

15015
Regolith Breccia
4770 grams

DRAFT



Figure 1: Photo of bottom surface of 15015 Cube is 1 inch. S71-43949

Introduction

Lunar sample 15015 is a large “football-sized rock” collected from the mare surface in front of the Lunar Module. It is a glass covered soil breccia with a rind of glass on all sides (figure 1). It is not significantly different from soil samples collected from the same location (Simon et al. 1986).

A small number of small micrometeorite craters occur on one surface of 15015 indicating it has not been exposed long on the lunar surface (Fechtig et al. 1974; Morrison et al. 1973).

Simon et al. 1986). Glass compositions are of a wide range (table 2) and include the green volcanic glass typical of the Apollo 15 site.

The glass coat is thick and frothy on the upper surface, thinner and smoother on the bottom (figure 1). The composition of the glass indicates that it may be a melt of 15015, not a splash, but the soils nearby are also of similar composition (Ryder 1985).

About 60% of 15015 is fine-grained dark matrix and includes a lot of glass fragments (Simon et al. 1986).

Petrography

15015 is a shock melted soil breccia with low agglutinate percentage and low soil maturity (Is/FeO = 3). It contains a high percentage of glass fragments including plastic forms, twisted and ropy forms, spheres and broken fragments (European Consortium 1977;

Mineralogical Mode for 15015

(European Consortium 77)

| | |
|-------------|--------|
| Matrix | 51.2 % |
| Rock frag. | 10.4 |
| Pyroxene | 19.1 |
| Plagioclase | 7.8 |
| Glass | 10 |
| Opagues | 1.5 |

Mineralogical Mode for 15015

(Simon et al. 1986)

| | | |
|--------------|--------------|---------------|
| Matrix | 59.6 % | |
| | 20-90 micron | 90-100 micron |
| Mare Basalt | 0.8 | 5.3 |
| KREEP Basalt | | |
| Feld. Basalt | | 0.6 |
| Plutonic | | 1 |
| Granulitic | 0.6 | 0.6 |
| Breccia | 0.3 | 0.5 |
| Olivine | 1.3 | 0.5 |
| Pyroxene | 9.8 | 3.9 |
| Plagioclase | 6.7 | 1.4 |
| Opagues | 0.4 | |
| Glass | 3.6 | 3.3 |
| Agglutinate | 0 | 0 |

Lithic clasts make up about 10% of the volume of 15015 (figures 13 -15). They are about 30% mare basalts, 33% Fra Mauro basalts, 22% feldspathic basalts and 15% impact melt rock. Mehta and Goldstein (1979) studied the metal particles.

Significant Clasts

Variolitic basalt clast 5b

The variolitic basalt is dark and has about 30% plagioclase. It is 3.4 b.y. old with a cosmic ray exposure age of 1050 m.y.

KREEP basalt clast 23b

It has a crystallization age of ~3.7 b.y. with an exposure to cosmic rays of ~400 m.y.

Chemistry

Laul and Schmitt (1973), Simon et al. (1986) and Wiesmann and Hubbard (1976) have reported the chemical composition of 15015 (table 1). Analyses by J.H. Scoon were reported by the European Consortium (1977). The matrix of 15015 is similar in composition to nearby soil 15021 (figure 3). A mixing model calculation by Simon et al. (1986) finds that 15105 can be explained by 38% mare basalt, 8% LKFM, 10% anorthosite, 30% KREEP and 14% green glass.

The European Consortium (1977) reported 121 ppm C, 630 ppm S and 54 ppm N.

Radiogenic age dating

Several subsamples of 15015 were studied by Ar/Ar (figures 4 and 5) (European Consortium 1977).

Cosmogenic isotopes and exposure ages

The clasts in 15015 have had a prior exposure before they became incorporated in the breccia matrix (European Consortium 1977).

Fechtig et al. (1974) quote an exposure age from solar flare tracks of only 50 years! (figure 6). Micrometeorite bombardment has not eroded the glass rind, indicating that 15015 must be of recent origin.

Other Studies

Cisowski et al. (1983) determined the remanent magnetism and magnetic properties of 15015.

Bogard and Nyquist (1972) report the rare gas isotopes.

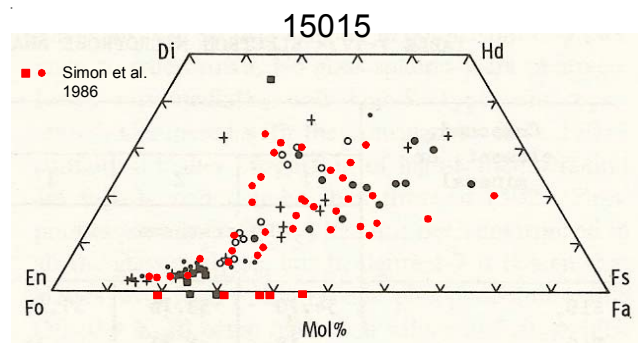


Figure 2: Composition of pyroxene and olivine in 15015 (European Consortium 1977 with Simon et al. 1986).

Processing

Pieces of 15015 are used for public displays at NASA Stennis Space Center, Mississippi and the NASA Glen Research Center in Cleveland, Ohio.

The large slab (,8; 150 g) was cut through the middle of 15015 (figure 9) and the column (,15) was studied by the European Consortium led by G. Eglinton (European Consortium 1977). A piece of this slab is now available for testing future scientific instruments in the PI experiment laboratory at JSC. The end piece (,7) has also been subdivided (figure 12). The other end (,0) is one of the largest uncut pieces of lunar rock (2870 g). There are 16 thin sections.

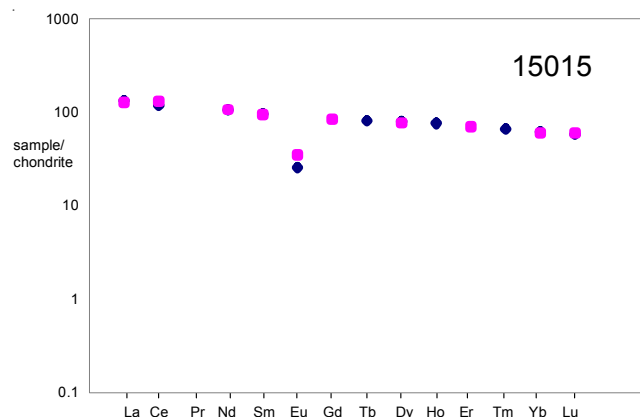


Figure 3: Normalized rare-earth-element diagram for 15015 (table 1).

Table 2. Chemical composition of glass in/on 15015.

| reference | European consortium. | | | | | | | | | | |
|--------------------------------|----------------------|-------|-------|--------|--------|--------|-------|-------|-------|--------|--------|
| weight | skin | skin | vein | sphere | splash | sphere | 8 | 9 | 10 | sphere | sphere |
| SiO ₂ % | 48.01 | 48.49 | 47.45 | 45.65 | 47.46 | 47.03 | 55.3 | 50.29 | 49.74 | 48.61 | 46.66 |
| TiO ₂ | 1.89 | 1.8 | 1.92 | 0.37 | 2.02 | 2.2 | 2.16 | 1.94 | 1.56 | 0.58 | 0.38 |
| Al ₂ O ₃ | 13.43 | 13.96 | 13.62 | 7.53 | 10.31 | 12.15 | 14.16 | 16.12 | 16.64 | 17.61 | 25.91 |
| FeO | 12.76 | 14.37 | 14.94 | 20.44 | 19.5 | 18.08 | 11.1 | 10.66 | 9.49 | 8.46 | 5.28 |
| MnO | | 0.23 | 0.02 | 0.31 | 0.32 | 0.27 | 0.17 | 0.16 | 0.17 | 0.16 | 0.08 |
| MgO | 10.16 | 9.56 | 9.5 | 17.74 | 11.52 | 8.27 | 4.7 | 6.38 | 9.26 | 14.31 | 7.84 |
| CaO | 11.16 | 10.41 | 9.94 | 8.25 | 10.36 | 11.06 | 8.9 | 10.25 | 10.56 | 10.82 | 10.24 |
| Na ₂ O | 0.56 | 0.51 | 0.51 | 0.23 | 0.3 | 0.25 | 1.06 | 0.82 | 0.76 | 0.06 | 0.17 |
| K ₂ O | 0.24 | 0.29 | 0.01 | 0.02 | 0.13 | 0.05 | 1.24 | 0.95 | 0.49 | 0.02 | 0 |
| P ₂ O ₅ | 0.05 | | | | | | 0.33 | 0.97 | 0.36 | | |

electron probe analyses

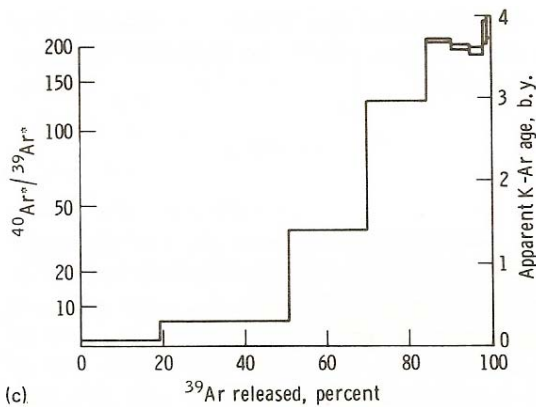
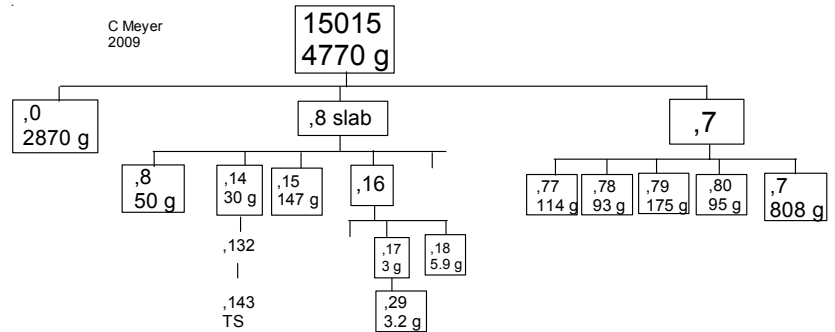


Figure 4: Ar/Ar release diagram for 23b, a Fra Mauro basalt clast.

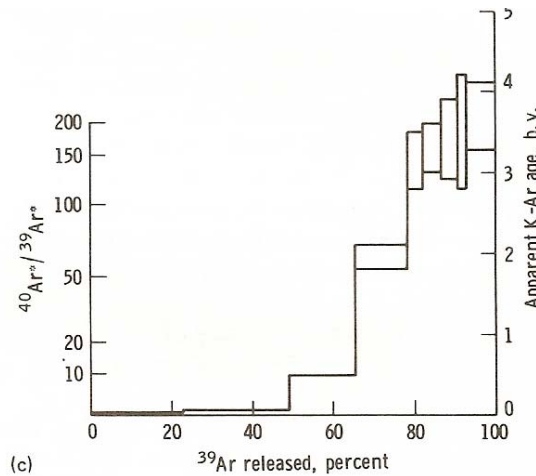


Figure 5: Ar/Ar release diagram for clast 5b, a variolitic basalt clast.

Summary of Age Data for 15015

| | Ar/Ar |
|--------------------------|----------------|
| KREEP basalt | 3.7 ± 0.1 b.y. |
| Variolitic basalt | 3.4 ± 0.2 |
| Frothy glass | ~1.1 b.y. |
| Matrix | ~1 b.y. |
| European Consortium 1977 | |

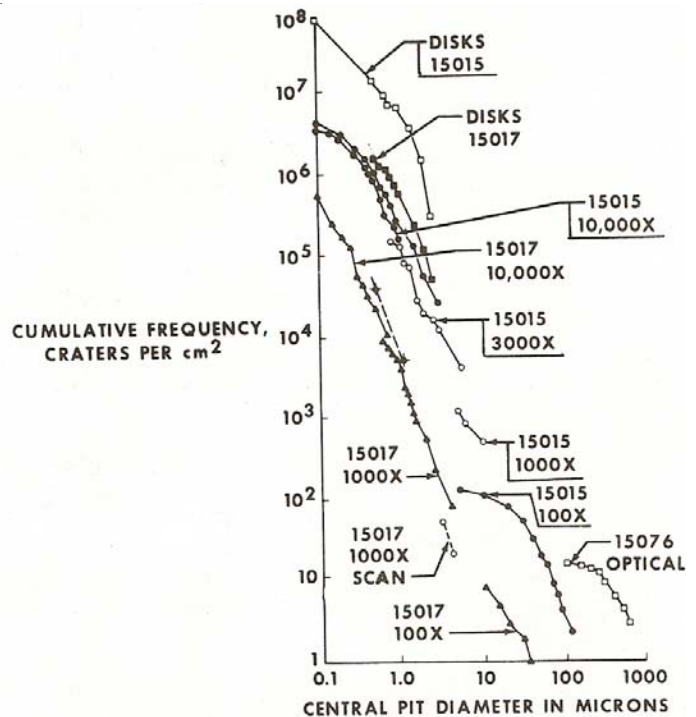


Figure 6: Zap pits on 15015 (Morrison et al. 1973).

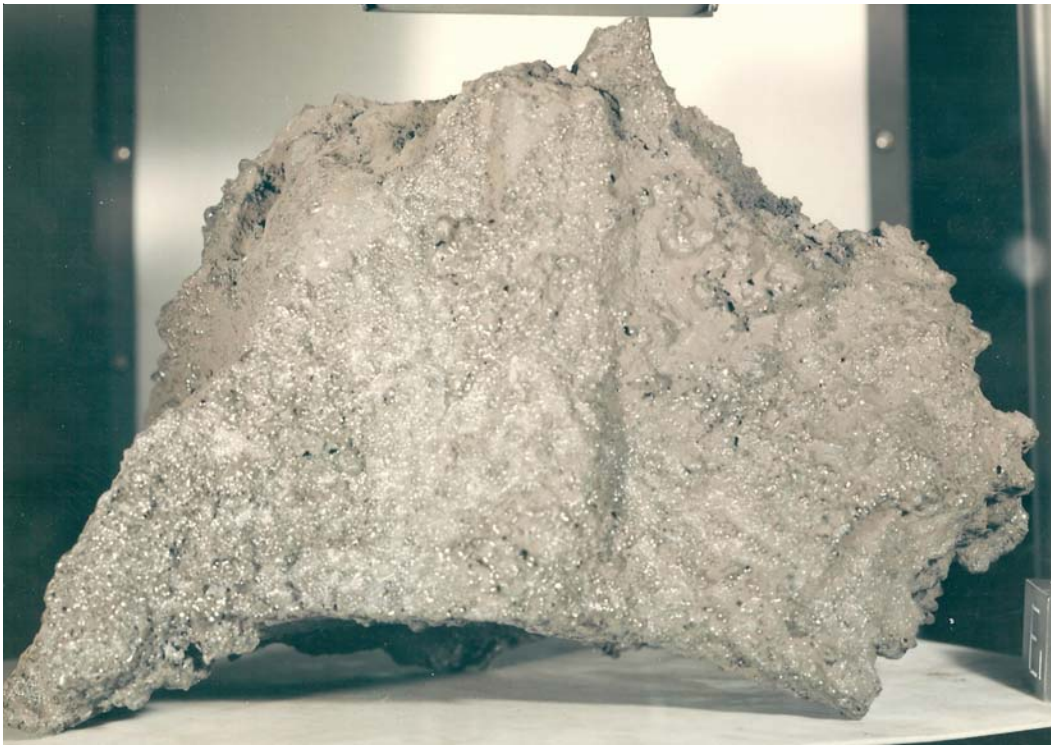


Figure 7: Photo of 15015. Surface is coated with glass. S71-43944



Figure 8: Photo of 15015. Surface is coated with glass. S71-43947.

Table 1. Chemical composition of 15015.

| reference weight | Wiesmann75 Church72 | | Laul73 | McKay89 | Simon86 | Chou74 | Scoon77 European | Rhodes 77 Consortium | | | |
|------------------|---------------------|------|-----------|---------|---------|--------|------------------|----------------------|-------|-------|-----|
| SiO2 % | | | | | | | 47.11 | (d) | 47.5 | 47.3 | (e) |
| TiO2 | 1.03 | 1.71 | (a) 1.5 | 1.5 | 1.7 | (b) | 1.9 | (d) | 1.76 | 1.74 | (e) |
| Al2O3 | | | 14.2 | 14.2 | 14 | (b) | 14.46 | (d) | 13.99 | 14.16 | (e) |
| FeO | | | 15.2 | 15.1 | 14.5 | (b) | 14.38 | (d) | 14.63 | 14.56 | (e) |
| MnO | | | 0.185 | 0.18 | 0.195 | (b) | 0.19 | (d) | 0.21 | 0.22 | (e) |
| MgO | | | 10 | 10 | 10.7 | (b) | 9.93 | (d) | 10.12 | 10.09 | (e) |
| CaO | | | 10.2 | 10 | 10.2 | (b) | 10.47 | (d) | 10.52 | 10.62 | (e) |
| Na2O | 0.51 | 0.48 | (a) 0.462 | 0.47 | 0.465 | (b) | 0.31 | (d) | 0.5 | 0.5 | (e) |
| K2O | 0.25 | 0.23 | (a) 0.25 | | 0.25 | (b) | 0.28 | (d) | 0.24 | 0.22 | (e) |
| P2O5 | | | | | | | 0.22 | (d) | 0.24 | 0.22 | (e) |
| S % | | | | | | | | | | | |
| sum | | | | | | | | | | | |
| Sc ppm | | | 27 | 28.8 | 27.4 | (b) | | | | | |
| V | | | 130 | 130 | 120 | (b) | | | | | |
| Cr | 2755 | 2685 | (a) 2800 | 2790 | 2805 | (b) | 2700 | | | | |
| Co | | | 43 | 43.6 | 39.1 | (b) | | | | | |
| Ni | | | | 232 | 180 | (b) | 229 | (c) | | | |
| Cu | | | | | | | | | | | |
| Zn | | | | | | | 13.5 | (c) | | | |
| Ga | | | | | | | 3.78 | (c) | | | |
| Ge ppb | | | | | | | 462 | (c) | | | |
| As | | | | | | | | | | | |
| Se | | | | | | | | | | | |
| Rb | 6.86 | 6.34 | (a) | | | | | | | | |
| Sr | 134 | 135 | (a) | 135 | 125 | (b) | | | | | |
| Y | | | | | | | | | | | |
| Zr | 445 | 387 | (a) 560 | 420 | 370 | (b) | | | | | |
| Nb | | | | | | | | | | | |
| Mo | | | | | | | | | | | |
| Ru | | | | | | | | | | | |
| Rh | | | | | | | | | | | |
| Pd ppb | | | | | | | | | | | |
| Ag ppb | | | | | | | | | | | |
| Cd ppb | | | | | | | 33 | (c) | | | |
| In ppb | | | | | | | 5.4 | (c) | | | |
| Sn ppb | | | | | | | | | | | |
| Sb ppb | | | | | | | | | | | |
| Te ppb | | | | | | | | | | | |
| Cs ppm | | | | 0.3 | | (b) | | | | | |
| Ba | 319 | 294 | (a) 300 | 306 | 320 | (b) | | | | | |
| La | 29.8 | 28 | (a) 30 | 29.6 | 31 | (b) | | | | | |
| Ce | 79.1 | 72.7 | (a) 80 | 77 | 71 | (b) | | | | | |
| Pr | | | | | | | | | | | |
| Nd | 48.1 | 44.7 | (a) | 46 | 48 | (b) | | | | | |
| Sm | 13.8 | 13 | (a) 14.2 | 13.8 | 14 | (b) | | | | | |
| Eu | 2.01 | 1.44 | (a) 1.6 | 1.52 | 1.43 | (b) | | | | | |
| Gd | 16.5 | 15.2 | (a) | | | | | | | | |
| Tb | | | 2.5 | 2.76 | 2.9 | (b) | | | | | |
| Dy | 18.6 | 17.3 | (a) 17 | | 19.3 | (b) | | | | | |
| Ho | | | | | 4.2 | (b) | | | | | |
| Er | 11.2 | 10.2 | (a) | | | | | | | | |
| Tm | | | | | 1.6 | (b) | | | | | |
| Yb | 9.86 | 9.3 | (a) 9.9 | 9.6 | 10 | (b) | | | | | |
| Lu | 1.46 | 1.34 | (a) 1.4 | 1.32 | 1.42 | (b) | | | | | |
| Hf | 12.9 | 11.2 | (a) 10 | 11.2 | 9.2 | (b) | | | | | |
| Ta | | | 1.4 | 1.37 | 1.25 | (b) | | | | | |
| W ppb | | | | | | | | | | | |
| Re ppb | | | | | | | | | | | |
| Os ppb | | | | | | | | | | | |
| Ir ppb | | | | 7.6 | | (b) | 7.6 | (c) | | | |
| Pt ppb | | | | | | | | | | | |
| Au ppb | | | | 3.6 | | (b) | 1.4 | (c) | | | |
| Th ppm | 4.9 | 4.4 | (a) 4.5 | 4.8 | 4.9 | (b) | | | | | |
| U ppm | 1.42 | 1.33 | (a) 1.4 | 1.24 | 1.3 | (b) | | | | | |

technique: (a) IDMS, (b) INAA, (c) RNAA, (d) classical wet, (e) XRF



Figure 9: Cutting diagram for 15015. S71-58731. The ruler is marked in cm.

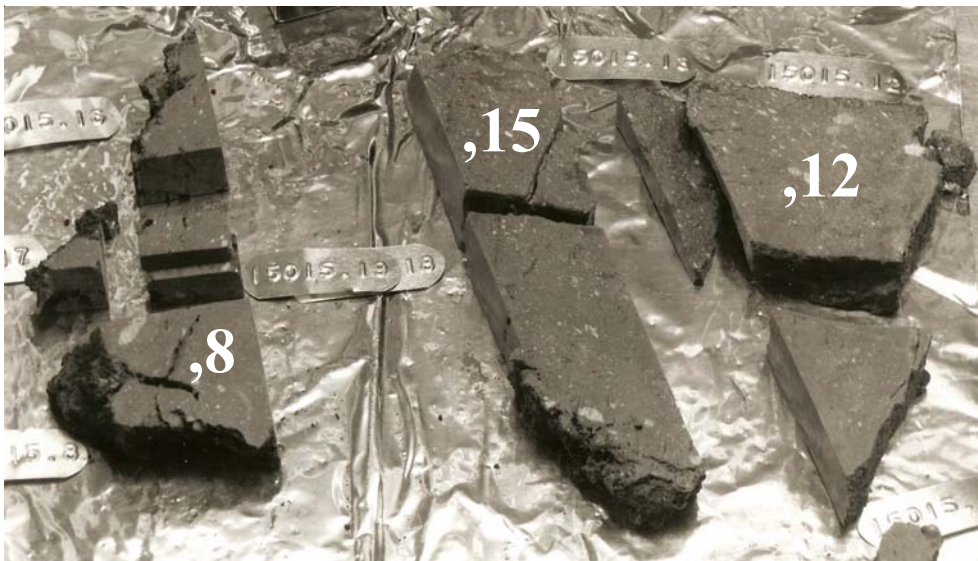


Figure 10: Sub-division of slab 15015,8 (west side). Cube is 1 inch. S71-59085.



Figure 11: Close-up view of 15015,79 (T1 surface). 6.5 cm across. S75-29722.

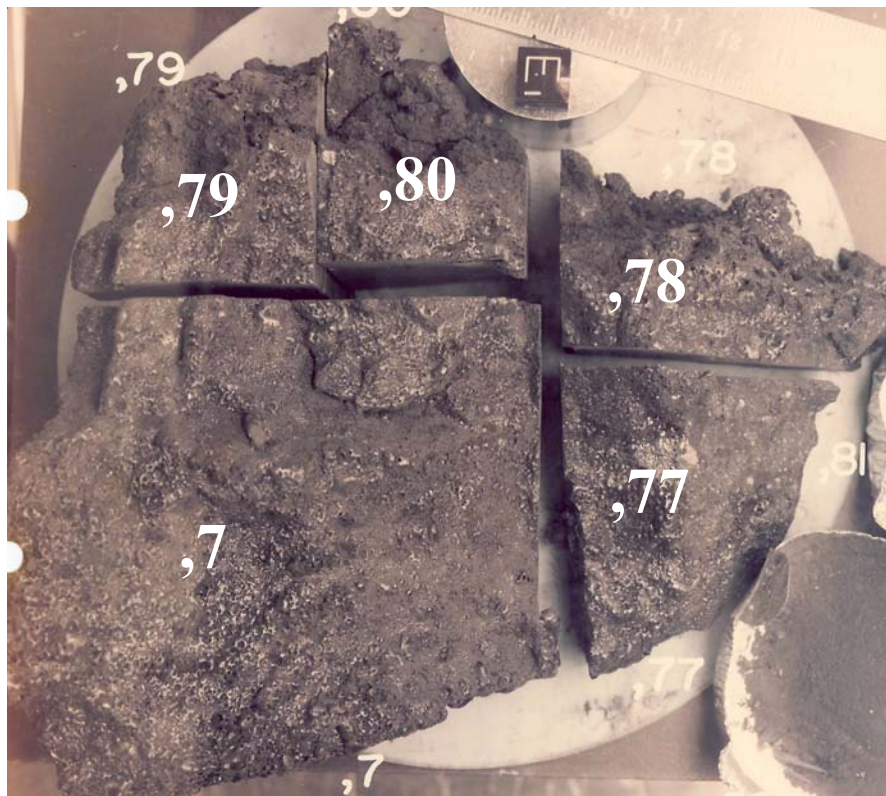
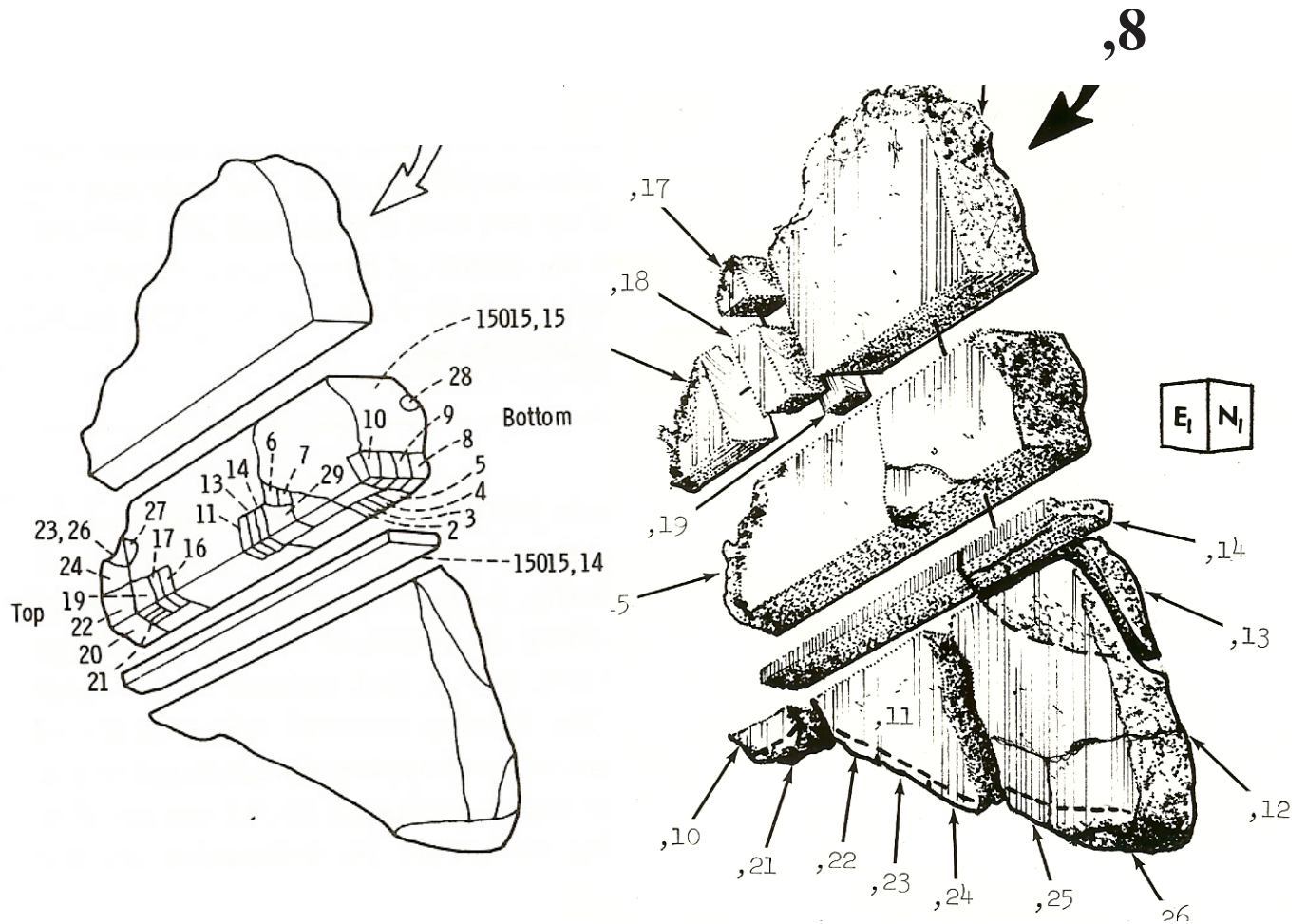


Figure 12: Sub-division of end piece 15015,7. Cube is 1 cm. S75-29723



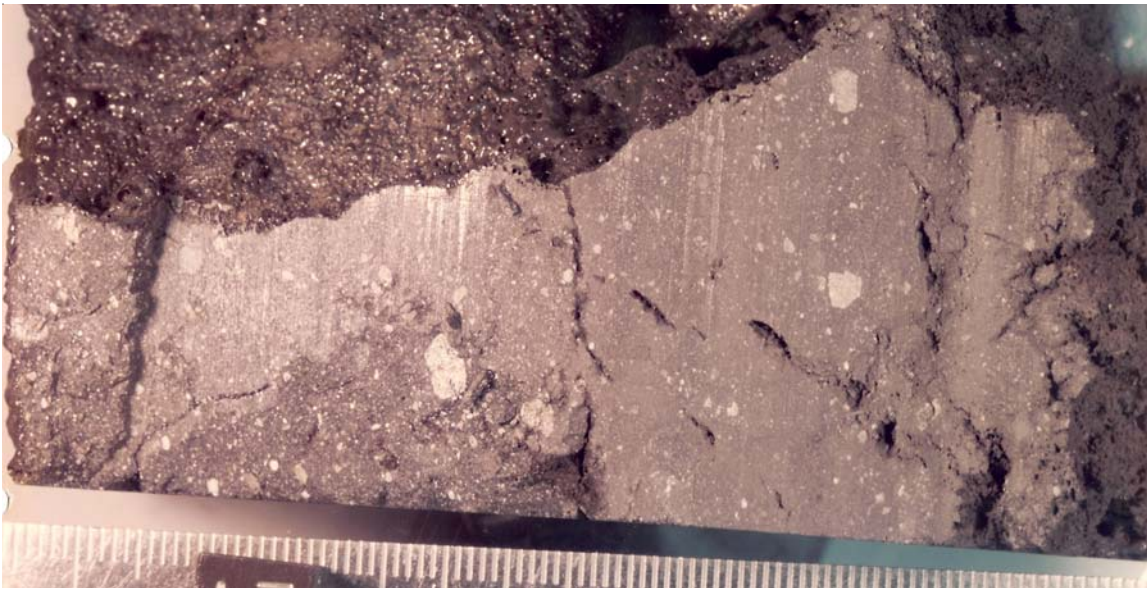


Figure 13: Close-up of T1 surface of 15015,7 (sawn piece). Scale in mm. S75-29726.

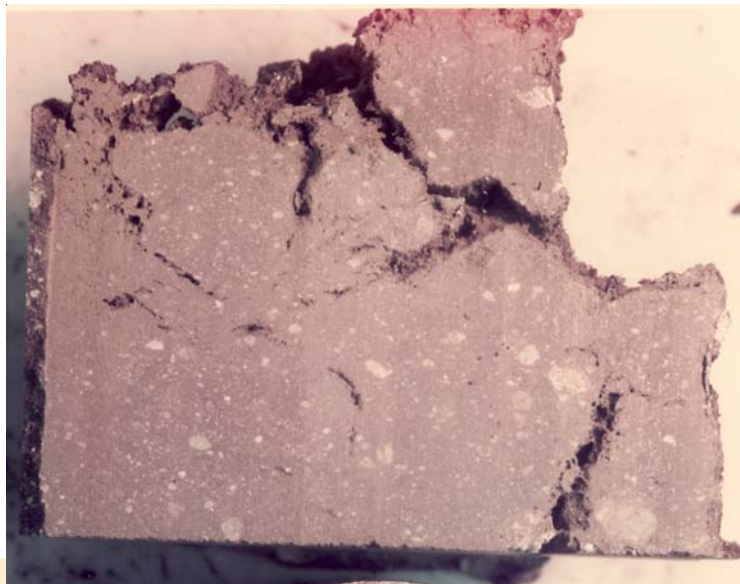


Figure 14: Close-up photo of 15015,80 (B1 surface). Sample is 5 cm across. S75-32785.

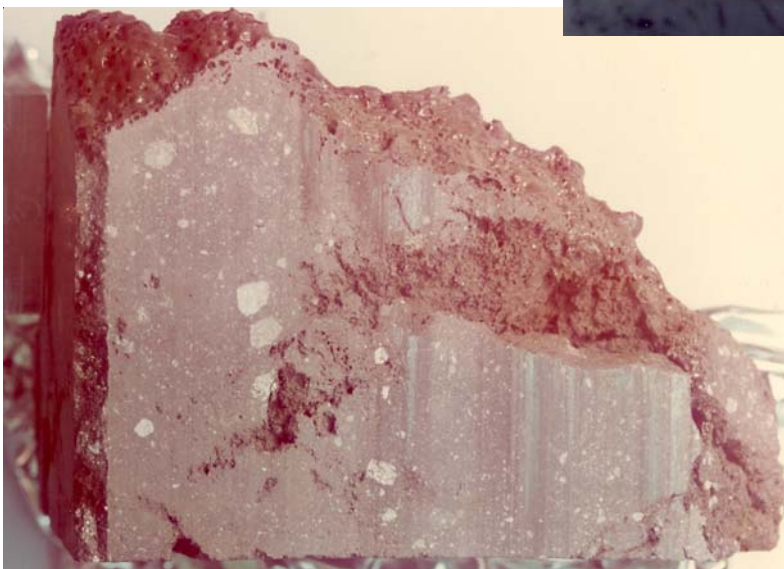


Figure 15: Close-up of N1 surface of 15015,78. Sample is about 5 cm across. S75-29725.

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