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UNITED STATES
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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Technical Letter
NTS-15
February 7, 1962

Federal Center, Denver 25, Colorado

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 five copies of:

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TECHNICAL LETTER: NTS-15

SUMMARY OF GEOLOGY FOR TWO POTENTIAL UNDER-
GROUND TEST SITES IN BASALTIC ROCKS
NEVADA TEST SITE

By

F. M. Byers, Jr., and R. M. Hazlewood

February 7, 1962

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Sincerely yours,

V. R. Wilmarth

V. R. Wilmarth
Program Supervisor
Nevada Test Site

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SUMMARY OF GEOLOGY FOR TWO POTENTIAL UNDER-
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F. M. Byers, Jr., and R. M. Hazlewood

INTRODUCTION AND SUMMARY

The geologic map of the Paiute Ridge (Papoose Lake SW) 7-1/2-minute quadrangle shows an area of about 4 square miles on the east side of Yucca Flat that is underlain by basaltic rocks (fig. 1). These rocks are estimated to be as much as 1,000 feet in places and occur as a capping on a small mesa and as lopoliths, igneous masses that in cross section are saucer-shaped. This area was further studied to determine the geologic features of the basaltic rocks in order to evaluate the potential use of this area for underground test sites in media other than tuff, alluvium and granite, particularly in media of high density. The results of this work are set forth in this report.

There are two possible test sites in basaltic rock in the area. Site 1 (AA, fig. 2) is suitable for a shallow test, whereas Site 2 (BB, fig. 2) could be used for a deep confined test in basaltic rock.

SITE 1

Site 1 is within Nevada State coordinates E 709,500 and 710,500 feet and N 854,000 and 856,000 feet (fig. 2). A basalt flow, 50 to

Figure 1.--Index map of Yucca Flat and vicinity, showing location of area (fig. 2) of basaltic rocks, Nevada Test Site, Nye County, Nevada.

Figure 2.--Generalized geologic map of part of the Papoose Lake SW quadrangle, Nevada Test Site, showing two possible basalt sites along lines of sections A-A' and B-B'. Explanation of symbols: Blank areas are Tertiary and older rocks; ba, basalt flow; hachured areas, intrusive basalt and microgabbro; black, augite monzonite; Qac, alluvium and colluvium; f, post-basalt fault, U, up-thrown side, D, downthrown side; dh, drill hole.

Figure 3.--Interpretive geologic cross sections along lines A-A' and B-B' (fig. 2), at two possible basalt sites, Papoose Lake SW quadrangle, Nevada Test Site, Nye County, Nevada. Blank areas, Tertiary and older rocks; hachured areas, intrusive basalt and microgabbro; Qac, alluvium and colluvium; f, post-basalt faults, barbs show direction of movement.

250 feet thick, with cinder beds as much as 50 feet thick in the base of the flow underlies the site. The basal cinder beds dip inward (section AA, figs. 2 and 3) and seemingly occur as a liner on the inner walls of a former crater. The upper surface of the flow is very flat throughout an area of about 1/10 of a square mile and is covered locally with a very thin soil. In cross section (fig. 3) the basaltic mass appears to be saucer shaped, with a central block 400 feet square by 150 feet deep, containing the thickest and most homogenous basalt. Faults are absent except on the east side where a post-basalt fault has downdropped a small segment of the flow rock (fig. 2). A small outlier to the southeast may have once been continuous, prior to erosion, with the fault segment. Drilling would be required to determine further the suitability of the basaltic mass for a test site.

SITE 2

Site 2 is bounded by Nevada State coordinates E 707,000 and E 712,000 feet and N 849,000 and N 853,000 feet. It is underlain by a large microgabbro mass having the general shape of a saucer or lopolith (section BB, figs. 2 and 3). The central part of the lopolith is very thick, possibly as much as 1,000 feet, and is composed chiefly of microgabbro, a basaltic rock composed of small crystals visible to the naked eye, and minor quantities of basalt and augite monzonite. The microgabbro was formed from a liquid basaltic magma that was intruded into the Oak Spring tuffs and because of thermal insulation provided by the overlying tuffs the magma had a much longer cooling history than the extrusive basalt at Site 1. As a result, the margins of the

intrusive mass were chilled to microcrystalline basalt and the central part evolved by chemical differentiation during cooling to discontinuous pods of augite monzonite (see fig. 2), a rock somewhat richer in silica and alkalis and correspondingly lower in iron and magnesium than the basalt (see table 2). Blocks of Oak Spring tuff, a few measuring hundreds of feet in length were engulfed by the magma and some were doubtless occluded within the magma as it crystallized to microgabbro. The result of the magmatic injection, incorporation of tuff fragments, and differentiation of the magma was to impart minor inhomogeneity to the lopolithic mass mainly in form of about 5 percent by volume of augite monzonite in the central part, and as much as 10 percent tuff inclusions, mainly along the margins.

The chemical and physical property measurements on samples of microgabbro, basalt, and augite monzonite given in tables 1, 2, and 3. All samples were collected from surface exposures. The average bulk density of the rocks that make up the lopolith is 2.69 g/cc.

In order to determine the subsurface configuration of the lopolith, a ground magnetic survey was made with a Ruska vertical magnetometer along an east-west and north-south line (fig. 2). Stations were occupied at intervals of 100 feet along these lines. The east-west line extended across the proposed site and was 6,400 feet in length, whereas the north-south line was 2,200 feet in length. The results of the magnetometer surveys indicated variations of as much as 200 gammas between stations 100 feet apart. Although these data could not be used in depth calculation, magnetometer surveys may prove useful in further exploration to define the distribution of magnetic rocks.

A test hole drilled at the intersection of the magnetic survey lines (fig. 2) penetrated altered tuff of the Oak Spring formation to a total depth of 105 feet. The altered tuff in the lower part of the hole is darker red and contains more fragments of microgabbro than the tuff in the upper part of the hole. These data suggest that the microgabbro would probably be penetrated within a few feet of the bottom of the hole.

Table 1:--Physical properties of basalt, microgabbro, and augite monzonite from lopolith intrusive mass at Site 2, Nevada Test Site, Nye County, Nevada

[Analysts: D. R. Cunningham, John Moreland, and E. F. Monk. Analysis made on air dried cores except sample PL-481 which is in air dried chips.]

Lab. No.	Field No.	Rock type	Porosity (percent)	Grain density	Dry bulk density	Magnetic susceptibility (cgs X 10 ⁻⁶)	
PL-480	PL-1052 M	Basalt	7.4	2.84	2.63	1,040.6	
PL-479	PL-0950 B	Microgabbro	2.8	2.75	2.67	159.7	
PL-481	PL-0950 M	do	6.4	2.83	2.65	415.3	
PL-482	PL-0950 G	Augite Monzonite	2.6	2.97*	2.89*	1,635.4	
PL-483	PL-1150 G	do	5.8	2.78	2.62	2,295.6	
Lab. No.	Field No.	Rock type	Young's modulus (lb/in ² X10 ⁶)	Modulus rigidity (lb/in ² X10 ⁶)	Poisson's ratio	Longitudinal velocity (ft/sec)	Transverse velocity (ft/sec)
PL-480A	PL-1052M	Basalt	3.87	1.76	.0994	10,629	7,089
PL-480B(rerun)	PL-1052M		4.43	2.02	.0965	11,307	7,138
PL-479	PL-0950B	Microgabbro	7.26	2.93	.2389	15,594	9,163
PL-481	PL-0950M		5.69	2.61	.0900	12,917	8,670
PL-482	PL-0950G	Augite monzo- nite	5.22	2.36	.1059	11,910	7,907
PL-483A	PL-1150G		3.80	1.64	.1585	11,321	7,212
PL-483B(rerun)	PL-1150G		3.60	1.56	.1538	10,883	6,960

* These density values are somewhat high for monzonite. Essentially the same values were obtained, however, on a second specimen.

Table 2:--Chemical analysis (percent by weight) of basalt, microgabbro, and
augite monzonite from lopolith intrusive mass at site 2, Nevada
Test Site, Nye County, Nevada

Analysts: Leonard Shapiro, Paul Elmore, Ivan Barlow, Samuel Botts, Gillison
Chloe/.

Rock type-----	Basalt	Microgabbro	Augite monzonite
Field no.-----	PL0950 B	PL1052 M	PL0950 G
SiO ₂	46.6	46.4	50.4
Al ₂ O ₃	18.0	17.2	16.2
Fe ₂ O ₃	9.4	9.3	5.4
FeO	1.1	1.2	2.8
MgO	4.8	5.4	2.2
CaO	7.8	8.2	7.3
Na ₂ O	3.2	3.4	4.8
K ₂ O	2.1	1.5	4.1
H ₂ O	3.8	4.1	2.0
TiO ₂	2.4	2.0	2.0
P ₂ O ₅	0.62	0.82	1.9
MnO	0.18	0.17	.16
CO ₂	<u>0.16</u>	<u>0.23</u>	<u>.85</u>
Total (rounded)	100	100	100

Table 3:--Semiquantitative spectrographic analysis of basalt, microgabbro, and augite monzonite from lopolith intrusive mass at site 2, Nevada Test Site, Nye County, Nevada

/Analysis by: R. G. Havens, USGS. Results are reported in percent to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1, etc., which represent approximate midpoints of group data on a geometric scale. The assigned group for semiquantitative results will include the quantitative value about 30 percent of the time.

0 = looked for but not detected

The following elements were looked for but not detected: Ag, As, Au, B, Bi, Cd, Ge, Hf, Hg, In, Li, Mo, Pb, Pd, Pt, Re, Sb, Sn, Ta, Te, Th, Tl, U, W, Zn, Pr, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm and Lu.]

Rock type-----	Basalt	Microgabbro	Augite monzonite
Field No.-----	PL0950B	PL1052 M	PL0950 G
Ba	0.05	0.05	0.1
Be	0	0	0.0003
Ce	0	0	0.02
Co	0.005	0.005	0.003
Cr	0.007	0.007	0.0005
Cu	0.005	0.005	0.005
Ga	0.003	0.003	0.003
La	0.005	0.005	0.01
Nb	0.003	0.003	0.005
Ni	0.007	0.007	0.002
Sc	0.003	0.005	0.005
Sr	0.1	0.1	0.07
V	0.03	0.03	0.02
Y	0.007	0.005	0.01
Yb	0.0007	0.0007	0.001
Zr	0.02	0.02	0.03
Nd	0.007	0.007	0.015