# **72441** - 450 grams
# **72461** - 125 grams
# Soil (under boulder)

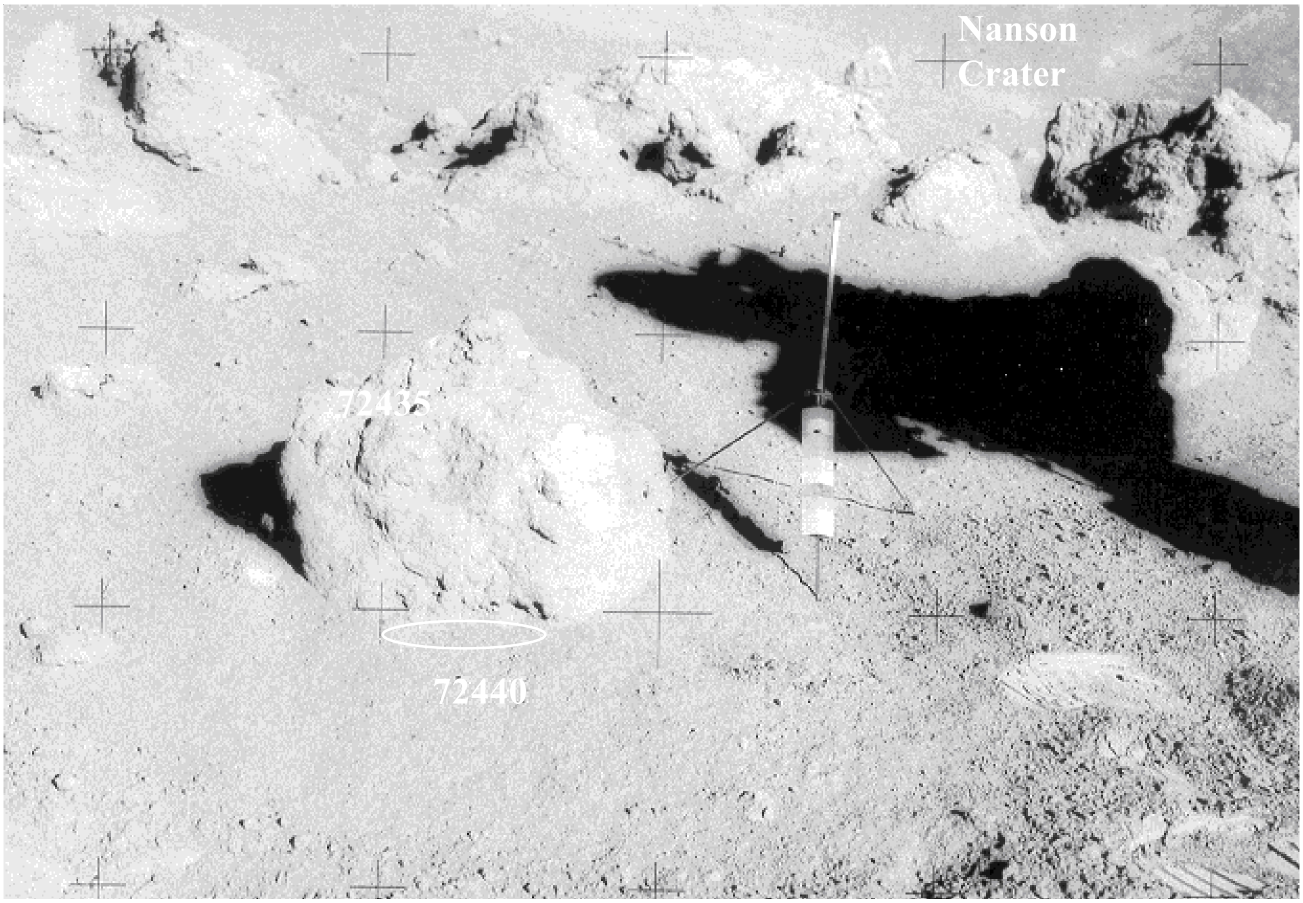


*Figure 1: Apollo 17 station 2, boulder #3 (72435 with clast 72415). Soils 72440 and 72460 were collected from underneath after rolling it over. AS17-138-21047. Legs on funny object are 0.5 meters apart (for scale).*

## Introduction

Lunar soils 72440 and 72460 were collected from under a small boulder (72435) were they had been shielded from recent cosmic radiation and meteoroid bombardment (Wolfe et al. 1981).

## Petrography

The maturity of 72441 and 72461 is $I_s$/FeO = 68 and 71, respectively, and the average grain size is 63 and 62 microns (Morris 1978, Graf 1993). The agglutinate count is 42 and 43 %.

Meyer (1973) cataloged the 4 – 10 mm coarse-fines from 72444 and 72462 and Jolliff et al. (1996) studied numerous 2 – 4 mm coarse-fine particles from 72443.

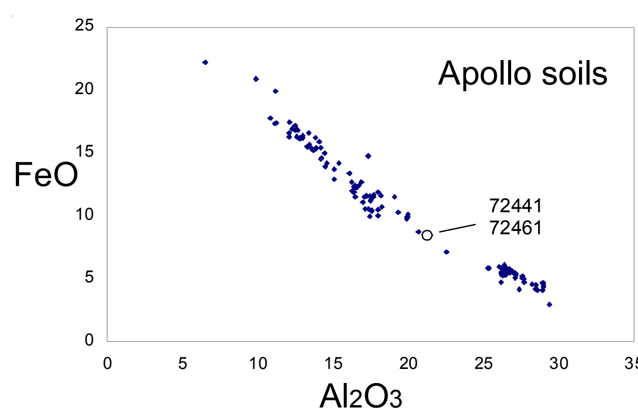


*Figure 2: Composition of lunar soils showing 72441 and 72461.*

**Modal content of soils 72441 and 72461.**
*From Heiken and McKay 1974*

| | 72441 | 72461 |
|---|---|---|
| Agglutinates | 41.7% | 43 |
| Basalt | 2.6 | 3 |
| Breccia | 34.9 | 29.3 |
| Anorthosite | 2.3 | 3.3 |
| Norite | 0.7 | 0.3 |
| Gabbro | | |
| Plagioclase | 6.7 | 11 |
| Pyroxene | 6.3 | 6 |
| Olivine | 0.7 | 0.3 |
| Ilmenite | 0.3 | 0.6 |
| Glass other | 3.2 | 4 |

The majority of these fragments are feldspathic melt breccias.

## Chemistry

The $Al_2O_3$ content of these soils is high - about 22 % (figure 2). The rare-earth-element content is high and characteristic of KREEP (from PKT?). The meteoritic siderophiles (Ni, Ir and Au) are also high, consistent with a mature soil.

Krahenbuhl et al. (1977) studied the distribution of volatile elements (Cd, Ge, Hg, In, Sb and Zn) as function of grain size for 72461, but found the same results as for 72501 (figure 8).

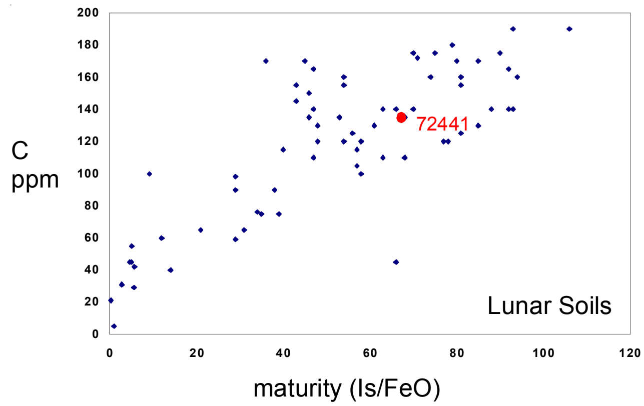


*Figure 3: Soil 72441 has a high maturity index and is "saturated" in carbon from the solar wind.*

Moore et al. (1974) determined 135 ppm carbon (figure 3).

## Cosmogenic isotopes and exposure ages

Keith et al. (1974) determined the cosmic-ray-induced activity of $^{22}Na$ = 47 dpm/kg, $^{26}Al$ = 65 dpm/kg, $^{46}Sc$ = 6 dpm/kg, $^{54}Mn$ = 38 dpm/kg and $^{56}Co$ = <300 dpm/kg.

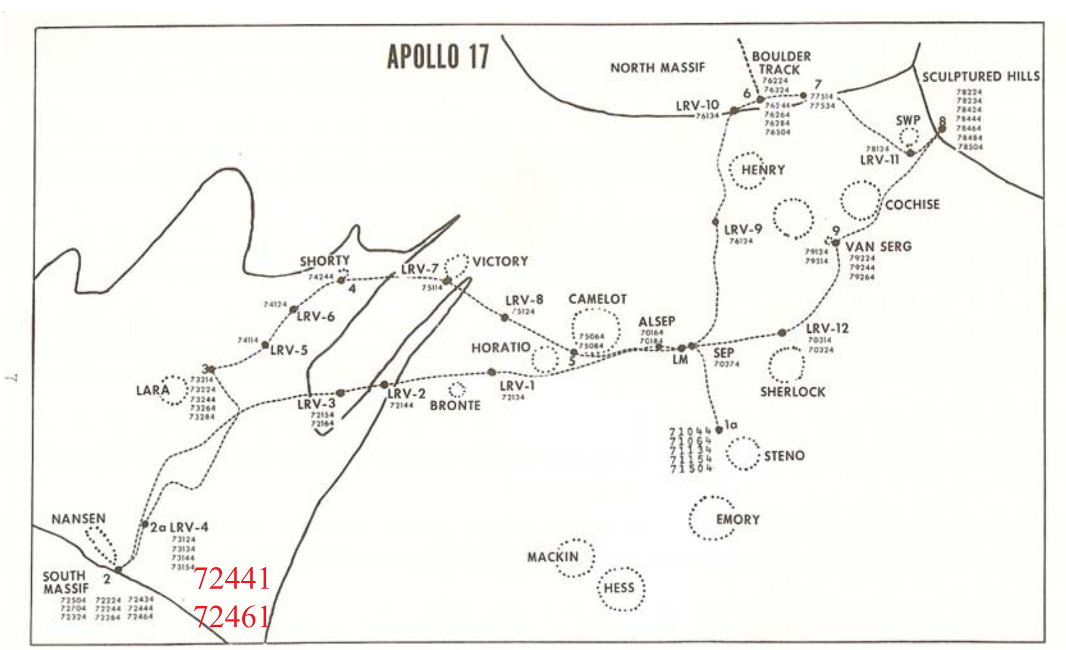


*Figure 4: Location of 72441 and 72461 at station 2, Apollo 17 (Meyer 1973). S73-24071.*

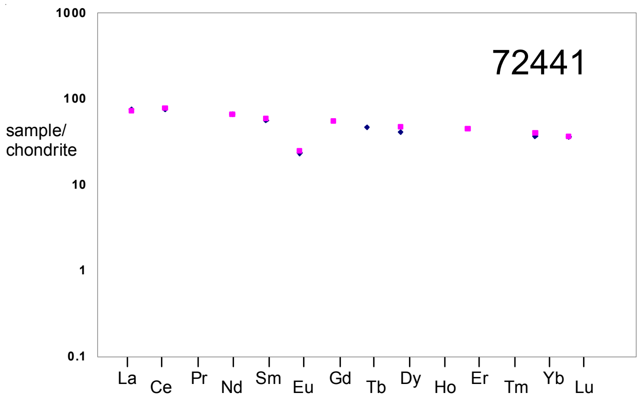


*Figure 5: Normalized rare-earth-element diagram for soil 72441 showing that data obtained by isotope dilution mass-spectrometry is in close agreement with that obtained by instrumental neutron activation analysis (Masuda et al. 1974, Laul and Schmitt 1974).*

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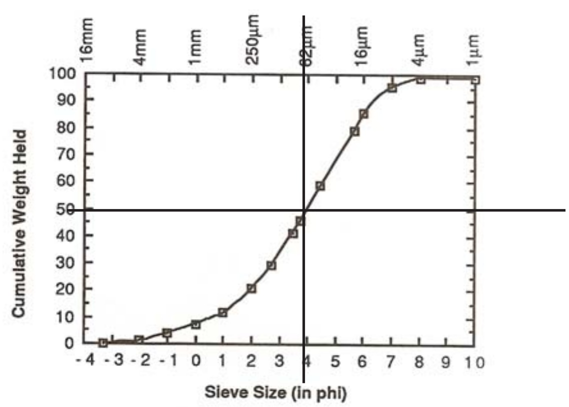



average grain size = 63 microns

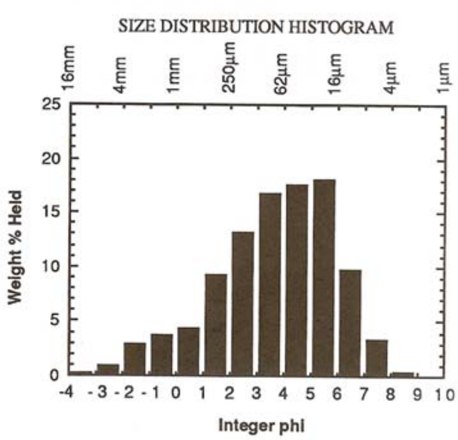
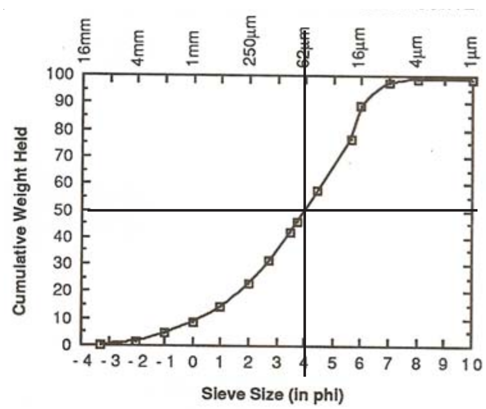



*Figure 6: Grain size distribution for 72440 (Graf 1993, data from McKay).*




average grain size = 62 microns

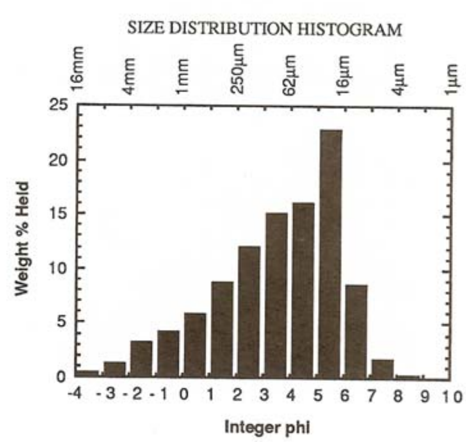



*Figure 7: Grain size distribution for 72460 (Graf 1993, data from McKay).*

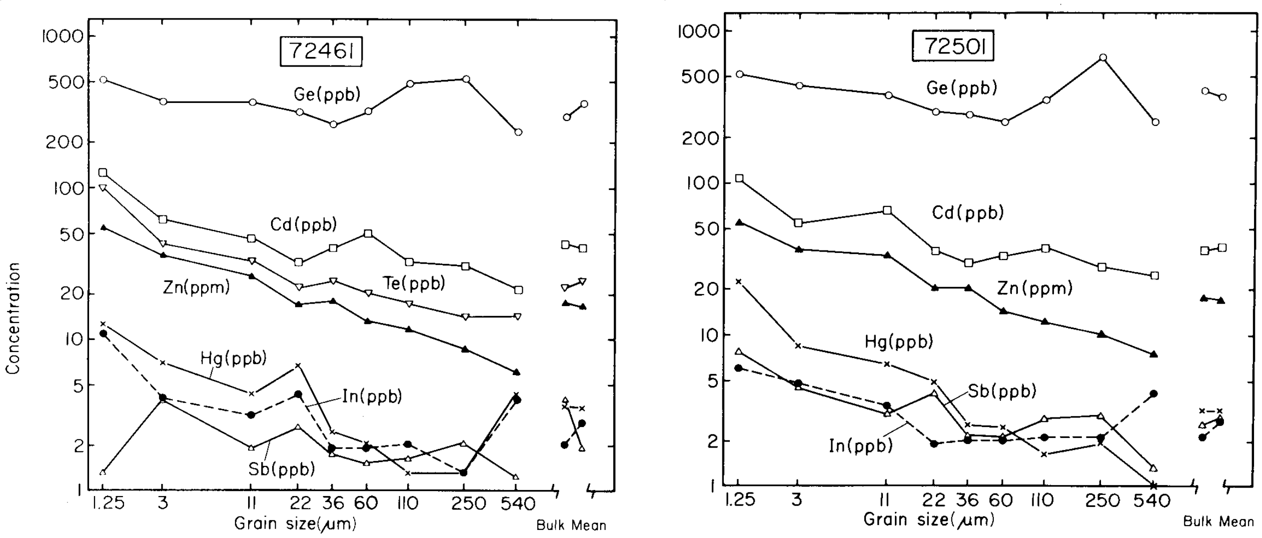
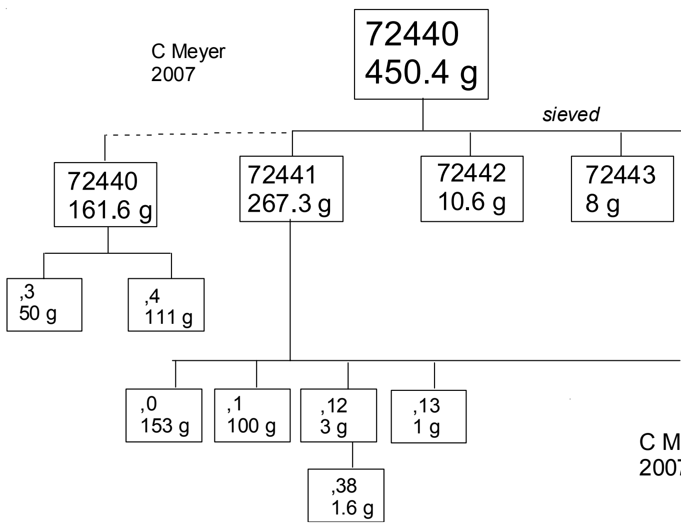
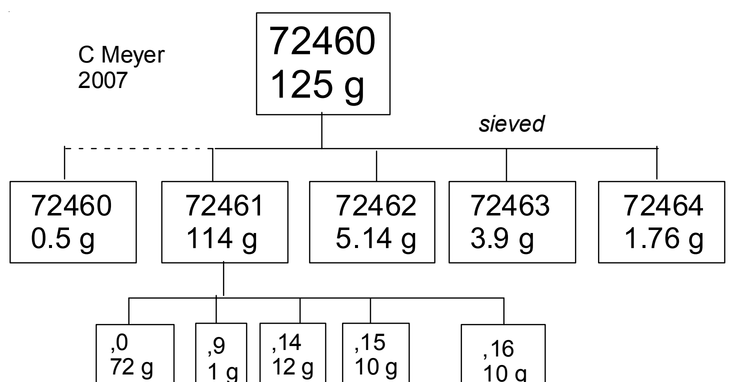



*Figure 8: Composition of grain-size separates of 72461 compared with those of reference soil 72501 (Krahenbuhl et al. 1977).*





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## Table 1. Chemical composition of 72441.

| *reference* | Mason74 | | Rhodes74 | | Rose74 | | Keith74 | | Masuda74 | | Laul74 | | Baedecker77 | | Jolliff96 | | Pearce77 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *weight* | | | | | | | | | | | | | | | | | | |
| SiO2 % | 44.84 | (g) | 45.03 | (b) | 45.17 | (c ) | | | | | | | | | | | | |
| TiO2 | 1.42 | (g) | 1.53 | (b) | 1.53 | (c ) | | | | | 1.5 | (e) | | | | | 1.51 | (e) |
| Al2O3 | 21.06 | (g) | 20.51 | (b) | 20.25 | (c ) | | | | | 21.1 | (e) | | | | | | |
| FeO | 8.54 | (g) | 8.85 | (b) | 8.68 | (c ) | | | | | 8.8 | (e) | 10 | (a) | 8.99 | (e) | 8.62 | (e) |
| MnO | 0.18 | (g) | 0.13 | (b) | 0.11 | (c ) | | | | | 0.111 | (e) | 0.135 | (a) | | | 0.116 | (e) |
| MgO | 9.99 | (g) | 9.89 | (b) | 10.78 | (c ) | | | | | 10 | (e) | | | | | | |
| CaO | 12.59 | (g) | 12.83 | (b) | 12.75 | (c ) | | | | | 11.6 | (e) | | | 13 | (e) | 12.7 | (e) |
| Na2O | 0.34 | (g) | 0.46 | (b) | 0.4 | (c ) | | | | | 0.49 | (e) | 0.54 | (a) | 0.47 | (e) | 0.48 | (e) |
| K2O | 0.27 | (g) | 0.17 | (b) | 0.16 | (c ) | 0.17 | (d) | | | 0.15 | (e) | | | | | 0.16 | (e) |
| P2O5 | 0.2 | (g) | 0.17 | (b) | 0.15 | (c ) | | | | | | | | | | | | |
| S % | | | 0.07 | (b) | | | | | | | | | | | | | | |
| *sum* | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| Sc ppm | | | | | 21 | (c ) | | | | | 18 | (e) | 22 | (a) | 19.6 | (e) | 19 | (e) |
| V | 35 | (f) | | | 28 | (c ) | | | | | 50 | (e) | | | | | 43 | (e) |
| Cr | 1650 | (f) | 1505 | (b) | 1916 | (c ) | | | | | 1519 | (e) | 1640 | (a) | 1568 | (e) | 1600 | (e) |
| Co | 42 | (f) | | | 36 | (c ) | | | | | 30 | (e) | 37 | (a) | 30.5 | (e) | 32 | (e) |
| Ni | 235 | (f) | 225 | (b) | 265 | (c ) | | | | | 270 | (e) | 283 | (h) | 267 | (e) | 281 | (e) |
| Cu | 8 | (f) | | | 14 | (c ) | | | | | | | | | | | | |
| Zn | 19 | (f) | 21 | (b) | 19 | (c ) | | | | | | | 19 | (h) | 31 | (e) | | |
| Ga | 6 | (f) | | | 3 | (c ) | | | | | | | 4.72 | (h) | | | | |
| Ge ppb | | | | | | | | | | | | | 493 | (h) | | | | |
| As | | | | | | | | | | | | | | | | | | |
| Se | | | | | | | | | | | | | | | | | | |
| Rb | | | 4.3 | (b) | 2.4 | (c ) | | | | | | | | | 4 | (e) | | |
| Sr | 190 | (f) | 155 | (b) | 155 | (c ) | | | | | | | | | 150 | (e) | | |
| Y | | | 64 | (b) | 64 | (c ) | | | | | | | | | | | | |
| Zr | 230 | (f) | 278 | (b) | 279 | (c ) | | | | | 200 | (e) | 256 | (a) | 248 | (e) | 210 | (e) |
| Nb | | | 19 | (b) | 12 | (c ) | | | | | | | | | | | | |
| Mo | | | | | | | | | | | | | | | | | | |
| Ru | | | | | | | | | | | | | | | | | | |
| Rh | | | | | | | | | | | | | | | | | | |
| Pd ppb | | | | | | | | | | | | | | | | | | |
| Ag ppb | | | | | | | | | | | | | | | | | | |
| Cd ppb | | | | | | | | | | | | | 39 | (h) | | | | |
| In ppb | | | | | | | | | | | | | 3.6 | (h) | | | | |
| Sn ppb | | | | | | | | | | | | | | | | | | |
| Sb ppb | | | | | | | | | | | | | | | | | | |
| Te ppb | | | | | | | | | | | | | | | | | | |
| Cs ppm | | | | | | | | | | | | | | | 0.18 | (e) | | |
| Ba | 155 | (f) | | | 240 | (c ) | | | 214 | (a) | 190 | (e) | | | 209 | (e) | 200 | (e) |
| La | | | | | 21 | (c ) | | | 17 | (a) | 17.8 | (e) | | | 18.5 | (e) | 17.3 | (e) |
| Ce | | | | | | | | | 47.2 | (a) | 46 | (e) | 47 | (a) | 48.2 | (e) | 46.8 | (e) |
| Pr | | | | | | | | | | | | | | | | | | |
| Nd | | | | | | | | | 29.9 | (a) | 30 | (e) | | | 28.4 | (e) | 28.1 | (e) |
| Sm | | | | | | | | | 8.73 | (a) | 8.3 | (e) | | | 8.89 | (e) | 8.3 | (e) |
| Eu | | | | | | | | | 1.4 | (a) | 1.31 | (e) | 1.6 | (a) | 1.36 | (e) | 1.36 | (e) |
| Gd | | | | | | | | | 10.9 | (a) | | | | | | | | |
| Tb | | | | | | | | | | | 1.7 | (e) | 1.8 | (a) | 1.85 | (e) | 1.74 | (e) |
| Dy | | | | | | | | | 11.6 | (a) | 10 | (e) | | | | | 10.4 | (e) |
| Ho | | | | | | | | | | | | | | | | | | |
| Er | | | | | | | | | 7.13 | (a) | | | | | | | | |
| Tm | | | | | | | | | | | | | | | | | | |
| Yb | | | | | 6 | (c ) | | | 6.5 | (a) | 6 | (e) | 5.5 | (a) | 6.52 | (e) | 5.9 | (e) |
| Lu | | | | | | | | | 0.886 | (a) | 0.86 | (e) | | | 0.91 | (e) | 0.87 | (e) |
| Hf | | | | | | | | | | | 6.1 | (e) | 7.5 | (a) | 7 | (e) | 6.4 | (e) |
| Ta | | | | | | | | | | | 0.86 | (e) | 0.92 | (a) | 0.9 | (e) | 0.97 | (e) |
| W ppb | | | | | | | | | | | | | | | | | | |
| Re ppb | | | | | | | | | | | | | | | | | | |
| Os ppb | | | | | | | | | | | | | | | | | | |
| Ir ppb | | | | | | | | | | | 9 | (e) | 7.8 | (h) | 8.6 | (e) | | |
| Pt ppb | | | | | | | | | | | | | | | | | | |
| Au ppb | | | | | | | | | | | 4 | (e) | 3.8 | (h) | 5.5 | (e) | | |
| Th ppm | | | | | | | 3.5 | (d) | | | 2.8 | (e) | 3.7 | (a) | 3 | (e) | 3 | (e) |
| U ppm | | | | | | | 0.83 | (d) | | | 1 | (e) | | | 0.82 | (e) | 0.79 | (e) |

*technique: (a) IDMS, (b) XRF, (c ) "microchemical", (d) radiation counting, (e) INAA, (f) emiss. spec. (g) fused-bead, (h) RNAA*

## Table 2. Chemical composition of 72461.

| *reference* | Rose74 | | Rhodes74 | | Laul74 | | Krahenbuhl77 | | Baedecker77 | |
|---|---|---|---|---|---|---|---|---|---|---|
| *weight* | | | | | | | | | | |
| SiO2 % | 44.79 | (a) | 44.98 | (b) | | | | | | |
| TiO2 | 1.56 | (a) | 1.5 | (b) | 1.4 | (c ) | | | | |
| Al2O3 | 20.63 | (a) | 20.87 | (b) | 21.8 | (c ) | | | | |
| FeO | 8.61 | (a) | 8.85 | (b) | 8.7 | (c ) | | | 9.65 | (c ) |
| MnO | 0.11 | (a) | 0.12 | (b) | 0.11 | (c ) | | | 0.13 | (c ) |
| MgO | 10.52 | (a) | 9.69 | (b) | 10 | (c ) | | | | |
| CaO | 12.87 | (a) | 12.97 | (b) | 12.5 | (c ) | | | | |
| Na2O | 0.43 | (a) | 0.47 | (b) | 0.47 | (c ) | | | 0.54 | (c ) |
| K2O | 0.17 | (a) | 0.17 | (b) | 0.15 | (c ) | | | | |
| P2O5 | 0.16 | (a) | 0.16 | (b) | | | | | | |
| S % | | | 0.06 | (b) | | | | | | |
| *sum* | | | | | | | | | | |
| | | | | | | | | | | |
| Sc ppm | 21 | (a) | | | 18 | (c ) | | | 21 | (c ) |
| V | 28 | (a) | | | 50 | (c ) | | | | |
| Cr | 1916 | (a) | 1437 | (b) | 1450 | (c ) | | | 1530 | (c ) |
| Co | 31 | (a) | | | 30 | (c ) | | | 33 | (c ) |
| Ni | 265 | (a) | 225 | (b) | 230 | (c ) | | | 302 | (d) |
| Cu | 15 | (a) | | | | | | | | |
| Zn | 19 | (a) | 21 | (b) | | | 17.5 | (d) | 20.2 | (d) |
| Ga | 2.9 | (a) | | | | | | | 4.7 | (d) |
| Ge ppb | | | | | | | 295 | (d) | 431 | (d) |
| As | | | | | | | | | | |
| Se | | | | | | | | | | |
| Rb | 2.6 | (a) | 4.2 | (b) | | | | | | |
| Sr | 149 | (a) | 155 | (b) | 180 | (c ) | | | | |
| Y | 63 | (a) | 61 | (b) | | | | | | |
| Zr | 279 | (a) | 265 | (b) | | | | | 251 | (c ) |
| Nb | 11 | (a) | 18 | (b) | | | | | | |
| Mo | | | | | | | | | | |
| Ru | | | | | | | | | | |
| Rh | | | | | | | | | | |
| Pd ppb | | | | | | | | | | |
| Ag ppb | | | | | | | | | | |
| Cd ppb | | | | | | | 44 | (d) | 42 | (d) |
| In ppb | | | | | | | 2 | (d) | 2.9 | (d) |
| Sn ppb | | | | | | | | | | |
| Sb ppb | | | | | | | 4 | (d) | | |
| Te ppb | | | | | | | 22 | (d) | | |
| Cs ppm | | | | | | | | | | |
| Ba | 209 | (a) | | | 190 | (c ) | | | | |
| La | 21 | (a) | | | 17.6 | (c ) | | | | |
| Ce | | | | | 45 | (c ) | | | 45 | (c ) |
| Pr | | | | | | | | | | |
| Nd | | | | | 28 | (c ) | | | | |
| Sm | | | | | 8.2 | (c ) | | | | |
| Eu | | | | | 1.32 | (c ) | | | 1.6 | (c ) |
| Gd | | | | | | | | | | |
| Tb | | | | | 1.6 | (c ) | | | *3.1* | (c ) |
| Dy | | | | | 10 | (c ) | | | | |
| Ho | | | | | | | | | | |
| Er | | | | | | | | | | |
| Tm | | | | | | | | | | |
| Yb | 5.8 | (a) | | | 6 | (c ) | | | 5 | (c ) |
| Lu | | | | | 0.86 | (c ) | | | | |
| Hf | | | | | 6 | (c ) | | | 7.5 | (c ) |
| Ta | | | | | 0.8 | (c ) | | | 0.86 | (c ) |
| W ppb | | | | | | | | | | |
| Re ppb | | | | | | | | | | |
| Os ppb | | | | | | | | | | |
| Ir ppb | | | | | 12 | (c ) | | | 9.6 | (d) |
| Pt ppb | | | | | | | | | | |
| Au ppb | | | | | 5 | (c ) | | | 3.8 | (d) |
| Th ppm | | | | | 2.8 | (c ) | | | 3.7 | (c ) |
| U ppm | | | | | 1 | (c ) | | | | |

*technique: (a) "microchemical", (b) XRF, (c ) INAA, (d) RNAA*

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