



**67627** – 80 grams

**67629** – 5.4 grams

**67695** – 14 grams

**67696** – 7.8 grams

**67697** – 5.5 grams

Vesicular Glass with white inclusions

Figure 1: Photo of 67695. S80-30292

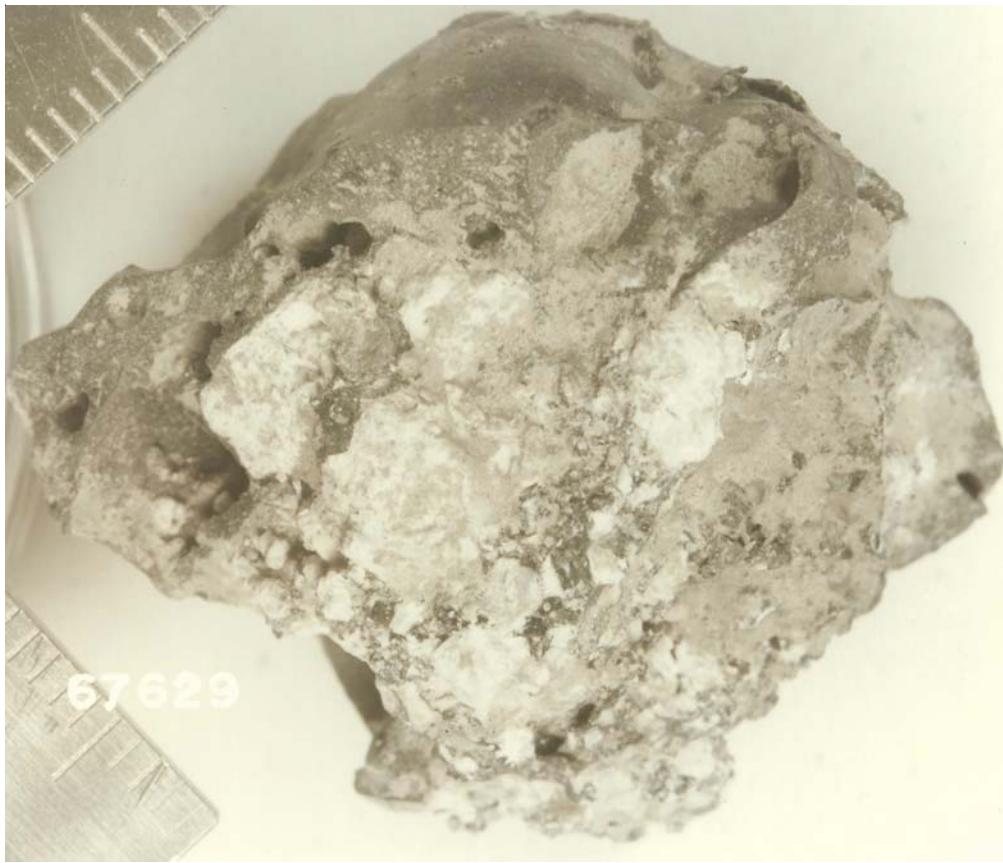


Figure 2: Photo of 67629 before it was renumbered. S72-51239

### Introduction

67627 and 67629 are glass-cemented aggregates that were collected as rake samples from the regolith just inside the rim of North Ray Crater – see section on 67601 and figure 6. They include numerous white feldspathic particles. The exposure age of these glass particles is about that of NRC.



Figure 3: Photo of 67696. S80-35153

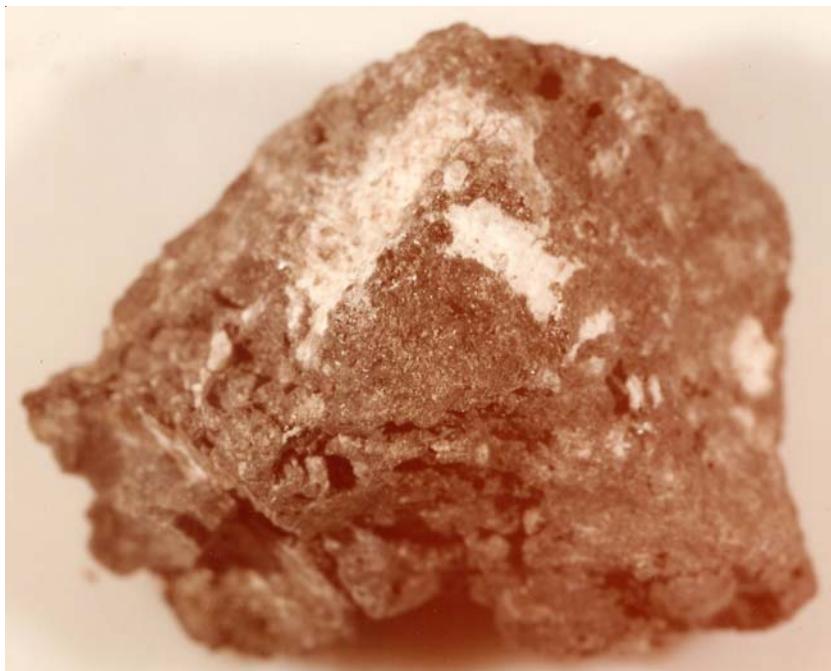


Figure 4: Photo of 67697. Sample is 2 cm. S80-35160

### Petrography

Borchardt et al. (1985) and Stoffler et al. (1985) carefully studied glass particles from North Ray Crater and correctly labeled these particles “glass bombs”. They have smooth exterior surfaces and are often devitrified in the interior. Plagioclase microlites, in various configurations, are prominent. Numerous plagioclase-rich inclusions (figure 11-13).

### Chemistry

Haskin et al. (1973), Wiesmann and Hubbard (1975), Stoffler et al. (1985) and Borchardt et al. (1985) determined the composition of these particles – there were no surprises (figure 10).



Figure 5: Processing photo of 67627. Cube is 1 cm. S96-01615

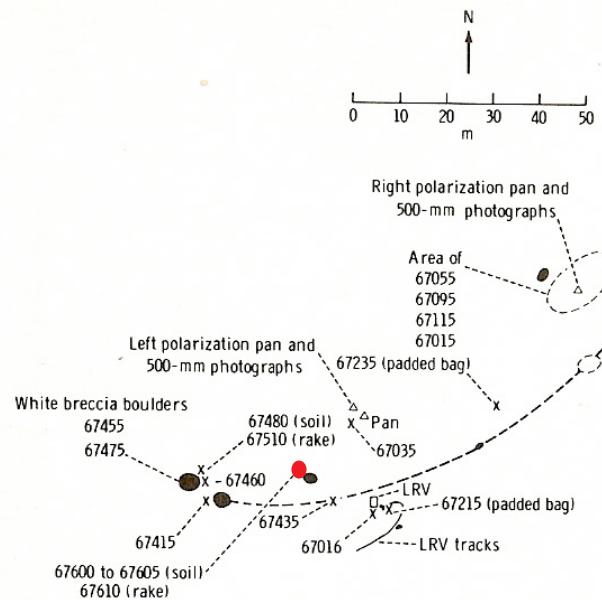


Figure 6: Map of south rim of North RayCrater.

### Radiogenic age dating

Borchardt et al. (1986) reported Ar/Ar ages of 1.19 b.y. for 67627 and 1.41 b.y. for 67629. A clast in 67627 was 3.63 b.y. old (figure 9).

### Cosmogenic isotopes and exposure ages

Borchardt et al. (1986) determined the  $^{38}\text{Ar}$  exposure age of 67627 to be 40 or 44 m.y., and 43 m.y. for 67629. This about the age of NRC.

### Processing

67627 was broken into several pieces (figure 5). 67629 was originally 4 pieces, which have since been relabeled 67629, 67695, 67696 and 67697 (figures 1 – 4 and 11 - 13). There are 6 thin sections of 67629.

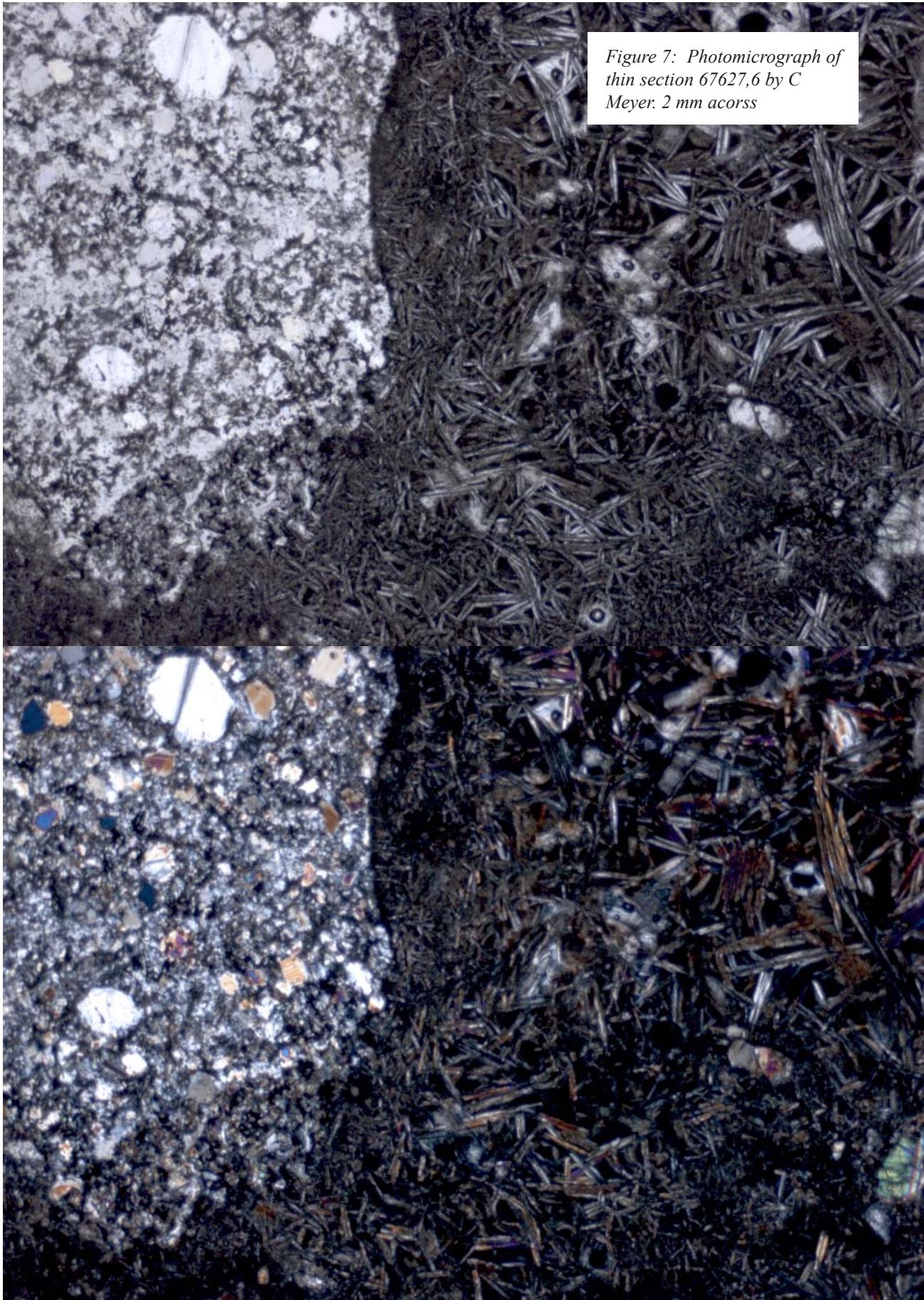


Figure 7: Photomicrograph of thin section 67627, 6 by C Meyer. 2 mm across

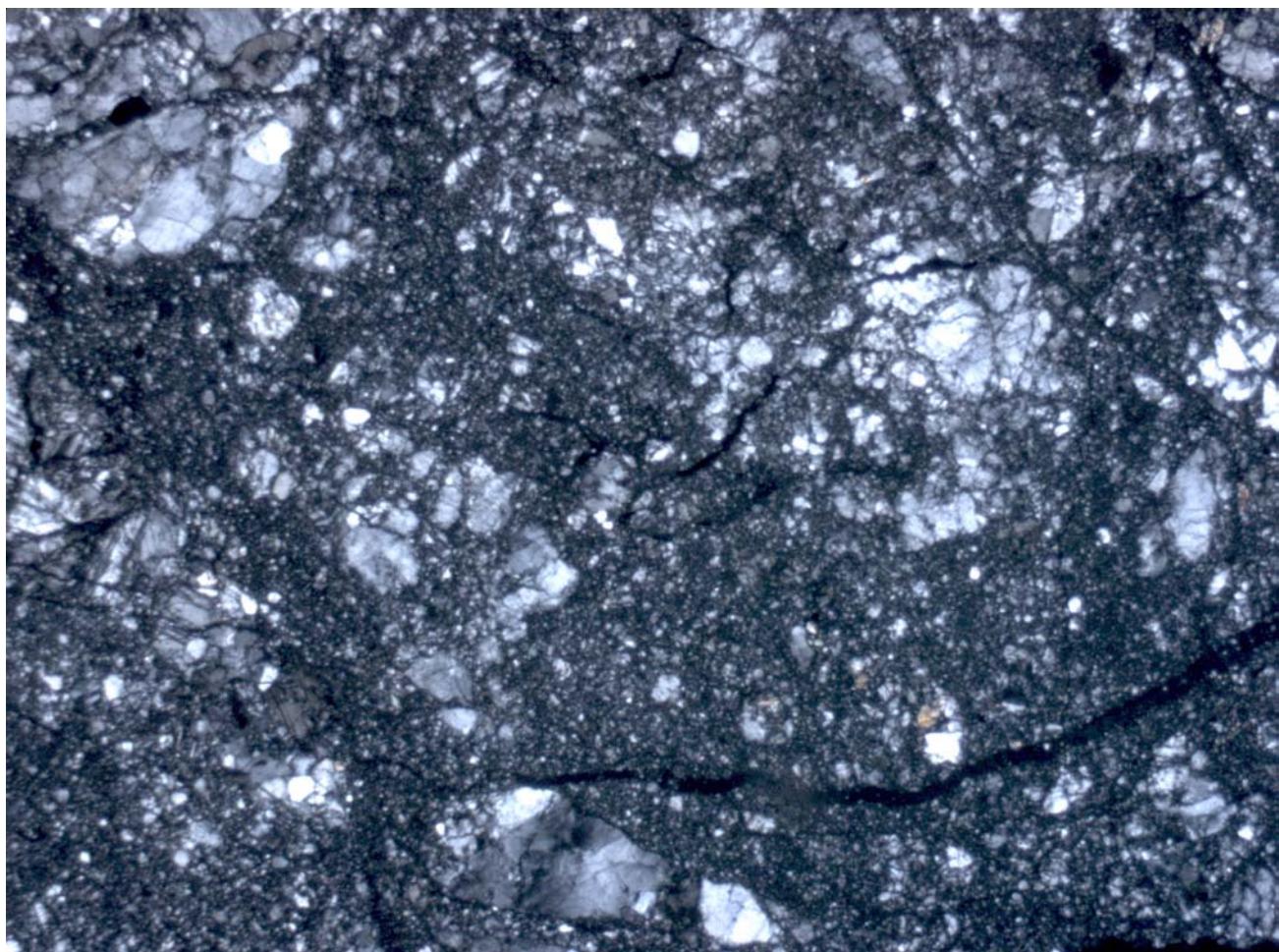


Figure 8: Photomicrograph of thin section of 67629 by C Meyer - corssed-nicols. 2 mm across

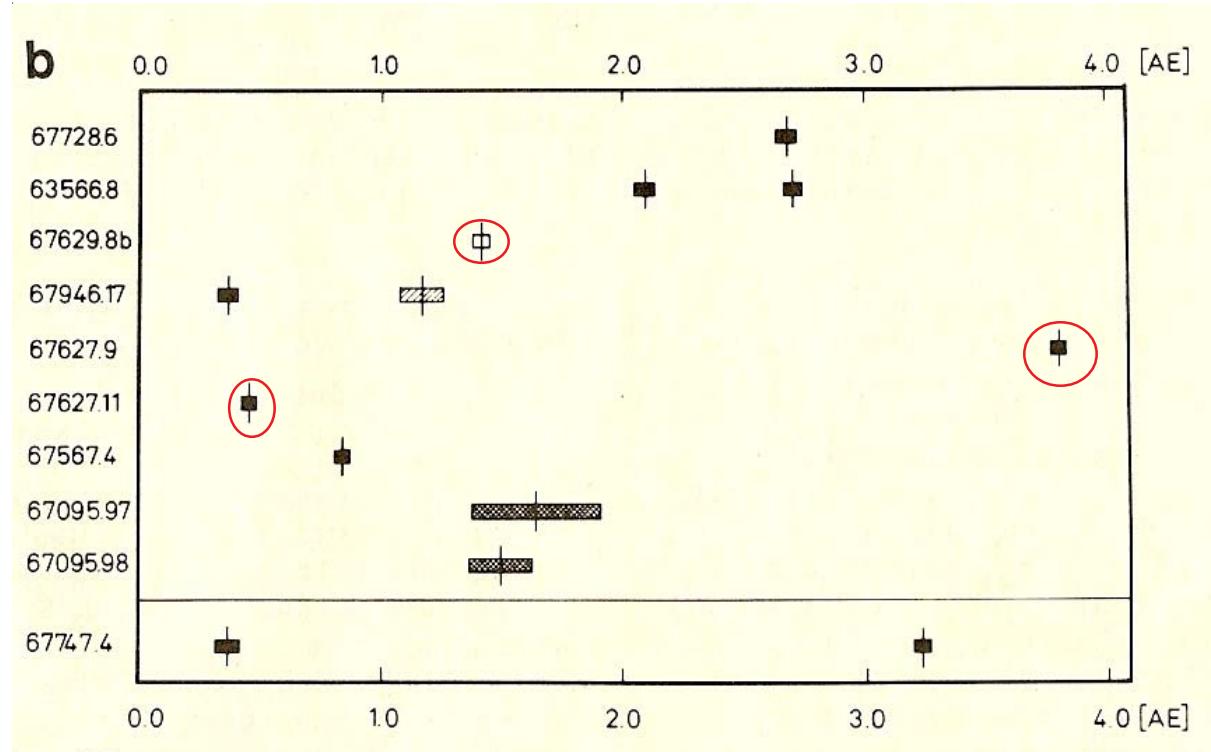
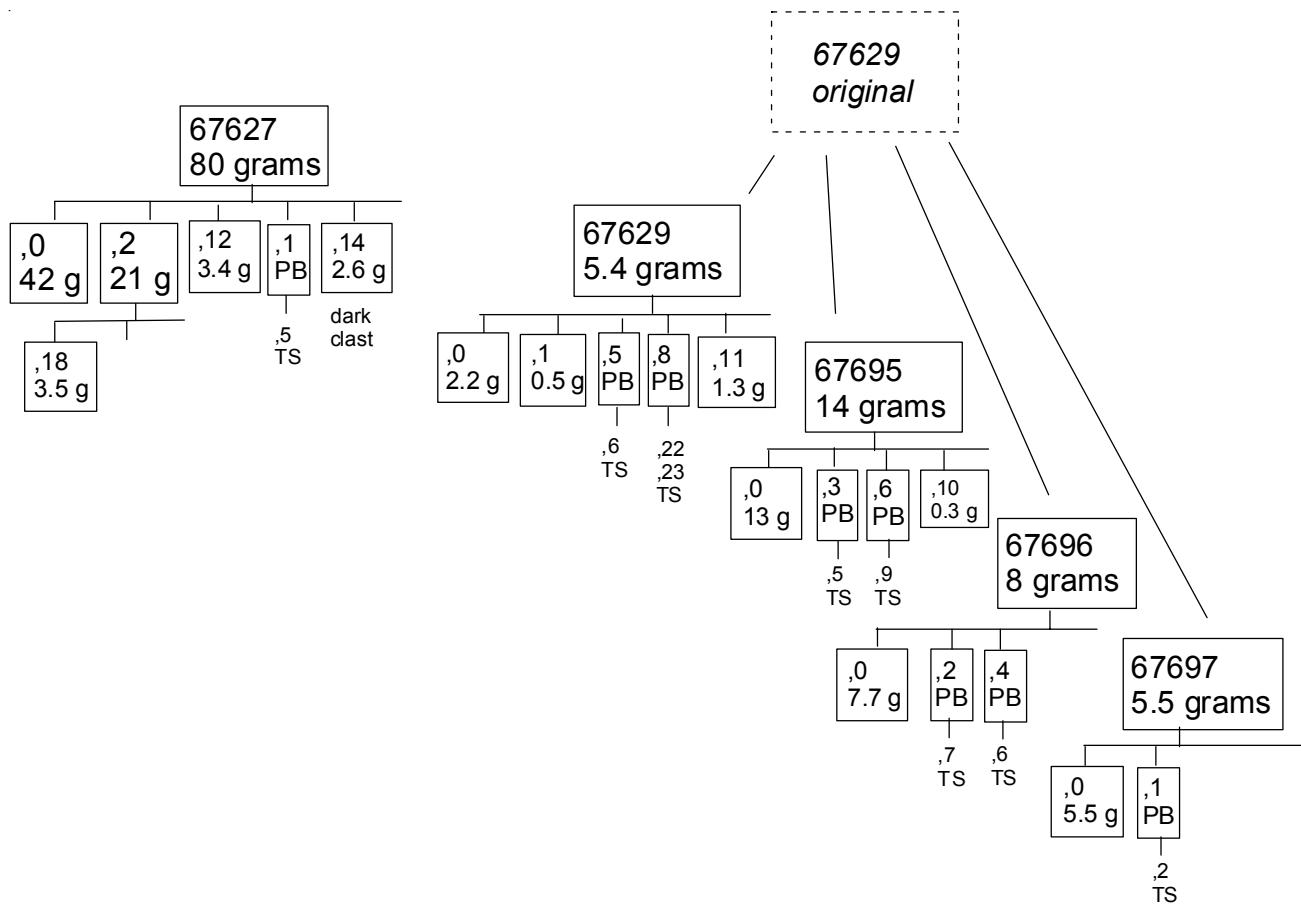


Figure 9: Ar/Ar ages of glass particles from rake samples at NRC (Stoffler et al. 1985).



**Table 1. Chemical composition of 67627**

| reference                      | Borchardt86 | Borchardt86 |          |
|--------------------------------|-------------|-------------|----------|
| weight                         |             | Stoffler85  |          |
| SiO <sub>2</sub> %             |             | 43.6        | (b)      |
| TiO <sub>2</sub>               | 0.58        | (a) 0.64    | (b)      |
| Al <sub>2</sub> O <sub>3</sub> |             | 28.2        | (b)      |
| FeO                            | 5.5         | 6.9         | (a) 4.1  |
| MnO                            |             | 0.03        | (b)      |
| MgO                            |             | 4.8         | (b)      |
| CaO                            | 13.2        | 14.1        | (a) 15.9 |
| Na <sub>2</sub> O              | 0.5         | 0.57        | (a) 0.61 |
| K <sub>2</sub> O               | 0.16        | 0.17        | (a) 0.14 |
| P <sub>2</sub> O <sub>5</sub>  |             |             | 0.05 (b) |
| S %                            |             |             |          |
| sum                            |             |             |          |
| Sc ppm                         | 10.2        | 10.2        | (a)      |
| V                              |             |             |          |
| Cr                             | 960         | 856         | (a)      |
| Co                             | 9           | 58          | (a)      |
| Ni                             | 71          | 940         | (a)      |
| Cu                             |             |             |          |
| Zn                             | 15          | 17          | (a)      |
| Ga                             | 3.82        | 5.23        | (a)      |
| Ge ppb                         |             |             |          |
| As                             |             | 0.27        | (a)      |
| Se                             |             |             |          |
| Rb                             |             | 6           | (a)      |
| Sr                             | 168         | 220         | (a)      |
| Y                              |             |             |          |
| Zr                             | 267         | 218         | (a)      |
| Nb                             |             |             |          |
| Mo                             |             |             |          |
| Ru                             |             |             |          |
| Rh                             |             |             |          |
| Pd ppb                         |             |             |          |
| Ag ppb                         |             |             |          |
| Cd ppb                         |             |             |          |
| In ppb                         |             |             |          |
| Sn ppb                         |             |             |          |
| Sb ppb                         |             |             |          |
| Te ppb                         |             |             |          |
| Cs ppm                         | 0.23        | 0.26        | (a)      |
| Ba                             | 210         | 170         | (a)      |
| La                             | 31.5        | 25.1        | (a)      |
| Ce                             | 50          | 42.8        | (a)      |
| Pr                             | 7.6         | 5.5         | (a)      |
| Nd                             | 31.5        | 25.1        | (a)      |
| Sm                             | 8.64        | 7.14        | (a)      |
| Eu                             | 1.32        | 1.34        | (a)      |
| Gd                             | 10.7        | 9.1         | (a)      |
| Tb                             | 1.79        | 1.5         | (a)      |
| Dy                             | 11.2        | 9.75        | (a)      |
| Ho                             | 2.48        | 2.11        | (a)      |
| Er                             | 6.3         | 5.8         | (a)      |
| Tm                             | 0.93        | 0.85        | (a)      |
| Yb                             | 6.26        | 5.38        | (a)      |
| Lu                             | 0.852       | 0.712       | (a)      |
| Hf                             | 6.72        | 5.54        | (a)      |
| Ta                             | 0.844       | 0.72        | (a)      |
| W ppb                          | 0.52        | 0.48        | (a)      |
| Re ppb                         |             |             |          |
| Os ppb                         |             |             |          |
| Ir ppb                         | 2           | 18          | (a)      |
| Pt ppb                         |             |             |          |
| Au ppb                         | 1           | 18.2        | (a)      |
| Th ppm                         | 2.98        | 2.37        | (a)      |
| U ppm                          | 0.86        | 0.74        | (a)      |

technique: (a) INAA+RNAA, (b) broad beam e probe

**Table 2. Chemical composition of 67629.**

| reference                      | Wiesmann76 | Haskin73  | Bourchardt86 | Stoffler85 | Bourchardt86          |
|--------------------------------|------------|-----------|--------------|------------|-----------------------|
| weight                         |            |           |              |            |                       |
| SiO <sub>2</sub> %             |            | 46.3      | (b)          | 44.4       | (d)                   |
| TiO <sub>2</sub>               |            | 0.85      | (b)          | 0.88       | (c) 0.44              |
| Al <sub>2</sub> O <sub>3</sub> |            | 24        | (b)          | 25.9       | (d)                   |
| FeO                            |            | 5.29      | (b)          | 5.24       | (c) 5.6               |
| MnO                            |            | 0.067     | (b)          | 0.09       | (d)                   |
| MgO                            |            | 5.94      | (b)          | 5.14       | (c) 6.5               |
| CaO                            |            | 15.2      | (b)          | 15.54      | (c) 15.1              |
| Na <sub>2</sub> O              |            | 0.62      | (b)          | 0.6        | (c) 0.51              |
| K <sub>2</sub> O               | 0.13       | (a) 0.137 | (b)          | 0.125      | (c) 0.08              |
| P <sub>2</sub> O <sub>5</sub>  |            |           |              |            | 0.03 (d)              |
| S %                            |            |           |              |            |                       |
| sum                            |            |           |              |            |                       |
| Sc ppm                         |            | 9.4       | (c)          | 9.28       | (c)                   |
| V                              |            |           |              |            |                       |
| Cr                             |            | 730       | (c)          | 674        | (c)                   |
| Co                             |            | 23.8      | (c)          | 24         | (c)                   |
| Ni                             |            | 350       | (c)          | 314        | (c)                   |
| Cu                             |            |           |              |            |                       |
| Zn                             |            | 11        | (c)          |            |                       |
| Ga                             |            | 4.08      | (c)          | 4.03       | (c)                   |
| Ge ppb                         |            |           |              |            |                       |
| As                             |            |           |              |            |                       |
| Se                             |            |           |              |            |                       |
| Rb                             |            | 2.88      | (a)          | 3.1        | (c) 3.8               |
| Sr                             |            | 185       | (a)          | 185        | (c)                   |
| Y                              |            |           | (a)          |            |                       |
| Zr                             |            | 161       | (a)          | 160        | (c)                   |
| Nb                             |            |           |              |            |                       |
| Mo                             |            |           |              |            |                       |
| Ru                             |            |           |              |            |                       |
| Rh                             |            |           |              |            |                       |
| Pd ppb                         |            |           |              |            |                       |
| Ag ppb                         |            |           |              |            |                       |
| Cd ppb                         |            |           |              |            |                       |
| In ppb                         |            |           |              |            |                       |
| Sn ppb                         |            |           |              |            |                       |
| Sb ppb                         |            |           |              |            |                       |
| Te ppb                         |            |           |              |            |                       |
| Cs ppm                         | 0.23       | 0.26      | (a)          | 0.13       | (c) 0.18              |
| Ba                             | 210        | 170       | (a)          | 129        | (a) 135               |
| La                             | 31.5       | 25.1      | (a)          | 11.6       | (a) 11.9              |
| Ce                             | 50         | 42.8      | (a)          | 29.2       | (a) 31.4              |
| Pr                             | 7.6        | 5.5       | (a)          |            | 4 (c)                 |
| Nd                             | 31.5       | 25.1      | (a)          | 20         | (a) 19 (c) 20.2       |
| Sm                             | 8.64       | 7.14      | (a)          | 5.29       | (a) 5.4 (c) 5.54      |
| Eu                             | 1.32       | 1.34      | (a)          | 1.3        | (a) 1.28 (c) 1.3 (c)  |
| Gd                             | 10.7       | 9.1       | (a)          | 7.23       | (a) 7 (c) 7.3 (c)     |
| Tb                             | 1.79       | 1.5       | (a)          |            | 1.08 (c) 1.15 (c)     |
| Dy                             | 11.2       | 9.75      | (a)          | 7.08       | (a) 7.2 (c) 7.3 (c)   |
| Ho                             | 2.48       | 2.11      | (a)          |            | 1.54 (c) 1.6 (c)      |
| Er                             | 6.3        | 5.8       | (a)          | 4.2        | (a) 4.1 (c) 4.2 (c)   |
| Tm                             | 0.93       | 0.85      | (a)          |            | 0.61 (c)              |
| Yb                             | 6.26       | 5.38      | (a)          | 3.85       | (a) 3.74 (c) 3.94 (c) |
| Lu                             | 0.852      | 0.712     | (a)          | 0.526      | (a) 0.55 (c) 0.55 (c) |
| Hf                             | 6.72       | 5.54      | (a)          |            | 4.15 (c)              |
| Ta                             | 0.844      | 0.72      | (a)          |            | 0.53 (c)              |
| W ppb                          | 0.52       | 0.48      | (a)          |            |                       |
| Re ppb                         |            |           |              |            |                       |
| Os ppb                         |            |           |              |            |                       |
| Ir ppb                         | 2          | 18        | (a)          |            | 12.3                  |
| Pt ppb                         |            |           |              |            |                       |
| Au ppb                         | 1          | 18.2      | (a)          |            | 4.3                   |
| Th ppm                         | 2.98       | 2.37      | (a)          |            | 1.81 (c)              |
| U ppm                          | 0.86       | 0.74      | (a)          |            | 0.54 (c)              |

technique: (a) IDMS, (b) AA, (c) INAA, (d) broad beam e probe

**Table 3. Chemical composition of 67695**

| reference                      | Borchardt86                       | Stoffler85  | Morris86 | See 86                 | clast |
|--------------------------------|-----------------------------------|-------------|----------|------------------------|-------|
| <i>weight</i>                  |                                   | Borchardt86 | See 86   |                        |       |
| SiO <sub>2</sub> %             |                                   | 43.4        | 43       | (b) 44.95<br>(a) 44.37 | (b)   |
| TiO <sub>2</sub>               |                                   | 0.32        | 0.31     | (b) 0.26<br>(a) 0.01   | (b)   |
| Al <sub>2</sub> O <sub>3</sub> |                                   | 25.5        | 24.2     | (b) 26.52<br>(a) 35.5  | (b)   |
| FeO                            | 6.4                               | (a) 6.2     | 7.3      | (b) 5.85<br>(a) 0.15   | (b)   |
| MnO                            |                                   | 0.09        | 0.12     | (b)                    | 0.06  |
| MgO                            |                                   | 7.5         | 9        | (b) 7.31<br>(a) 4.09   | (b)   |
| CaO                            | 14.3                              | (a) 14.5    | 14       | (b) 14.72<br>(a) 16.7  | (b)   |
| Na <sub>2</sub> O              | 0.51                              | (a) 0.5     | 0.55     | (b) 0.57<br>(a) 0.42   | (b)   |
| K <sub>2</sub> O               |                                   | 0.11        | 0.1      | (b) 0.08<br>(a) 0.13   | (b)   |
| P <sub>2</sub> O <sub>5</sub>  |                                   | 0.06        | 0.03     | (b)                    |       |
| S %                            |                                   |             |          |                        |       |
| <i>sum</i>                     |                                   |             |          |                        |       |
| Sc ppm                         | 5.82                              | (a)         |          | 5.47                   | (a)   |
| V                              |                                   |             |          |                        |       |
| Cr                             | 950                               | (a)         |          | 772                    | (a)   |
| Co                             | 72.3                              | (a)         |          | 59                     | (a)   |
| Ni                             | 1380                              | (a)         |          | 1091                   | (a)   |
| Cu                             |                                   |             |          |                        |       |
| Zn                             | 18                                | (a)         |          |                        |       |
| Ga                             |                                   |             |          |                        |       |
| Ge ppb                         |                                   |             |          |                        |       |
| As                             |                                   |             |          |                        |       |
| Se                             |                                   |             |          |                        |       |
| Rb                             |                                   |             |          |                        |       |
| Sr                             | 140                               | (a)         |          |                        |       |
| Y                              |                                   |             |          |                        |       |
| Zr                             |                                   |             |          |                        |       |
| Nb                             |                                   |             |          |                        |       |
| Mo                             |                                   |             |          |                        |       |
| Ru                             |                                   |             |          |                        |       |
| Rh                             |                                   |             |          |                        |       |
| Pd ppb                         |                                   |             |          |                        |       |
| Ag ppb                         |                                   |             |          |                        |       |
| Cd ppb                         |                                   |             |          |                        |       |
| In ppb                         |                                   |             |          |                        |       |
| Sn ppb                         |                                   |             |          |                        |       |
| Sb ppb                         |                                   |             |          |                        |       |
| Te ppb                         |                                   |             |          |                        |       |
| Cs ppm                         | 0.18                              | (a)         |          |                        |       |
| Ba                             | 100                               | (a)         | 89       | (a)                    |       |
| La                             | 8.57                              | (a)         | 6.85     | (a)                    |       |
| Ce                             | 25                                | (a)         | 20.1     | (a)                    |       |
| Pr                             |                                   |             |          |                        |       |
| Nd                             | 12                                | (a)         |          |                        |       |
| Sm                             | 3.92                              | (a)         | 3.07     | (a)                    |       |
| Eu                             | 0.95                              | (a)         | 1.11     | (a)                    |       |
| Gd                             |                                   |             |          |                        |       |
| Tb                             | 0.79                              | (a)         | 0.8      | (a)                    |       |
| Dy                             | 4.8                               | (a)         |          |                        |       |
| Ho                             | 1.04                              | (a)         |          |                        |       |
| Er                             |                                   |             |          |                        |       |
| Tm                             |                                   |             |          |                        |       |
| Yb                             | 2.75                              | (a)         | 2.21     | (a)                    |       |
| Lu                             | 0.38                              | (a)         | 0.29     | (a)                    |       |
| Hf                             | 2.96                              | (a)         | 2.67     | (a)                    |       |
| Ta                             | 0.33                              | (a)         | 0.45     | (a)                    |       |
| W ppb                          |                                   |             |          |                        |       |
| Re ppb                         |                                   |             |          |                        |       |
| Os ppb                         |                                   |             |          |                        |       |
| Ir ppb                         | 3.7                               | (a)         |          |                        |       |
| Pt ppb                         |                                   |             |          |                        |       |
| Au ppb                         | 1.7                               | (a)         |          |                        |       |
| Th ppm                         | 1.23                              | (a)         |          | 1.87<br>(a)            |       |
| U ppm                          | 0.38                              | (a)         |          | 0.5<br>(a)             |       |
| technique:                     | (a) INAA, (b) broad beam e. probe |             |          |                        |       |

### References for 67627 and 67629

Borchardt R., Stoffler D., Spettel B., Palme H., Wanke H., Wacker K. and Jessberger E.K. (1986) Composition, structure and age of the Apollo 16 subregolith basement as deduced from the chemistry of post-Imbrium melt bombs. *Proc. 17<sup>th</sup> Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* **90**, E43-E54.

Butler P. (1972a) Lunar Sample Information Catalog Apollo 16. Lunar Receiving Laboratory. MSC 03210 Curator's Catalog. pp. 370.

Deutsch A. and Stoffler D. (1987) Rb-Sr-analyses of Apollo 16 melt rocks and a new age estimate for the Imbrium basin: Lunar basin chronology and the early heavy bombardment of the moon. *Geochim. Cosmochim. Acta* **51**, 1951-1964.

Haskin L.A., Helmke P.A., Blanchard D.P., Jacobs J.W. and Telunder K. (1973) Major and trace element abundances in samples from the lunar highlands. *Proc. 4<sup>th</sup> Lunar Sci. Conf.* 1275-1296.

Head J.W. (1974b) Stratigraphy of the Descartes region (Apollo 16): Implications for the origin of samples. *The Moon* **11**, 77-99.

LSPET (1973b) The Apollo 16 lunar samples: Petrographic and chemical description. *Science* **179**, 23-34.

LSPET (1972c) Preliminary examination of lunar samples. In Apollo 16 Preliminary Science Report. NASA SP-315, 7-1—7-58.

Morris R.V., See T.H. and Horz F. (1986) Composition of the Cayley Formation at Apollo 16 as inferred from impact melt splashes. *Proc. 17<sup>th</sup> Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* **90**, E21-E42.

Reimold W.U., Nyquist L.E., Bansal B.M., Wooden J.L., Shih C.-Y., Wiesmann H. and Mackinnon I.D.R. (1985) Isotope analysis of crystalline impact-melt rocks from Apollo 16 stations 11 and 13. North Ray Crater. *Proc. 15<sup>th</sup> Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* **90**, C431-C448.

Ryder G. and Norman M.D. (1980) Catalog of Apollo 16 rocks (3 vol.). Curator's Office pub. #52, JSC #16904

See T.H., Horz F. and Morris R.V. (1986) Apollo 16 impact-melt splashes: Petrography and major-element composition. *Proc. 17<sup>th</sup> Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* **91**, E3-E20.

Smith J.V. and Steele I.M. (1972c) Apollo 16 rake samples 67515 to 68537: Sample classification, description and inventory. Curator Catalog, JSC

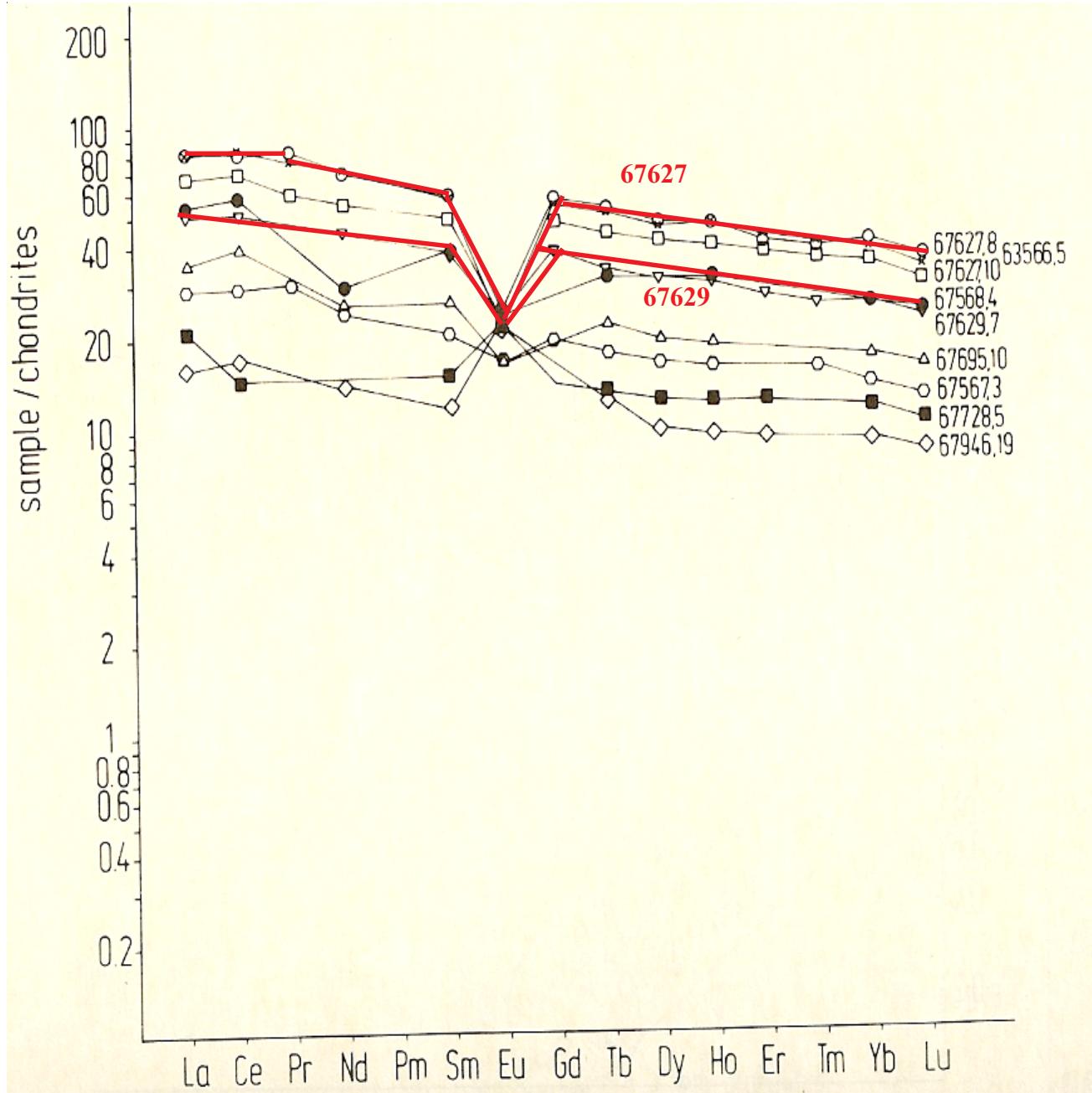


Figure 10: Normalized rare-earth-element diagram for glass-bearing samples from NRC (a la Stöffler et al. 1985)..

Stöffler D., Ostertag R., Reimold W.U., Borchardt R., Malley J. and Rehfeldt A. (1981) Distribution and provenance of lunar highland rock types at North Ray Crater, Apollo 16. *Proc. 12<sup>th</sup> Lunar Planet. Sci. Conf.* 185-207.

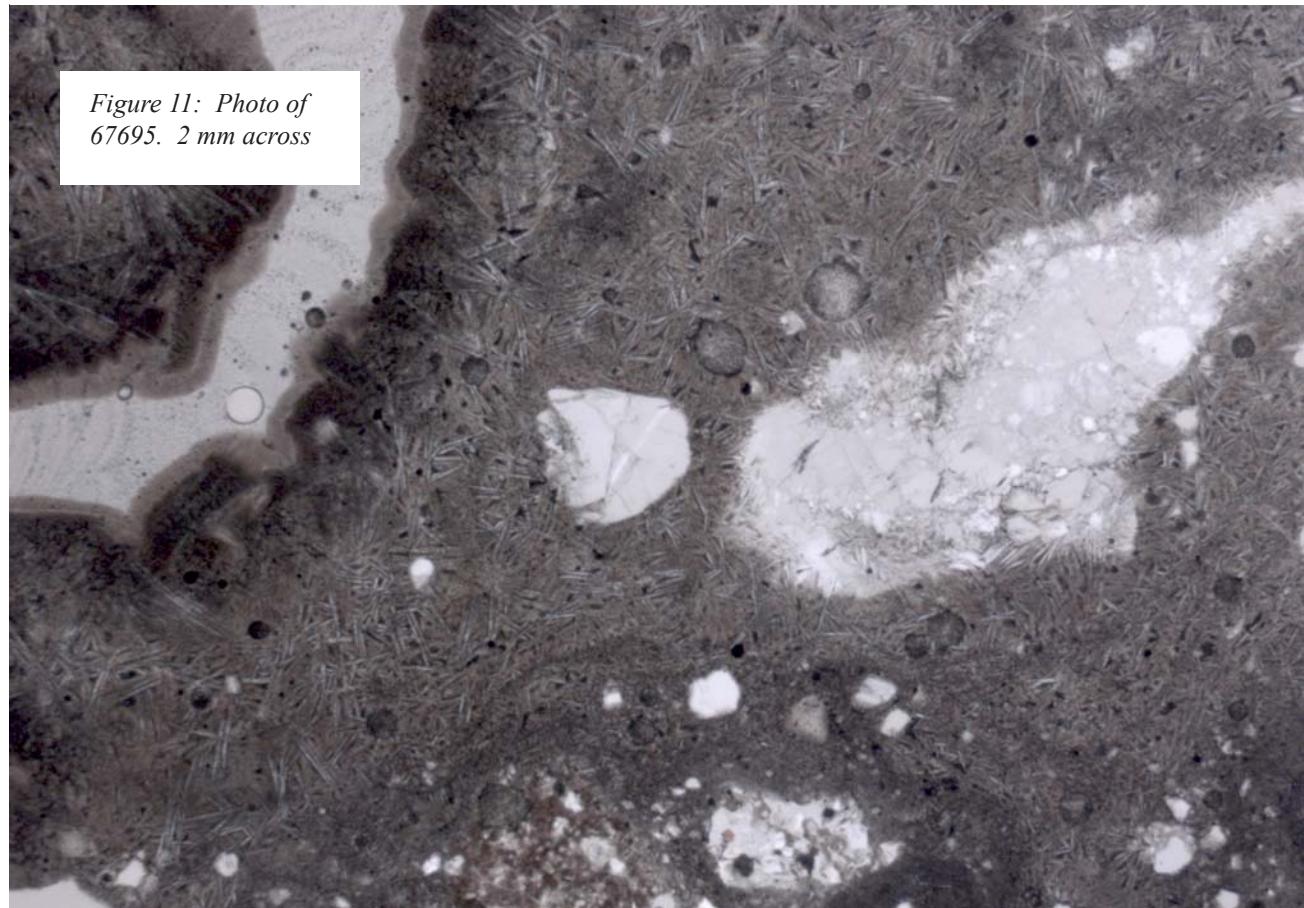
Stöffler D., Bischoff A., Borchardt R., Burghelle A., Deutsch A., Jessberger E.K., Ostertag R., Palme H., Spettel B., Reimold W.U., Wacker K. and Wanke H. (1985) Composition and evolution of the lunar crust in the Descartes

highlands. *Proc. 15<sup>th</sup> Lunar Planet. Sci. Conf.* in *J. Geophys. Res.* **90**, C449-C506.

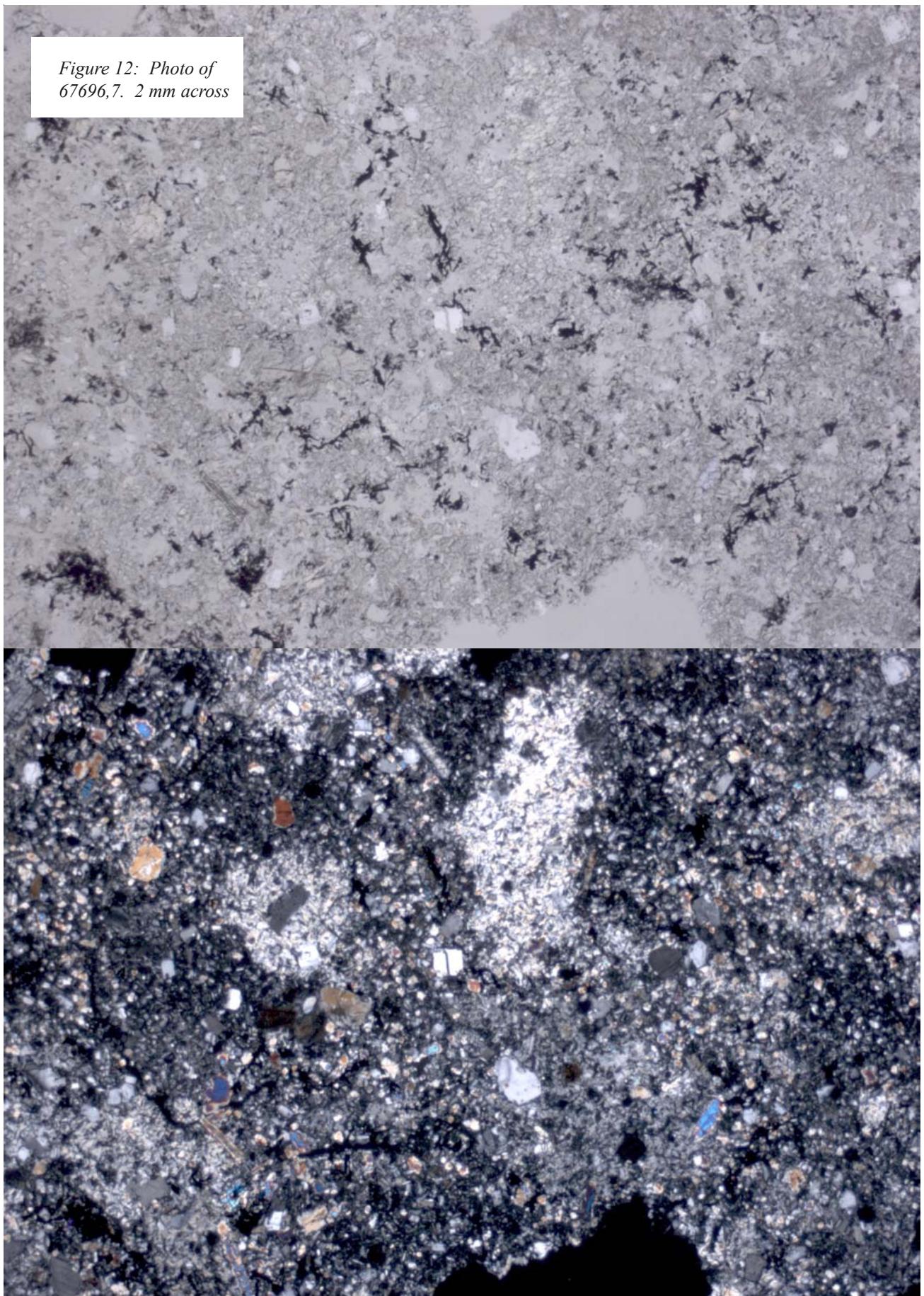
Sutton R.L. (1981) Documentation of Apollo 16 samples. In *Geology of the Apollo 16 area, central lunar highlands.* (Ulrich et al. ) U.S.G.S. Prof. Paper 1048.

Wiesmann H. and Hubbard N.J. (1975) A compilation of the Lunar Sample Data Generated by the Gast, Nyquist and Hubbard Lunar Sample PI-Ships. Unpublished. JSC

*Figure 11: Photo of  
67695. 2 mm across*



*Figure 12: Photo of  
67696,7. 2 mm across*



*Figure 13: Photos of  
67697,2. 2 mm across*

