TEI-789

GEOLOGY OF THE 410 AREA
NEVADA TEST SITE
NYE COUNTY, NEVADA

By Robert E. Davis

Trace Elements Investigations Report 789

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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Washington 25, D. C.
AUG 22 1961

AEC-267/1

Mr. James E. Reeves
Assistant Manager for Test Operations
Albuquerque Operations Office
U.S. Atomic Energy Commission
P.O. Box 5400
Albuquerque, New Mexico

Dear Mr. Reeves:

Transmitted herewith are ten copies of TEI-789, "Geology of the 410 Area, Nevada Test Site, Nye County, Nevada," by Robert E. Davis, June 1961. We plan to release this report to the public through the open files.

Sincerely yours,

Edwin B. Eckel, for

V. E. McKelvey
Assistant Chief Geologist
Interagency Programs and
Supporting Activities

TEI-789

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOLOGY OF THE 410 AREA, NEVADA TEST SITE, NYE COUNTY, NEVADA*

By

Robert E. Davis

June 1961

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This report is preliminary and
has not been edited for conformity
with Geological Survey format.

*Prepared on behalf of the U.S. Atomic Energy Commission.

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By Robert E. Davis

ABSTRACT

The 410 Area occupies about 5 square miles in the south-central part of the Nevada Test Site, about 10 miles northwest of Mercury. The area is underlain by tuffs, tuffaceous sedimentary rocks, and volcanic flow rocks, tentatively assigned to the Oak Spring Formation of Tertiary age (Miocene(?) or younger).

The predominant structural feature is a large gently tilted block, bounded on two sides by high-angle northeast-trending normal faults. Within the block high-angle normal faults with small displacements parallel the bounding fault along the southeast side, but along the northwest side, where alluvium is abundant, similar faults were not observed although they are believed to be present. The faults are relatively open and form channelways for the easy passage of ground water to the subsurface. The porosity, density, permeability, hardness, unconfined compressive strength, and cesium exchange capacity of samples of the different rock types were determined. The maximum measurements are porosity 47.3 percent, density 2.67 g/cc, permeability 81.38 millidarcies, hardness 7.0, unconfined compressive strength 10,200 psi, and cesium exchange capacity 78.51 meg/100 grams.

INTRODUCTION

The 410 Area is in the south-central part of the Nevada Test Site approximately 10 miles northwest of Mercury. It occupies about 5 square miles in the southwest corner of the Cane Spring SE 7½-minute quadrangle and the southeast corner of the Cane Spring SW 7½-minute quadrangle (fig. 1). The area is bounded by the Nevada State coordinates N. 730,000, N. 742,000, and E. 656,000, and E. 668,000. Its principal topographic feature is a south-trending valley surrounded on the west, north, and east by hills which rise as much as 600 feet above the valley. The highest point is Hampel Hill, in the southeast corner of the mapped area, which stands about 4,940 feet above sea level.

The geology of the 410 Area was mapped on a 1:24,000 topographic base in August 1960 by R. E. Davis, D. P. Elston, D. D. Dickey, F. N. Houser, and V. R. Wilmarth. This work was done on behalf of the U.S. Atomic Energy Commission, Albuquerque Operations Office, as part of the U.S. Geological Survey's program to define the overall geologic environment of the Nevada Test Site for the purpose of assessing ground-water contamination problems.

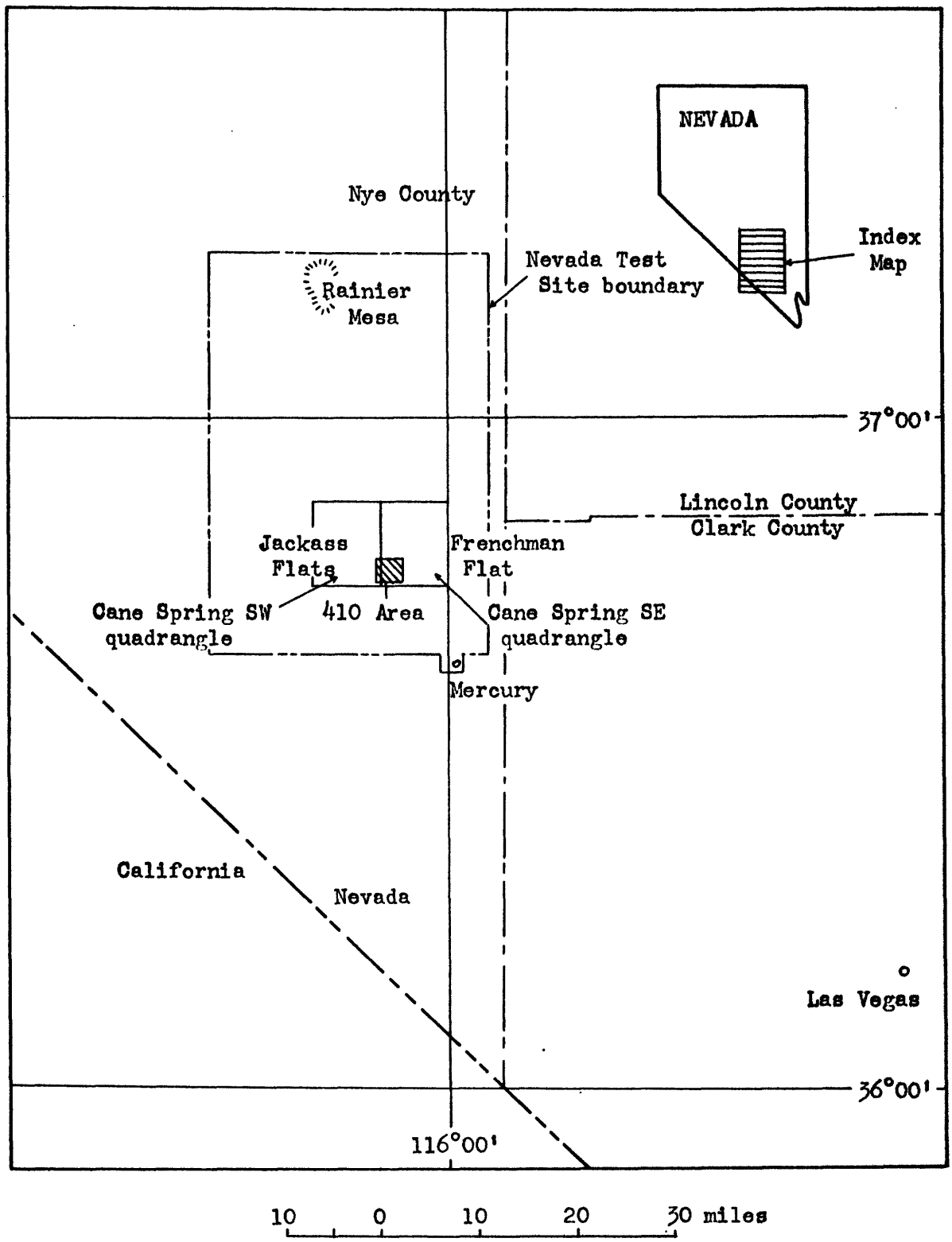

Figure 1. -- Index Map showing 410 Area, Nevada Test Site, Nye County, Nevada

GEOLOGY

The 410 Area is underlain by a sequence of tuffs, agglomerates, tuffaceous conglomerates and sandstones, and lava flows, all of which are assigned tentatively to the Oak Spring Formation of Miocene(?) or younger age. In places remnants of a thin basalt flow, Tertiary(?) or Quaternary(?) in age, overlie the rocks of the Oak Spring Formation. The basalt and older rocks are overlain locally by beds of conglomerate of probable Quaternary age. Recent alluvium occurs in the large valleys. The rocks are broken by joints and faults, most of which trend northeast. The vertical displacements along faults range from a few inches to as much as 200 feet. The major structural feature in the 410 Area is a large northwest-tilted fault block, bounded on the northwest and southeast by the northeast-trending Cane Spring fault and Hampel Hill fault zone, respectively.

Stratigraphy

Rocks of Tertiary age

Oak Spring Formation

The thick sequence of volcanic rocks that crops out extensively on the Nevada Test Site was named the Oak Spring Formation by Johnson and Hibbard (1957, p. 367) and was assigned to the Tertiary (Miocene(?) or younger). The formation consists chiefly of thick ash fall and ash flow tuffs, some of which were deposited in water, and subordinately of fluviatile and lacustrine tuffaceous conglomerates and sandstones, and lava flows of varied composition. These rocks were deposited on

an erosion surface of considerable relief cut in the deformed older sedimentary and igneous rocks. Because of the relief on this surface, the thickness of the Oak Spring Formation varies from place to place throughout the Test Site and locally is greater than 3,000 feet.

The rocks exposed in the 410 Area are probably equivalent to part of the Oak Spring Formation (F. G. Poole and P. P. Orkild, oral communication, 1961), and here will be considered as such, although none of the mapped units have been correlated definitely with units of known stratigraphic position in other parts of the Test Site. In the mapped area, the thickness of the Oak Spring is greater than 2,000 feet locally.

That part of the Oak Spring Formation exposed in the 410 Area has been subdivided into seven units, numbered consecutively from oldest to youngest (fig. 2). The best and most nearly complete section is at Hampel Hill, where all units except the felsite agglomerate and the felsite flow sequence are exposed.

Lithic tuff.--In the 410 Area, the oldest rock exposed is here called lithic tuff to emphasize the relatively high proportion of fragments of previously formed rock (lithic fragments) which it contains. The total thickness of the unit is not known, as only the upper 50 to 60 feet is exposed at Hampel Hill. However, at U.S. Geological Survey Test Hole F (fig. 2), in the southern part of the 410 Area, a predominantly lithic tuff sequence with a few thin tuffaceous sandstone

beds was penetrated from the surface to a depth of at least 1,100 feet before a distinctly different rock type was encountered.

The unit consists of white through cream to light-gray fine tuff, which contains 30 to 35 percent by volume of angular to rounded lithic fragments. These fragments range from a few millimeters to 200 mm in long dimension; they consist chiefly of lavas or densely welded tuffs and in color are various shades of gray and reddish gray. Quartz, feldspar, and black biotite crystals totalling 5 to 8 percent by volume of the rock are disseminated throughout the tuff. Pumice constitutes 5 to 10 percent of the tuff and occurs as scattered fragments 2 to 10 mm in longest dimension.

The lithic tuff generally is nonlayered, although pronounced layering can be seen locally. At these localities, the amount of coarse lithic fragments in the tuff is considerably less than elsewhere.

The lithic tuff crops out only in the southern part of the area, where it is best exposed in a belt that extends from the base of Hampel Hill southwestward into the main valley. Locally it crops out in isolated patches along minor stream valleys. The tuff weathers readily into rounded slopes commonly covered with a pavement of the harder lithic fragments or round pebble-size nodules of pumiceous tuff. Some of the nodules have a lithic fragment core, whereas in others the core is slightly opalized tuff.

Tuffs and tuffaceous sedimentary rocks.--Conformably overlying the lithic tuff unit is a sequence of generally well stratified, in part waterlaid, pumiceous to lithic tuffs and tuffaceous sandstone and conglomerate. The rocks of this unit occur only in the southern half of the mapped area. The best exposures are on the west slope of Hampel Hill and in the complexly faulted area to the north. At Hampel Hill the unit attains its apparent maximum thickness of about 75 feet.

The rocks of this unit include layers and lenses of pumiceous tuff, lithic tuff, tuffaceous sandstone, and tuffaceous conglomerate, all of which are commonly some shade of gray, although locally they are yellowish or red. The pumiceous tuff is fine to coarse and consists principally of pumice fragments with several percent of quartz, feldspar, hornblende, and black biotite crystals. The pumice fragments, the largest dimensions of which range from about 1 to 20 mm, make up as much as 50 percent by volume of the tuff. The lithic tuff of this unit is similar in texture and mineral composition to most of the tuff in the underlying unit, but in contrast is well layered. The tuffaceous sandstone consists of coarse tuff containing more than 50 percent coarse sand grains and granules of quartz, feldspar, biotite, and lithic fragments. The tuffaceous sandstone grades both laterally and vertically into beds of pebble to cobble conglomerate. The conglomerate beds are lenticular and consist of abundant rounded to subangular fragments of red, brownish, and gray welded tuffs and lavas in a tuffaceous sandstone matrix.

The most prominent feature of the sequence of tuffs and tuffaceous sedimentary rocks is the distinct layering, the strata ranging from about 1 inch to more than 6 feet in thickness. The unit is generally recognizable on steep slopes by the thin ledges that are formed and by the platy to slabby debris that covers the slope. In the valley west of Hampel Hill, however, the slopes underlain by this unit are gentle and are covered with residual material, consisting largely of rounded coarse lithic fragments, that cannot be distinguished from the residual material derived from the underlying lithic tuff unit. The low ridges that slope gently down into the valley, therefore, may be capped locally with remnants of the sequence of tuffs and tuffaceous sedimentary rocks rather than consisting entirely of the lithic tuff unit, as shown on the geologic map (fig. 2).

Pumiceous agglomerate.--Overlying the well-stratified sequence of tuffs and tuffaceous sedimentary rocks, probably unconformably, is the thick unit of indistinctly layered to nonlayered pumiceous agglomerate. The pumiceous agglomerate is so named because it consists chiefly of tuff that contains a large proportion of pumice and rock fragments of the same composition as the matrix. At Hampel Hill the agglomerate is 150 feet thick, but it is somewhat thicker on the rounded hill about a mile northwest of Hampel Hill.

At Hampel Hill, the unit can be roughly divided into two parts based on the amount of contained lithic fragments. The lower 65 feet is light-gray to tan-gray, essentially nonlayered pumiceous agglomerate which contains few lithic fragments. The matrix of the agglomerate is a fine to coarse tuff, commonly glassy, with as much as 25 percent quartz, feldspar, hornblende, and biotite crystals. Locally the tuff has been zeolitized. Set in the matrix are abundant pumice fragments, ranging from coarse ash to lapilli, and fresh pumiceous tuff fragments of the same composition as the enclosing matrix. The fragments of pumiceous tuff range from about 1 inch to 2 feet in long dimension and in some places constitute as much as 50 percent by volume of the rock. Locally in the lower part of the unit, the pumiceous fragments are imbricated. At Hampel Hill, this lower 65 feet of the unit is a resistant cliff former.

The upper 85 feet of the unit is an indistinctly layered pumiceous agglomerate that contains a much greater proportion of lithic fragments than does the lower part. The rounded to subangular pebbles and cobbles (lithic fragments) are similar to those in the underlying lithic tuffs and consist chiefly of welded tuffs and lavas. The upper 85 feet is less resistant than the lower part and weathers to reddish or purplish slopes with discontinuous reddish benches or ledges.

On the hill about a mile north-northwest of Hampel Hill, the pumiceous agglomerate unit contains thin beds of tuffaceous sandstone. These beds seem to be of limited areal extent and comprise only a small part of the entire unit.

In the northeast part of the 410 Area, a lens (or lenses) of felsite (intermediate to silicic lava) agglomerate that occurs near the top of the pumiceous agglomerate unit has been mapped separately (fig. 2). This agglomerate is overlain by 60 to 65 feet of pumiceous tuff containing abundant biotite, which is assigned tentatively to the pumiceous agglomerate unit. It is possible that the rocks in the northeast part of the mapped area that are assigned to the pumiceous agglomerate unit because of their lithologic similarity to the rocks of that unit at Hampel Hill are, at least in part, older than the pumiceous agglomerate. Detailed geologic mapping east and northeast of the 410 Area is necessary to establish their position relative to the Hampel Hill section.

The rocks assigned to the pumiceous agglomerate crop out extensively within the 410 Area. They underlie a large part of the central valley, as well as parts of the hills and valleys along the north and northeast boundaries of the 410 Area.

Conglomerate.--On the northwest side of Hampel Hill and in nearby areas to the north and northwest, the pumiceous agglomerate unit is overlain unconformably by an apparently discontinuous cobble and boulder conglomerate. At Hampel Hill, the conglomerate is as much as 18 feet

thick, but elsewhere its thickness may be no greater than that of a single layer of boulders, and in still other localities it is absent.

The conglomerate is best seen on the north slopes of Hampel Hill, where it consists of cobble conglomerate overlain by boulder conglomerate. The cobble conglomerate contains subangular to subrounded fragments, as much as 1 foot in diameter, of light-gray to reddish-gray welded tuff or felsite in a matrix of gray, coarse-grained, tuffaceous sandstone. The overlying boulder conglomerate contains rounded fragments from 1 foot to 4 feet in diameter of dark-gray porphyritic andesite, some of which contain inclusions of dark-gray very fine grained andesite. The nature of the contact between the two conglomerates is not known.

The conglomerate can be traced by discontinuous exposures from the north side of Hampel Hill along the hills to the north, and from there to the west side of the main valley where it pinches out.

Tuffaceous sandstone.--A tuffaceous sandstone unit crops out only in the southeast part of the 410 Area and is best exposed on the flanks of Hampel Hill. It unconformably overlies the conglomerate unit and the pumiceous agglomerate unit. The tuffaceous sandstone is a large wedge-shaped unit, which pinches out a mile north of Hampel Hill but thickens to the south; at the south end of Hampel Hill, it is as much as 300 feet thick.

The tuffaceous sandstone is predominantly very thin bedded, weathers to light gray or yellow gray, and is medium to coarse grained. It consists of rounded to subrounded sand-size particles of quartz, feldspar, and tuff, and contains generally less than 1 percent of scattered lithic fragments, which range from about 1 mm to 12 mm in largest dimension. Within the sandstone are a few lenses of granule to small-pebble conglomerate, composed of as much as 50 percent of lithic fragments, as much as 12 mm in diameter, in a coarse sandstone matrix. Locally the top of the unit is massive and conglomeratic. The conglomeratic parts contain small angular to rounded fragments of welded tuff and a few rounded fragments of dark-gray andesite like those found in the underlying conglomerate unit.

Felsite flow sequence.--In the northern and northwestern parts of the 410 Area, the pumiceous agglomerate unit is overlain unconformably by a thick sequence of silicic to intermediate flow rocks of varied color. The exact composition of the flow rocks is not known, but they are here referred to as felsites. It is thought that the felsites in this area form the southern and southeastern edge of a flow sequence that is thicker and more fully exposed north and northwest of the 410 Area (F. G. Poole, oral communication, 1961). Several hundred feet of felsite is exposed in the northwest corner of the mapped area.

The felsites are light to dark gray and reddish brown; these color variations probably represent different flows within the sequence. They are distinctly porphyritic and commonly contain 25 to 40 percent phenocrysts of feldspar, hornblende, biotite, and minor quartz, which suggests a range in composition from latite to andesite. The phenocrysts range from about 1 mm to about 6 mm in long dimension, and are set in a very fine grained groundmass. The color of the groundmass imparts the overall color to the rock.

The exact age relation between the felsites and the rocks of the conglomerate and tuffaceous sandstone units cannot be established in the mapped area because of inadequate exposures. The rock types in the felsite flows are similar to some of the cobbles and boulders in the conglomerate and to some of the small rock fragments in the tuffaceous sandstone. On the other hand, certain field relations suggest that at least that part of the flow sequence exposed in the 410 Area is younger than the tuffaceous sandstone, although direct evidence supporting this suggestion has not been observed.

Pumiceous tuff.--The uppermost unit of the Oak Spring Formation in the 410 Area is pumiceous tuff; that is, a tuff one of whose distinguishing characteristics is the conspicuous amount of pumice it contains. The pumiceous tuff unconformably overlies the tuffaceous sandstone unit, the conglomerate unit, and the pumiceous agglomerate. West of the 410 Area, it also overlies unconformably rocks of the felsite flow sequence. The maximum thickness of the pumiceous tuff unit is not known, but it is about 200 feet thick at Hampel Hill.

The pumiceous tuff can be divided into three parts--a lower soft white tuff, a middle soft pink tuff, and an upper, hard, light-gray to pinkish-gray tuff. A general lack of biotite and an abundance of pumice fragments are features common to all three parts.

The lower part of the unit is a distinctive, soft, white, fine to coarse tuff, which generally contains less than 1 percent each of biotite and lithic fragments and less than about 2 percent quartz crystals. Few of the lithic fragments exceed 5 mm in longest dimension. By visual estimate the tuff contains 20 to 25 percent pumice fragments, most of which average about 5 mm in longest dimension.

The soft white tuff grades upward into the middle part, which consists of soft salmon-pink tuff. Tuff of the middle part is similar in composition to that of the lower part but generally contains several percent more lithic fragments.

The upper part of the pumiceous tuff unit consists of fine to coarse, hard, incipiently welded tuff. The fresh rock is white to light gray, but weathered surfaces are light pink to pinkish gray. The tuff contains as much as 15 percent of fibrous glassy pumice fragments generally less than 12 mm long; some of the pumice fragments are partly collapsed, whereas others show no indication of collapse. Crystals of quartz, feldspar, and bronze biotite, with a very few small lithic fragments, make up 10 to 15 percent of the tuff in most places.

In general, the pumiceous tuff is not layered, although locally, near the base of the unit, some beds are thin to very thin.

The lower and middle parts of the pumiceous tuff unit weather into slopes, which are capped by the cliffs of incipiently welded tuff of the upper part. The thickness of the lower and middle parts varies from place to place, owing to the uneven surface upon which the tuffs of the unit were deposited. The base of the cliff-forming upper part, therefore, is less than 50 to more than 100 feet above the base of the unit.

The pumiceous tuff crops out in a broad arcuate belt, which extends from Hampel Hill north-northwestward and around the head of the main valley. In the west-central part of the 410 Area, it is covered by younger sedimentary rocks.

Rocks of Tertiary(?) or Quaternary(?) age

Basalt

Small remnants of a basalt flow (or flows) occur in the north and west parts of the 410 Area. No evidence has been noted to establish the age of the basalt, and it is shown on the geologic map (fig. 2) as Tertiary(?) or Quaternary(?) age. With one exception, the basalt directly overlies the pumiceous tuff unit. The maximum thickness is at the north-central edge of the area, where 30 to 35 feet of basalt caps a narrow northeast-trending ridge. In the west-central part of the mapped area, several small isolated masses of basalt are present,

suggesting that the basalt was probably quite extensive prior to removal by erosion or burial by the younger conglomerate. In at least two of the small masses the rocks consist of basalt rubble, residual from weathering of the flow rocks.

The base of the basalt consists of 1 to 2 feet of reddish to black basalt and basalt flow breccia. Flow banding is absent in the lower part but is distinct in the upper part. A few small vesicles filled with caliche and limonite are present in the upper 10 feet of the basalt. Small phenocrysts of feldspar and olivine, much of which has been altered to iron oxide, are most abundant in the upper half of the basalt though they rarely exceed 3 percent by volume of the rock.

On the north side of the basalt-capped ridge at the north-central edge of the mapped area, the basalt overlies reddish-brown felsite, which in turn appears to overlie the pumiceous tuff unit. The felsite, though not definitely correlated with any unit in the Oak Spring Formation, may be a unit in the upper part of the pumiceous tuff. A talus-covered slope obscures the actual relation between the felsite and the tuff, and it is not known whether the rocks are in depositional or fault contact.

Conglomerate

Unconformably overlying basalt and older rocks in the western part of the area is a conglomerate, the exact age of which is not known. Its thickness is 160 feet at the western edge of the mapped

area, but it thins eastward into the valley where it forms a thin veneer on the older rocks.

The conglomerate is poorly sorted, firmly cemented with calcium carbonate, and consists of pebbles, cobbles, and boulders as much as 8 feet in diameter in a firmly cemented matrix of coarse to very coarse sand. The rounded to subangular fragments include almost all the older rock types exposed in the hills surrounding the 410 Area, but the resistant felsites and welded tuffs are dominant. Basalt cobbles, boulders, and blocks are abundant locally. The conglomerate weathers to loose rubble-covered slopes which contain abundant fragments of caliche. It is shown on figure 2 as Tertiary(?) or Quaternary(?) in age.

Rocks of Quaternary age

Alluvium

Unconsolidated mixed sand, gravel, and boulders occur more or less continuously along the stream bottom in the main valley and as discontinuous patches along tributary valleys. These deposits are shown on the geologic map (fig. 2) only where they form a significant cover on the bedrock in the valley bottoms.

Structure

The hilly region between Frenchman Flat and Jackass Flats, of which the 410 Area is a part, is one of many closely spaced faults

and diversely dipping rocks, although the regional dip is generally eastward and southeastward. In this region most of the faults are normal, dip steeply, and trend northeast, though a few trend north to northwest.

With few exceptions most of the faults mapped in the 410 Area fit into the regional fault pattern; that is, they have normal movement and trend northeast. Vertical displacements range from 5 to 200 feet but generally are less than 50 feet. Most of the faults strike N. 35° to 45° E. and dip 76° NW. to vertical. Because of their strong parallelism and normal displacements, the northeast-trending faults are considered to be tension faults formed by lateral expansion of the rock in this area. Gouge is sparse or absent along these faults and therefore they are presumed to be fairly open and permeable, thus allowing surface waters to percolate readily to the regional water table.

The major structural feature in the 410 Area is a large gently tilted block that forms the central part of the mapped area. This block is bounded on the northwest and southeast by high-angle northeast-trending normal faults. The Cane Spring fault, with a vertical displacement of at least 200 feet down on the southeast side, is the bounding fault on the northwest. The east border of the block is the northeast-trending Hampel Hill fault zone, with a vertical displacement of about 50 feet up on the northwest side.

The Cane Spring fault crosses the northwest corner of the mapped area and, along most of its fairly well defined trace, separates the pumiceous tuff unit of the Oak Spring Formation in the tilted block

from older rocks northwest of the fault (fig. 2). It has been traced northeast of the mapped area at least 2 miles and probably extends a comparable distance to the southwest. The fault dips steeply southeast. The rocks on the southeast side have been displaced downward a minimum of 200 feet relative to the rocks on the northwest side. The altitude of the basalt remnants in the tilted block relative to that of basalt flows west of the area suggests that the displacement across the fault might be as much as 400 feet.

The southeast side of the tilted block is defined by the Hampel Hill fault zone (fig. 2). This fault zone crosses the northwest shoulder of Hampel Hill and ranges from 10 to 500 feet in width. It consists of two northeast-trending faults, one of which dips 84° NW. and the other dips 80° SE. Tangential faults of less than 10 feet vertical displacement intersect the fault zone. The net vertical displacement across this fault zone is about 50 feet, with the rocks moved up on the northwest side. Reconnaissance east and northeast of the 410 Area suggests that the Hampel Hill fault zone may connect to the Cane Spring fault northeast of the mapped area.

The numerous northeast-trending faults with 10 to 20 feet vertical displacement that are about 1,500 feet northwest of the Hampel Hill fault zone are predominantly normal faults and can be traced on the surface generally less than 3,000 feet. They were formed contemporaneously with the tilting of the block between the two boundary faults.

The differential displacement along the bounding faults has resulted in a rotation of the block and a general north to northwest dip of the strata within it. Owing to poor exposures, few faults were seen in the northwest half of the block; however, it is quite possible that the rocks southeast of the Cane Spring fault are broken by a series of northeast-trending faults similar to those northwest of the Hampel Hill fault zone. If this is so, a fairly open and permeable channelway or system of channels exists along the downdip (northwest) side of the tilted block.

West-, north-, and northwest-trending faults in the area are few, and most have displaced the rocks vertically less than 10 feet. The notable exception is the main northwest-trending fault which separates the pumiceous agglomerate from the pumiceous tuff in the northeast part of the mapped area. The amount of vertical displacement across this fault is not known, but it may be as great or greater than that on the Cane Spring fault. North- and northwest-trending faults are earlier than, and have been offset by, northeast-trending faults.

Joints have the same directional patterns as faults, thus suggesting that they too are tension features. Prominent vertical and nearly vertical joints strike about N. 25° to 35° E. and nearly east-west. Slightly less prominent vertical sets strike north or a little west of north and about N. 30° W. The joint patterns are readily seen on aerial photographs, particularly in the broad areas of outcrop of the pumiceous agglomerate of Toh3 in the central part of the 410 Area.

PHYSICAL PROPERTIES

The porosity, density, permeability, Shore hardness, unconfined compressive strength, and the cesium exchange capacity were determined on 16 samples of tuffs, tuffaceous agglomerates, and felsites from the 410 Area. All samples were collected from the surface and therefore the values for all properties are considered representative of weathered rock. The data are summarized in table 1.

REFERENCE CITED

Johnson, M. S., and Hibbard, D. E., 1957, Geology of the Atomic Energy Commission Nevada Proving Grounds area, Nevada: U.S. Geol. Survey Bull. 1021-K.

Table 1.--Some physical properties of samples from Oak Spring Formation, 410 Area, Nevada Test Site, Nye County, Nevada

/All analyses by Dave Cunningham except cesium exchange capacity measurements by Edward Villasana/

Sample number	Map unit	Rock type	Porosity (percent)	Grain density (g/cc)	Bulk density (g/cc)	Permeability (millidarcies) 1/	Shore hardness (saturated)	Unconfined compressive strength (saturated) (psi)	Cesium exchange capacity 2/ (meq/100 g)
TH-2A	Toh2	Bedded tuff	36.3	2.43	1.55	11.32	8	----------	74.39±8.52
TH-2D	do	Tuffaceous sandstone	27.9	2.27	1.63	----------	13	----------	50.10± .20
TH-3	Toh3	Pumiceous agglomerate matrix	35.4	2.57	1.66	3.88	13	1,300	10.25± .19
DV-29	do	Pumiceous tuff	17.9	2.27	1.86	<0.01	22	2,500	51.88± .83
DV-11	Toh4	Andesite boulder	11.8	2.62	2.31	7.55	46	6,600	3.59± .18
DV-2	Toh5	Tuffaceous sandstone	32.3	2.38	1.61	.65	11	700	18.78±1.32
TH-5	do	do	37.2	2.06	1.29	122.00	9	1,300	54.28± .46
DV-13	do	do	33.7	2.52	1.67	----------	9	----------	78.51±3.74
WV-6	Toh6	Felsite	5.0	2.58	2.45	<0.01	56	7,600	6.26± .18
WV-7	do	do	1.5	2.57	2.53	<0.01	70	10,200	2.09± .20
WV-9	do	do	10.3	2.67	2.39	<0.01	41	7,600	9.78± .27
DV-26	do	do	12.7	2.30	2.00	<0.01	20	2,500	42.85± .26
TH-6A	Toh7	Tuff	40.4	2.52	1.50	2.92	17	2,500	4.37± .18
TH-6B	do	do	44.2	2.31	1.29	----------	7	----------	8.55± .23
DV-14	do	Lower tuff	47.3	2.66	1.40	81.38	9	200	14.13± .18
DV-3	d0	Incipiently welded tuff	38.7	2.40	1.47	10.67	17	600	2.69± .21

1/ Permeability measurements made by using distilled water at a pressure of 2 atmospheres.

2/ Analysis on disaggregated thoroughly mixed samples.