# 15601

Soil

1467.6 grams

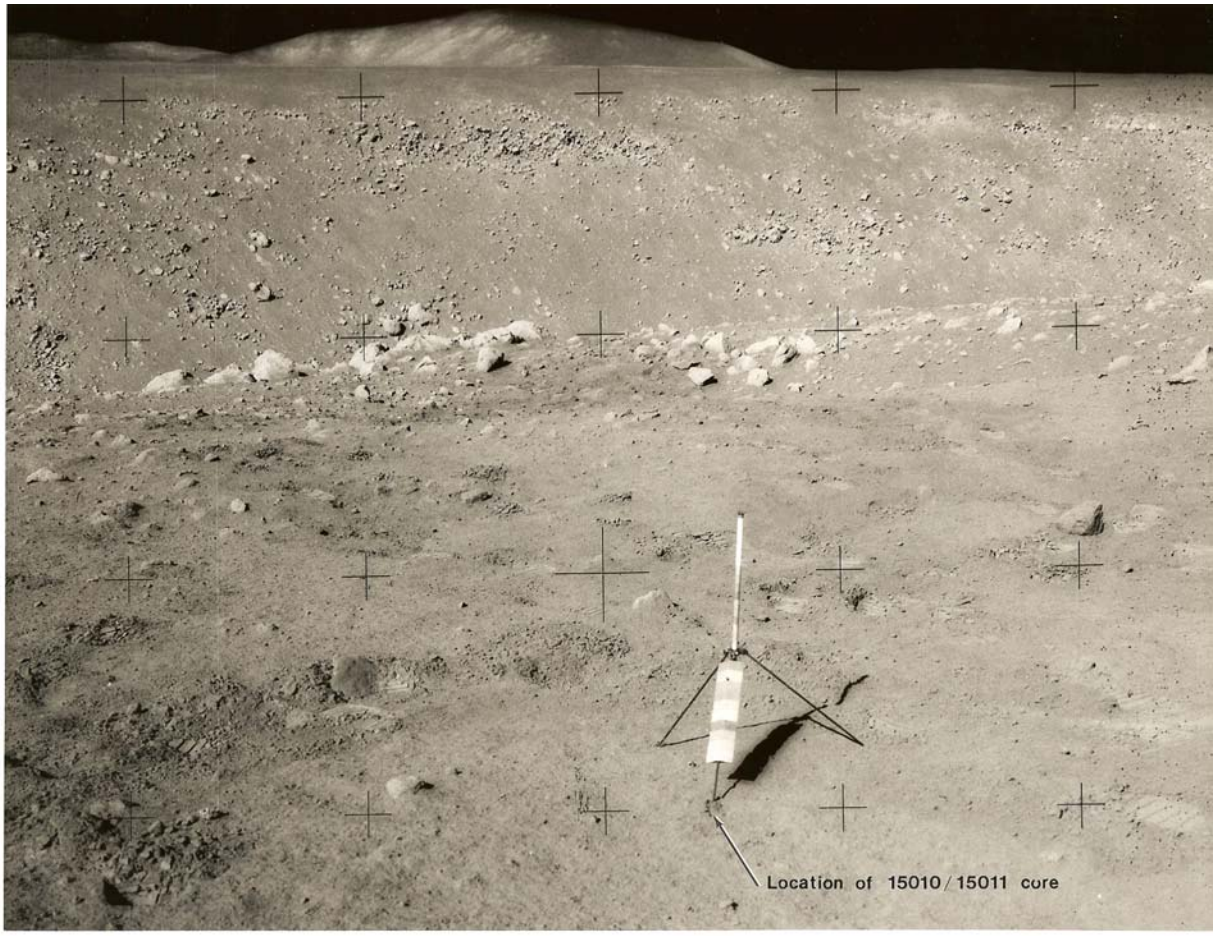



*Figure 1: Telescopic photo of station 9a, on edge of Hadley Rille, looking across the Rille. The soil and rake samples were taken just to the left, about 20 meters back from the edge of the Rille. AS15-82-11159. The feet of the gnomen are 50 cm apart.*

## Introduction

15600 is a large soil sample that was collected about 20 meters from edge of Hadley Rille (station 9a). The soil sample and the adjacent rake sample contained many olivine-normative basalt samples (156xx). Only about 2/3 of the soil sample was sieved, with about 400 grams remaining unsieved. Small rocks are described separately (see sections on 15605, 15614 etc).

15600 is part of a comprehensive suite of samples, including nearby core 15010/11, large rake sample (15612-15689) and several rocks (15545, 15595). 15531 was also collected nearby.

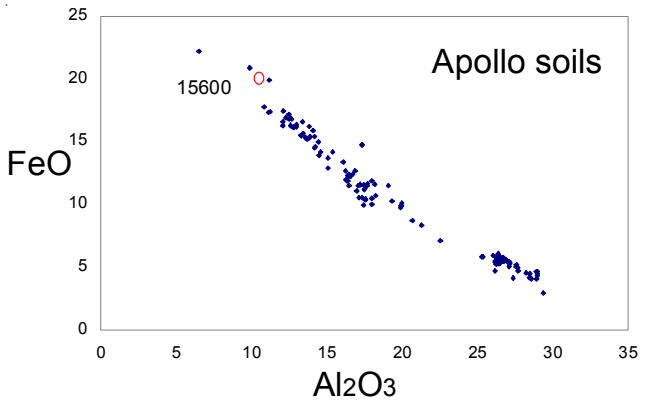



*Figure 2: Chemical composition of Apollo soil samples with 15601.*

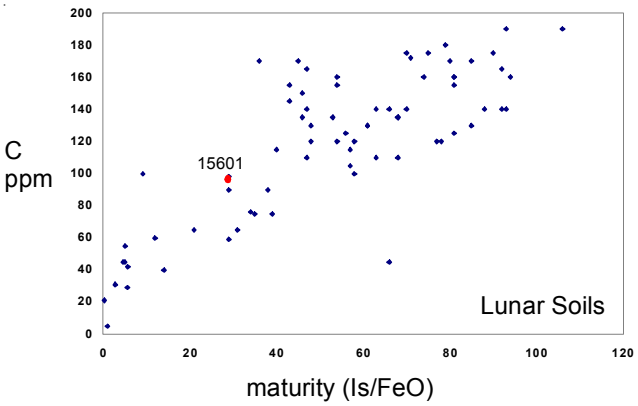



*Figure 3: Carbon content and maturity index for lunar soils with 15600 (Moore et al 1973, Morris 1978).*

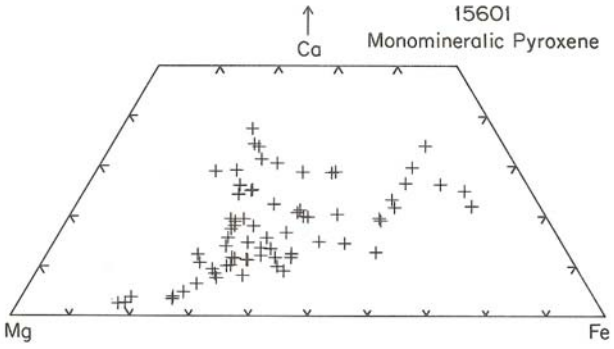



*Figure 4: Composition of pyroxene in 15601 (Basu et al. 1980).*

## Petrography

15601 is an immature soil with $I_s$/FeO = 29 and only 32 % agglutinates (Morris 1978). The average grain size is 89 microns.

Basu et al. (1980) and Griffiths et al. (1981) determined the mineralogic mode showing high content of mare basalt, pyroxene and olivine.

**Modal content of soil 15601**.
*From Basu et al. 1980.*

| | |
|---|---|
| Agglutinates | 32 % |
| Basalt | 15 |
| Breccia | 4.9 |
| Anorthosite | |
| Norite | |
| Gabbro | 0.3 |
| Plagioclase | 7.5 |
| Pyroxene | 27.2 |
| Olivine | 4.3 |
| Ilmenite | 0.7 |
| Glass other | 7.5 |

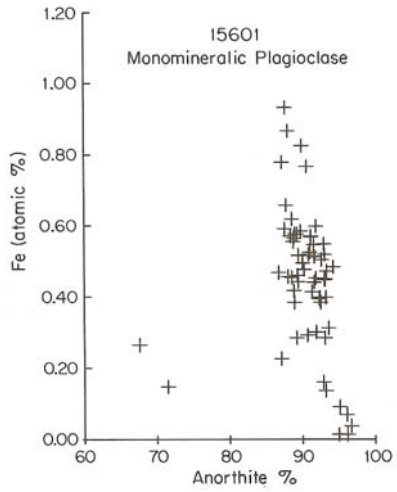
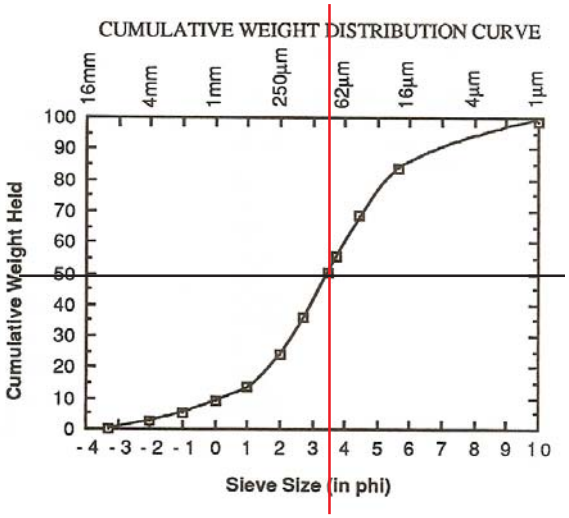



*Figure 5: Fe content of plagioclase in 15601 (Basu etal. 1980).*




**Average grain size = 89 microns**

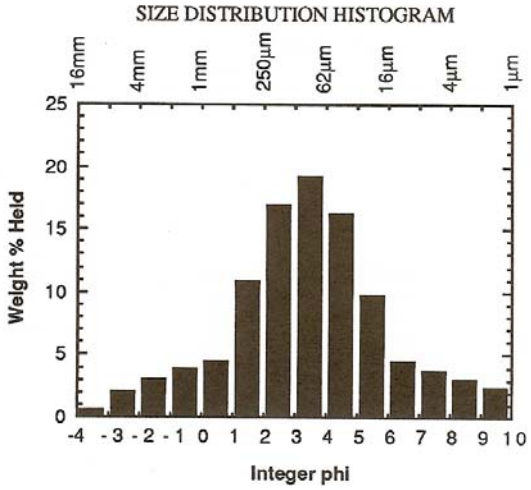



*Figure 6: Grain size distibution of 15600 (from Graf 1993).*

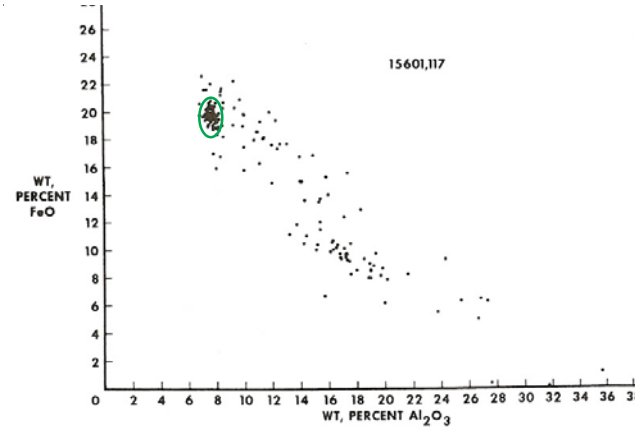



*Figure 7: Composition of individual glass beads from soil sample 15601 (Reid et al. 1972).*

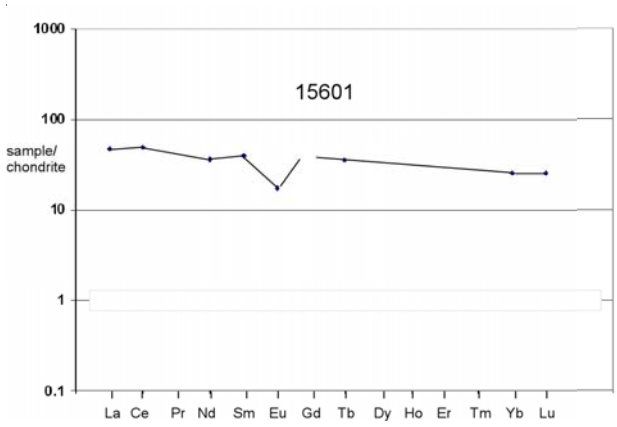



*Figure 8: REE for 15601 (from Korotev 1987).*

15601 was the subject of a European Consortium to study regolith maturation and agglutinate formation (Pillinger et al. 1978, Gardiner et al. 1977, 1978).

Powell et al. (1973), Cameron et al. (1972, 1973), Helmke et al. (1973) and Ryder and Sherman (1989) studied the coarse fines from 15602 – 16504.

Walker and Papike (1981) calculated that 15601 was about 83% mare basalt, 9 % KREEP, 10 % green glass and the rest some sort of anorthosite (but they did not get a good match to known components). Schonfeld (1975) calculated 68% olivine basalt, 6 % KREEP, 17 % brown matrix breccia and 8 % green glass. However, Korotev (1987) lectures on the use of chemical mixing models.

**Glass:** Warner et al. (1972) and Reid et al. (1972) determined the chemical composition of numerous glass particles, finding a significant percentage with the composition of the green glass found at Spur Crater (figure 7).

## Chemistry

This is the most Fe-rich soil returned, because it contained mostly mare basalt fragments (figure 2). The REE pattern is given in figure 8.

The carbon content of 15600 and 15601 is 72 or 95 ppm C (Moore et al. 1973). Kaplan et al. (1976), Petrowski et al. (1976), Gardiner et al. (1977, 1978) and Muller (1973) also determined carbon and nitrogen.

Woodcock and Pillinger (1978) determined the composition of agglutinates as a function of grain size , finding an added highland component.

**Summary of Age Data for 15603**

| | Ar/Ar |
|---|---|
| Husain 1974 | 3.24 ± 0.12 b.y. |
| | 3.35 ± 0.05 |
| | 3.31 ± 0.03 |
| | 3.17 ± 0.07 |
| | 3.26 ± 0.05 |
| | 3.26 ± 0.08 |

## Radiogenic age dating

Husain (1974) obtained the age of six basalt fragments from the coarse fines.

## Cosmogenic isotopes and exposure ages

Husain (1974) determined the $^{38}Ar$ exposure age of 8 fragments from 15603, ranging from ~50 to 440 m.y.

Eldridge et al. (1972) and O'Kelley et al. (1972) determined the cosmic-ray-induced activity of $^{22}Na$ = 55 dpm/kg, $^{26}Al$ = 112 dpm/kg, $^{54}Mn$ = 32 dpm/kg and $^{56}Co$ = 28 dpm/kg.

## Other Studies

Haggerty (1972) found a particle of enstatite chondrite in 15602.

Bogard et al. (1972), Jordan et al. (1974), Heymann et al. (1972), Schultz et al. (1978, 1979) and others have determined the concentration and isotopic ratio of the rare gasses in 15601, with special attention to the agglutinates.

## Processing

15600 was returned in a sample collection bag (#7) placed in ALSRC#2 (which did not seal).

## Table 1. Chemical composition of 15601.

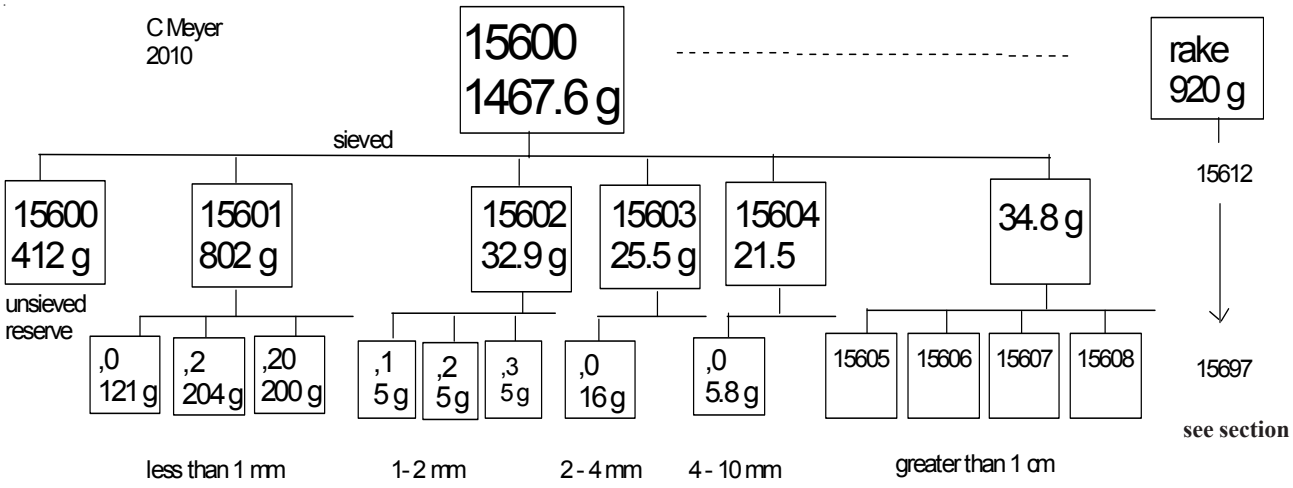
| *reference* | LSPET72 | | Korotev87 | | Wanke72 | | Wanke73 | | Brunfelt72b | | O'Kelley72 | | Janghorbani73 Helmke72 | | Juan72 | Chou74 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *weight* | | | | | | | | | | | | | | | | | |
| SiO2 % | 45.05 | (d) | | | 46.6 | (b) | 46.64 | (b) | | | | | 48.35 | | 46.23 | | |
| TiO2 | 1.98 | (d) | 1.5 | (a) | 1.57 | (b) | 1.5 | (b) | 2 | (b) | | | 2.33 | | 2.16 | | |
| Al2O3 | 10.2 | (d) | 10.7 | (a) | 10.77 | (b) | 10.71 | (b) | 11 | (b) | | | 10.8 | | 10.86 | | |
| FeO | 19.79 | (d) | 19.9 | (a) | 19.3 | (b) | 19.68 | (b) | 18.8 | (b) | | | 19.2 | | 19 | | |
| MnO | 0.26 | (d) | | | 0.24 | (b) | 0.243 | (b) | 0.25 | (b) | | | 0.23 | | 0.246 | | |
| MgO | 10.89 | (d) | 11.2 | (a) | 11.27 | (b) | 11.22 | (b) | 11.4 | (b) | | | 11.1 | | 10.56 | | |
| CaO | 9.87 | (d) | 8.6 | (a) | 9.37 | (b) | 9.37 | (b) | 9.5 | (b) | | | 7.6 | | 10.08 | | |
| Na2O | 0.29 | (d) | 0.3 | (a) | 0.3 | (b) | 0.33 | (b) | 0.32 | (b) | | | 0.34 | | 0.315 | | |
| K2O | 0.1 | (d) | | | 0.1 | (b) | 0.105 | (b) | 0.2 | (b) | 0.108 | (c ) | | | 0.091 | | |
| P2O5 | 0.11 | (d) | | | | | | | | | | | | | | | |
| S % | 0.06 | (d) | | | | | | | | | | | | | | | |
| *sum* | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| Sc ppm | | | 39.7 | (a) | 36.3 | (b) | 36.3 | (b) | 35.1 | (b) | | | 37.1 | (b) | | | |
| V | | | | | | | | | 200 | (b) | | | | | | | |
| Cr | 3831 | (d) | 3680 | (a) | 3540 | (b) | 3540 | (b) | 3510 | (b) | | | *5500* | (b) | | | |
| Co | | | 53.2 | (a) | 51 | (b) | 51 | (b) | 48.9 | (b) | | | 49.3 | (b) | 74 | | |
| Ni | | | 142 | (a) | 90 | (b) | 132 | (b) | 170 | (b) | | | | | 189 | 157 | (b) |
| Cu | | | | | 8.2 | (b) | | | 6.4 | (b) | | | | | 10 | | |
| Zn | | | | | 1.33 | (b) | | | 9.8 | (b) | | | 16 | (b) | 27 | 19.5 | (b) |
| Ga | | | | | 3.4 | (b) | | | 3.1 | (b) | | | 4.9 | (b) | | 3.4 | (b) |
| Ge ppb | | | | | 200 | (b) | | | | | | | | | | 184 | (b) |
| As | | | | | 15.3 | (b) | | | | | | | | | | | |
| Se | | | | | | | | | | | | | | | | | |
| Rb | 3.1 | (d) | | | | | | | 5.3 | (b) | | | | | 2.4 | | |
| Sr | 109 | (d) | 90 | (a) | 104 | (b) | | | 120 | (b) | | | | | 223 | | |
| Y | 47 | (d) | | | | | | | | | | | | | | | |
| Zr | 199 | (d) | 250 | (a) | | | | | | | | | | | | | |
| Nb | 13 | (d) | | | | | | | | | | | | | | | |
| Mo | | | | | | | | | | | | | | | | | |
| Ru | | | | | | | | | | | | | | | | | |
| Rh | | | | | | | | | | | | | | | | | |
| Pd ppb | | | | | | | | | | | | | | | | | |
| Ag ppb | | | | | | | | | | | | | | | 50 | | |
| Cd ppb | | | | | | | | | | | | | | | | 102 | (b) |
| In ppb | | | | | | | | | | | | | | | | 3.4 | (b) |
| Sn ppb | | | | | | | | | | | | | | | | | |
| Sb ppb | | | | | | | | | | | | | | | | | |
| Te ppb | | | | | | | | | | | | | | | | | |
| Cs ppm | | | 0.13 | (a) | 0.27 | (b) | | | 0.3 | (b) | | | | | | | |
| Ba | | | 105 | (a) | 120 | (b) | | | 135 | (b) | | | | | | | |
| La | | | 10.8 | (a) | 12.9 | (b) | 13.1 | (b) | 11.3 | (b) | | | 12.5 | (b) | | | |
| Ce | | | 29 | (a) | 35 | (b) | | | 29 | (b) | | | 30.7 | (b) | | | |
| Pr | | | | | 4.6 | (b) | | | 3 | (b) | | | | | | | |
| Nd | | | 16 | (a) | | | | | | | | | 24 | (b) | | | |
| Sm | | | 5.74 | (a) | 4.6 | (b) | 6.4 | (b) | 6.32 | (b) | | | 6.62 | (b) | | | |
| Eu | | | 0.953 | (a) | 1.03 | (b) | 1.03 | (b) | 1 | (b) | | | 0.96 | (b) | | | |
| Gd | | | | | 9.4 | (b) | | | | | | | 8.2 | (b) | | | |
| Tb | | | 1.27 | (a) | 1.6 | (b) | 1.6 | (b) | 1.3 | (b) | | | 1.39 | (b) | | | |
| Dy | | | | | 8.6 | (b) | 9.1 | (b) | 9.7 | (b) | | | 9 | (b) | | | |
| Ho | | | | | 1.4 | (b) | 1.6 | (b) | 1.8 | (b) | | | 1.8 | (b) | | | |
| Er | | | | | 6.1 | (b) | | | 5.7 | (b) | | | 4.9 | (b) | | | |
| Tm | | | | | | | | | | | | | | | | | |
| Yb | | | 4.11 | (a) | 5.05 | (b) | 4.71 | (b) | 5.2 | (b) | | | 4.5 | (b) | | | |
| Lu | | | 0.614 | (a) | 0.72 | (b) | 0.77 | (b) | 0.9 | (b) | | | 0.66 | (b) | | | |
| Hf | | | 4.6 | (a) | 5.5 | (b) | 4.4 | (b) | 4.86 | (b) | | | *10.6* | (b) | | | |
| Ta | | | 0.63 | (a) | 0.68 | (b) | 0.46 | (b) | 0.6 | (b) | | | | | | | |
| W ppb | | | | | | | | | 66 | (b) | | | | | | | |
| Re ppb | | | | | | | | | | | | | | | | | |
| Os ppb | | | | | | | | | | | | | | | | | |
| Ir ppb | | | | | | | | | | | | | | | | 3 | (b) |
| Pt ppb | | | | | | | | | | | | | | | | | |
| Au ppb | | | | | | | | | | | | | | | | 1.2 | (b) |
| Th ppm | | | 1.31 | (a) | | | | | 1.72 | (b) | 1.8 | (c ) | | | | | |
| U ppm | | | 0.43 | (a) | | | | | 0.46 | (b) | 0.51 | (c ) | | | | | |

*technique: (a) INAA, (b) INAA + RNAA, (c ) radiation counting, (d) XRF*

Table 2: Walnuts and rake samples station 9a.

| | weight | Ryder | ref |
|---|---|---|---|
| 15605 | 6.1 | coarse-grained olivine-normative mare basalt | |
| 15606 | 10.1 | coarse-grained olivine-normative mare basalt | |
| 15607 | 14.8 | coarse-grained olivine-normative mare basalt | |
| 15608 | 1.2 | porphritic spherulitic q-normative mare basalt | |
| 15609 | 1.1 | fine-grained olivine-normative mare basalt | |
| 15610 | 1.5 | coarse-grained olivine-normative mare basalt | |
| 15612 | 5.9 | medium-grained olivine-normative basalt | |
| 15613 | 1 | medium-grained olivine-normative basalt | Dowty 73 |
| 15614 | 9.7 | coarse-grained olivine-normative mare basalt | |
| 15615 | 1.7 | medium-grained olivine-normative basalt | Dowty 73 |
| 15616 | 8 | medium-grained olivine-normative basalt | |
| 15617 | 3.1 | medium-grained olivine-normative basalt | Dowty 73 |
| 15618 | 0.8 | medium-grained olivine-normative basalt | |
| 15619 | 0.6 | medium-grained olivine-normative basalt | |
| 15620 | 6.6 | medium-grained olivine-normative basalt | Dowty 73 |
| 15621 | 1.6 | medium-grained olivine-normative basalt | |
| 15622 | 29.5 | medium-grained olivine-normative basalt | Chappell |
| 15623 | 3 | medium-grained olivine-normative basalt | Dowty 73 |
| 15624 | 0.2 | medium-grained olivine-normative basalt | |
| 15625 | 0.5 | medium-grained olivine-normative basalt | |
| 15626 | 0.6 | medium-grained olivine-normative basalt | |
| 15627 | 0.4 | medium-grained olivine-normative basalt | |
| 15628 | 0.4 | medium-grained olivine-normative basalt | |
| 15629 | 0.4 | medium-grained olivine-normative basalt | |
| 15630 | 23.2 | medium-grained olivine-normative basalt | |
| 15632 | 2.3 | medium-grained olivine-normative basalt | |
| 15633 | 7.4 | coarse-grained olivine-normative mare basalt | Dowty 73 |
| 15634 | 5.2 | coarse-grained olivine-normative mare basalt | |
| 15635 | 0.5 | medium-grained olivine-normative basalt | |
| 15636 | 336.7 | coarse-grained olivine-normative mare basalt | Chappell |
| 15637 | 0.9 | medium-grained olivine-normative basalt | |
| 15638 | 3.6 | medium-grained olivine-normative basalt | |
| 15639 | 7 | medium-grained olivine-normative basalt | |
| 15640 | 0.5 | medium-grained olivine-normative basalt | |
| 15641 | 6.9 | medium-grained olivine-normative basalt | Dowty 73 |
| 15642 | 1.9 | medium-grained olivine-normative basalt | |
| 15643 | 17.9 | medium-grained olivine-normative basalt | Dowty 73 |
| 15644 | 0.4 | medium-grained olivine-normative basalt | |
| 15645 | 0.5 | medium-grained olivine-normative basalt | |
| 15647 | 58.2 | medium-grained olivine-normative basalt | Dowty 73 |
| 15648 | 9.1 | brecciated olivine-normative basalt | |
| 15649 | 6.2 | fine-grained olivine-normative mare basalt | Steele 72 |
| 15650 | 3.4 | fine-grained olivine-normative mare basalt | |
| 15651 | 1.6 | fine-grained olivine-normative mare basalt | Dowty 73 |
| 15652 | 0.7 | fine-grained olivine-normative mare basalt | |
| 15653 | 0.4 | fine-grained olivine-normative mare basalt | |
| 15654 | 0.2 | fine-grained olivine-normative mare basalt | |
| 15655 | 0.4 | fine-grained olivine-normative mare basalt | |
| 15656 | 0.2 | fine-grained olivine-normative mare basalt | |
| 15658 | 11.6 | medium-grained olivine-normative basalt | Chappell |
| 15659 | 12.6 | medium-grained olivine-normative basalt | Steele 72 |
| 15660 | 8.9 | medium-grained olivine-normative basalt | |
| 15661 | 5.9 | medium-grained olivine-normative basalt | Steele 72 |
| 15662 | 4.9 | medium-grained olivine-normative basalt | |
| 15663 | 10.3 | medium-grained olivine-normative basalt | Dowty 73 |
| 15664 | 7.4 | medium-grained olivine-normative basalt | |
| 15665 | 10.2 | fine-grained olivine-normative mare basalt | Dowty 73 |
| 15666 | 3.9 | porphritic variolitic pigeonite basalt | Dowty 73 |
| 15667 | 1.1 | porphritic variolitic pigeonite basalt | Steele 72 |
| 15668 | 15.1 | fine-grained olivine-normative mare basalt | |

| | | | |
|---|---|---|---|
| 15669 | 4.4 | fine-grained olivine-normative mare basalt | Dowty 73 |
| 15670 | 2 | medium-grained olivine-normative basalt | |
| 15671 | 6.1 | medium-grained olivine-normative basalt | |
| 15672 | 21.4 | medium-grained olivine-normative basalt | Dowty 73 |
| 15673 | 5.9 | medium-grained olivine-normative basalt | |
| 15674 | 35.7 | fine-grained olivine-normative mare basalt | Chappell |
| 15675 | 34.5 | fine-grained olivine-normative mare basalt | |
| 15676 | 25.3 | fine-grained olivine-normative mare basalt | Dowty 73 |
| 15677 | 6.4 | fine-grained olivine-normative mare basalt | |
| 15678 | 7.5 | fine-grained olivine-normative mare basalt | Dowty 73 |
| 15679 | 0.7 | fine-grained olivine-normative mare basalt | |
| 15680 | 0.3 | fine-grained olivine-normative mare basalt | |
| 15681 | 0.3 | fine-grained olivine-normative mare basalt | |
| 15682 | 50.6 | porphritic variolitic pigeonite basalt | Dowty 73 |
| 15683 | 22 | fine-grained olivine-normative mare basalt | Steele 72 |
| 15684 | 1.4 | glass containing mare basalt | Dowty 73 |
| 15685 | 0.8 | soil breccia | |
| 15686 | 0.9 | soil breccia | |
| 15687 | 1.4 | agglutinatic glass | |
| 15688 | 5.3 | agglutinatic glass | |
| 15689 | 2.8 | soil breccia | |
| 15695 | 10.7 | medium-grained olivine-normative basalt | |
| 15696 | 12.8 | medium-grained olivine-normative basalt | |
| 15697 | 4.13 | fine-grained olivine-normative mare basalt | |
| 15698 | 3.93 | glass bomb | |



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