldera overlying the lavas or the older alkali rhyolites.

Therefore, I believe that the K/Ar dates simply indicate that the age of the entire sequence is between 15 and 18 m.y., and that the ages of the component parts cannot be defined more exactly with the present data.

In any case, the dates fit the scheme of Armstrong and others (1969), which shows that, in general, the silicic volcanic rocks decrease in age in concentric bands from a center in east-central Nevada.

REFERENCES CITED

Armstrong, R. L., Ekren, E. B., McKee, E. H., and Noble, D. C., 1969, Space-time relations of Cenozoic silicic volcanism in the Great Basin of the western United States: Am. Jour. Sci., v. 267, no. 4, p. 478-490.

Curry, D. L., 1960, The geology of the Cordero quicksilver mine area, Humboldt County, Nevada: Oregon Univ., Eugene, M.S. thesis, 60 p.

Fisk, E. L., 1968, Cordero mine, Opalite mining district, in Ore deposits of the United States, 1933-1967 (Graton-Sales Volume), V. 2: New York, Am. Inst. Mining, Metall., and Petroleum Engineers, p. 1573-1591.

Goddard, E. N., chairman, and others, 1948, Rock-color chart: Washington, D. C., Natl. Research Council; reprinted by Geol. Soc. America, 1951.

Greene, R. C., 1972, Preliminary geologic map of Jordan Meadow quadrangle, Nevada-Oregon: U.S. Geol. Survey Misc. Field Inv. Studies MF-341.

Greene, R. C., Walker, G. W., and Corcoran, R. E., 1972, Geologic map of the Burns AMS quadrangle, Oregon: U.S. Geol. Survey Misc. Geol. Inv. Map I-680.

Gunn, B. M., and Watkins, N. D., 1970, Geochemistry of the Steens Mountain basalts, Oregon: Geol. Soc. America Bull., v. 81, no. 5, p. 1497-1515.

Huber, N. K., and Rinehart, C. D., 1966, Some relationships between the refractive index of fused glass beads and the petrologic affinity of volcanic rock suites: Geol. Soc. America Bull., v. 77, p. 101-110.

Lipman, P. W., 1966, Water pressures during differentiation and crystallization of some ash-flow magmas from southern Nevada: Am. Jour. Sci., v. 264, no. 10, p. 810-826.

Lipman, P. W., Christiansen, R. L., and O'Connor, J. T., 1966, A compositionally zoned ash-flow sheet in southern Nevada: U.S. Geol. Survey Prof. Paper 524-F, p. F1-F47.

McDonald, Ray, and Bailey, D. K., 1973, The chemistry of the peralkaline oversaturated obsidians, in Data of geochemistry, 6th ed.: U.S. Geol. Survey Prof. Paper 440-N-1, 37 p.

McKee, E. H., Greene, R. C., and Foord, E. E., 1975, Chronology of volcanism, tectonism, and mineralization of the McDermitt caldera, Nevada-Oregon [abs.]: Geol. Soc. America, Abs. with Programs, v. 7, no. 5, p. 629.

McKee, E. H., and Marvin, R. M., 1973, Summary of radioactive ages of Tertiary volcanic rocks in Nevada, Pt. 4, Northwestern Nevada: Isochron/West, no. 10, p. 1-7.

Noble, D. C., 1965, Gold flat member of the Thirsty Canyon tuff, a pantellerite ash-flow sheet in southern Nevada, in Geological Survey research 1965: U.S. Geol. Survey Prof. Paper 525-B, p. B85-B90.

_____ 1968, Laminar viscous flowage structures in ash-flow tuffs from Gran Canaria, Canary Islands--A discussion: Jour. Geology, v. 76, no. 6, p. 721-723.

Noble, D. C., and Haffty, Joseph, 1969, Minor element and revised major element contents of some Mediterranean pantellerites and commendites: Jour. Petrology, v. 10, no. 3, p. 502-509.

Rittmann, A., 1952, Nomenclature of volcanic rocks: Bull. Volcanol., ser. 2, v. 12, p. 75-102.

Schmincke, H. U., and Swanson, D. A., 1967, Laminar viscous flowage structures in ash-flow tuffs from Gran Canaria, Canary Islands: Jour. Geology, v. 7, p. 641-664.

Shapiro, Leonard, 1967, Rapid analysis of rocks and minerals by a single-solution method, in Geological Survey research 1967: U.S. Geol. Survey Prof. Paper 575-B, p. B187-B191.

Shapiro, Leonard, and Brannock, W. W., 1962, Rapid analysis of silicate, carbonate, and phosphate rocks: U.S. Geol. Survey Bull. 1144-A, p. A1-A56.

Smith, J. G., McKee, E. H., Tatlock, D. B., and Marvin, R. F., 1971, Mesozoic granitic rocks in northwestern Nevada--A link between the Sierra Nevada and Idaho Batholiths: Geol. Soc. America Bull., v. 82, p. 2933-2944.

Smith, R. L., 1960, Ash flows: Geol. Soc. America Bull., v. 71, p. 795-842.

Stewart, J. H., and Carlson, J. E., 1974, Preliminary geologic map of Nevada: U.S. Geol. Survey Misc. Field Inv. Studies Map MF-609.

Tuttle, O. F., and Bowen, N. L., 1958, Origin of granite in the light of experimental studies in the system $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2-H_2O: Geol. Soc. America Mem. 74, 151 p.

Walker, G. W., and Repenning, C. A., 1965, Reconnaissance geologic map of the Adel quadrangle, Lake, Harney, and Malheur Counties, Oregon: U.S. Geol. Survey Misc. Geol. Inv. Map I-446, scale 1:250,000.

_____ 1966, Reconnaissance geologic map of the west half of the Jordan Valley quadrangle, Malheur County, Oregon: U.S. Geol. Survey Misc. Geol. Inv. Map I-457, scale 1:250,000.

Walker, G. W., and Swanson, D. A., 1968, Laminar flowage in a Pliocene soda rhyolite ash-flow tuff, Lake and Harney Counties, Oregon, in Geological Survey research 1968: U.S. Geol. Survey Prof. Paper 600-B, p. B37-B47.

Willden, C. R., 1961, Preliminary geologic map of Humboldt County, Nevada: U.S. Geol. Survey Misc. Inv. Field Studies Map MF-236, scale 1:200,000.

Yates, R. G., 1942, Quicksilver deposits of the Opalite district, Malheur County, Oregon, and Humboldt County, Nevada: U.S. Geol. Survey Bull. 931-N, p. 319-348.

76-753

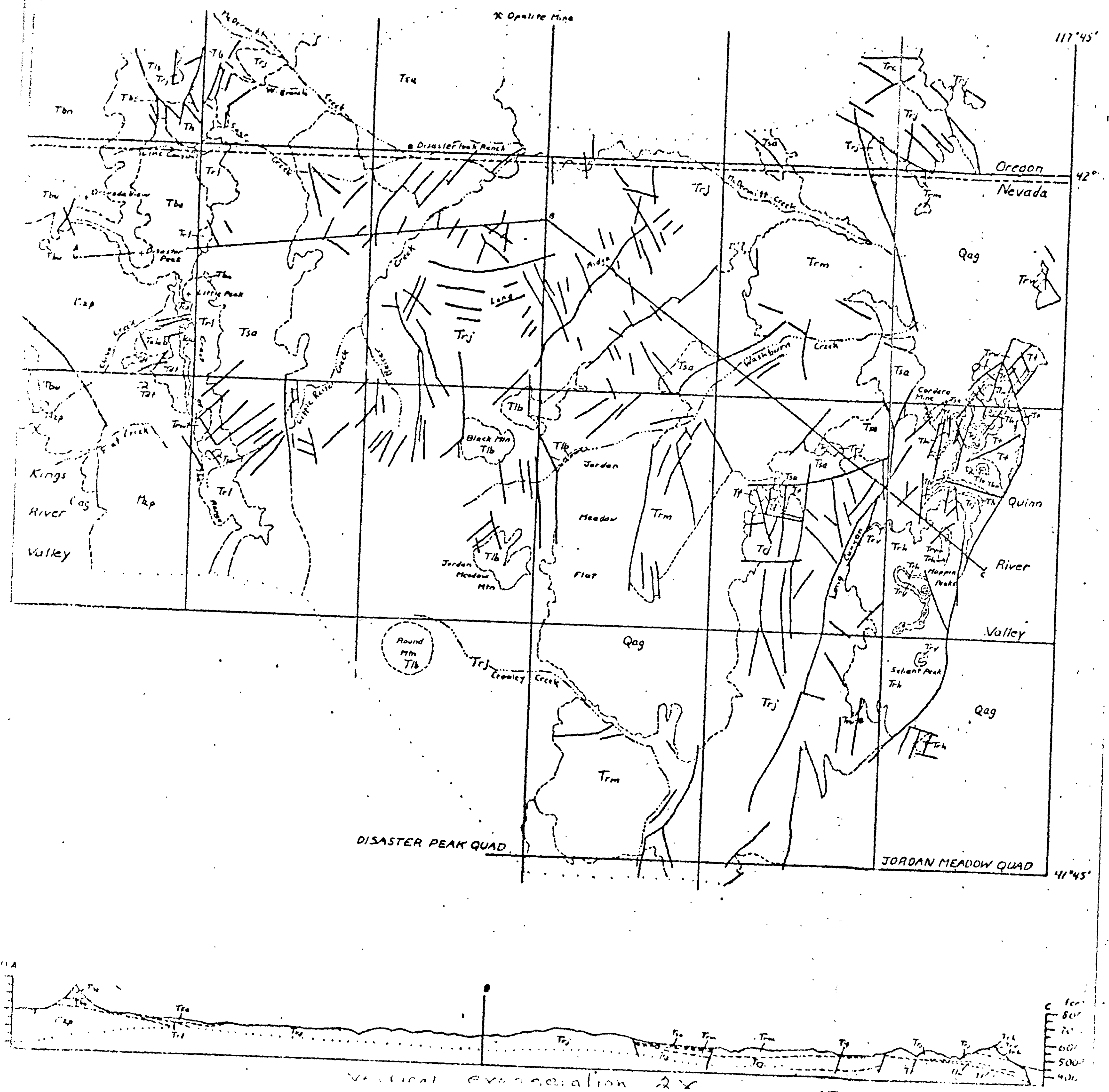


Figure 3. Geologic map of the Jordan Meadow quadrangle and adjacent areas.

EXPLANATION

QUATERNARY

Pleistocene and Holocene

Qag — Alluvium and gravel

TERTIARY

Miocene

Tsa — Sedimentary rocks and andesite

Tlb — Quartz latite of Black Mountain

Trm — Rhyolite of McDermitt Creek

Trv — Alkali rhyolite of Washburn Creek

Trh / Trv — Rhyolite of Hoppin Peaks
Trh, rhyolite
Trv, vitrophyre

Trj — Alkali rhyolite of Jordan Meadow

Trl — Rhyolite of Little Peak

Trc — Rhyolite of McCormick Ranch

Trwt — Lower alkali rhyolite welded tuff

Tls — Quartz latite of Sage Creek

Tlv / Tlm — Quartz latite of McConnell Canyon
Tlv, vitrophyre
Tlm, quartz latite

Tt — Trachyandesite

Tbu, Tbn, Tbs, Tba, Tca — Basalt and andesite of Orevada View

Tdlab — Dacite, quartz latite, andesite and basalt

Tdt — Dacite welded tuff

CRETACEOUS

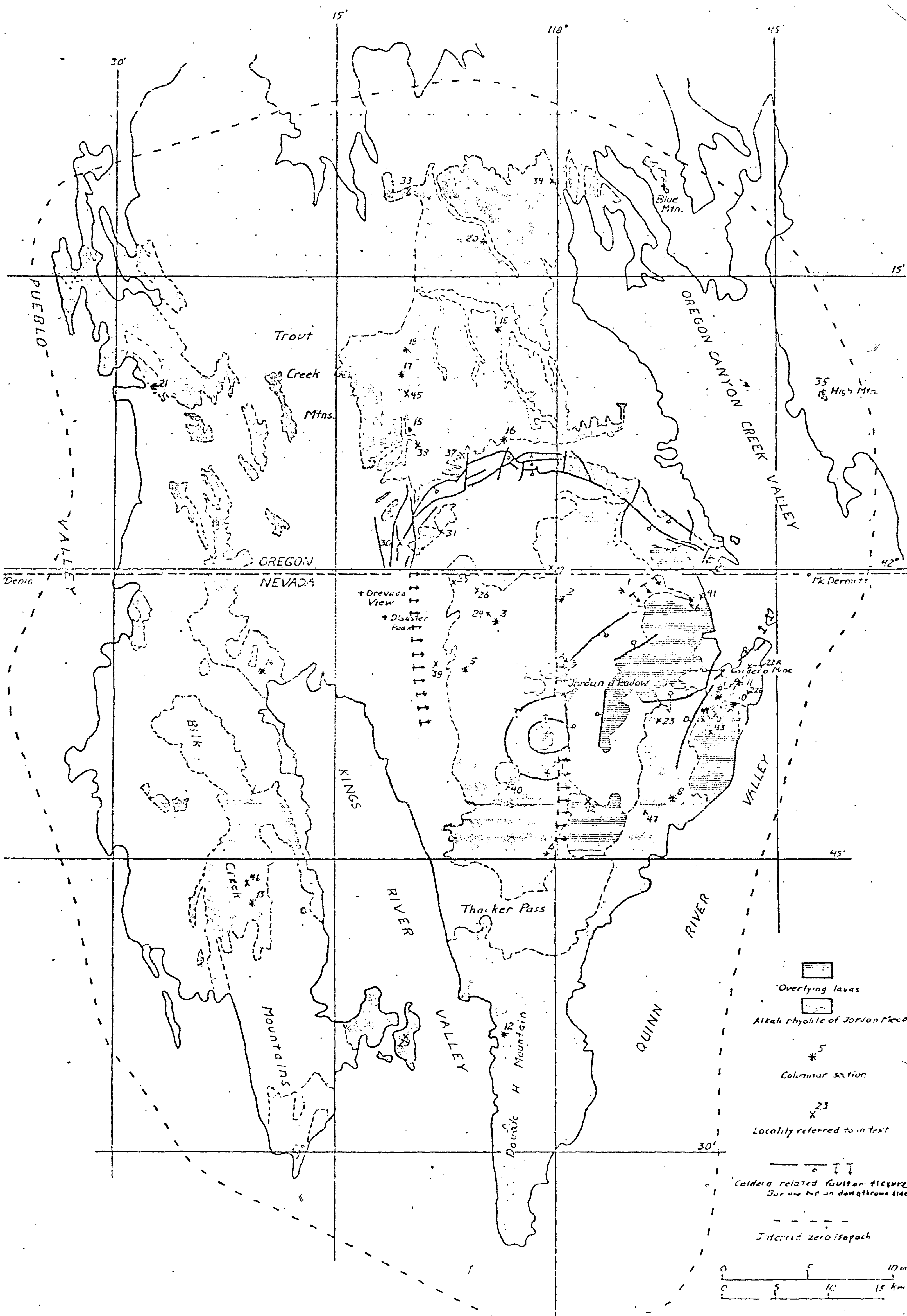
Mzp — Plutonic rocks

Contact

Fault

0 1 2 3 4 miles

0 1 2 3 4 5 6 kilometres



15'
118°
45'
30'
15'
42°
45'
30'
PUEBLO
VALLEY
Trout
Creek
Mtns.
OREGON CANYON CREEK VALLEY
Blue Mtn.
High Mtn.
OREGON
NEVADA
Denio
Ft. McDermitt
Drevaca View
Disaster Peak
Jordan Meadow
Cordero Mine
BILK
Creek
Mountains
KINGS
RIVER
VALLEY
Thacker Pass
QUINN
RIVER
VALLEY
Double H Mountain
Overlying lavas
Alkali rhyolite of Jordan Meado
Columnar section
Locality referred to in text
Caldera related fault or flexure
Inferred zero isopach
0
5
10 mile
0
5
10
15 km

76 753