Snow in some places maps as "formations", biostratigraphic units?

1963 approved or

Geoffrey Greacen Snow, 1964 - bound, Mineralogy and Geology of The Dolly Varden Mountains, Elko County, Nevada, Ph.D., Univ. Utah.

Joana Lst.

lg. bx. blocks; frags. 2 in. → 20 ft.
relations to other rocks unknown.
m. xline, dk. gy. to blk., fetid-smelling lst-bx cemented by lt. gy. to whitish c-xline cc. Blk. & tannish chert nodules present; exhibit cataclastic texture.

Ferguson Mtn. Fm. - at least 1200 ft thk.
defined by Slade ('61, p. 59)
entirely Wolfcamp. here.
upper contact = base of 1st sandy bed of Pequop Fm. (Steele's suggestion [1960]).
Exposed as alternating covered slopes & rounded outcrops
Covered slopes (6-25' thick) - t/bdd, granular & bioclastic lst.
Rounded outcrops (3-6' thk.) - 6" to few ft. thk., dense, f. xline, partly bioclastic lst. dk. gy. (fresh), lt. gy. (weath.).
Also Lst. w/ paper-thin silty partings, some w/ blk. & m. gy. cht. nod

W. of Mike's Cyn: round-weathering, lt. gy., fusulinid-bearing lst. (fusuline coquinites).

Pequop Fm. (2,300 to 2,500' thik)

<u>E. Range Front:</u> horiz. or gently-dipping homoclinal flt. blks. w/ alternating ledgy outcrops of m. bdd. lsts and slope-forming ss. On steep hills the ss. produces brn. talus runs -- characteristic of Pequop

<u>S. Part of Area</u>

Upper part is poorly outcropping sequence of very silty, dolomitic lst. & dol'ic ss.; produce smooth-weathering hills w/ ribs of micro-to f. xline bioclastic lst.

Large part of fm. has been intruded & altered by ign. rk.

Pequop Fm. lst. generally weathers to a smoother textured surface than the Ferguson Mtn. Fm. lst.

Upper Bdy. base of slope-forming yellow-tan, silty ss. & lst. of Loray Fm.

No distinctive mappable beds except a thin lst. bed w/ characteristic blk. & tan cht. Basis for structural interpretations in s. part of Rg.

Upper Pequop — dolomite & sl. more cht.
Lower " — cyclical alt. of ss. & lst.

Lst. - pure, lt. gy., f. grn., aphan. to f. xline.

Upper Pequop — distinctive yel.-or. to red. weathering sts., sty. ss. & dol'ic. ss.

Abund. fusulinids. Also bryozoa, echinoid spines, brachs. & crinoid coquinas.

Loray Fm. — (≈ 200 ft. thick.)

Very poorly exposed. Recognized only where overlain by Kaibab Fm.

Slope-forming silty ss. & lst.
t/bdd. platy yell-tan, f. grn. sty. ss. intbdd. w/ buff sty. lsts. & t/bdd friable calc. ss.

Kaibab Fm. (~ 225-275 feet)

best map unit in D.V. Rg. Cliffs.
Thick/bdd. lst. & cht. Lt. gy., micro- to f.-xline, in part almost lithographic lsts. are intbdd. w/ bioclastic & fossilif. lst. & lt. gy. cht. Mass. m-bdd. dol. overlies lst. at Castle Peak included w/in Kaibab.

Plympton Fm. (~ 50 ft)

tan to milk-wh., m. bdd. chert — No dol.

Lent to
W.W. Moore

Triassic (Thaynes) (~ 300-400')

[Lintz, J., Jr., 1957, Nevada oil and gas drilling data, 1906-1953: Nev. Bur. Mines Bull. 52, p. 28-38.]

↑ 295' of Tr in Steptoe Valley, 6 mi. NW of DV Mtns.

t/bdd (1-4 in.) gy. lst., weath. to dk., m. brn., intbdd. w/ choc brn. shaly beds.
Meekoceras zone - in brn. sty. lsts & sh.

Dolly Varden volcanic series (>2500 ft)

andesite, ignimbrite, qtz. latite, rhyolite & volc. bx. Vitric tuff, block & ash flows & glassy horizons.
Youngest volc. rx. here that were involved in a major episode of basin-range type faulting. tilted 15°-20° east. (⇒ 30°)
Deposition of later volc. & seds. was later than this period of def.

Snow thinks that this series is restricted to the D.V. Mtns. except perhaps for the andesite "which may be equiv. to rks in the Boone Sprgs. Hills.

Quat. Highest Lake deposits = ~ 5900'

Porph. Q.M. stock & assoc. rx. — 125 m.y. +20, -5 m.y.
by [illegible] (Melrose Stock) Mouth of Horse Cyn. K-A.

Dolly Varden Range

Snow	Me
Tr	Tr
Ts	Tst
Ta	
Tb	
Tdb	
Tdrt	
Tdrf	Tdv
Tdvt	
Tdba	
Tdi	
Tda	
Tdat	
Ku	Kt
Ppc	Ppc
Pk	
Pl	
Pp	Pa
Pfm	
Mj	Mj
Pqm	Pqm

TERTIARY SYSTEM

Rocks of Tertiary age crop out over the northeastern one-third of the Dolly Varden Mountains, and in aggregate are about 2,700 feet thick. The oldest Tertiary rocks are a sequence of flow and pyroclastic rocks herein referred to as the Dolly Varden volcanic series. Rocks of this series are correlated with similar rocks in eastern Nevada and assigned a probable age of Oligocene.

Restricted flows and calcareous sediments are included with the younger Tertiary rocks of questionable Miocene-Pliocene age. A rhyolite plug and associated flow, and small (less than one-half square mile) flows of andesite and basalt are included in this younger group. Tertiary sedimentary rocks include limestones, marlstones, and poorly lithified conglomerates.

Dolly Varden Volcanics

General Features

Volcanic rocks, here named the Dolly Varden volcanic series, overlie, with varying degrees of angular unconformity, Triassic sediments, the Permian Pequop Formation, and Lower Cretaceous intrusive rocks. In the area mapped a thickness of more than 2,500 feet of volcanic rocks is present. Subdivisions within this series are based both on composition and lithology since in many cases rocks of a single composition have numerous lithologic variations. The principal units of this subdivision are andesite, ignimbrite, quartz latite, rhyolite, and volcanic breccias. Vitric tuff, block-and-ash-flows, and glassy horizons have also been delineated on the map. They are of limited extent, are found at various horizons within the series, and may represent lithologic variations of the principal units or intercalcated deposits within or between these units.

Flows and most units of coarse fragmental rock appear to be lenticular and of limited extent. Units of tuffaceous rock are more extensive, although it is difficult or impossible to trace any unit for long distances because of poor exposures and abrupt changes in lithology and thickness.

Angular and local unconformities occur within this series as faulting was contemporaneous with extrusion, and erosion occurred between periods of deposition.

The Dolly Varden volcanics are the youngest volcanic rocks in this area that were involved in the major episode of basin-range type of faulting. As can be seen from the bedding of the crystal tuffs and the planes of flattening in the welded rocks, the entire volcanic sequence has been tilted to the east an average of 15° - 20°, and a maximum of 30°. Because of the difficulty in determining attitudes in critical areas, the relations between the Dolly Varden volcanics and later volcanics and sediments are conjectural, but deposition of these later units antedated a period of faulting and erosion.

Distribution

In the area mapped the volcanic rocks of the Dolly Varden series are exposed in the central, eastern and northern parts of the range. Erosion has stripped most of the volcanic rocks from the crest and shoulders of Melrose Mountain, but a belt extends along the east flank of the mountains for a distance of 8-1/2 miles. Scattered outcrops are also found on the western range front. They extend to the northwest under alluvium as they have been discovered in a drill hole about one mile west of Mizpah Canyon where volcanic rocks were encountered at a depth of 235 feet and were still present at the bottom of the hole, 780 feet in depth.

Andesite

The lowest unit in the Dolly Varden volcanic series is composed of flow and pyroclastic rocks whose composition ranges from andesite to calcic quartz latite. An estimation of the thickness of this unit on the basis of surface exposures is difficult to make; however, data obtained from a drill hole collared in Juniper Basin indicate that at least 1,000 feet are present (pl. 1, sec. B-B'). This unit was extruded on an irregular terrain with local relief up to several hundred feet.

A white vitric-crystal, and lithic-crystal tuff, which is in part water laid, forms the basal part of this unit. The well-bedded tuff is found resting on the Pequop Formation and on Triassic rocks in patches around the north and west edge of Juniper Basin (pl. 1) where it varies in thickness from 5 to 25 feet. Younger flow rocks of andesite composition rest directly on Triassic and intrusive(?) rock in Spring Canyon, and on the Pequop Formation at the northwest margin of Juniper Basin. A crystal tuff is between the Triassic and the andesite along Dolly Varden Canyon near Watson Spring.

The andesite flow is exposed in the western part of Juniper Basin as ledgy and rounded outcrops of an olive-green hornblende-rich variety. It weathers to a grus-like soil. Near Spring Canyon more bold outcrops characterize the unit. Columnar jointing may be seen, and on the hills a thickness of several hundred feet of this unit is exposed. A welded andesite tuff is a light-gray to pinkish brown hornblende and biotite-rich unit in which well developed sheeting is parallel to the plane of compaction. Outcrops of this unit usually form cliffs with 20 to 50 feet of relief.

Rocks of the andesite unit occupy the greater part of Juniper Basin where they cover an area of about 3-1/2 square miles. The andesite is overlain by an ignimbrite along Dolly Varden Canyon, and more of the northeast portion of the andesite was once covered by the less resistant ignimbrite which has, except for isolated remnants, been stripped away.

Phenocrysts constitute 25 to 30 percent of the andesite flows, and are clustered producing glomeroporphyritic texture. Plagioclase

(An_{40} - An_{54}) constitutes 65 to 75 percent of the phenocrysts as subrounded rectangular grains. Inclusions mostly of glass are common and are localized along zones or aggregated in the cores of the phenocrysts (fig. 6). The remainder of the phenocrysts are basaltic hornblende and hornblende. The hornblende is pleochroic from yellow-brown (X) to dark olive-green (Z), but where severely oxidized pleochroism is absent and only 10 percent of the original mineral remains. A few stout prisms of hypersthene are present. Pilotaxitic texture characterizes the groundmass (fig. 6) where 0.04 millimeter microlites of andesine are arrayed with magnetite trichites in a sub-parallel fashion. The feldspar of the groundmass is more sodic than that of the phenocrysts. Common accessories are enstatite, apatite, biotite, and magnetite which is always present. The andesite has been little altered since emplacement. Weathered hornblende is altered to chlorite and magnetite, some calcic plagioclase is altered to calcite, and hematite is present as an oxidation product.

Ignimbrite

The term ignimbrite is used in the sense of Cook (1961); that is a pyroclastic rock unit formed during a single eruptive episode and containing a variety of lithologic types ranging from nonwelded to firmly welded rock. Here the nomenclature of the pyroclastic rocks follows the usage of Wentworth and Williams (1932). The pumice-lapilli tuff, welded tuff, and breccias which make up the ignimbrite, form, for the

Figure 6. Photomicrograph showing fluidal structure in andesite of Dolly Varden volcanics. Two grains of basaltic hornblende are next to plagioclase phenocrysts. Core and outer zone have been corroded and contain groundmass materials, especially glass. Plain light, x 41

most part, massive poorly bedded units, varicolored in pale-yellow, maroon, black, red-brown, and gray shades. White ash-fall crystal tuff and some water laid volcanic ejecta are intercalcated within the ignimbrite. All are mainly or wholly composed of quartz latite material.

The ignimbrite is a single(?) cooling unit (Smith, 1960), which consists of a lower partially welded portion, a middle densely welded portion, and a thick upper portion, part of which is nonwelded. The map subdivisions Tdi_1, Tdi_2, and Tdi_3, roughly correspond to these units. Where a sequence could be recognized obsidian vitrophyres were used as marker beds. Unit Tdi_1 constitutes the lower part of the cooling unit since it is mapped at the base of the lowermost vitrophyre. Unit Tdi_2 does not include the entire middle welded portion since its upper boundary is placed at the base of a second vitrophyre (fig. 8). This vitrophyre which immediately underlies the upper partially welded portion is seldom more than 50 feet thick. Subdivisions within the ignimbrite have been mapped from south of Dolly Varden Canyon north to the head of Profile Canyon. From this point north the map units mentioned above are no longer recognizable; however, vitrophyres have been mapped and appear on Plate 1 as glassy units within the undifferentiated ignimbrite.

With the exception of some of the vitrophyres most lighologic units cannot be mapped for great distances because of abrupt changes in lithology and thickness. An instructive outcrop in Dolly Varden Canyon shows where a tough brown, lithophysae-bearing, strongly welded tuff has changed in the space of 3 feet to an easily weathered, friable, light-gray perlite with only the lithophysae to hint of the first identity (fig. 9). In this locality as elsewhere glassy lithologies, vitrophyres, and perlites appear on the map (pl. 1) as open-ended units, which means they are not terminated but are lost because of cover or change of lithology.

The ignimbrite unconformably overlies rocks of the andesite flow, the quartz monzonite stock, and sediments of Triassic age. Fragments of rock older than the ignimbrites, especially the intrusive rock, have been observed within the ignimbrite at numerous localities; however, they are not common. Quartz monzonite fragments are rounded and are generally less than one foot in diameter. The older fragments are most common in block-and-ash-flows and in the lower pumice-lapilli tuffs.

The average thickness of the ignimbrite is about 1,000 feet but differs greatly from place to place for several reasons: 1) it was deposited on an irregular surface, 2) since its deposition it has experienced differential compaction, and 3) faulting was probably contemporaneous with extrusion. For example, the Tdi_1 unit is about 250 feet thick where it is cut by a northwest fault at the head of Profile Canyon (pl. 1). The unit north of that fault is mapped as Tdi, undifferentiated; it has the same lithologic characteristics, composition, and stratigraphic position as Tdi_1, but is about 600 feet thick. These two particular units may be equivalent, but not sufficient evidence was found to warrant their being called the same unit on the map.

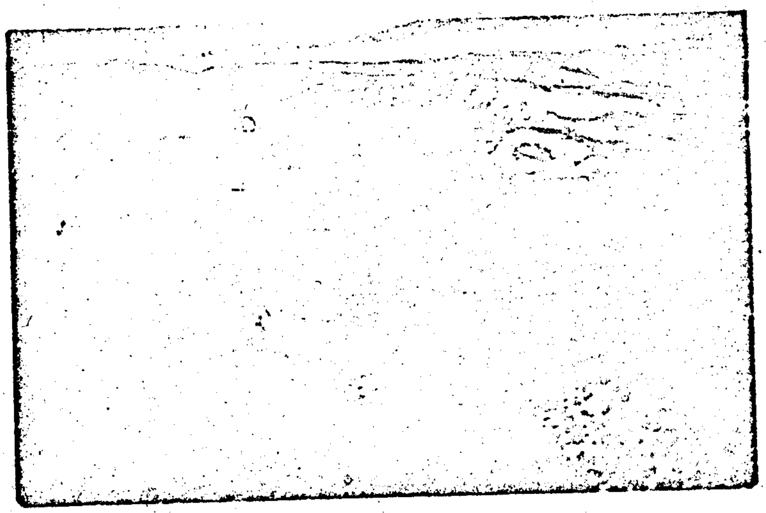

Figure 7. View north across Juniper Basin. Tree-covered outcrops in the foreground are the andesite of Dolly Varden volcanic series. The ignimbrite is well exposed as the rounded light colored hills at the upper right.

Figure 8. Detail of Ignimbrite units Tdi_1 and Tdi_2. Typically rounded hill of east-dipping partially welded pumice lapilli tuff underlies densely welded, black glass vitrophyre.

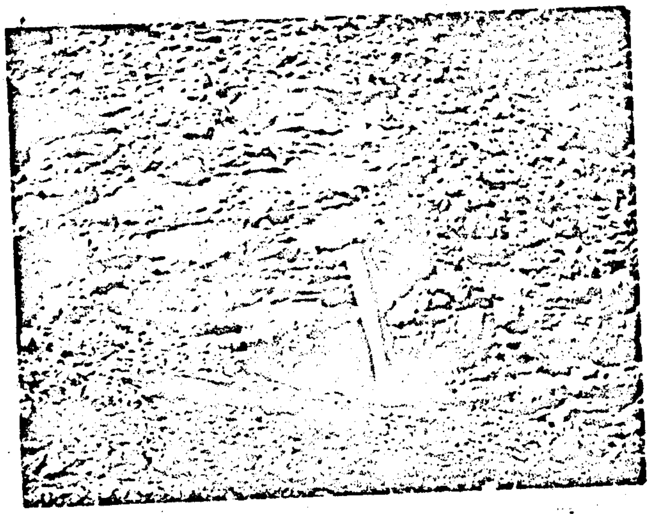

Figure 9. Example of abrupt change in lithology in a unit of the Dolly Varden volcanics. A brown densely welded tuff changes in space of two feet into gray perlite.

Under the microscope the ash-flow character of this deposit is attested to by the absence of sorting and the presence of welding and devitrification. Rocks from the tuff and pumice-lapilli zones exhibit similar characteristics which differ in quantity, not quality. The most apparent difference within the ignimbrite is the change in the amount of crystal fragments and in the relative amounts of pumice and lithic fragments. Rocks of the ignimbrite exhibit differing degrees of welding, depending on whether they are from the partially welded base, the densely welded middle zone, or the zone of partial welding above. All samples of the ignimbrite examined are quartz latite in composition and are classified as more-or-less welded, crystal-vitric pumice tuffs with varying amounts of lithic fragments. Crystal fragments of quartz, sanidine, plagioclase, and biotite are common; microcline is infrequently seen. The quartz grains are broken and many are resorbed and corroded by the groundmass. Feldspars are sub-angular, commonly showing one or more euhedral faces, but where corroded by the matrix may be seen as sub-rounded grains. Average phenocryst size is about 0.7 millimeters, but grains as large as 3 millimeters are common. There is no apparent relationship between percentage of crystal fragments, which range from 10 to 35 percent, and position within the ignimbrite. Two types of tuff fragments, shards, and pumice, are universally present (fig. 10). Flat, or more commonly slightly curved, shard plates, which were derived from elongate bubbles, are present in

Figure 10. Crystal pumice tuff from partially welded portion of ignimbrite. Tuff shows only slight welding but platelike shards at top are bent around fragment of feldspar. Note platelike shards below feldspar grain. Plain light, x 82

Figure 11. Photomicrograph of glassy pumice tuff which is essentially nonwelded. Retained tubular structure of the uncollapsed pumice fragments is shown in the light-gray areas. Note perlitic cracks in pumice fragment in upper right. Plain light, x 41

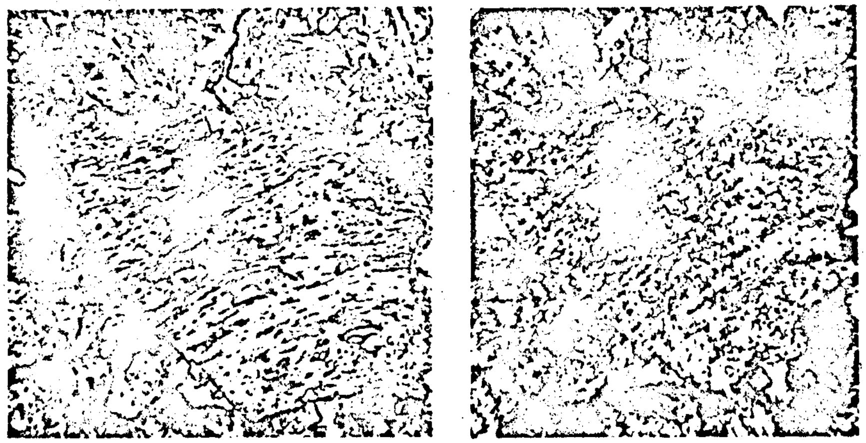

Figure 12. Enlarged lower right portion of Fig. 11 showing pumice structure and the same area under crossed nicols. This shows coarse-grained intergrowth of feldspar and cristobalite in the pumice fragment. Plain light and crossed nicols, x 86

Figure 13. An enlarged view of shards in the right part of Fig. 10 shows within the shards parallel intergrowths of cristobalite and feldspar which well represent axiolitic structure. Plain light, x 386

U-shape or much elongated Y-shaped forms. Within a single thin section the shards have a limited size range, but when thin sections from different parts of the ignimbrite are compared, the range is substantial, from 0.08 millimeters to 1 millimeter with a modal size of about 0.3 millimeters. Pumice fragments are always present and may or may not be collapsed depending upon their position within the cooling unit. The pumice fragments are much larger than the shards and vary within a single thin section from 0.4 millimeters to 6 millimeters. Uncollapsed pumice fragments seen only in a sample of the uppermost portion of the ignimbrite and in a water laid(?) crystal tuff are roughly equidimensional and exhibit the tubular structure (fig. 10) seen in hand specimen. Where collapsed, the pumice fragments are compacted so that their length exceeds their width by a ratio 5 to 1 in the partially welded portion of the ignimbrite, and by 8 or 10 to 1 in the densely welded portion. Pumice fragments are molded around the crystal fragments where the two are juxtaposed (fig. 10). When seen in cross section (fig. 15) the collapsed pumice fragments have a fairly regular, although often bent, upper and lower surface; the ends, however, feather out to the matrix. When seen in the plane of flattening, the fragments are discoid or ovoid in shape.

Except for the least welded portion of the ignimbrite the rocks have a eutaxitic (Ross and Smith, 1961, p. 4) texture in which the flattened shards and pumice fragments impart a foliate structure to the

Figure 14. Eutaxitic structure in specimen from unit Tdi_1 of Dolly Varden series. The lighter colored matrix shows fine-grained pyroclastic structure. Several lithic fragments are included. The darker areas represent completely collapsed welded pumice fragments. The pumice character is shown by the feathered ends of many of the pumice areas.

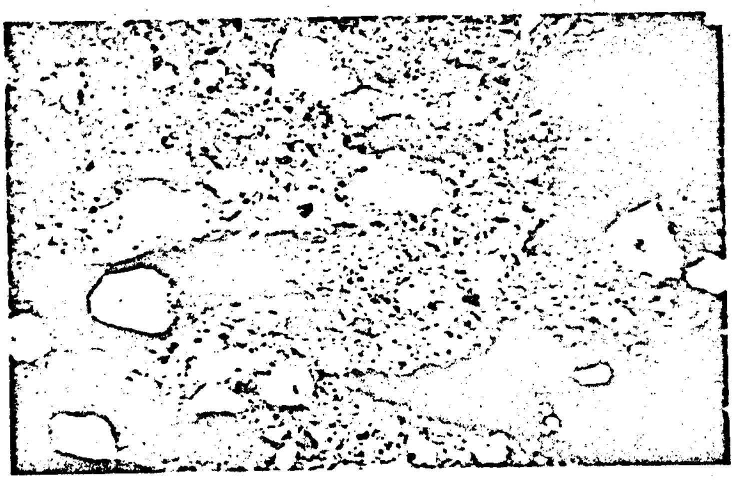

Figure 15. Photomicrograph of crystal-pumice tuff showing eutaxitic structure. Compare with Fig. 14. Dark-colored areas represent collapsed pumice fragments in which no pore space remains. Traces of original pumice structure are retained in tail-like projections extending toward the right. Pumice fragments are molded against and around crystal grains. Plain light, x 39

rock (figs. 14 and 15). The fabric is a function of the degree of welding and the relative arrangement, particularly of the shards, but also of the crystal and pumice fragments. The degree of deformation of the pumice fragments and shards is expressed in the fabric.

Thin sections show that rocks of the ignimbrite have experienced varying degrees of devitrification. In every slide examined the devitrification process was superimposed on a fabric resulting from the welding and distortion of the pyroclastic material. However, even though the primary shard structures have been modified by devitrification (fig. 12), they retain evidence of their origin. Axiolitic structure (Zirkel, 1876, p. 167) represents the most common type of devitrification structure seen in these rocks (figs.10 and 13). Aggregates of crystobalite(?) and feldspar are found in collapsed pumice fragments from the most densely welded portion of the ignimbrite. Spherulites of the same minerals are also commonly present as products of devitrification.

Welded Quartz Latite

The welded quartz latite unit, although of pyroclastic origin and of the same composition as the ignimbrite, is separated from it because of its younger age and dissimilar lithology. The unit is uniformly quartz latite in composition and a variety of welded lithologies are present. These lithologies vary from crystal-lithic tuff to felsite tuff. The tuffs of this unit are various shades of pink-orange, gray-brown, and gray.

Where densely welded, the units are fairly resistant to weathering and form blocky angular outcrops; where less welded, they are found as rounded slopes. In some places the quartz latite occupies the same stratigraphic position as the ignimbrite in that it overlies the andesite in Juniper Basin and the quartz monzonite north of Mizpah Canyon. Its thickness is generally less than 300 feet.

Two lithologic varieties crop out in the southwest part of Juniper Basin (pl. 1). A prominent hill is composed largely of pink-brown, moderately welded, crystal-vitric tuff containing minute vessicles. Feldspar and biotite constitute the bulk of the crystal fragments; lithic fragments are present but not plentiful. Eutaxitic texture can be detected in hand specimen, but it is not as obvious as with the more welded varieties. A northwest-striking, southwest(?)-dipping vitrophyre probably underlies the above described tuff and separates it from an apparently older densely welded variety. These conspicuously banded older(?) rocks are pink to light-brown, and form prominent, well-jointed outcrops.

Other rocks in the quartz latite member appear much like those of the middle ignimbrite unit, in that they are densely welded tuffs with abundant crystal fragments and conspicuous eutaxitic texture. At the mouths of Horse, Crow, and Mizpah Canyons on the western range front (pl. 1) this unit is varicolored from light-gray to maroon to dark-brown. The rocks are densely welded and contain abundant quartz fragments, collapsed pumice, and commonly lithic fragments which seldom exceed 1-1/2 inches in diameter. Approximately 98 percent of the lithic fragments are of other volcanic rocks. Some quartz monzonite fragments are seen, but no sedimentary inclusions were noted.

In the southwest corner of Juniper Basin the quartz latite unit crops out over an area of approximately one square mile. There it overlies the andesite unit to the north and east, and the Pequop Formation to the west and south. No evidence has been found to indicate that its margin is anything but an erosional edge. Also within Juniper Basin, but to the north (pl. 1), are two small exposures: one, 1,000 yards square, the other, about one-quarter square mile. Both outcrops rest on the andesite; the larger may also rest on or be equivalent to rocks of the ignimbrite. North of Mizpah Canyon (pl. 1) the quartz latite is faulted into contact with the quartz monzonite, and apparently overlies or is equivalent to the ignimbrite on the east. The small exposure near Crow Canyon is faulted down into contact with the quartz monzonite. At Horse Canyon the quartz latite probably overlies the Pequop(?) Formation which is in fault contact with the quartz monzonite stock to the east. At Bellows Canyon and farther south this unit overlies the Permian limestones.

Thin sections of rocks from the quartz latite unit exhibit many of the same features seen in rocks from the central, densely welded unit of the ignimbrite. The felsite, referred to above, in Juniper Basin is unique in that it contains only 5 percent crystal fragments. In hand specimen the rock is a minutely-banded, pink felsite which under the microscope exhibits eutaxitic texture. Devitrification has all but obliterated the original shard structure and microscopically discernible grains of feldspar and cristobalite can be seen. Trichites and skeleton crystals are common in the glassy groundmass. Most of the crystal fragments are plagioclase (An_{29}). Corroded quartz crystals and biotite make up the remainder.

The quartz latite unit is something of a catch-all and its relations with other rocks are complex; therefore, only the most general estimate of thickness can be made. Such an estimate would place 500 feet as a minimum thickness.

Rhyolite

The rhyolite unit is comprised of a flow and welded tuff of limited aerial extent. The flow overlies the ignimbrite at the mouth of Dolly Varden Canyon and is exposed over an area of half a square mile. An associated welded equivalent is of about the same extent.

The flow is exposed as blocky outcrops on the hill south of where the road enters Dolly Varden Canyon (pl. 1) and the tuff on a rounded hill one drainage to the south of the rhyolite. The rhyolite is pink to light red with flow banding a conspicuous feature. Around the margin of the outcrop the flow banding has generally flat dips, but toward the top of the hill the banding becomes contorted, and at the summit a spectacular flowage syncline, about 100 feet across, has been formed by the ballooning-out of this viscous flow very near its source. Examination of the flow bands reveals evidence indicative of the high viscosity of this flow. Bands (one-quarter to 1 inch thick), which were less fluid than others have developed tension cracks perpendicular to the direction of flowage. These tension cracks have opened as much as 1/8 inch and are spaced an inch or two apart within the band. Blocky outcrops of the rhyolite are scattered on the hillside and are cut by small pebble or breccia dikes commonly an inch or two across. These dikes contain breccia fragments of the rhyolite, cemented in a dense calcedonic matrix. They are responsible for supporting the outcrops.

The welded rhyolite to the south is cream colored to light pink. It is poorly exposed except where breccias cemented by silica, as is in the case of the flow, support small outcrops. A slabby to chip-like detritus is produced upon weathering. Within the tuffaceous unit, are thinly banded welded crystal-vitric tuffs, slightly pumaceous tuffs, and vessicular tuffs. The contact between the rhyolite tuff and the rhyolite flow is gradational and the tuff is apparently an ash-flow associated with the extrusion of the rhyolite flow.

Near the mouth of Dolly Varden Canyon the rhyolite flow overlies the ignimbrite, and to the south the tuff overlies the andesite. The unit has an exposed thickness of 300 to 400 feet and covers an area of about one square mile.

Thin sections of the rhyolite flow exhibit fluidal structure. The groundmass contains an intimate mixture of microfelsite and microcrystalline patches set in a matrix of vermillion, hematitically-stained glass. Phenocrysts are as large as 1 millimeter and average 0.1 millimeter in diameter. They are comprised of sanidine, plagioclase, and quartz, and are broken, or at least exhibit such cataclastic structures as bent twins and undulatory extinction. These phenocrysts and the cryptocrystalline aggregates constitute about 60 percent of the rock which was extruded as a viscous, crystal mush with a high proportion of solids. Spherulites with an average size of 0.8 millimeters are present as devitrification products.

The ash fall has the same phenocryst minerals as the flow, but they constitute only 15 to 20 percent of this rock. They are set in an eutaxitic groundmass of shards and collapsed pumice fragments which have length to width ratios of 2 to 1. Hematitically-stained spherulites are present and average 0.3 millimeters in diameter. Some beds are porous and the vugs are lined with zeolites. Amygdules of stilbite and tridymite(?) are also found.

Breccia

Outcrops of breccia which contain angular blocks of andesite up to 12 feet in diameter are found aligned on the eastern range front, north of Dolly Varden Canyon. Although the composition of the matrix may vary slightly from that of the enclosed blocks, it is generally the same. This unit probably represents the last stage of the Dolly Varden series. The breccias may in fact be localized along fissures which were the source of much of the rock within the series.

The breccias are made up of an unsorted jumble of large and small angular blocks, set in a matrix which is similar in composition and texture to the blocks. Although some blocks are as large as 12 feet across, their modal diameter is generally between 9 and 12 inches. The breccia blocks and matrix are composed of brown to tan weathering andesite characterized by the presence of biotite and clear crystal fragments of plagioclase. On fresh fracture this dense andesite is seen to be a banded, tan to maroon rock containing amygdules filled with silica. The breccia crops out as isolated low hills east of the range (pl. 1), and their dark color is particularly striking when compared with the light tans and yellows of most of the nearby ignimbrite. Outcrops stand with 10 to 50 feet of relief above the surrounding gravels and ash flows. Two rows of these outcrops are aligned slightly west of north in en echelon fashion. This alignment of breccia outcrops is believed to represent a fissure zone. Some of the breccias, in which the maximum size of the blocks is 5 feet, may have moved a short distance, but occurrences in which the larger blocks are present are probably in place as vent or fissure breccias.

Both fragments and matrix are banded and in thin section exhibit fluidal structure. Crystal fragments make up 20 to 25 percent of the rock and are comprised of plagioclase (An_{40} - An_{50}), having an average size of 0.8 millimeters, minor amounts of hornblende and biotite, both with flamed rims, and augite. The groundmass is made up of hematitically-stained glass and devitrification products which include microlites of feldspar. Amygdules which may be as large as 3 millimeters are filled with radial chalcedony, and rimmed with tridymite(?). Abundant magnetite is always present as an accessory.

Lithologic varieties. The three varieties separated on the map (pl. 1) represent either lithologic varieties of the above described principal units in the volcanic series, or are intercalcated within or between them at various horizons. Deposits of these varieties are not intended to be correlated with one another; however, in special cases certain beds, particularly of tuff, might be equivalent.

Distinctive light-gray to white well-bedded vitric-crystal tuffs are found interbedded with, or closely associated with most of the principal units. In the western part of Juniper Basin (pl. 1) is a unit up to 25 feet thick, which underlies the andesite and overlies the Pequop Formation. At the south end of the same basin a 100 foot thick tuff is the youngest unit there overlying rocks of the andesite and quartz latite units. In Corral Valley at the north end of the range the vitric tuff overlies the quartz monzonite and underlies the ignimbrite.

These bedded tuffs are usually banded and in south Juniper Basin the banding is crenulated and contorted as if the tuff were deposited on a hillside and, before cooling, had slumped down slope. A crystal tuff resting island-like on the quartz monzonite at the north end of Melrose Mountain (pl. 1) is well bedded. This rock is slabby in outcrop (fig. 16) and has been used as hearth and paving stone by inhabitants of the range.

Thin sections of the pyroclastic tuff reveal that it may or may not be welded. The welded varieties exhibit structures and textures similar to tuffs of the ignimbrite described above. Pumice fragments which constitute the bulk of the nonwelded or partially welded tuffs are generally not collapsed. These glassy fragments range from 0.1 millimeters to 3 millimeters in size and are set in a matrix of shards. Broken grains of quartz, plagioclase (An_{23} - An_{31}) and biotite are universally present, and occasionally sanidine is seen. Perlitic cracks are well developed in some samples and are seen in their incipient stages in others (fig. 11). Water-laid tuffs have been included with the ones of pyroclastic origin on the map. The constituents of both are the same, and they both occur interspersed throughout the volcanic section. The water-laid tuffs commonly contain about 60 percent lithic fragments; glass and arenite-size crystal fragments in varying proportions make up the remainder. A water-laid tuff in Spring Canyon (pl. 1), which rests between Triassic limestone and andesite, exhibits graded bedding. Graded bedding, cross-bedding, and current ripple marks have been observed in the tuff on the north side of Dolly Varden Canyon near its mouth.

Figure 16. Well banded crystal-vitric tuff. In detail the banding is crenulated and its attitude is in part the result of slumping.

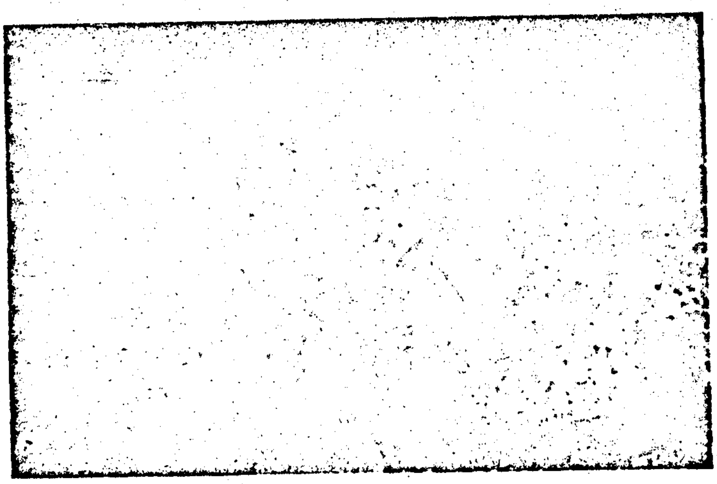

Figure 17. View of block-and-ash-flow showing unsorted material, variety of clasts, range of clast size, and ash matrix. This exposure is probably a lahar.

Outcrops mapped as block-and-ash-flows are typified by sub-angular to rounded blocks and lapilli set in a matrix of ash (fig. 17). Although these flows may be equivalent in time to units already described, they are worthy of separate mention. The location of these flows within the volcanic stratigraphy is not always clear and they were probably deposited during several intervals. They represent a variety of deposits which may include true flows of blocks and ash, lahars, agglomerates, and volcanic conglomerates.

A notable example of this type of deposit which probably represents a block-and-ash-flow is found in Spring Canyon 1,500 feet upstream from its junction with Keystone Canyon. An outcrop in the stream channel reveals an agglomerate which has a light-gray very friable, lithic perlite matrix which is roughly stratified. Stratification was caused by the sorting of the lithic fragments, which range in size from 1 to 5 millimeters from layer to layer. Most of the grains are less than 2 millimeters in diameter. Agglomeritic inclusions of blocks and lapilli have a maximum dimension of 3 feet in diameter, sphericity of 0.5, and are sub-angular to rounded. At least 11 different lithologies are represented, including 4 inch fragments of pink rhyolite, 5 inch fragments of hornblende pumice, 8 inch fragments of hornblende andesite, and 2 foot fragments of hornblende vitrophyre.

Another isolated outcrop just 500 feet to the west has blocks as large as 12 by 15 feet set in a tuffaceous matrix. The large blocks are

angular, whereas blocks and lapilli in the 6 inch to
generally sub-angular to sub-round. Fragments of andesite
common, although many other rock types are present. The matrix
crystal tuff containing quartz, biotite, and feldspar. No bedding or
banding could be found in the matrix.

In general the area of exposure of the block-and-ash-flows can be measured in thousands of square yards. Their occurrence is limited to the southern and southeastern margin of the volcanic field. Certainly flows with huge blocks could not have moved far from their source.

Vitrophyres and perlites are included in the glassy units. These are easily mappable although their significance is not always clear. Some of the vitrophyres have definite stratigraphic position; others, however, seem to crop out at random. Their location is a function of the degree of welding in that particular area. Perlites are found as lithologic varieties of many of the principal units in the volcanic series. They no doubt formed when their parent material encountered ponds or damp ground.

Age and correlation

From evidence available in the field, rocks of the Dolly Varden volcanic series can be said to be younger than Lower Triassic and older than the main period of basin-range faulting. A Lower Cretaceous radioactive age date on the quartz monzonite stock raises the lower limit somewhat, but since no fossils were found and no radioactive age date from the volcanic rocks has been obtained, more precise dating of this series is not possible. The writer believes, however, that rocks of this series were probably contemporaneous, though by no means contiguous, with the ignimbrites and associated flows in southeastern Nevada (Cook, 1961). In the Sheep Pass Canyon area in the Egan Range 100 miles to the south, an ignimbrite has been dated as approximately 34 million years (early Oligocene) by the Potassium-Argon method (Harris, 1959). Young (1960) described a sequence of ignimbrites(?) and flows in the central Schell Creek Range which he considers to be of Eocene-Oligocene age. Volcanic rocks of the Schell Creek Range have similar gross lithology to those in the Dolly Varden Mountains, but they differ in detail. Data supplied by Armstrong (oral communication) show that extrusives in the eastern Great Basin range in age from 14 to 38 million years, most of them occurring in the period from 25 to 30 million years. It is on the basis of the indirect evidence described above that the Dolly Varden volcanic series is called Oligocene(?).

The writer believes that this series, with the exception of the andesite which may be equivalent to rocks in the Boone Spring Hills, constitutes a deposit localized within this range, and does not represent a remnant of a widespread sheet such as those characteristic of the ash flow tuffs in the ignimbrite province south of Ely.

Sedimentary and Volcanic Rocks of Miocene(?) - Pliocene(?) Age

General features

Calcareous sediments and restricted flows of volcanic rock some of which antedate the period of basin-range faulting, are found in a few places in the Dolly Varden Mountains. The flows, each covering areas of less than half a square mile, are composed of rhyolite, andesite, and basalt.

Distribution

The volcanic rocks crop out peripheral to the southern part of the range (pl. 1). The sedimentary rocks are found along the northeast margin of the range.

Andesite

A small andesite hill south of Teakettle Canyon on the eastern range front (pl. 1) represents the total extent of a late Tertiary flow, which may have been extruded from a fissure related to the high angle faults which traverse that area. The rock is dark gray, dense, and has a concoidal fracture. Near the top of the flow, banding is contorted and blocks which represent flow breccia are found. Zirkel (in Emmons, 1877, p. 479) describes the rock as being "rich in plagioclase and yellow-brown augite". These phenocryst minerals are set in a groundmass of pilotaxitic microlites. Emmons (1877, p. 479) reports a silica analysis of 62.46 percent for this rock.

A small andesite flow located on the southwest border of the range covers a basin-range fault there. Where the flow laps on the Pequop Formation a brick-red oxidized margin, which ranges from paper thin to 20 feet thick, can be seen.

Andesites at the southern extremity of the mapped area are part of the volcanics of the Boone Spring Hills. They are tentatively mapped with the younger Tertiary group because they are isolated, and their relations with rocks of the older Dolly Varden volcanic series are not known. These andesites may in fact belong with the Oligocene(?) group, but until geologic relations in the area south of the Dolly Varden Mountains are determined, these scattered outcrops will be called, simply, Tertiary andesites, with full knowledge that their exact age is not known.

Basalt

The remnant of a restricted basalt flow is exposed on the southwest margin of the range where it rests on the quartz latite unit of the Dolly Varden volcanic series. The basalt is cut by a high-angle fault. In several outcrops the scoriaceous top of the flow is preserved.

Rhyolite

A columnar jointed rhyolite plug has pierced the Ferguson Mountain Formation south of Bellows Canyon near the western range front (pl. 1). The plug crops out over an area of about 2,000 square yards and has local relief of up to 75 feet (fig. 18). The flow associated with this plug is preserved where it overlies a range boundary fault and the quartz latite unit of the Dolly Varden volcanic series a short distance to the northwest of the plug. The contact between the plug and the enclosing limestone is complex. Much of the limestone in this part of the range has been recrystallized and bleached. Whether these widespread thermal effects can be simply attributed to this plug is questionable. But certainly the sediments peripheral to the plug were thermally metamorphosed. Encircling the plug is a chilled zone, 5 to 10 feet thick, of felsitic rhyolite which includes fragments of quartz monzonite and marble. Flow banding within this chilled zone is generally parallel to the margin of the plug. Glass dikes or diatremes, not a part of the chilled zone, penetrate the limestone for distances of up to 40 feet from the plug. They probably represent deposits from a gas-charged volatile phase which was liberated as the plug cooled. The change in lithology between the chilled felsitic zone and the crystalline rhyolite is abrupt, taking place within a few inches. Columnar jointing within the plug is well developed. The joints (fig. 19) are about 2 feet in diameter, and, for the most part, are roughly perpendicular to the margin of the plug. In one area the direction of jointing changes from vertical to horizontal in the space of 20 feet (fig. 18). The rhyolite is composed of phenocrysts of rounded smoky quartz, 1 to 8 millimeters in diameter, euhedral sanidine, up to 1 centimeter long, and some biotite set in a gray aphanitic groundmass. Both the quartz

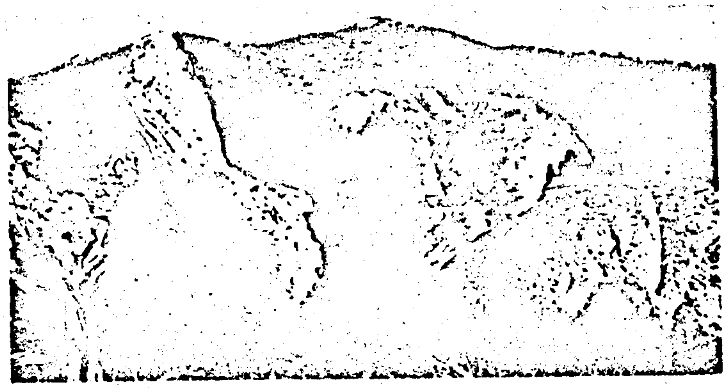

Figure 18. View of rhyolite plug showing columnar jointing. Note that the attitude of the joints changes within a few tens of feet. The rhyolite-limestone contact is to the left of the highest part of the outcrop.

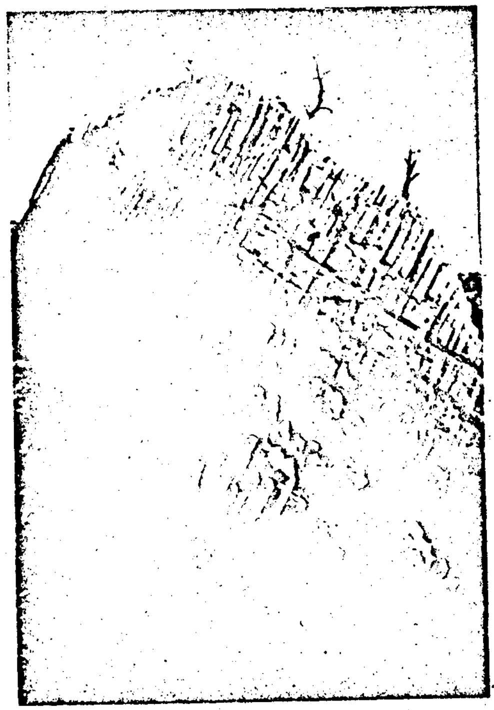

Figure 19. Close-up of well developed columnar jointing. Columns have an average diameter of about 18 inches.

and the feldspar grains are cracked.

Calcareous sediments

At the north end of the range a sequence of predominantly white sedimentary rocks are conformable(?) on rocks of the Dolly Varden volcanic series. A thickness of approximately 200 feet is present.

Outcrops are scattered, as most of the formation is covered by a gravel veneer from the higher volcanic hills. Best exposures are found along the stream valleys where a typical outcrop contains a conglomerate, which ranges from 5 to 12 feet thick, overlying a 10 foot thick tuffaceous, limy arenite, which in turn overlies a sequence of marlstones and limestones at least 40 feet thick. The conglomerate contains sub-angular to sub-rounded clasts up to 4 feet in diameter, with an average size of 6 inches or less, in a limy matrix. Pebbles and cobbles of practically every older rock exposed at this end of the range are present including quartz monzonite, vitrophyre, welded quartz latite, and limestone. The arenite is made of crystal fragments and smaller shards cemented by carbonate. The sequence below is composed of yellow-white, dense, concoidally fracturing marlstone and tuffaceous(?) limestone.

Age and correlation

Rocks of this younger group were deposited after the Dolly Varden volcanics and prior to the lake sediments of Pleistocene age. The sedimentary rocks were deposited prior to the period of basin-range faulting. The absolute age of these rocks is open to question as no evidence was found upon which to base an estimate. Van Houten (1956) has indicated that during the Miocene and Pliocene rocks of a similar nature were deposited in north-central Elko County.

The younger volcanic flows on the west side of the range cover faults which cut the older volcanic rocks, and overlie sediments which were probably not exposed until after the period of basin-range faulting. The tops of the flows there, as with the andesite flow south of Teakettle Canyon, are horizontal. On the basis of the above described structural and lithologic considerations, the rocks of this younger group are tentatively assigned an age of Miocene(?) - Pliocene(?).

QUATERNARY SYSTEM

The deposits within this system have not been subdivided on the map, but include talus and landslide deposits, fan gravels, gravel veneers on pediment, older and younger stream gravels, as well as earlier, Pleistocene beach, bar, and other related lake deposits. The elevation of the highest lake deposits is about 5,900 feet.

All Quaternary and older deposits are presently being dissected and entrenched. This change from aggradation to degradation is probably a result of over-grazing and of more arid climatic conditions.

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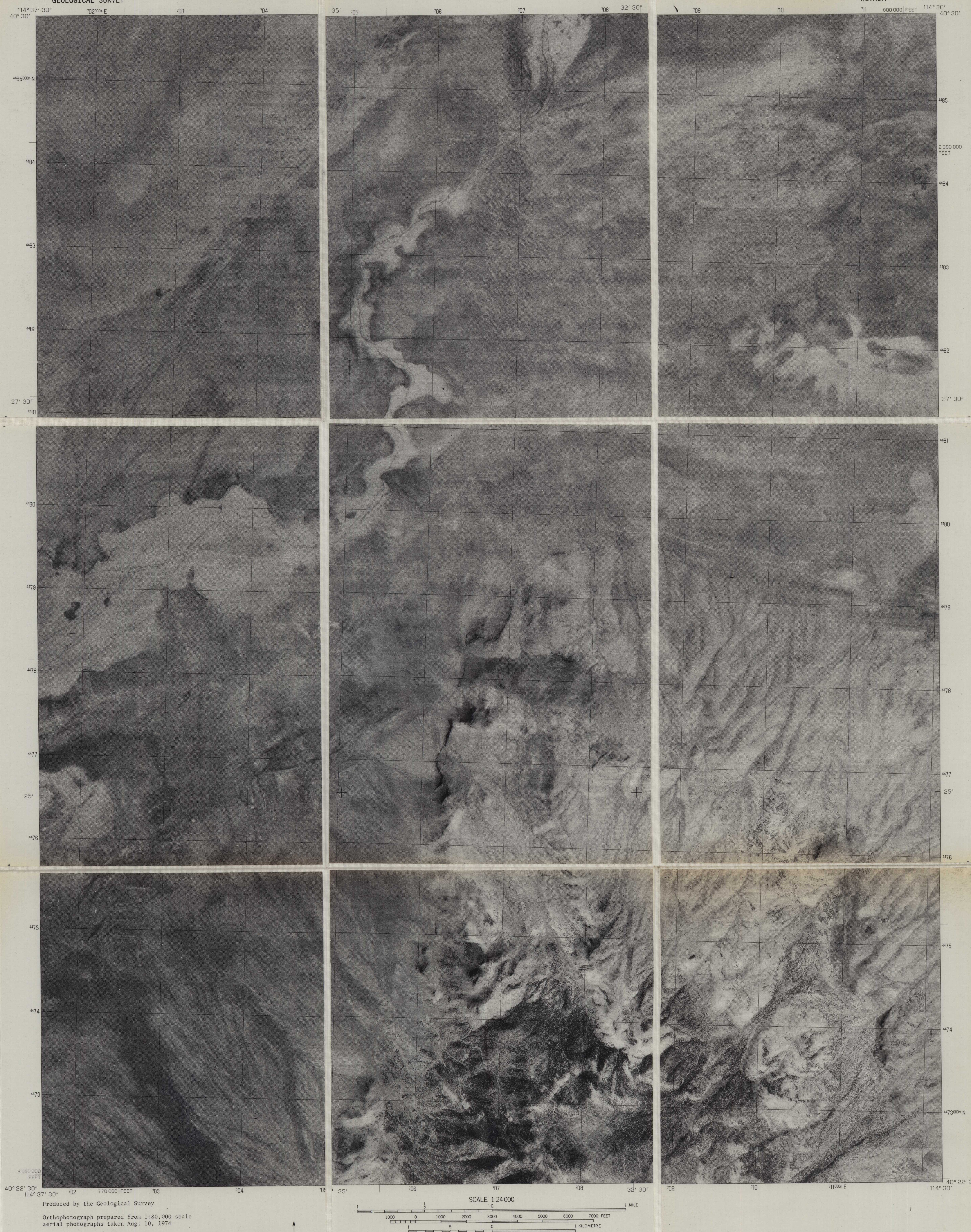
NEVADA



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Orthophotograph prepared from 1:80,000-scale aerial photographs taken Aug. 10, 1974

Projection and 10,000-foot grid ticks: Nevada coordinate system, east zone (transverse Mercator) 1000-metre Universal Transverse Mercator grid, zone 11. 1927 North American datum

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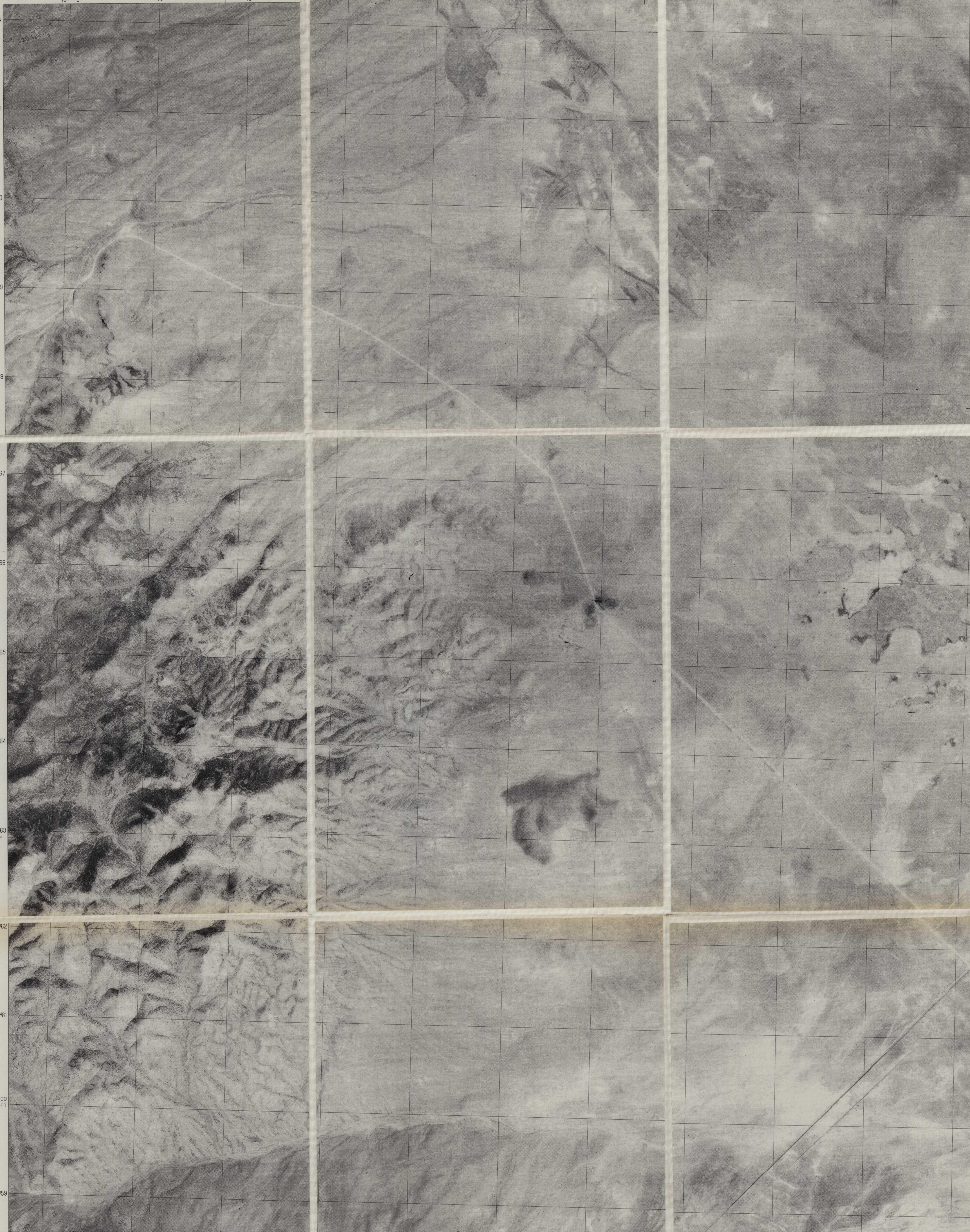
FERGUSON SPRINGS 2 SW ORTHOPHOTOQUAD
NEVADA

114° 30′ | 40° 22′ 30″ | 713000m E | 714 | 715 | 27′ 30″ | 716 | 717 | 718 | 719 | 25′ | 720 | 830 000 FEET | 722 | 114° 22′ 30″ | 40° 22′ 30″ | 2 050 000 FEET



4472000m N | 4471 | 4470 | 4469 | 4468 | 20′ | 4467 | 4466 | 4465 | 4464 | 4463 | 17′ 30″ | 4462 | 4461 | 2 010 000 FEET | 4460 | 4459000m N

40° 15′ | 114° 30′ | 713 | 714 | 810 000 FEET | 27′ 30″ | 717 | 718 | 719 | 25′ | 720 | 721 | 722000m E | 40° 15′ | 114° 22′ 30″

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NORTH

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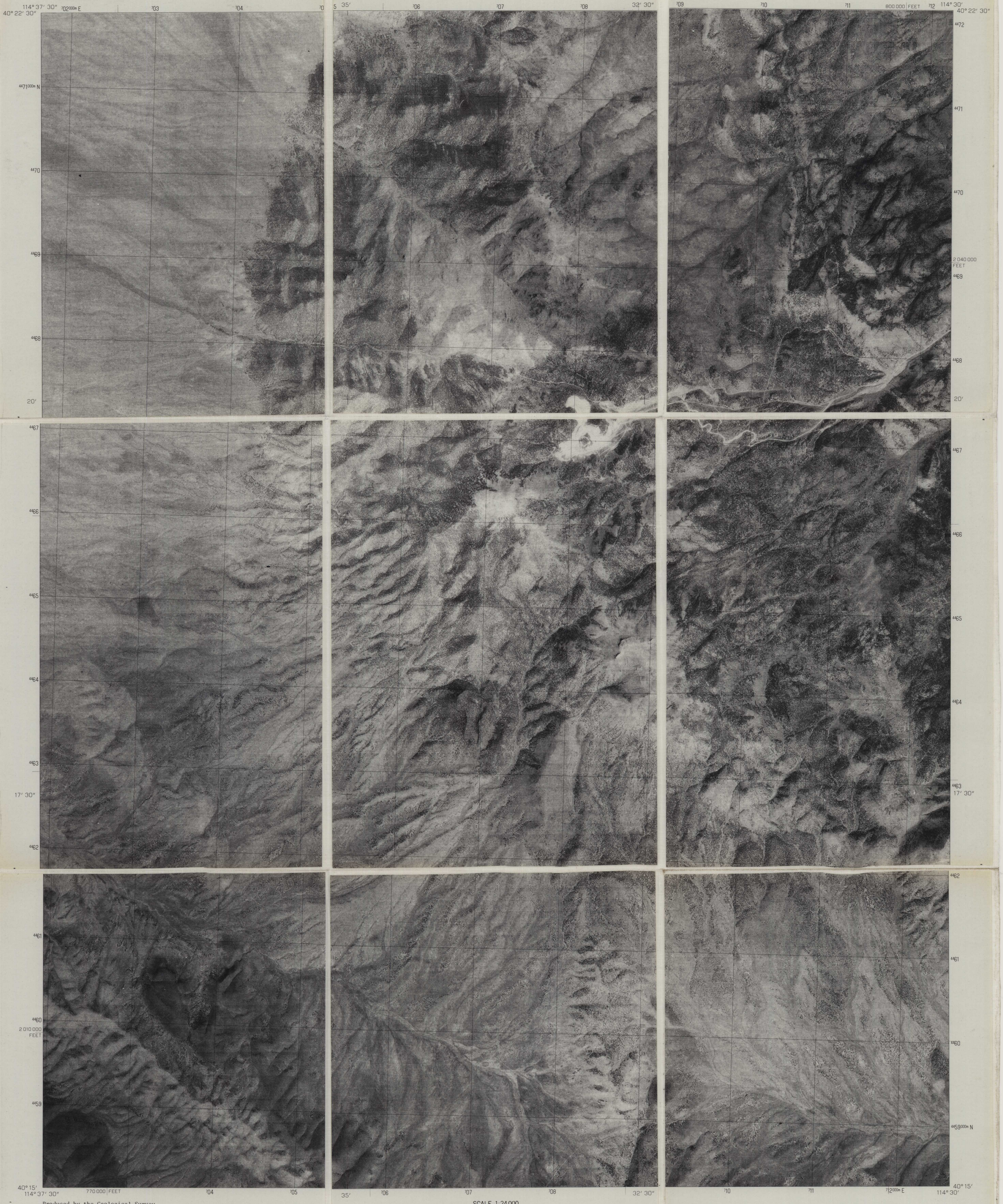

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