# 15013

Soil (vacuum container)

296.2 grams

*Figure 1: SESC used to collect soil sample 15013 from under Lunar Module. The wire was caught in the seal and the container was not under vacuum when opened. NASA S71-44784.*

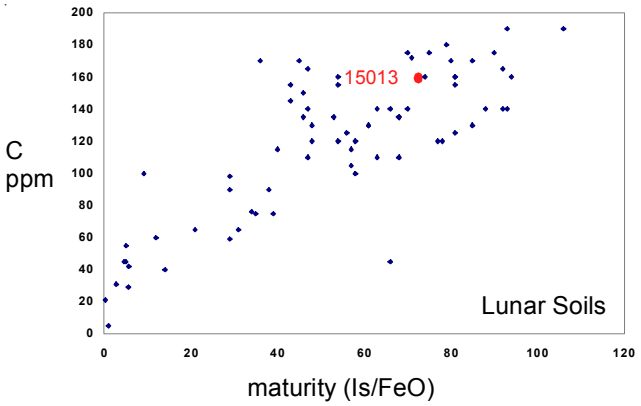



*Figure 2: Maturity index and carbon content of 15013 (data from Moore et al. 1973, Morris 1978).*

## Introduction

This soil was collected from the surface under the Lunar Module and placed in a special environmental sample container (SESC). ***However, when the sample was opened in Berkeley by Burlingame, it was found to not have sealed (see figure 1).***

Simoneit et al. (1973) found that the breakdown products ($NO_2$, $H_2O$, $CO_2$) of the LM exhaust were present in this sample, but could be released at relatively low temperatures in a vacuum (figure 6).

## Petrography

15013 is a mature soil, based on $I_s/FeO = 77$ (Morris 1978) and average grain size = 52 microns (figure 2). Another soil taken near the LM is 15020 ($I_s/FeO = 70$), with agglutinate content 48 % (Basu 1981). Experiments should be done on both sample – for comparison.

The particles extracted from 15013 are shown in figures 8a,b. *They have apparently escaped notice by lunar petrologists.*

## Chemistry

Christian et al. (1976) and Korotev (1987) have analyzed 15013 (table 1, figures 3 and 4). It is similar in composition to 15020, which was collected nearby.

Moore et al. (1973) and Des Marais et al. (1973) determined 150 ppm and 103 ppm carbon, respectively (figure 2). Kothari and Goel (1972) and Muller (1973) reported 98 ppm and 113 ppm nitrogen, respectively.

## Other Studies

Simoneit et al. (1973) seems to have found "lightly bound" exhaust products from the LM (figure 6).

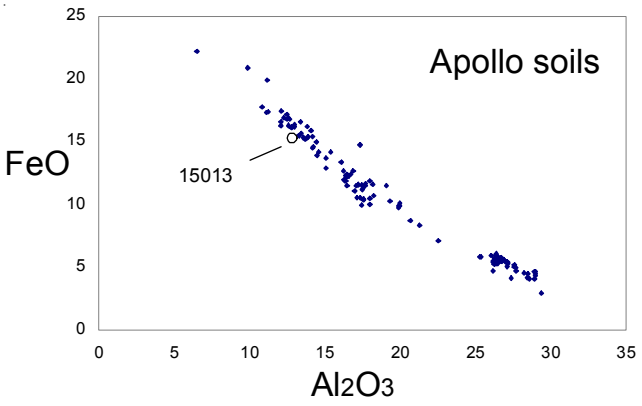



*Figure 3: Composition diagram for all Apollo soil samples indiating 15013.*

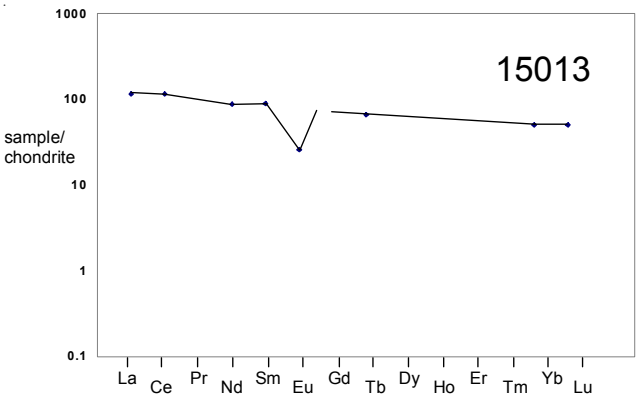
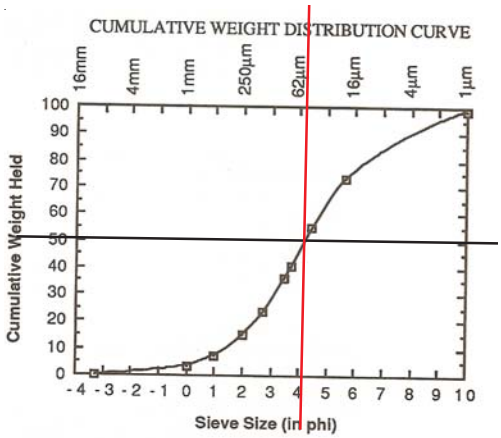



*Figure 4: Normalized rare-earth-element diagram for 15013 (Korotev 1987).*




**Average grain size = 53 microns**

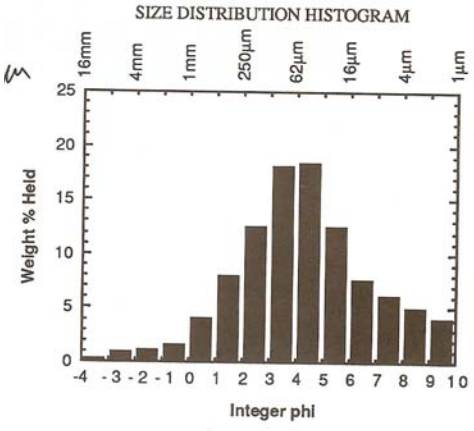
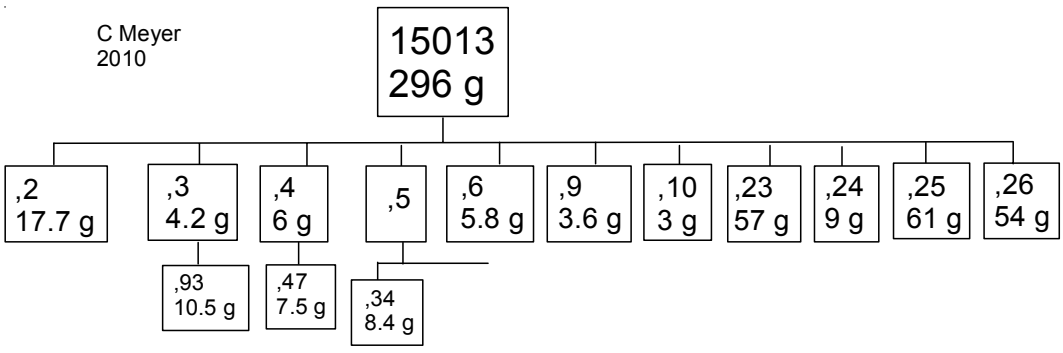



*Figure 5: Grain size distribution of 15013 (Graf 1993).*



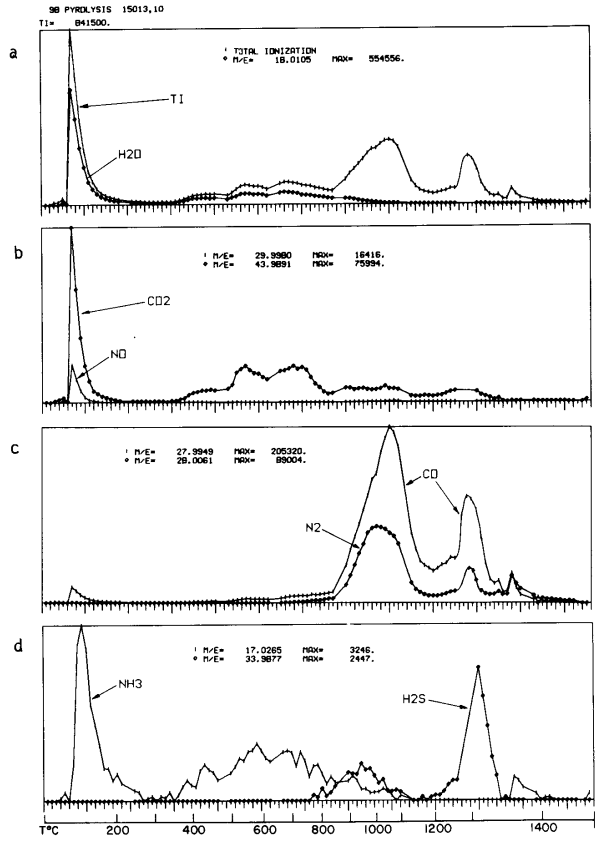



*Figure 6: Temperature release pattern for heating soil sample 15013, showing breakdown products of Lunar Module exhaust (hydrozene and N2O4 ?) - from Simoneit et al. 1973.*

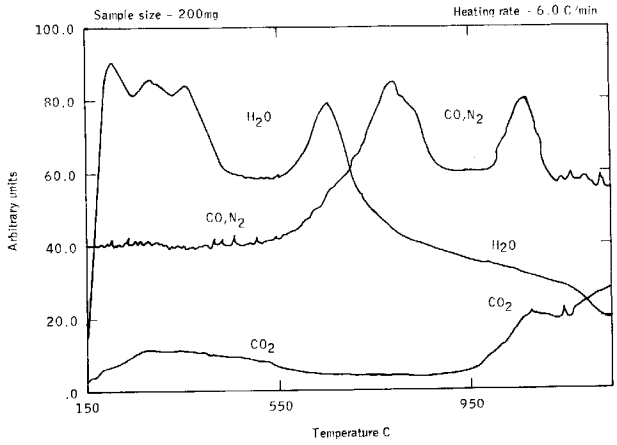



*Figure 7: Volatile release curve for typical mature lunar soil (15020) for comparison (from Gibson and Moore 1972).*

## Processing

There was a mistake in the early documentation (Swann et al. 1971, 1972; Graf 1993) related to the numbering of SESC containers 15014 (trench bottom, station 8) and 15013 (collected under LM). In the early documentation, these sample numbers were switched. However, by the time 15013 was sent to Berkeley the numbering was correct.

15013 was transferred directly to Burlingame, opened in He in Berkeley and distributed directly to PIs (Simoneit et al. 1971).

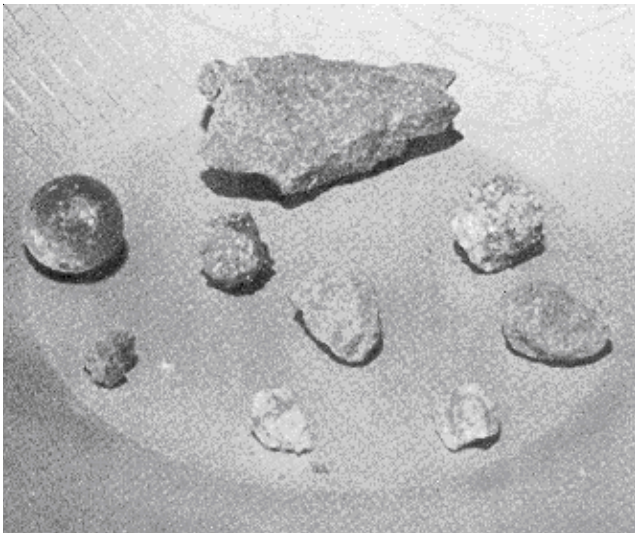


*Figure 8a: Small rock particles found in 15013 (from Simoneit et al.1972).*

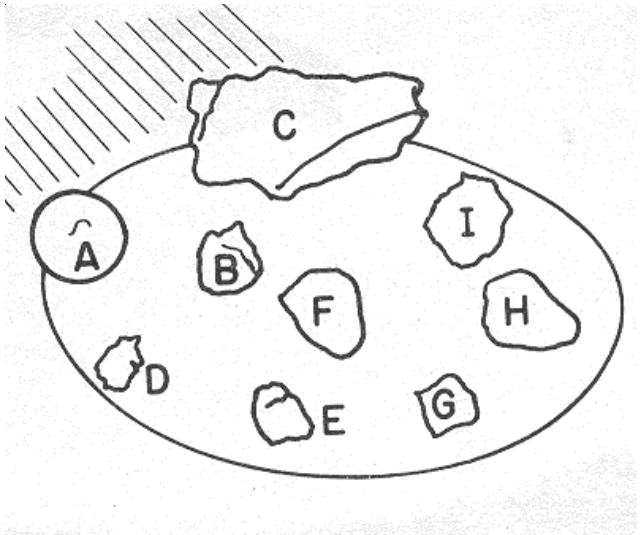



*Figure 8b: Sketch of small rock particles found in 15013 (from Simoneit et al.1972).*

## Table 1. Chemical composition of 15013 (and 15020).

| | | | | | 15021 (for ref.) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *reference* | Christian76 | | Korotev87 | | Laul73 | | | Wanke73 | |
| *weight* | | | | | | | | | |
| SiO2 % | 46.94 | (a) | | | | | | 47.07 | (b) |
| TiO2 | 1.72 | (a) | 1.97 | (b) | 1.8 | 1.8 | (b) | 1.75 | (b) |
| Al2O3 | 14.46 | (a) | 14.8 | (b) | 14.1 | 14.1 | (b) | 14.17 | (b) |
| FeO | 14.98 | (a) | 14.8 | (b) | 15 | 15 | (b) | 14.92 | (b) |
| MnO | 0.21 | (a) | 0.2 | (b) | 0.19 | 0.184 | (b) | 0.18 | (b) |
| MgO | 10.35 | (a) | 10.8 | (b) | | 10 | (b) | 10.44 | (b) |
| CaO | 10.38 | (a) | 10 | (b) | 10.8 | 10.7 | (b) | 8.95 | (b) |
| Na2O | 0.44 | (a) | 0.46 | (b) | 0.434 | 0.426 | (b) | 0.39 | (b) |
| K2O | 0.22 | (a) | | | 0.22 | 0.22 | (b) | 0.2 | (b) |
| P2O5 | 0.22 | (a) | | | | | | | |
| S % | | | | | | | | | |
| *sum* | | | | | | | | | |
| | | | | | | | | | |
| Sc ppm | | | 28.7 | (b) | 28 | 27 | (b) | 26.6 | (b) |
| V | | | 115 | (b) | 114 | 113 | (b) | | |
| Cr | 2395 | (a) | 2780 | (b) | 2737 | 2668 | (b) | 2500 | (b) |
| Co | | | 76.5 | (b) | 40 | 42 | (b) | 42 | (b) |
| Ni | | | 278 | (b) | | | | | |
| Cu | | | | | | | | | |
| Zn | | | | | | | | | |
| Ga | | | | | | | | | |
| Ge ppb | | | | | | | | | |
| As | | | | | | | | | |
| Se | | | | | | | | | |
| Rb | | | | | | | | | |
| Sr | | | 140 | (b) | | | | | |
| Y | | | | | | | | | |
| Zr | | | 410 | (b) | 350 | 400 | (b) | | |
| Nb | | | | | | | | | |
| Mo | | | | | | | | | |
| Ru | | | | | | | | | |
| Rh | | | | | | | | | |
| Pd ppb | | | | | | | | | |
| Ag ppb | | | | | | | | | |
| Cd ppb | | | | | | | | | |
| In ppb | | | | | | | | | |
| Sn ppb | | | | | | | | | |
| Sb ppb | | | | | | | | | |
| Te ppb | | | | | | | | | |
| Cs ppm | | | 0.27 | (b) | | | | | |
| Ba | | | 290 | (b) | 320 | 300 | (b) | | |
| La | | | 27.2 | (b) | 26 | 27 | (b) | 25 | (b) |
| Ce | | | 70 | (b) | 73 | 71 | (b) | 65 | (b) |
| Pr | | | | | | | | | |
| Nd | | | 40 | (b) | | | | | |
| Sm | | | 13.2 | (b) | 12.9 | 12.9 | (b) | 8.8 | (b) |
| Eu | | | 1.455 | (b) | 1.4 | 1.4 | (b) | 1.34 | (b) |
| Gd | | | | | | | | | |
| Tb | | | 2.43 | (b) | 2.3 | 2.3 | (b) | | |
| Dy | | | | | | | | 15 | (b) |
| Ho | | | | | | | | 2.3 | (b) |
| Er | | | | | | | | | |
| Tm | | | | | | | | | |
| Yb | | | 8.2 | (b) | 9.5 | 8.7 | (b) | 8.3 | (b) |
| Lu | | | 1.23 | (b) | 1.3 | 1.3 | (b) | 1.2 | (b) |
| Hf | | | 10 | (b) | 9.9 | 10 | (b) | | |
| Ta | | | 1.34 | (b) | 1.2 | 1.2 | (b) | | |
| W ppb | | | | | | | | | |
| Re ppb | | | | | | | | | |
| Os ppb | | | | | | | | | |
| Ir ppb | | | 7.9 | (b) | | | | | |
| Pt ppb | | | | | | | | | |
| Au ppb | | | 2.6 | (b) | | | | | |
| Th ppm | | | 5.2 | (b) | | | | | |
| U ppm | | | 1.1 | (b) | | | | | |

*technique: (a) "microchemical", (b) INAA*

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