# 14305
## Crystalline Matrix Breccia
2497 grams


*Figure 1: Sawn surface of 14305 showing dark clast in lighter matrix. Cube and scale are in cm. NASA S86-30442.*

### Introduction

Lunar sample 14305 is a Fra Mauro breccia similar in texture and clast distribution to 14321 (figure 1). This "football-sized" rock was collected about 100 m from the LM landing site at Apollo 14. A piece broke off during transit and was orginally numbered 14302. When both pieces were found to exactly fit together, 14302 was renumbered 14305,18.

Since 14305 has zap pits on both sides and has higher $^{26}Al$ on the bottom, it has had a complicated exposure history (i.e. has turned over). Using $^{53}Mn$, Herpers et al. (1974) showed that the rock has "tumbled" (figure 2). Eugster et al. (1984) concluded that 14305 did not originate from Cone Crater, mainly because its exposure age is slightly higher than the age of Cone Crater.

One large, glass-lined, micrometeorite pit records the location on rock 14305 that almost ruptured the rock (see figure 3 in Gault et al. 1972).

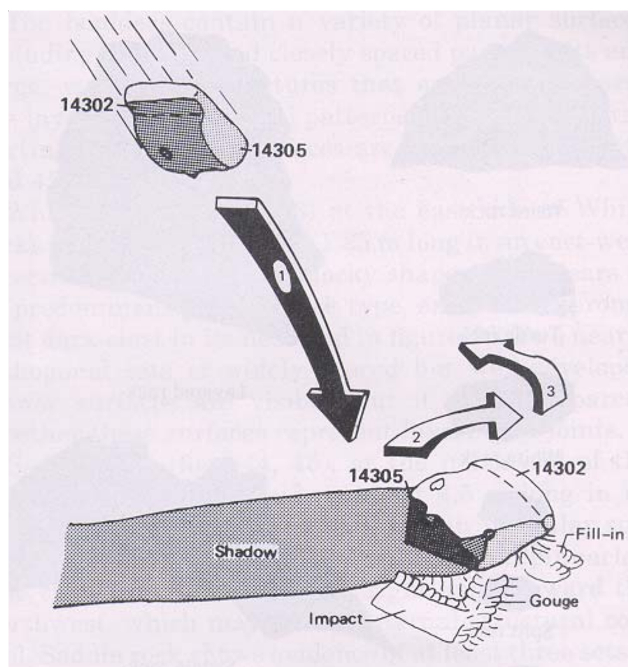



*Figure 2: Illustration of emplacement and tumbling of 14305-14302 on lunar regolith.*

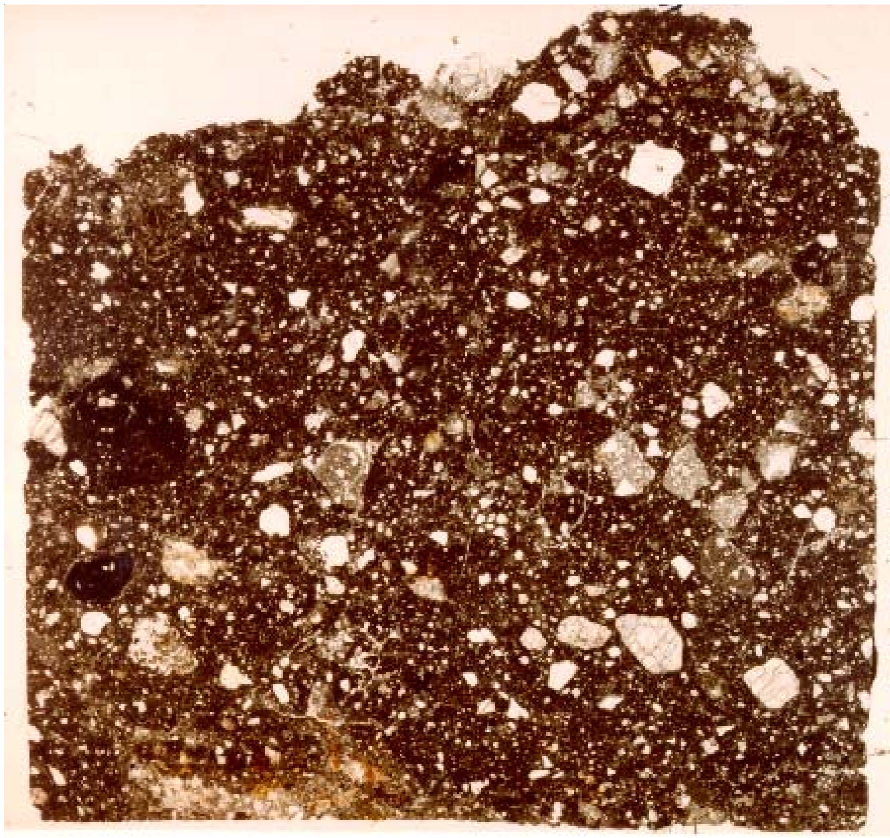


*Figure 3: Thin section photomicrograph of 14305,255. NASA photo #S80-42342. Field of view about 2 cm.*

The crystallization age of 14305 was found to be 3.92 b.y. with an exposure to cosmic rays of about 28 m.y. However, various clasts in this breccia are older, and zircons are found to be extremely old (4.35 b.y.).

## Petrography

Petrographic descriptions of breccia 14305 are found in Juan et al. (1972), Klein and Drake (1972), Dence and Plant (1972), Lovering et al. (1972), Carlson and Walton (1978), Shervais and Taylor (1983). According to the classification schemes of Simonds et al. (1977) and Stöffler et al. (1980), 14305 is a clast-rich, crystalline matrix breccias (figure 4). The seriate matrix (down to <25 microns) consists of intergrown, blocky decussate pyroxenes with plagioclase laths and granular opaques (figure 3). Lithic clasts >1 mm comprise about 30% of the sample (Wilshire and Jackson 1972). Dark gray microbreccia is the dominant clast type (figure 1), with basalt, plagioclase-olivine cumulates and granites as minor clast types (figure 8). Juan et al. found that the fine-grain basalt clasts were like 14310. They also reported gabbroic anorthosite from the highlands. Shervais et al. (1985) also studied the plagioclase rich basalt clasts in 14305 and termed them VHK basalts.

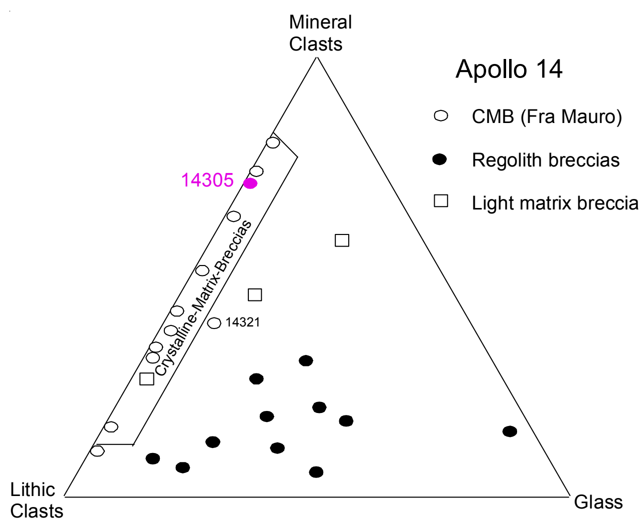



*Figure 4: 14305 is a crystalline matrix breccia (Simonds et al. 1977).*

Twedell et al. (1978) mapped some of the surfaces of 14305 and Carlson and Walton (1978) summarized what was known up to that time. Shervais and Taylor (1983) documented what was known about breccia

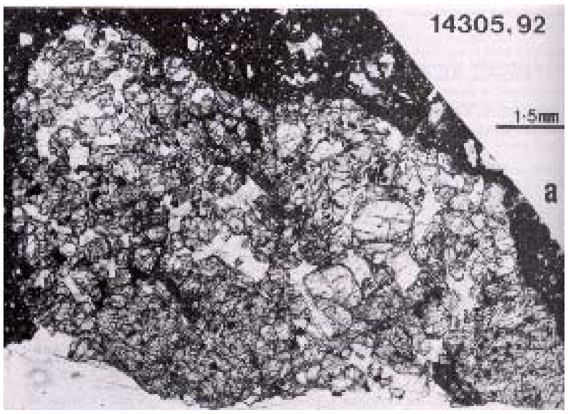



*Figure 5: Thin section photomicrograph of basalt clast in 14305 (from Taylor et al. 1983). This is the olivine gabbronorite that proved to be 4.2 b.y.*

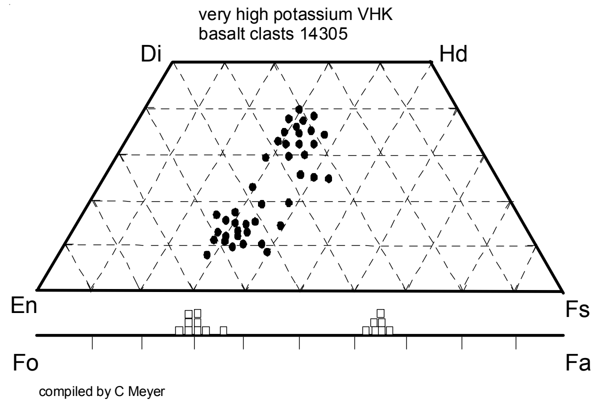



*Figure 7: Olivine and pyroxene compositions of VHK basalt clasts in 14305 (after Shervais et al. 1983).*

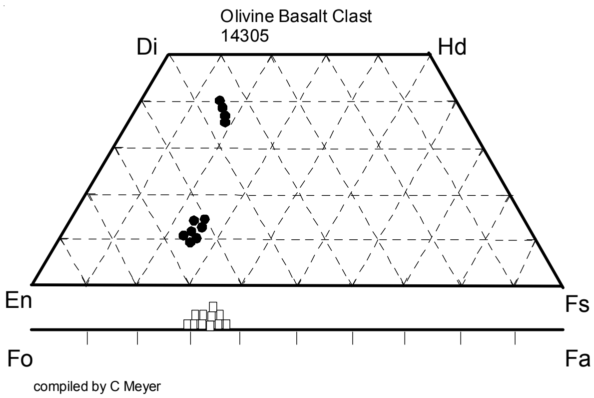



*Figure 6: Composition of mafic minerals in olivine basalt clast in 14305,92 (from Taylor et al. 1983).*

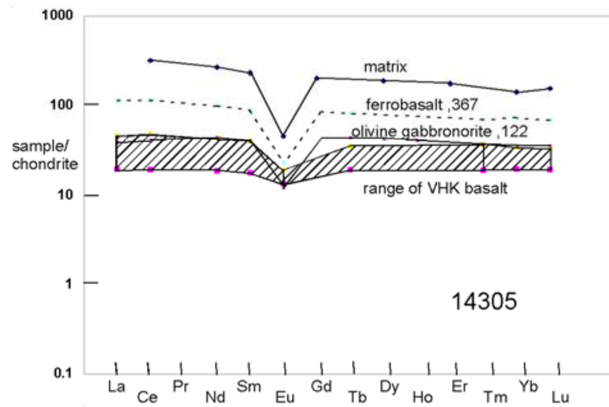



*Figure 8: Normalized rare-earth-element diagram for 14305 matrix and some of its basalt clasts. (data from table 2)*

sample 14305 in 1983 and began a search for rock clasts as part of a "pull-apart" project. They "mapped" some of the new surfaces created by new saw cuts. The most important finding from the study of 14305 was the discovery a large clast of very old mare basalt (see below).

## Mineralogy

***Pyroxene***: Klein and Drake (1972) present pyroxene analyses – including orthopyroxene in the matrix. Pyroxene compositions of the clasts in this breccia are reproduced in figures 5, 6 and 10.

***Spinel:*** Dence and Plant (1972) give an analysis of pink spinel in 14305,5.

***Phosphate:*** Brown et al. (1972) and Warren et al. (1983) give analyses of whitlockite. Analyses for apatite from clasts can be found in Shervais et al. (1984).

***Ternary Feldspar:*** Shervais and Taylor (1983) reported feldspars with roughly equal amounts of K, Na and Ca in granophryic clasts in 14305.

***Zircon:*** Lovering et al. (1972) found U-rich zircon in a monzonite clast. Meyer et al. (1988, 1991) studied zircons in two norite clasts in 14305. Taylor et al. (2009) studied zircons from sawdust and Nemchin et al. (2008) dated 6 zircons in thin section.

## Significant clasts

***,122 Olivine Gabbronorite (mare basalt)***

Hunter and Taylor (1983) and Taylor et al. (1983) describe a large clast of olivine gabbronorite (basalt) in thin section 14305,92 (table 2, figure 5, 6 and 14). They dug the remainder of this clast out of the adjacent epoxy mount and determined the age by Rb-Sr internal mineral isochron 4.2 b.y. (see below). This clast is a mare basalt very similar to 12005 (see also Ari et al. 2006).

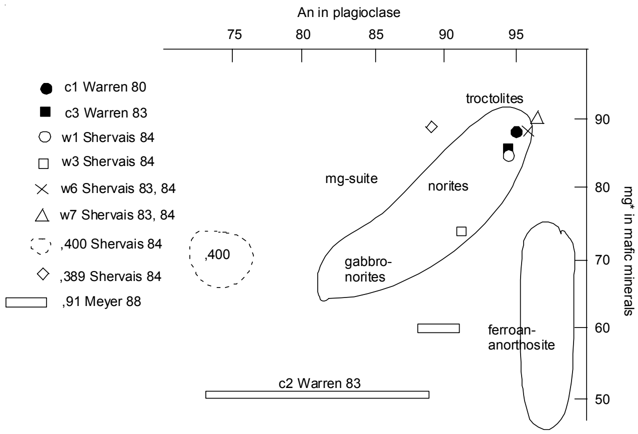



*Figure 9: Composition of plagioclase and mafic minerals for white clasts in 14305 (see text for explanation).*

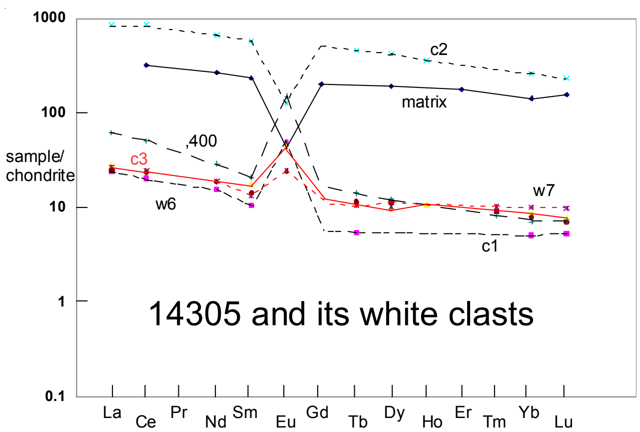



*Figure 10: Normalized rare-earth-element diagram for 14305 matrix and its white clasts (data from table 2).*

### *,304 VHK Basalt*

Shervais et al. (1985) studied several high potassium basalt clasts (table 2, figure 7). One of these was dated by Shih et al. (1983) (figure 15).

### *,367 ferrobasalt*

An analysis of an "ilmenite ferrobasalt" is presented in Shervais et al. (1985), but no details are given (figure 8).

### *c1 from ,18*

Warren and Wasson (1980) analyzed a white troctolite clast from the top corner of 14305,18. Thin section ,268 showed that this clast was 30% olivine ($Fo_{87}$), 70% plagioclase ($An_{95}$). This clast is similar to 14172 (which might be a piece of same rock). The clast is pristine (Ir < 0.05 ppb).

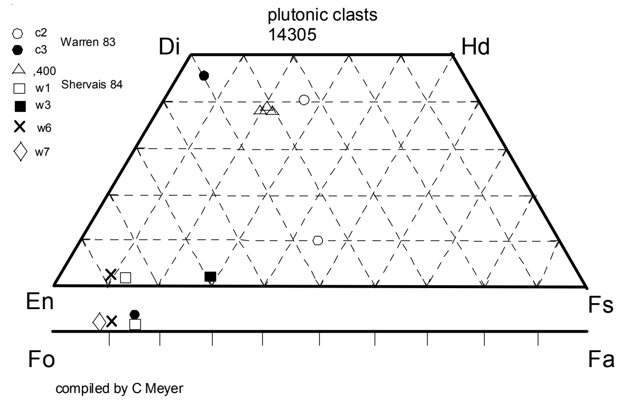



*Figure 11: Pyroxene and olivine compositions of troctolite, anorthosite and norite clasts in 14305 (from Warren et al. 1983 and Shervais et al. 1983).*

### *c2 trace-element-rich "anorthosite"*

Warren et al. (1983) analyzed a whitlockite-rich anorthosite clast 14305,283 (table 2, figure 10). The plagioclase ranged widely in composition ($An_{68-90}$). Shervais et al. (1984) also studied an alkali anorthosite clast (,400) with plagioclase $An_{71-77}$.

### *c3*

Warren et al. (1983) also found a troctolite clast (7 x 6 mm) on 14305,27 with 90% plagioclase ($An_{94}$), 10% mafic minerals ($Fo_{85}$) – see table 2 and figure 11.

### *w1*

Shervais et al. (1984) identified a troctolitic anorthosite ,394 (no analysis) with 90% plagioclase ($An_{95}$), 10% olivine ($Fo_{85}$) and trace pyroxene (figures 9, 10 and 11).

### *w3*

Shervais et al. (1984) studied a rare norite clast in thin section (no analysis). It was 92% plagioclase ($An_{91}$) and 8% enstatite ($En_{73}$).

### *w6 from ,27 and ,290*

Shervais et al. (1983, 1984) analyzed (in duplicate) an enstatite troctolite clast (9 x 5 mm) that was dissected by the saw cut. The thin section showed 25% maskelynite ($An_{96}$), 25% olivine ($Fo_{89}$), and 5% enstatite ($En_{90}$).

### *w7 from ,27*

Shervais et al. (1983, 1984) analyzed (in duplicate) a magnesium anorthosite clast that is made up mostly of plagioclase ($An_{97}$) with trace olivine ($Fo_{90}$). The chemical composition is similar to w6 (figure 9).

## Table 1. Chemical composition of 14305.

| *reference* | Keith72 | Fields72 | Yokoyama 72 | | | | LSPET72 | | Wanke 72 | | Willis 72 | | Philpotts72 | | Palme78 | | Wiik73 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *weight* | 380 g | | | | | | | | | | | | sawdust | | | | |
| SiO2 % | | | | | | | 49.2 | (a) | 48.35 | (c ) | 47.92 | (d) | 48.2 | | | | 47.92 |
| TiO2 | | | | | | | 1.67 | (a) | 1.52 | (c ) | 1.71 | (d) | 1.71 | | | | 1.78 |
| Al2O3 | | | | | | | 16.1 | (a) | 16.25 | (c ) | 15.47 | (d) | 15.16 | | | | 16.64 |
| FeO | | | | | | | 9.52 | (a) | 10.42 | (c ) | 11.34 | (d) | 10.88 | | 10.8 | (e) | 10.59 |
| MnO | | | | | | | 0.18 | (a) | 0.13 | (c ) | 0.14 | (d) | 0.13 | | 0.14 | (e) | 0.14 |
| MgO | | | | | | | 13 | (a) | 10.28 | (c ) | 11.14 | (d) | 11.12 | | | | 10.37 |
| CaO | | | | | | | 7.4 | (a) | 9.93 | (c ) | 9.96 | (d) | 10.13 | | | | 12.12 |
| Na2O | | | | | | | 0.85 | (a) | 0.76 | (c ) | 0.73 | (d) | 0.87 | | 0.8 | (e) | 0.89 |
| K2O | 0.64 | (b) | | | | | 1.2 | (a) | 0.64 | (c ) | 0.68 | (d) | 0.73 | | 0.64 | (e) | 0.62 |
| P2O5 | | | | | | | | | | | 0.57 | (d) | 0.64 | | | | 0.65 |
| S % | | | | | | | | | | | 0.094 | (d) | 0 | | | | 0.09 |
| *sum* | | | | | | | | | | | 99.75 | | 99.57 | | | | |
| | | | | | | | | | | | | | | | | | |
| Sc ppm | | | | | | | | | 24 | (e) | | | | | 25.3 | (e) | 24 |
| V | | | | | | | 52 | (a) | | | | | | | | | 30 |
| Cr | | | | | | | 1200 | (a) | 1330 | (c ) | | | | | 1395 | (e) | 1369 |
| Co | | | | | | | 32 | (a) | 31 | (c ) | | | | | 33.4 | (e) | 20 |
| Ni | | | | | | | 205 | (a) | 200 | (c ) | | | | | 300 | (e) | 210 |
| Cu | | | | | | | 13 | (a) | 10.9 | (c ) | | | | | | | 20 |
| Zn | | | | | | | | | 2.1 | (c ) | | | | | | | |
| Ga | | | | | | | | | 5 | (c ) | | | | | 4.9 | (e) | |
| Ge ppb | | | | | | | | | 44 | (c ) | | | | | | | |
| As | | | | | | | | | 0.077 | (c ) | | | | | | | |
| Se | | | | | | | | | | | | | | | | | |
| Rb | | | | | | | 31 | (a) | 25 | | 17.9 | (d) | 19 | (e) | | | |
| Sr | | | | | | | 200 | (a) | 190 | | 162 | (d) | 166 | (e) | 185 | (e) | 160 |
| Y | | | | | | | 210 | (a) | | | 238 | (d) | | | | | 200 |
| Zr | | | | | | | 900 | (a) | | | 1158 | (d) | 1060 | (e) | | | 840 |
| Nb | | | | | | | 49 | (a) | | | 70.7 | (d) | | | | | |
| Mo | | | | | | | | | | | | | | | | | |
| Ru | | | | | | | | | | | | | | | | | |
| Rh | | | | | | | | | | | | | | | | | |
| Pd ppb | | | | | | | | | | | | | | | | | |
| Ag ppb | | | | | | | | | | | | | | | | | |
| Cd ppb | | | | | | | | | | | | | | | | | |
| In ppb | | | | | | | | | | | | | | | | | |
| Sn ppb | | | | | | | | | | | | | | | | | |
| Sb ppb | | | | | | | | | | | | | | | | | |
| Te ppb | | | | | | | | | | | | | | | | | |
| Cs ppm | | | | | | | | | 1.36 | (c ) | | | | | | | |
| Ba | | | | | | | 930 | (a) | 830 | (c ) | 913 | (d) | 924 | (e) | 950 | (e) | 640 |
| La | | | | | | | 54 | (a) | 109 | (c ) | | | | | 111 | (e) | 83 |
| Ce | | | | | | | | | 200 | (c ) | | | 193 | (e) | 220 | (e) | |
| Pr | | | | | | | | | 26 | (c ) | | | | | | | |
| Nd | | | | | | | | | 140 | (c ) | | | 121 | (e) | 137 | (e) | |
| Sm | | | | | | | | | 23 | (c ) | | | 34.4 | (e) | 32.4 | (e) | |
| Eu | | | | | | | | | 2.6 | (c ) | | | 2.56 | (e) | 2.6 | (e) | |
| Gd | | | | | | | | | 38 | (c ) | | | 40.1 | (e) | | | |
| Tb | | | | | | | | | 7.4 | (c ) | | | | | 6.9 | (e) | |
| Dy | | | | | | | | | 43 | (c ) | | | 46.7 | (e) | 43.9 | (e) | |
| Ho | | | | | | | | | 6.5 | (c ) | | | | | | | |
| Er | | | | | | | | | 32 | (c ) | | | 28.3 | (e) | | | |
| Tm | | | | | | | | | | | | | | | | | |
| Yb | | | | | | | 28 | (a) | 24.2 | (c ) | | | 23.3 | (e) | 26 | (e) | 23 |
| Lu | | | | | | | | | 3.5 | (c ) | | | 3.82 | (e) | 3.62 | (e) | |
| Hf | | | | | | | | | 26 | (c ) | | | 28.6 | (e) | 26.5 | (e) | |
| Ta | | | | | | | | | 3.2 | (c ) | | | | | 3.2 | (e) | |
| W ppb | | | | | | | | | 1940 | (c ) | | | | | 2.6 | (e) | |
| Re ppb | | | | | | | | | | | | | | | | | |
| Os ppb | | | | | | | | | | | | | | | | | |
| Ir ppb | | | | | | | | | 10 | (c ) | | | | | 11 | (e) | |
| Pt ppb | | | | | | | | | | | | | | | | | |
| Au ppb | | | | | | | | | 6.7 | (c ) | | | | | | | |
| Th ppm | 13.9 | 16.4 | 14.6 | 13.3 | 14.3 | (b) | | | 17.4 | (c ) | | | | | 13.2 | (e) | |
| U ppm | 3.8 | 4.13 | 3.8 | 3.8 | 3.8 | (b) | | | 5.15 | (c ) | | | | | 3.6 | (e) | |

*technique (a) Optical Emission, (b) Radiation counting, (c ) INAA, (d) XRF, (e) IDMS*

## Table 2. Chemical composition of 14305 clasts.

| | *monzonite* | troctolite | | anor? | troctolite | anor. | basalt | VHK bas. | VHK | K-anor. | Pxite |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *reference* | *Lovering 72* | Warren 80 | Warren 83 | Warren 83 | Shervais 83 | | Taylor 83 | Shervais | Shih 86 | Shervais 84 | |
| *weight* | *ts only* | c1 | c3 | c2 | ,317 | ,322 | ,122 | ,304 | ,304 | ,400 | ,389 |
| SiO2 % | 59.6 | 43.64 | 43.4 | | | | | | | | |
| TiO2 | 0.6 | 0.04 | 0.54 | 1.69 | 0.13 | 0.13 | 3.6 | 2.4 | | 0.2 | <0.5 |
| Al2O3 | 20.6 | 27.96 | 28.54 | | 21.9 | 34 | 4 | 9.9 | | 29.9 | 1.1 |
| FeO | 3.3 | 2.83 | 2.25 | 2.55 | 4.2 | 0.43 | 22.4 | 18.1 | | 0.19 | 7.3 |
| MnO | | 0.031 | 0.026 | 0.037 | 0.049 | 0.007 | 0.25 | 0.23 | | 0.003 | 0.11 |
| MgO | 3.3 | 11.44 | 8.3 | | 17.6 | 1.4 | 22 | 15 | | <1 | 35 |
| CaO | 7.9 | 14.28 | 15.96 | 16.8 | 11.7 | 20.7 | 6.5 | 9 | | 15.3 | 0.73 |
| Na2O | 0.9 | 0.43 | 0.47 | 1.48 | 0.44 | 0.34 | 0.16 | 0.34 | | 2.4 | 0.04 |
| K2O | 4.7 | 0.07 | 0.07 | 0.506 | 0.063 | 0.055 | 0.04 | 0.62 | | 0.46 | 0.01 |
| P2O5 | | | | | | | | | | | |
| S % | | | | | | | | | | | |
| *sum* | | | | | | | | | | | |
| | | | | | | | | | | | |
| Sc ppm | | 1.78 | 2.6 | 8.6 | 3.9 | 0.75 | 56 | 50 | | 0.54 | 4.7 |
| V | | | | | 70 | | 190 | 120 | | | 40 |
| Cr | | 140 | 201 | 111 | 2395 | 116 | 821 | 3968 | | | |
| Co | | 19 | 12.6 | 3.6 | 17.8 | 2.5 | 56.5 | 37 | | 0.4 | 28.5 |
| Ni | | 19 | | | 20 | 10 | 150 | 60 | | | 110 |
| Cu | | | | | | | | | | | |
| Zn | | 0.58 | | | | | | | | | |
| Ga | | | | | | | | | | | |
| Ge ppb | | 12 | | | | | | | | | |
| As | | | | | | | | | | | |
| Se | | | | | | | | | | | |
| Rb | | | | 5.3 | | | 0.606 | | 14.18 | | |
| Sr | | | 211 | 400 | 120 | 210 | 39.17 | | 67.42 | | |
| Y | | | | | | | | | | | |
| Zr | | 120 | | 196 | <30 | 20 | 230 | 80 | | | |
| Nb | | | | | | | | | | | |
| Mo | | | | | | | | | | | |
| Ru | | | | | | | | | | | |
| Rh | | | | | | | | | | | |
| Pd ppb | | | | | | | | | | | |
| Ag ppb | | | | | | | | | | | |
| Cd ppb | | | | | | | | | | | |
| In ppb | | | | | | | | | | | |
| Sn ppb | | | | | | | | | | | |
| Sb ppb | | | | | | | | | | | |
| Te ppb | | | | | | | | | | | |
| Cs ppm | | | | | | | | | | | |
| Ba | | 630 | 450 | 1180 | 140 | 110 | <50 | 200 | | 600 | 40 |
| La | | 5.6 | 6.6 | 201 | 6.6 | 5.4 | 9.2 | 4.6 | | 14.5 | 10.3 |
| Ce | | 12.2 | 14.8 | 520 | 15 | 13 | 25 | 11.7 | | 31 | 24 |
| Pr | | | | | | | | | | | |
| Nd | | 7.1 | 8 | 305 | 9.4 | 7.3 | 20 | 8.5 | 8.447 | 13 | 15 |
| Sm | | 1.56 | 2.16 | 86 | 2 | 1.95 | 6 | 2.6 | 2.803 | 3.1 | 2.5 |
| Eu | | 2.72 | 2.6 | 7.2 | 1.45 | 1.35 | 0.7 | 0.75 | | **8.4** | 0.13 |
| Gd | | | | | | | | | | | |
| Tb | | 0.2 | 0.4 | 16.7 | 0.4 | 0.36 | 1.6 | 0.7 | | 0.52 | 0.32 |
| Dy | | | 2.33 | 103 | 2.6 | 2.5 | 10.5 | 4.8 | | 3 | <3 |
| Ho | | | 0.6 | 20.1 | | | 2.3 | | | | |
| Er | | | | | | | | | | | |
| Tm | | | | | | | 0.9 | 0.46 | | 0.2 | 0.2 |
| Yb | | 0.83 | 1.44 | 43 | 1.7 | 1 | 5.8 | 3.2 | | 1.15 | 1 |
| Lu | | 0.13 | 0.19 | 5.7 | 0.25 | 0.12 | 0.87 | 0.47 | | 0.18 | 0.14 |
| Hf | | 0.25 | 0.37 | 2.4 | 0.88 | 0.45 | 6.2 | 2.5 | | 1.3 | 0.72 |
| Ta | | <0.3 | 0.07 | 0.49 | 0.05 | 0.07 | 1.6 | 0.65 | | 0.22 | 0.2 |
| W ppb | | | . | | | | | | | | |
| Re ppb | | 0.6 | | | | | | | | | |
| Os ppb | | | | | | | | | | | |
| Ir ppb | | <0.05 | | | | | | | | | |
| Pt ppb | | | | | | | | | | | |
| Au ppb | | 0.016 | | | | | | | | | |
| Th ppm | | 0.22 | 0.46 | 21.6 | 0.35 | 0.52 | 1.2 | 0.61 | | 1.3 | 0.94 |
| U ppm | | 0.17 | 0.15 | 3 | <0.1 | <0.1 | <0.4 | <0.2 | | <0.5 | <0.4 |

*technique (a) INAA, (b) IDMS*

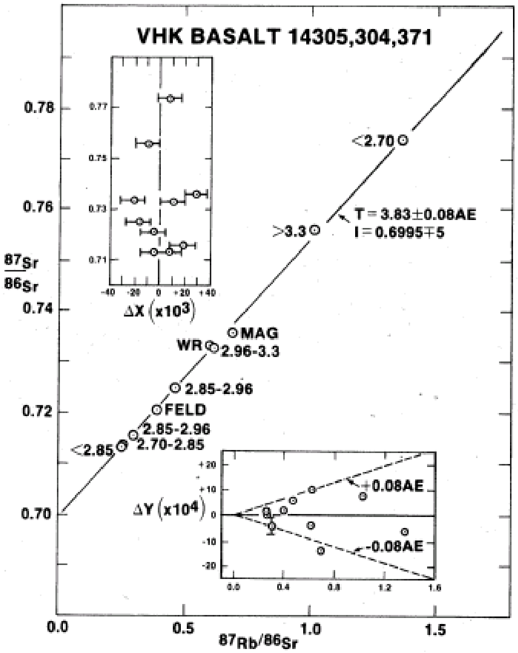



Figure 12: Rb-Sr isochron diagram of high-K basalt clast in 14305 (from Shih et al. 1986).

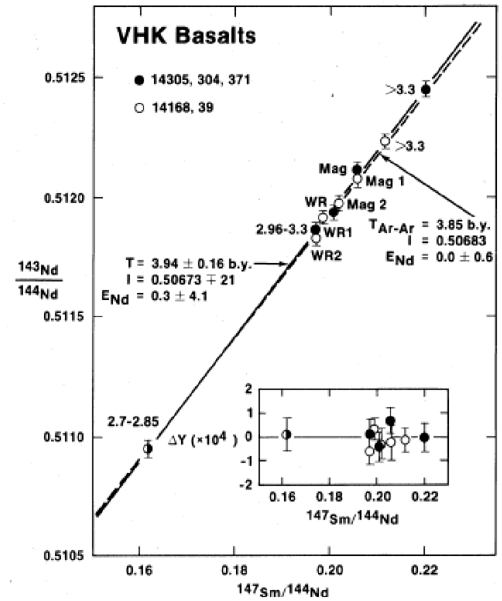



Figure 13: Sm-Nd isochron diagram for 14305 basalt clast (from Shih et al. 1986).

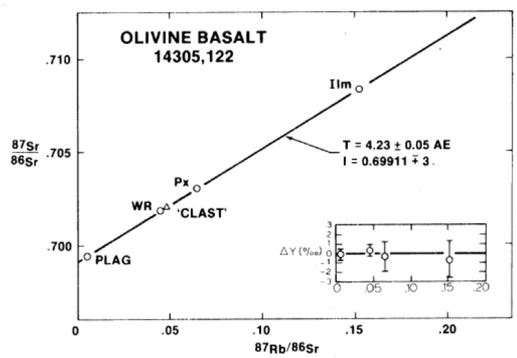



Figure 14: Rb-Sr isochron for clast in 14305 (from Taylor et al. 1983). Note the significant old age.

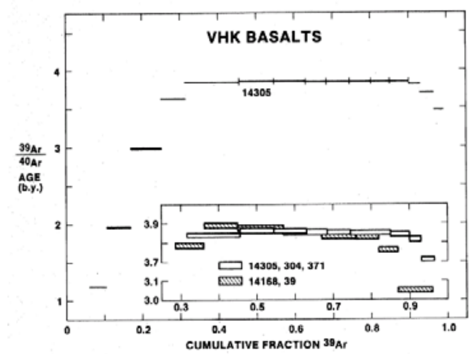



Figure 15: Ar plateau age for 14305 basalt clast (from Shih et al. 1986).

### *Granite*

Shervais and Taylor (1983) studied several small clasts of "micrographic granite" in thin sections 14305,102 and ,111.

### *,77 Monzonite clast*

Lovering et al. (1972) studied a 2 mm white fragment with ~35% plagioclase, 18% Ca-poor pyroxene in 44% interstitial mesostasis rich in Si and K. Apatite (50 ppm U), whitlockite (75 ppm U) and zircon (140-1300 ppm U) were accessory phases in this clast.

**Summary of Age Data for 14305** (b.y. = billion years)

| | Ar release | Rb-Sr | Sm-Nd | U-Pb | |
|---|---|---|---|---|---|
| Matrix | 3.92 ± 0.03 b.y. | | | | Eugster et al. (1984) |
| 14305,122 | | 4.23 ± 0.05 | | | Taylor et al. 1983 |
| 14305,304 | 3.85 ± 0.02 | 3.83 ± 0.08 | 3.95 ± 0.17 | | Shih et al. 1986 |
| 14305,91 | | | | 4.2 b.y. | Meyer et al. (1991) |
| Zircons | | | | 3.97 to 4.35 b.y. | Nemchin et al. (2008) |
| | | | | | Taylor et al. (2007) |

**Caution: Not corrected for new radiogenic decay constants.**

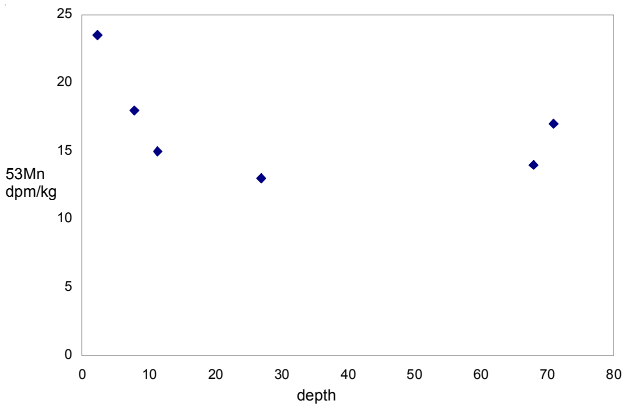



*Figure 16: Depth profile for 53Mn in 14305. This is evidence for "tumbling" (Herpers et al. 1974).*

***,91 Gabbronorite***

Meyer et al. (1988) dated a small zircon included in an igneous rock clast with 48% plagioclase ($An_{90}$), 48% pyroxene ($En_{70}$), 2% ilmenite, apatite and whitlockite.

***,103 Gabbronorite***

Meyer et al. (1988) reported another small clast of gabbronorite (with included zircon) in thin section 14305,103.

## Chemistry

Keith et al. (1972) determined Th = 13.9 ppm for a large piece of 14305 by radiation counting (table 1). This is a good guide for which chemical analysis to use as representative of the bulk rock. Philpotts et al. (1972) analyzed the "sawdust" from 14305, which should be representative of the rock as a whole (figures 8 and 10). Analyses by Wanke et al. (1972), Wiik et al. (1973) and Palme et al. (1978) are in agreement and show very high K, P and REE content. Ni, Ir and Au are high, indicating a high content of meteoritic material. Jovanovic and Reed (1976) determined Ru and Os.

Warren et al. (1980, 1983) and Shervais et al. (1983, 1984) analyzed a large number of clasts in 14305 (table 2, figures 8 and 10).

## Radiogenic age dating

Eugster et al. (1984) determined an Ar release age of 3.92 ± 0.03 b.y. for several subsamples (presumably matrix material). Taylor et al. (1983) and Ari et al. (2006) found the oldest mare basalt as a clast in this breccia (figure 14). Shih et al. (1986) dated one of the high K basalt fragments (figures 11, 12, 14). Meyer et al. (1991) were able to date a zircon in a gabbronorite clast by the ion microprobe method. Taylor et al. (2009) dated zircons from sawdust of 14305, while Nemchin et al. (2008) dated zircons found in thin section.

## Cosmogenic isotopes and exposure ages

Eugster et al. (1984) determined an exposure age of 27.6 ± 1.5 for several subsamples of 14305 by the $^{81}Kr$ method. Since 14305 has higher $^{26}Al$ on the bottom side (160 ± 60 dpm) than the top side (63 ± 34 dpm/kg), it is thought that it has turned over in the regolith (Yokoyama et al. 1972). Herpers et al. (1974) also demonstrated that the rock had "tumbled" while on the lunar surface. They found that the $^{53}Mn$ depth profile was at a minimum in the middle of the rock (figure 16).

## Other Studies

Eugster et al. (1984) determined the rare gas content of 14305.

Herr et al. (1972) determined the activity of $^{53}Mn$. Keith et al. (1972) determined activity of $^{26}Al$, $^{22}Na$, $^{54}Mn$, $^{56}Co$ and $^{46}Sc$.

Herpers et al. (1974) studied the density of cosmic ray tracks in olivine and plagioclase as a function of depth in this rock. They also determined the enrichment of $^{187}Re$ due to neutron capture.

## Processing

14302 was re-labeled 14305,18 when it was found to be a broken piece of 14305. The main mass of 14305 was cut thru the center to yield a large slab for allocations (figures 17 - 19). In 1982, 14305,27 was again sawn to produce slab ,290 and again in 1985 to create slab ,483. 14305,29 was cut to produce slab ,459. Numerous "clasts" were extracted from these new slabs as part of a "breccia-pull-apart" project by Larry Taylor.

Shervais and Taylor (1983) produced a guidebook for this rock, summarizing the work up to 1983. There are over 100 thin sections of this rock (figure 26). This rock is featured in the Lunar Petrographic Educational Thin Section Package (Meyer 2003).

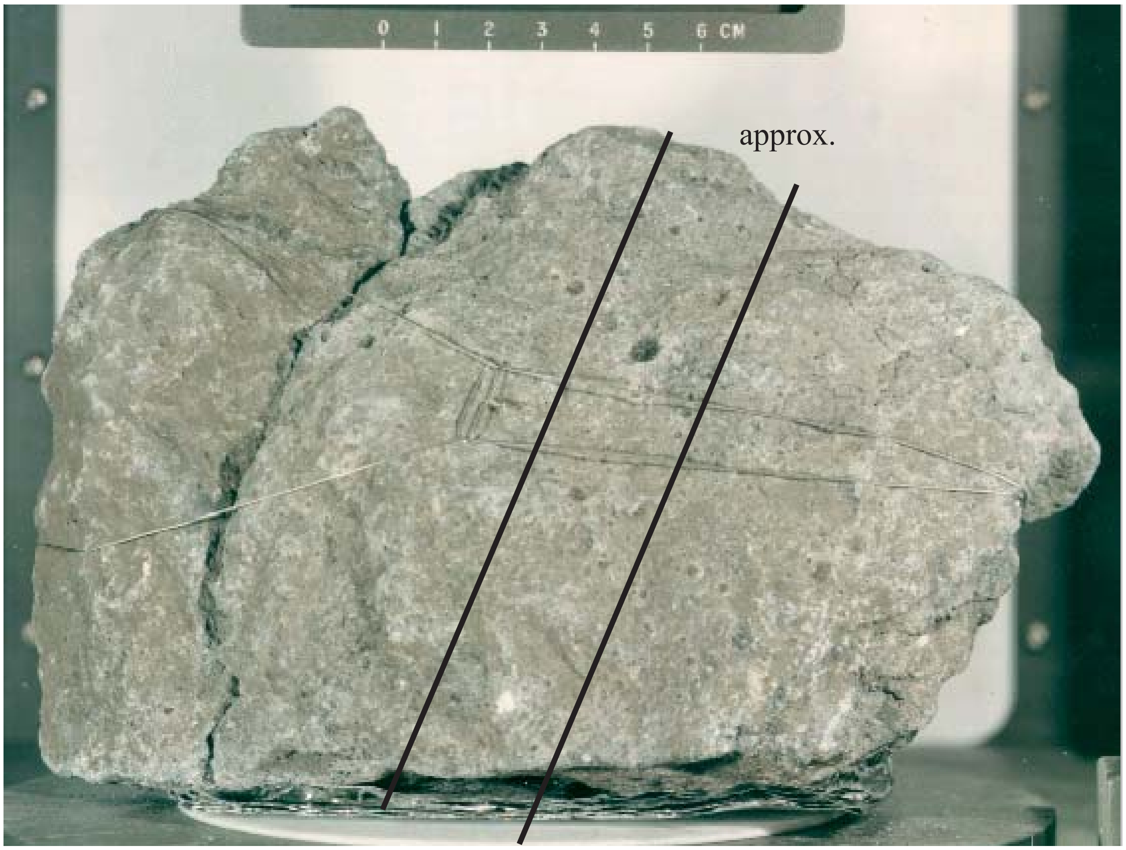



*Figure 167: NASA photo of 14305 with 14302 attached. # S71-31391. Scale at top is in cm.*

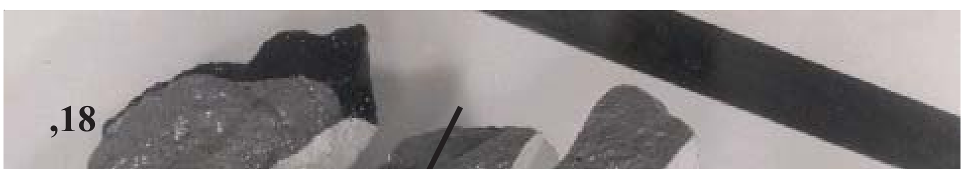
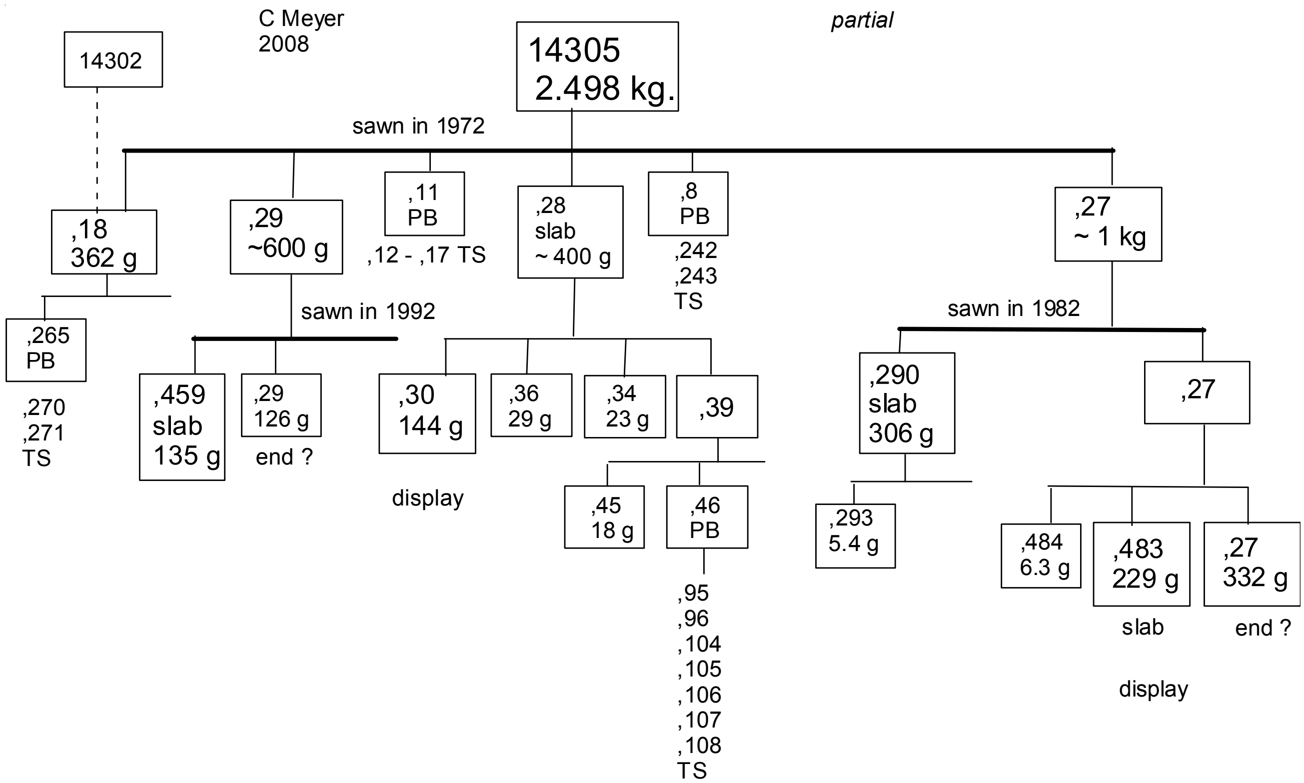



*Figure 18: Exploded parts diagram for 14305 and 14302 (now called 14305,18)*



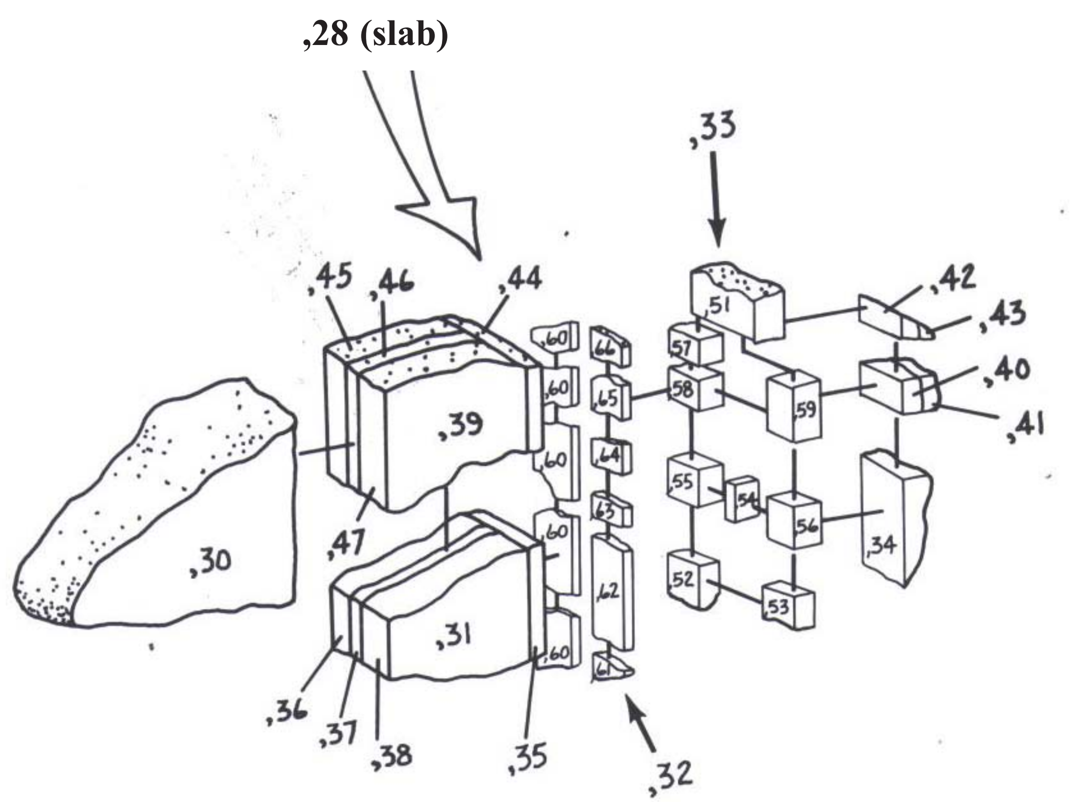




*Figure 19: Exploded parts diagram for first slab.*


*Figure 20: Sawn interior surface of 14305,30 (display piece) illustrating dark microbreccia clasts in light matrix. Cube is 1 inch. NASA photo #S77-21471.*

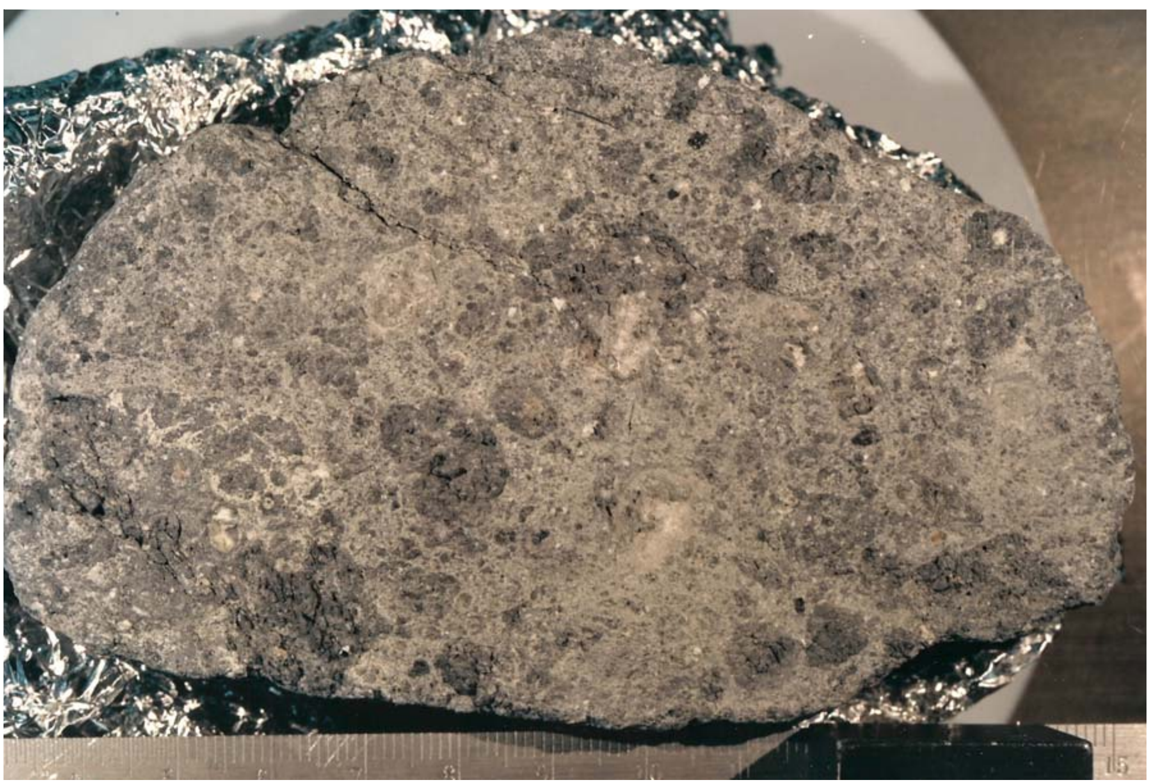


*Figure 21: Interior surface of 14305,459. Scale is in cm. no number*

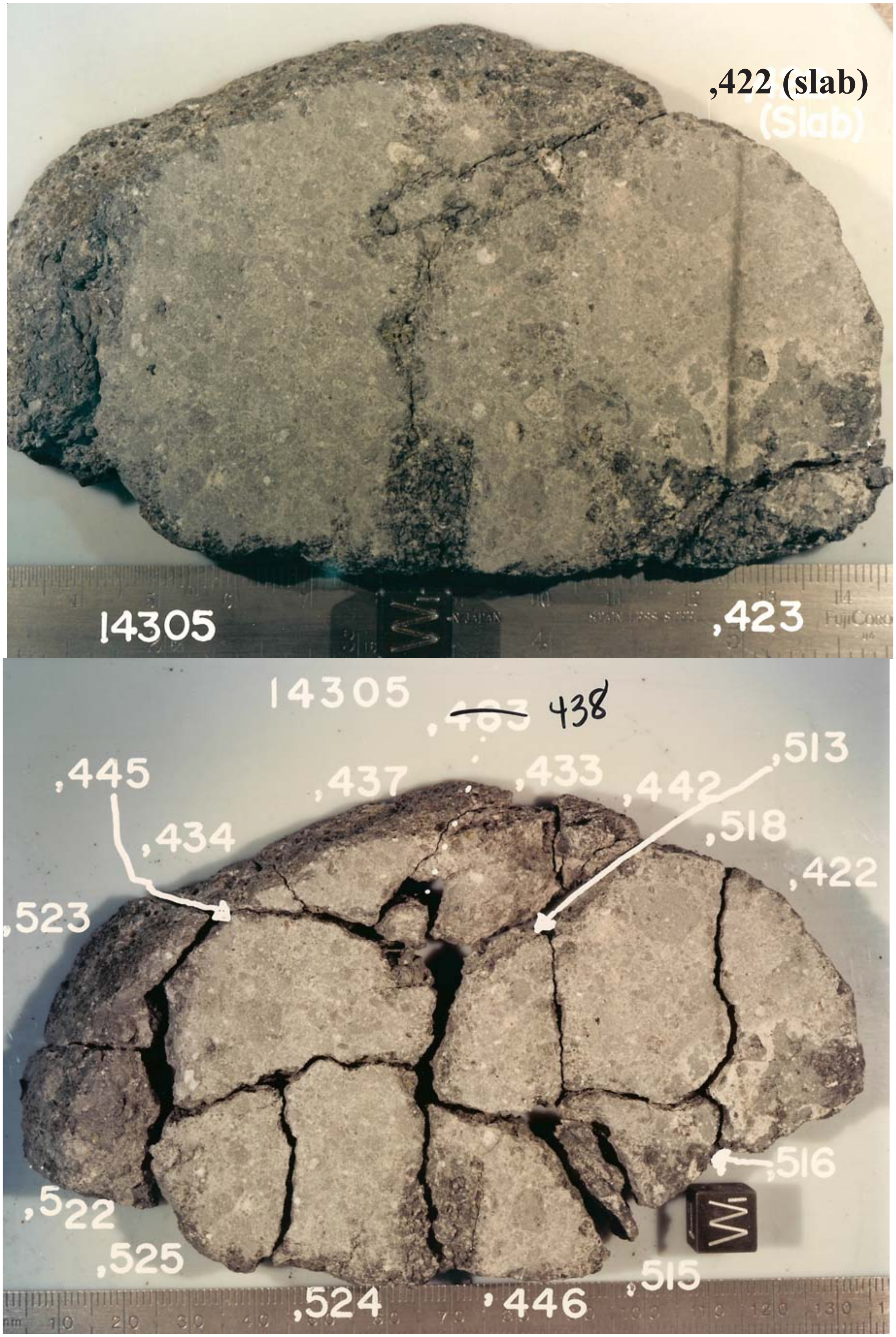


*Figure 22: Photos of slab 14305,422 before and after processing. Cube is 1 cm. NASA S85-38255 and S87-29851.*

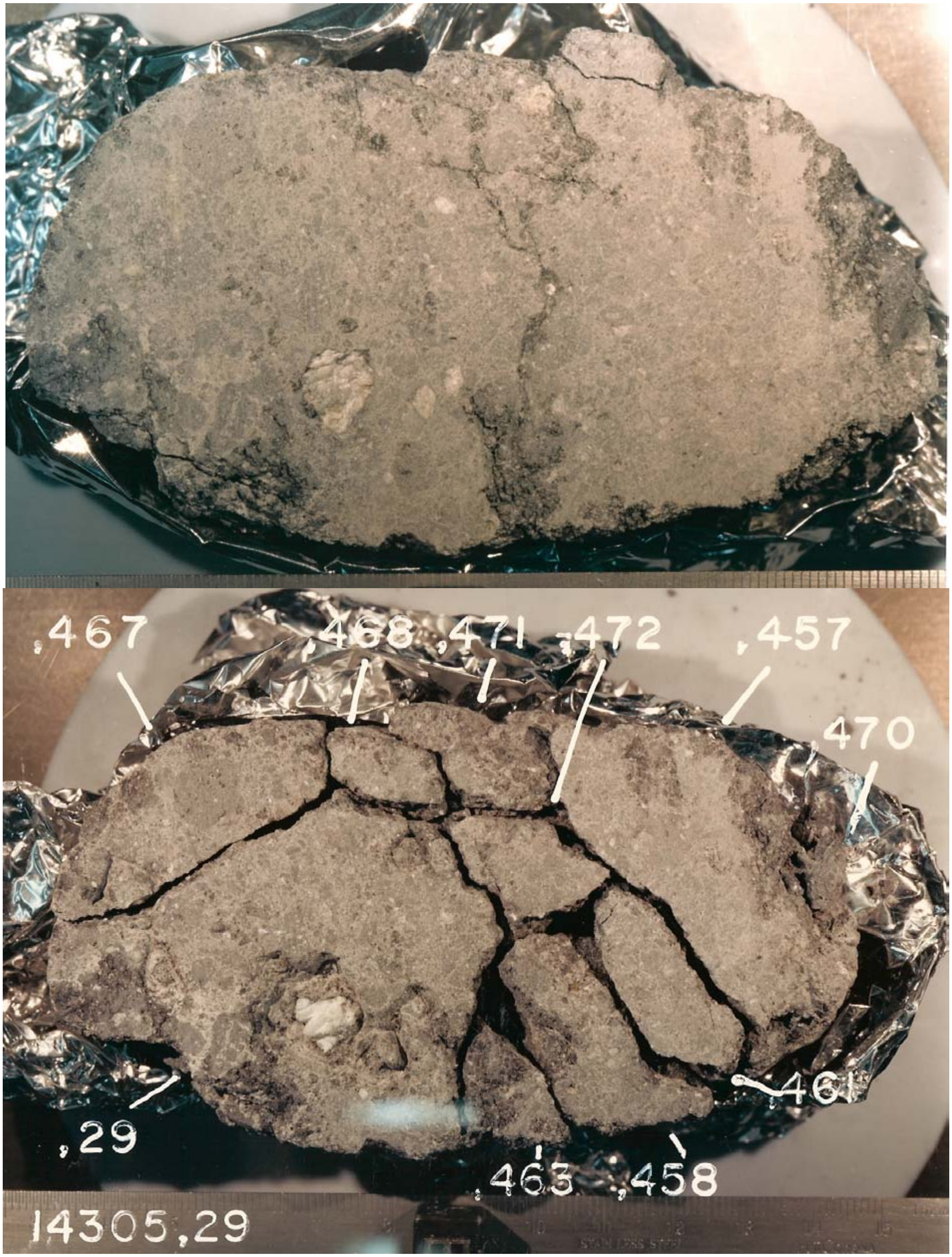



*Figure 23: Photo of end piece 14305,29 showing processing chips. Scale is 1 cm. NASA S85-38259 and 39002.*


*Figure 24: Sawn surface of slab 14305,483. Cube is 1 cm. NASA photo S86-25842.*


*Figure 25: Sawn surface of 14305,27 (end piece). Scale bar in cm. NASA S86-25845.*

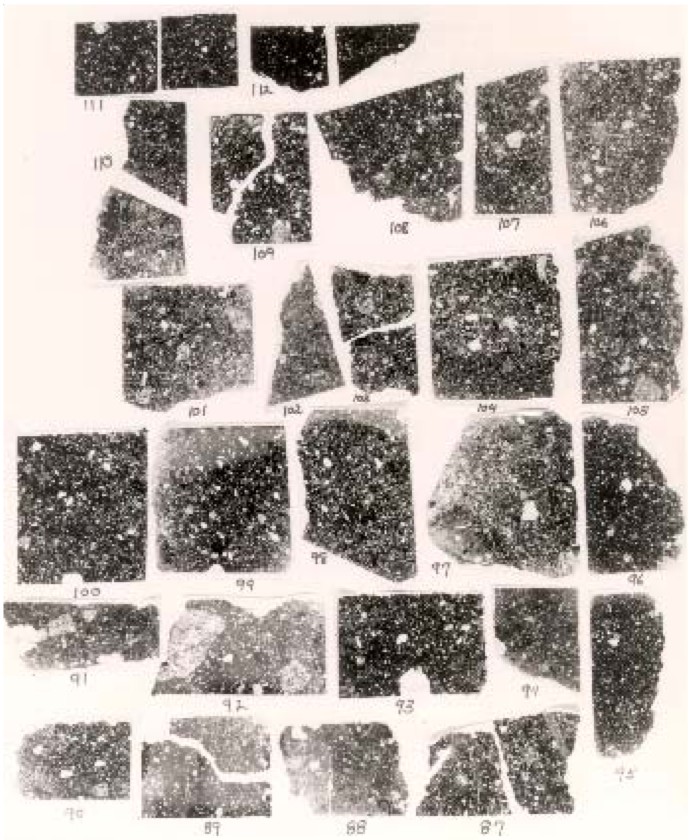


*Figure 26: Numerous thin section of 14305. Note the large basalt clast in ,92. Each section is about 2 cm across.*

| **Partial List of** | **Photo #s for 14305** |
|---|---|
| S71-31391-9 | color mug shots |
| S75-33045 | ,29 sawn surface |
| S85-39002 | ,29 processing |
| S77-21470-3 | ,30 |
| S77-21474-5 | ,18 |
| S77-21476 | ,27 sawn surface |
| S83-34589 | |
| S85-38259 | ,29 end |
| S85-38255 | ,422 slab |
| S86-25842 | ,483 slab |
| S86-25845 | ,27 end |
| S86-30442 | ,290 slab |
| S87-29851 | ,438 slab |

Clast correlations for 14305

| | from | size mm | analyses | duplicate | thin section | age | authors |
|---|---|---|---|---|---|---|---|
| c1 | ,18 | 7 x 5 | ,264 | | ,268 | | Warren 80 |
| c2 | | 6 x 5 | ,283 | ,303 | | | Warren 83 |
| c3 | ,27 | 7 x 6 | ,279 | ,301 | | | Warren 83 |
| w1 | ,29 | 8 x 3 | | | ,394 | | Shervais 84 |
| w3 | ,29 | 2 x 1.5 | | | ,396 | | Shervais 84 |
| w6 | ,27 | 9 x 5 | ,358 | ,317 | ,377 ,347 | | Shervais 83, 84 |
| w7 | ,27 | 6 x 4 | ,361 | ,322 | ,362 ,320 | | Shervais 83, 84 |
| ,400 | ,51 | 10 x 5 | ,400 | | ,412 | | Shervais 84 |
| M1 | ,29E | 4 x 3 | ,389 | | ,405 | | Shervais 84 |
| ,122 | ,92 | | | | ,92 | | Taylor 83 |
| M1 | ,18 | | ,304 | ,370 | ,343 ,344 | ,371 | Shervais 85, Shih 85 |
| M2 | ,18 | | ,385 | ,384 | ,383 | | Shervais 85 |
| M3 | ,18 | | ,382 | | ,388 | | Shervais 85 |
| M11 | ,27 | | ,373 | | ,380 | | Shervais 85 |
| ,390 | | | ,390 | | ,393 | | Shervais 85 |
| ,367 | | | ,367 | | | | Shervais 85 |

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