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OCCURRENCE OF ANT FRAGMENTS IN LUNAR SOILS AND  
BRECCIAS: GUIDE TO POLISHED THIN SECTIONS

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## Introduction

This booklet is a listing of lithic clasts of ANT observed in polished thin sections of lunar material available in the Curator's collections at the Johnson Space Center during June and July, 1976. The term ANT was first used by Prinz et al. (1973) as an acronym for anorthosite - norite - troctolite rocks and types intermediate among them. Rocks of the ANT suite are generally compositionally and texturally distinct from most common lunar materials. Although a few large samples and many smaller clasts in breccias and fragments in the regolith belong to the ANT suite, this compilation is limited to smaller clasts and fragments identified in polished thin sections.

Most ANT rocks are much richer in plagioclase than are mare basalts or the common polymict breccias. True anorthosite, troctolitic and noritic anorthosite, and anorthositic norite and troctolite are abundant in the ANT suite which also includes troctolite, norite, and minor gabbro and dunite. The ANT suite includes coarse-grained, plutonic rocks with igneous textures or igneous textures modified by Apollonian metamorphism (Stewart, 1975). The thoroughly-studied, relatively large-sized ANT rocks of this group (some of which are clasts in breccias) are the population reviewed by Warren and Wasson (1977). They are important because many of them are probable vestiges of the initial lunar crust. Most ANT fragments (but relatively few large samples) have the granoblastic or poikiloblastic textures of metamorphic rocks (Bickel and Warner, 1978). The large samples of these "granulitic impactites" were reviewed by Warner et al. (1977). Most granulitic impactites originated as polymict breccias, but they are now much more thoroughly recrystallized and equilibrated than are the common lunar polymict breccias. We have speculated that most or all of the granulitic impactites recrystallized in early breccia sheets that predate the end of the lunar cataclysm at about 4.0 AE. (Warner et al., 1977).

Thus the ANT rocks are the most ancient of lunar materials. They are particularly important because they crystallized during that period of lunar history when the moon was the most active. Because these rocks are so important and they make up only a fraction of the lunar collection, it is desirable that eventually they be studied exhaustively. But many of the smaller ANT fragments in polymict breccias and the regolith have neither been studied nor identified.

As a first step toward producing a catalog of ANT fragments we conducted a survey of the Curator's thin section collection at the Johnson Space Center, Houston, Texas. The survey occurred during June and July, 1976, and thus only sections present at JSC during that time interval were examined. Sections from the following collections were searched:

1. The main Curator's collection of thin sections that have been allocated and returned or have never been allocated: Apollo 14, 15, 16, and 17.
2. The special Curator's library of one section from each rock that are not intended to be further allocated. All sections from Apollo 16 and 17 and Apollo 15 sections through 15072.
3. The Apollo 14 Comprehensive sample; sections were obtained from William C. Phinney and are now in the Curator's main collection.

All thin sections cut from polymict breccias, rake samples, or relatively coarse-grained soil separated were examined for fragments of ANT materials. The only sections that were not examined were cut from well known ANT rocks or from mare basalts. In general coarse-grained, plutonic fragments were listed if their sizes exceed 1.0 mm and fragments of granulitic impactites were listed if their sizes exceed 0.5 mm. Although technically they are lithic fragments, single grains of plagioclase with rare inclusions of mafic silicates were not listed because they cannot be adequately classified with respect to texture. Very-fine-grained or hypocrySTALLINE igneous-textured fragments that probably crystallized from impact melts were not listed, but some holocrystalline igneous-textured rocks with grain sizes well below 1 mm were listed even though many of them may contain an appreciable KREEP component and thus may not belong to the ANT suite. When there was doubt as to whether a fragment should be listed it was included.

The sections that contain ANT fragments are listed in the attached tables.

#### References Cited

- Bickel C.E. and Warner J.L. (1978) Survey of lunar plutonic and granulitic lithic fragments. Proc. Lunar Sci. Conf., 9th. In press.
- Prinz M., Dowty E., Keil K., and Bunch T.E. (1973) Mineralogy, petrology and chemistry of lithic fragments from Luna 20 fines: origin of the cumulate ANT suite and its relationship to high-alumina and mare basalts. Geochim. Cosmochim. Acta, 37, 979-1006.
- Stewart D.B. (1975) Apollonian metamorphic rocks (abstract). In Lunar Science VI, p. 774-776. The Lunar Science Institute, Houston.
- Warner J.L., Phinney W.C., Bickel C.E., and Simonds C.H. (1977) Feldspathic granulitic impactites and pre-final bombardment lunar evolution. Proc. Lunar Sci. Conf., 8th, p. 2051-2066.
- Warren P.H., and Wasson J.T. (1977) Pristine nonmare rocks and the nature of the lunar crust. Proc. Lunar Sci. Conf. 8th, p. 2215-2235.

## APOLLO 14

14063, 60	14166, 12
14066, 37 (2 grains)	14168, 13 (2 grains)
14066, 47	14171, 23
14066, 48	14173, 3
14068, 10 (2 grains)	14179, 3
14082, 11	14258, 2
14082, 46	14258, 11
14149, 66	14258, 47
14149, 68	14258, 48
14161, 50	14258, 59
14161, 66	14258, 75
14161, 77	14258, 78
14162, 77	14259, 100 (2 grains)
14162, 78	14259, 222
14162, 88	14259, 225
14162, 96 (2 grains)	14266, 4
14162, 112	14270, 9 (2 grains)
14162, 113	14274, 5
14163, 259	14275, 5
14163, 261	14279, 4
14163, 265	14283, 6
14163, 339	14301, 12

14301, 13		14311, 96	(2 grains)
14301, 76	(2 grains)	14312, 12	(2 grains)
14301, 78		14312, 17	
14301, 81	(3 grains)	14313, 6	
14303, 5	(2 grains)	14313, 39	
14303, 46	(3 grains)	14313, 41	
14303, 50	(several grains)	14313, 44	
14303, 51	(2 grains)	14313, 49	(2 grains)
14303, 55		14313, 58	
14303, 89		14314, 11	
14304, 2		14314, 12	
14304, 10		14314, 13	
14305, 2	(2 grains)	14318, 4	
14305, 88		14318, 10	
14305, 89		14318, 11	
14305, 93		14319, 119	(2 grains)
14305, 100	(2 grains)	14319, 4	
14305, 112	(2 grains)	14319, 5	
14306, 68		14319, 16	
14306, 69		14319, 18	
14307, 13		14319, 19	(2 grains)
14307, 38		14319, 25	
14307, 46		14319, 33	
14311, 95		14320, 7	

14321, 196

14321, 240

14321, 460

## APOLLO 15

15021, 183		15304, 52	
15025, library		15304, 59	
15032, 19		15304, 60	(2 grains)
15059, 48		15304, 61	
15072, 20	(several grains)	15311, 11	
15082, 17	(2 grains)	15314, 103	
15231, 15	(2 grains)	15314, 114	
15231, 17		15314, 118	
15231, 94	(several grains)	15314, 126	
15261, 12		15324, 2	(2 grains)
15265, 9	(2 grains)	15329, 7	
15266, 19	(several grains)	15405, 13	
15271, 12		15405, 16	
15271, 13		15412, 22	(several grains)
15285, 32		15425, 10	(several grains)
15289, 7	(2 grains)	15425, 12	(several grains)
15298, 6	(2 grains)	15425, 13	
15299, 56	(several grains)	15425, 19	
15299, 108	(2 grains)	15426, 17	
15299, 109		15426, 19	
15301, 14		15426, 21	
15302, 47		15426, 72	

15427, 55  
15434, 135  
15434, 143  
15459, 3 (2 grains)  
15459, 4 (2 grains)  
15459, 13  
15459, 123  
15459, 125  
15459, 126  
15472, 27 (several grains)  
15498, 101  
15498, 105  
15501, 102 (several grains)  
15502, 20  
15515, 51  
15558, 8  
15558, 9  
15601, 262

## APOLLO 16

60016, 92	(3 grains)	60502, 8	
60018, 53	(several grains)	60502, 11	
60018, 57		60502, 12	
60019, 13		60618, 4	(several grains)
60019, 14		61015, 15	
60019, 84		61015, 44	
60019, 91		61135, 7	(2 grains)
60019, 94		61135, 8	
60019, 98		61143, 5	(2 grains)
60115, 9		61143, 8	
60255, 73	(several grains)	61155, 7	
60255, 79		61156, 29	
60255, 81	(2 grains)	61175, 99	
60275, 13		61175, 100	(2 grains)
60275, 14		61175, 102	(2 grains)
60275, 15		61175, 108	
60275, 47	(2 grains)	61195, 39	
60335, 63		61242, 27	
60501, 65	(several grains)	61295, 9	(2 grains)
60501, 66	(2 grains)	61295, 10	(2 grains)
60501, 67	(several grains)	61295, 32	
60501, 68	(several grains)	61295, 37	

62235, 6		64475, 64	
62235, 65		64475, 65	
62241, 34		64476, 7	
62255, 43		64476, 8	
62255, 44		64477, 14	(2 grains)
63355, 49		64478, 13	
63502, 23		64501, 78	(2 grains)
63507, 13		64501, 79	(several grains)
63527, 9		64502, 22	(several grains)
63529, 7		64502, 24	
63595, 3	(2 grains)	64502, 26	(2 grains)
63596, 4		64536, 23	
64421, 33		64819, 3	
64435, 6		65015, 76	
64435, 7		65015, 86	
64435, 71		65015, 87	
64435, 73		65016, 16	
64435, 75		65016, 17	
64435, 80		65035, 6	
64475, 56		65035, 7	
64475, 57		65035, 8	
64475, 58		65056, 13	
64475, 60		65056, 14	(3 grains)
64475, 61		65095, 49	(several grains)

65095, 50		66095, 139
65095, 51	(2 grains)	66095, 140
65315, 4		67015, 9 (several grains)
65315, 86		67015, 25 (2 grains)
65315, 87		67015, 74
15315, 89		67015, 75 (2 grains)
65315, 91		67015, 76 (2 grains)
65315, 93		67015, 77 (several grains)
65315, 94		67015, 78
65502, 12	(2 grains)	67015, 79
65785, 4		67015, 80
65902, 15		67015, 141
66035, 2		67015, 143
66037, 6		67015, 146 (2 grains)
66041, 43		67016, 117 (2 grains)
66042, 7	(2 grains)	67016, 188
66055, 63		67033, 6
66055, 65		67033, 8 (several grains)
66055, 75		67035, 4
66055, 78		67035, 6
66075, 61	(several grains)	67035, 15 (3 grains)
66075, 62	(several grains)	67115, 30 (several grains)
66095, 86		67415, 13 (several grains)
66095, 88	(2 grains)	67415, 14 (several grains)

67415, 16	(several grains)	67941, 43	
67455, 47	(several grains)	67941, 46	(several grains)
67455, 49	(several grains)	67946, 14	
67455, 52	(2 grains)	67975, 13	(several grains)
67455, 53		67975, 14	(several grains)
67475, 47		68035, 7	
67475, 48	(3 grains)	68115, 3	
67475, 99	(2 grains)	68115, 4	
67480, 5		68115, 94	
67480, 13		68115, 96	
67600, 13		68501, 172	
67600, 17	(3 grains)	68501, 175	
67705, 5		68501, 177	
67705, 6		68502, 34	(2 grains)
67735, 13		68815, 17	
67915, 75	(several grains)	68815, 155	
67915, 76	(several grains)	68815, 158	
67915, 78	(several grains)	68841, 4	
67915, 79	(several grains)	69935, 64	
67915, 80	(2 grains)	69942, 1	
67915, 81	(2 grains)	69955, 27	
67915, 83	(2 grains)	69955, 28	
67915, 86	(3 grains)	69955, 30	
67915, 87	(several grains)	69961, 97	

69961, 98	(several grains)
69961, 99	(several grains)
69962, 24	(2 grains)
69962, 25	
69962, 27	
69962, 28	

## APOLLO 17

70019, 92	(2 grains)	73155, 29	(2 grains)
71502, 30		73155, 30	(2 grains)
72215, 10		73215, 47	(2 grains)
72215, 12		73215, 109	
72235, 54	(several grains)	73215, 117	(2 grains)
72255, 108		73215, 123	
72275, 11	(several grains)	73215, 189	
72275, 13	(several grains)	73215, 192	(3 grains)
72315, 7		73215, 193	(2 grains)
72315, 8	(several grains)	73215, 197	
72315, 13	(several grains)	73215, 221	
72315, 76	(several grains)	73215, 224	(2 grains)
72355, 4	(several grains)	73215, 234	
72355, 6	(several grains)	73215, 236	
72395, 76	(several grains)	73215, 246	
72435, 40		73215, 248	
73141, 48	(several grains)	73216, 26	(2 grains)
73141, 49	(several grains)	73216, 27	(3 grains)
73141, 50	(several grains)	73218, 27	
73142, 9	(several grains)	73218, 28	
73143, 5	(several grains)	73235, 7	(2 grains)
73143, 6		73235, 58	(several grains)

73235, 62	(several grains)	76035, 26	(several grains)
73235, 63	(3 grains)	76035, 27	(several grains)
73235, 67		76055, 11	(2 grains)
73235, 69	(several grains)	76055, 12	(several grains)
73235, 71		76055, 16	
73235, 74	(several grains)	76135, 28	
73235, 75		76215, 61	
73235, 77		76250, 5	
73235, 80		76255, 73	
73235, 82	(several grains)	76255, 77	(3 grains)
73235, 83		76275, 51	
73255, 58	(several grains)	76275, 59	
73255, 287		76295, 92	(2 grains)
73255, 291		76315, 13	(3 grains)
73275, 58	(2 grains)	76315, 93	
73275, 62		76315, 95	
73275, 69	(several grains)	76322, 8	(several grains)
73275, 71	(several grains)	76335, 27	
73275, 72		76335, 28	
74115, 6	(2 grains)	76502, 24	(2 grains)
74115, 8		76502, 25	
75083, 32		76502, 26	(several grains)
76015, 9		76502, 27	(several grains)
76015, 11		76502, 28	(2 grains)

76502, 29	(several grains)	79035, 8
77035, 65		79035, 67
77035, 69		79135, 24 (2 grains)
77035, 71		
77035, 81		
77035, 93		
77115, 11		
77135, 23		
77135, 28	(several grains)	
77135, 29		
77135, 98		
77135, 121		
77135, 128		
77215, 141		
78122, 9		
78222, 8		
78501, 131		
78501, 132		
78502, 25	(2 grains)	
78502, 27	(2 grains)	
78502, 28		
78502, 31	(2 grains)	
78503, 27		