APPENDICES

APPENDIX I

Reference Abbreviations

AJS: *American Journal of Science*

Ancient Sun: *The Ancient Sun: Fossil Record in the Earth, Moon and Meteorites* (Eds. R. O. Pepin, et al.), Pergamon Press (1980) Geochim. Cosmochim. Acta Suppl. 13

Ap. J.: *Astrophysical Journal*

Apollo 15: *The Apollo 15 Lunar Samples,* Lunar Science Institute, Houston, Texas (1972)

Apollo 16 Workshop: *Workshop on Apollo 16,* LPI Technical Report 81-01, Lunar and Planetary Institute, Houston (1981)

Basaltic Volcanism: *Basaltic Volcanism on the Terrestrial Planets*, Pergamon Press (1981)

Bull. GSA: *Bulletin of the Geological Society of America*

EOS: *EOS, Transactions of the American Geophysical Union*

EPSL: *Earth and Planetary Science Letters*

GCA: *Geochimica et Cosmochimica Acta*

GRL: *Geophysical Research Letters*

Impact Cratering: *Impact and Explosion Cratering* (Eds. D. J. Roddy, et al.), 1301 pp., Pergamon Press (1977)

JGR: *Journal of Geophysical Research*

LS III: *Lunar Science III* (Lunar Science Institute) see extended abstract of Lunar Science Conferences Appendix II

LS IV: *Lunar Science IV* (Lunar Science Institute)

LS V: *Lunar Science V* (Lunar Science Institute)

LS VI: *Lunar Science VI* (Lunar Science Institute)

LS VII: *Lunar Science VII* (Lunar Science Institute)

LS VIII: *Lunar Science VIII* (Lunar Science Institute

LPS IX: *Lunar and Planetary Science IX* (Lunar and Planetary Institute

LPS X: *Lunar and Planetary Science X* (Lunar and Planetary Institute)

LPS XI: *Lunar and Planetary Science XI* (Lunar and Planetary Institute)

LPS XII: *Lunar and Planetary Science XII* (Lunar and Planetary Institute)

Lunar Highlands Crust: *Proceedings of the Conference in the Lunar Highlands Crust*, 505 pp., Pergamon Press (1980) Geochim. Cosmochim. Acta Suppl. 12

Mare Basalts: *Origin of Mare Basalts*, Lunar Science Institute Contrib. 234 (1975)

Mare Crisium: *Mare Crisium:* The View from Luna 24, 742 pp., Pergamon Press (1978) Geochim. Cosmochim. Acta Suppl. 9

Moon: *The Moon*

Moon and Planets: *The Moon and Planets*

Multi-Ring Basins: *Proceedings, Conference on Multi-Ring Basins,* Pergamon Press (1981)

NASA SP: National Aeronautics and Space Administration Special Publication Series

PCE: *Physics and Chemistry of the Earth*

PEPI: *Physics of the Earth and Planetary Interiors*

PLC 1: *Proceedings Apollo 11 Lunar Science Conference,* Geochim. Cosmochim. Acta Suppl. 1 (1970)

PLC 2: *Proceedings 2nd Lunar Science Conference*, Geochim. Cosmochim. Acta Suppl. 2 (1971)

PLC 3: *Proceedings 3rd Lunar Science Conference*, Geochim. Cosmochim. Acta Suppl. 3 (1972)

PLC 4: *Proceedings 4th Lunar Science Conference*, Geochim. Cosmochim. Acta Suppl. 4 (1973)

PLC 5: *Proceedings 5th Lunar Science Conference*, Geochim. Cosmochim. Acta Suppl. 5 (1974)

PLC 6: *Proceedings 6th Lunar Science Conference*, Geochim. Cosmochim. Acta Suppl. 6 (1975)

PLC 7: *Proceedings 7th Lunar Science Conference*, Geochim. Cosmochim. Acta Suppl. 7 (1976)

PLC 8: *Proceedings 8th Lunar Science Conference*, Geochim. Cosmochim. Acta Suppl. 8 (1977)

PLC 9: *Proceedings 9th Lunar and Planetary Science Conference*, Geochim. Cosmochim. Acta Suppl. 10 (1978)

PLC 10: *Proceedings 10th Lunar and Planetary Science Conference*, Geochim. Cosmochim. Acta Suppl. 11 (1979)

PLC 11: *Proceedings 11th Lunar and Planetary Science Conference*, Geochim. Cosmochim. Acta Suppl. 14 (1980)

PLC 12: *Proceedings 12th Lunar and Planetary Science Conference*, Geochim. Cosmochim. Acta Suppl. 15 (1981)
Rev. Geophys. Space Phys.: *Reviews of Geophysics and Space Physics*
USGS: United States Geological Survey

APPENDIX II

Lunar Primary Data Sources

I. Lunar Sample Preliminary Examination Team (LSPET) Reports.

Apollo 11, *Science*. 165: 211 (Sept. 19, 1969).
Apollo 12, *Science*. 167: 1325 (March 6, 1970).
Apollo 14, *Science*. 173: 681 (August 20, 1971).
Apollo 15, *Science*. 175: 363 (Jan. 28, 1972).
Apollo 16, *Science*. 179: 23 (Jan. 5, 1973).
Apollo 17, *Science*. 182: 659 (Nov. 16, 1973).

II. Preliminary Science Reports: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Surveyor Program Results, NASA SP 184 (1969).

Apollo 11 NASA SP 214 (1969) 209 pp.
Apollo 12 NASA SP 235 (1970) 235 pp.
Apollo 14 NASA SP 272 (1971) 313 pp.
Apollo 15 NASA SP 289 (1972) 502 pp.
Apollo 16 NASA SP 315 (1972) 636 pp.
Apollo 17 NASA SP 330 (1973) 710 pp.

III. USGS Apollo Geology Team Reports.

Apollo 11 geologic setting is included in PET article, *Science*. 165: 1211 (Sept. 19, 1969).
Apollo 12 geologic setting contained in PET article, *Science*. 167: 1325 (March 6, 1970).
Apollo 14, *Science*. 173: 716 (Aug. 20, 1971).
Apollo 15, *Science*. 175: 407 (Jan. 28, 1972).
Apollo 16, *Science*. 179: 62 (Jan. 5, 1973).
Apollo 17, *Science*. 182: 672 (Nov. 16, 1973).

IV. Lunar Sample Information Data Catalogs. NASA Johnson Space Center, Houston, Texas.

Apollo 11 Aug. 31, 1969 (No identifying number).
Apollo 12 MSC-S-243 (June, 1970).

Apollo 14 TM X-58062 (Sept., 1971).
Apollo 15 MSC-03209 (Nov., 1971).
Apollo 16 MSC-03210 (July, 1972).
Apollo 17 MSC-03211 (April, 1973).
A short guide to Lunar Sample Information has been published by the Lunar Science Institute (Contribution No. 200). For updated information, contact the Lunar Sample Curator, NASA Johnson Space Center, Houston, Texas 77058.

V. Extended Abstracts of the Lunar Science Conference have been published by the Lunar Science Institute, Houston, Texas for the 3rd–8th Lunar Science Conferences.

Lunar Science III, 1972.
Lunar Science IV, 1973.
Lunar Science V, 1974.
Lunar Science VI, 1975.
Lunar Science VII, 1976.
Lunar Science VIII, 1977.
These are referred to in the references as LS III through LS VIII, respectively. Extended abstracts of Lunar and Planetary Science Conferences (9th–12th) have been published by the Lunar and Planetary Institute, Houston, Texas.

Lunar and Planetary Science IX, 1978.
Lunar and Planetary Science X, 1979.
Lunar and Planetary Science XI, 1980.
Lunar and Planetary Science XII, 1981.
These are referred to in the references as LPS IX through XII. In addition, an extended set of abstracts deals with the Apollo 15 samples:

The Apollo 15 Samples, J. W. Chamberlain and Carolyn Watkins, editors, 1972. This is cited as "Apollo 15" in the references.

Extended abstracts for other conferences are available from the Lunar and Planetary Institute, Houston, Texas.
Abstracts Presented to the Conference on Luna 24 (1977) LPI 304.
Abstracts Presented to the Conference on the Origins of Planetary Magnetism (1978) LPI 348.

Proceedings of a Topical Conference on Origins of Planetary Magnetism. In *Physics of the Earth and Planetary Interiors* **20** (1979) Elsevier. LPI 376.

Abstracts Presented to the Conference on the Ancient Sun: Fossil Record in the Earth, Moon and Meteorites (1979) LPI 390.

Abstracts Presented to the Conference on the Lunar Highlands Crust (1979) LPI 394.

VI. Science Conference Proceedings.

Proceedings of the Apollo 11 Lunar Science Conference, 1970 (A. A. Levinson, ed.). *Geochimica et Cosmochimica Acta, Supplement 1.* Pergamon Press, Elmsford N.Y.

Proceedings of the Second Lunar Science Conference, 1971 (A. A. Levinson, ed.). *Geochimica et Cosmochimica Acta, Supplement 2. MIT* Press, Cambridge, Mass. (Distributed by Pergamon Press).

Proceedings of the Third Lunar Science Conference, 1972 (E. A. King, Jr., D. Heymann, and D. R. Criswell, eds.) *Geochimica et Cosmochimica Acta, Supplement 3. MIT* Press, Cambridge, Mass. (Distributed by Pergamon Press).

All subsequent Proceedings have been published by Pergamon Press, Elmsford, N.Y. 10523:

Proceedings of the Fourth Lunar Science Conference (W. A. Gose, ed.), 1973. GCA Supp. 4.

Proceedings of the Fifth Lunar Science Conference (W. A. Gose, ed.), 1974. GCA Supp. 5.

Proceedings of the Sixth Lunar Science Conference (R. B. Merrill, ed.), 1975. GCA Supp. 6.

Proceedings of the Seventh Lunar Science Conference (R. B. Merrill, ed.), 1976. GCA Supp. 7.

Proceedings of the Eight Lunar Science Conference (R. B. Merrill, ed.), 1977. GCA Supp. 8.

Proceedings of the Ninth Lunar and Planetary Science Conference (R. B. Merrill, ed.), 1978. GCA Supp. 10.

Proceedings of the Tenth Lunar and Planetary Science Conference (R. B. Merrill, ed.), 1979. GCA Supp. 11.

Proceedings of the Eleventh Lunar and Planetary Science Conference (R. B. Merrill, ed.), 1980. GCA Supp. 14.

Proceedings of the Twelfth Lunar and Planetary Science Conference. Proceedings of Lunar and Planetary Science, vol. 12B (R. B. Merrill and R. Ridings, eds.), 1981. GCA Supp. 15.

*Index to the Proceedings of the Lunar and Planetary Science Conferences 1970–*1978 (Compiled by A. R. Masterson; R. B. Merrill, ed.), 1979.

VII. Other Conference Proceedings:

Mare Crisium: The View from Luna 24. Proceedings of the Conference on Luna 24, Houston, Texas, December 1977. Pergamon Press, 1978. GCA Supp. 9.

Impact and Explosion Cratering. Proceedings of the Symposium on Planetary Cratering Mechanics, Flagstaff, Arizona, September 1976. Pergamon Press, 1978.

Proceedings of the Conference on the Lunar Highlands Crust. November 1979, Houston, Texas. Pergamon Press, 1980. GCA Supp. 12.

The Ancient Sun: Fossil Record in the Earth, Moon and Meteorites. Proceedings of the Conference on the Ancient Sun: Fossil Record in the Earth, Moon and Meteorites, Boulder, Colorado, October 1979. (R. O. Pepin, J. A. Eddy, and R. B. Merrill, eds.) Pergamon Press, 1981.

Proceedings of the Conference on Multi-Ring Basins: Formation and Evolution, Houston, Texas, November 1980. Proceedings of Lunar and Planetary Science, vol. 12A (P. H. Schultz and R. B. Merrill, eds.). Pergamon Press, 1981. GCA Supp. 15.

Workshop on Apollo 16 (O. B. James and F. Hörz, eds.). LPI Tech Rpt. 81-01. Lunar and Planetary Institute, Houston, Texas, 1981.

APPENDIX III

Diameter and Location of Lunar Craters Mentioned in the Text†

Crater	Lat.	Long.	Diameter (km)
Abulfeda	13.8° S	13.9° E	65
Aitken	16.5° S	173.1° E	131
Albategnius	11.2° S	4.1° E	136
Alphonsus	13.4° S	2.8° W	119
Alphonsus R	14.4° S	1.9° W	3
Anaxagoras	73.4° N	10.1° W	51
Antoniadi	69.8° S	172.0° W	135
Apollo	35.5° S	149.6° W	503
Apollonius	4.5° N	61.1° E	53
Arago	6.2° N	21.4° E	26
Archimedes	29.7° N	4.0° W	83
Ariadaeus	4.6° N	17.3° E	11
Aristarchus	23.7° N	47.4° W	40
Aristillus	33.9° N	1.2° E	55
Arzachel	18.2° S	1.9° W	97
Autolycus	30.7° N	1.5° E	39
Bailly	66.8° S	69.4° W	303
Beer	27.1° N	9.1° W	10
Berzelius	36.6° N	50.9° E	51
Bessel	21.8° N	17.9° E	16
Bode	6.7° N	2.4° W	19
Bonpland	8.3° S	17.4° W	60
Cauchy	9.6° N	38.6° E	12
Chaucer	3.7° N	140.0° W	45
Clavius	58.4° S	14.4° W	225
Compton	56.0° N	105.0° E	162
Copernicus	9.7° N	20.0° W	93
Copernicus H	6.9° N	18.3° W	5
Cyrillus	13.2° S	24.0° E	98
D'Alembert	51.3° N	164.6° E	225
Darwin	19.8° S	69.1° W	130
Davy	11.8° S	8.1° W	35
DeLisle	29.9° N	34.6° W	25
Descartes	11.7° S	15.7° E	48
Dionysius	2.8° N	17.3° E	18
Diophantus	27.6° N	34.3° W	18
Dollond B	7.7° S	13.8° E	37
Doppler	12.8° S	159.9° W	100
Eratosthenes	14.5° N	11.3° W	58
Euler	23.3° N	29.2° W	28

Crater	Lat.	Long.	Diameter (km)
Fauth	6.3° N	20.1° W	12
Flammarion	3.4° S	3.7° W	75
Flamsteed	4.5° S	44.3° W	21
Fra Mauro	6.0° S	17.0° W	95
Fracastorius	21.2° S	33.0° E	124
Galilaei	10.5° N	62.7° W	16
Gassendi	17.5° S	39.9° W	110
Giordano Bruno	35.9° N	102.8° E	22
Grimaldi	5.2° S	69.6° W	410
Gruithuisen	32.9° N	39.7° W	16
H.G. Wells	41.0° N	122.7° E	103
Hausen	65.5° S	88.4° W	167
Hell	32.4° S	7.8° W	33
Herigonius	13.3° S	33.9° W	15
Herodotus	23.2° N	49.7° W	35
Herschel	5.7° S	2.1° W	41
Hevelius	2.2° N	67.3° W	106
Hippalus	24.8° S	30.2° W	58
Hommel	54.6° S	33.0° E	125
Humboldt	27.2° S	80.9° E	207
Hyginus	7.8° N	6.3° E	9
Icarus	5.3° S	173.2° W	96
Inghirami	47.5° S	68.8° W	91
Jansen	13.5° N	28.7° E	24
Janssen	44.9° S	41.5° E	190
Jules Verne	34.8° S	146.9° E	134
Julius Caesar	9.0° N	15.4° E	91
Kant	10.6° S	20.1° E	33
Kepler	8.1° N	38.0° W	32
King	5.0° N	120.5° E	77
Kopff	17.4° S	89.6° W	42
Korolev	4.4° S	157.4° W	453
Kramers	53.6° N	127.6° W	62
La Hire A	28.5° N	23.4° W	5
Lalande	4.4° S	8.6° W	24
Lambert	25.8° N	21.0° W	30
Langrenus	8.9° S	60.9° E	132
Lansberg	0.3° S	26.6° W	39
Lassell	15.5° S	7.9° W	23
Lavoisier	38.2° N	81.2° W	70
Le Monnier	26.6° N	30.6° E	61
Linné	27.7° N	11.8° E	2
Littrow	21.5° N	31.4° E	31
Longomontanus	49.5° S	21.7° W	145
Lyell	13.6° N	40.6° E	32

Crater	Lat.	Long.	Diameter (km)
Macrobius	21.3° N	46.0° E	64
Marco Polo	15.4° N	2.0° W	28
Marius	11.9° N	50.8° W	41
Maskelyne	2.2° N	30.1° E	24
Maunder	14.6° S	93.8° W	55
Maurolycus	41.8° S	14.0° E	114
Mendeleev	5.6° N	141.5° E	330
Mutus	63.6° S	30.1° E	78
Nansen	81.3° N	95.3° E	122
Neper	8.8° N	84.5° E	137
Olbers	7.4° N	75.9° W	75
Omar Khayyam	58.0° N	102.1° W	70
Peirce	18.3° N	53.5° E	19
Petavius	25.3° S	60.4° E	177
Picard	14.6° N	54.7° E	23
Piccolomini	29.7° S	32.2° E	88
Planck	57.9° S	135.8° E	344
Plato	51.6° N	9.3° W	101
Playfair	23.5° S	8.4° E	48
Plutarch	24.1° N	79.0° E	68
Poincaré	56.7° S	163.6° E	319
Posidonius	31.8° N	29.9° E	95
Proclus	16.1° N	46.8° E	28
Ptolemaeus	9.2° S	1.8° W	153
Pythagoras	63.5° N	62.8° W	130
Regiomontanus	28.4° S	1.0° W	124
Regiomontanus A	28.0° S	0.6° W	6
Reiner	7.0° N	54.9° W	30
Rheita	37.1° S	47.2° E	70
Ritter	2.0° N	19.2° E	29
Ross	11.7° N	21.7° E	25
Rothmann G	28.4° S	24.3° E	92
Sabine	1.4° N	20.1° E	30
Schickard	44.4° S	54.6° W	227
Schroter	2.6° N	7.0° W	35
Sirsalis	12.5° S	60.4° W	42
Sulpicius Gallus	19.6° N	11.6° E	12
Taruntius	5.6° N	46.5° E	56
Taylor	5.3° S	16.7° E	42
Theophilus	11.4° S	26.4° E	100
Timocharis	26.7° N	13.1° W	34
Tsiolkovskiy	20.4° S	129.1° E	180
Tycho	43.3° S	11.2° W	85
Van de Graaff	27.0° S	172.0° E	234

Crater	Lat.	Long.	Diameter (km)
Vasco da Gama	13.9° N	83.8° W	96
Vitello	30.4° S	37.5° W	42
Vitruvius	17.6° N	31.3° E	30
Wargentin	49.6° S	60.2° W	84
Widmanstatten	6.1° S	85.5° E	46
Wolf	22.7° S	16.6° W	25
Xenophon	22.8° S	122.1° E	25
Zwicky	15.9° S	167.6° E	135

†Data from D. Kinsler, Lunar and Planetary Institute, Houston, Texas.

APPENDIX IV

Lunar Multi-ring Basins†

Basin	Diameter of topographic basin rim (km)		Age
Orientale	930		
Imbrium	1500		Imbrian
Schrödinger	320		
Sikorsky-Rittenhouse	310		
Bailly	300		
Hertsprung	570		
Serenitatis	880		Nectarian
Crisium	1060		
Humorum	820		
Humboldtianum	700	(ave.)	
Mendeleev	330		
Mendel-Rydberg	630		
Korolev	400		
Moscoviense	445		
Nectaris	860		
Apollo	505		
Grimaldi	430		
Freundlich-Sharonov	600		
Birkhoff	330		
Planck	325		
Schiller-Zucchius	325		
(Amundsen)	355		
Lorentz	360		
Smythii	840		
Coulomb-Sarton	530		
Keeler-Heaviside	800		
Poincaré	340		
Ingenii	650		
(Lomosov-Fleming)	620		Pre-Nectarian
(Nubium)	690		
(Fecunditatis)	690		
(Mutus-Vlacq)	700		
(Tranquillitatis)	775		
Australe	880		
(Al Khwarizmi-King)	590		
(Pingre-Hausen)	300		
(Werner-Airy)	500		
(Flamsteed-Billy)	570		
(Marginis)	580		
(Insularum)	600		
(Grissom-White)	600		
(Tsiolkovsky-Stark)	700		
South Pole-Aitken	2500		
Procellarum	3200		

†Basins listed in order of relative age. Existence not definitely established for basin names in parentheses. List adapted from Wilhelms, D. E. (1982) *The Geologic History of the Moon* (Tables 901 and 902), NASA SP. In press.

APPENDIX V

Terrestrial Impact Craters

	Name	Diameter (km)	Age (m.y.)	Coordinates
1	Barringer, Arizona, USA	1.2	*	35° N 111° W
2	Boxhole, N.T. Australia	0.2	*	23° S 135° E
3	Campo del Cielo, Argentina	0.1	*	28° S 62° W
4	Dalgaranga, W.A., Australia	0.02	*	28° S 117° E
5	Haviland, Kansas, USA	0.01	*	38° N 99° W
6	Henbury, N.T. Australia	0.15	*	25° S 133° E
7	Kaalijarvi, Estonian SSR	0.11	*	58° N 23° E
8	Odessa, Texas, USA	0.17	*	32° N 102° W
9	Sikhote Alin, Primorye Terr. Siberia, USSR	0.03	*	46° N 135° E
10	Wabar, Saudi Arabia	0.10	*	21° N 50° E
11	Wolf Creek, W.A., Australia	0.85	*	19° S 128° E
12	Aouelloul, Mauritania	0.37	3.1 ± 0.3	20° N 13° W
13	Araguainha Dome, Brazil	40	<250	17° S 53° W
14	Beyenchime Salaatin, USSR	8	< 65	72° N 123° E
15	Boltysh, Ukrainian SSR, USSR	25	100 ± 5	49° N 32° E
16	Bosumtwi, Ghana	10.5	1.3 ± .2	6° N 1° W
17	B.P. structure, Libya	2.8	<120	25° N 24° E
18	Brent, Ontaria, Canada	3.8	450 ± 30	46° N 78° W
19	Carswell, Saskatchewan, Canada	37	485 ± 50	58° N 109° W
20	Charlevoix, Quebec, Canada	46	360 ± 25	48° N 70° W
21	Clearwater L. East, Quebec, Canada	22	290 ± 20	56° N 74° W
22	Clearwater L. West, Quebec, Canada	32	290 ± 20	56° N 74° W
23	Crooked Creek, Missouri, USA	5.6	320 ± 80	38° N 91° W
24	Decaturville, Missouri, USA	6	<300	38° N 93° W
25	Deep Bay, Saskatchewan, Canada	12	100 ± 50	56° N 103° W
26	Dellen, Sweden	15	230	62° N 17° E
27	Flynn Creek, Tennessee, USA	3.8	360 ± 20	36° N 86° W
28	Gosses Bluff, N.T. Australia	22	130 ± 6	24° S 132° E
29	Gow L., Saskatchewan, Canada	5	<200	56° N 104° W
30	Haughton Dome, N.W.T. Canada	20	15	75° N 90° W
31	Holleford, Ontario, Canada	2	550 ± 100	44° N 77° W
32	Ile Rouleau, Quebec, Canada	4	<300	51° N 74° W
33	Ilintsy, USSR	4.5	495 ± 5	49° N 28° E
34	Janisjarvi, USSR	14	700	62° N 31° E
35	Kaluga, USSR	15	360 ± 10	54° N 36° E
36	Kamensk, USSR	25	65	48° N 40° E
37	Kara, USSR	50	57	69° N 65° E
38	Kentland, Indiana, USA	13	300	41° N 87° W
39	Kelley West, N.T. Australia	2.5	550	19° S 133° E
40	Kursk, USSR	5	25 ± 80	52° N 36° E
41	Lac Couture, Quebec, Canada	8	420	60° N 75° W
42	Lac La Moinerie, Quebec, Canada	8	400	57° N 67° W
43	Lappajärvi, Finland	14	<600	63° N 24° E
44	Liverpool, N.T. Australia	1.6	150 ± 70	12° S 134° E
45	Lonar, India	1.83	0.05	20° N 77° E

	Name	Diameter (km)	Age (m.y.)	Coordinates
46	Manicouagan, Quebec, Canada	70	210 ± 4	51°N 69°W
47	Manson, Iowa, USA	32	< 70	43°N 95°W
48	Mien L., Sweden	5	118 ± 2	56°N 15°E
49	Middlesboro, Kentucky, USA	6	300	37°N 84°W
50	Mishina Gora, USSR	2.5	<360	59°N 28°E
51	Mistastin, Labrador, Canada	28	38 ± 4	56°N 63°W
52	Monturaqui, Chile	0.46	1	24°S 68°W
53	New Quebec Crater, New Quebec, Canada	3.2	5	61°N 74°W
54	Nicholson L., N.W.T., Canada	12.5	<450	63°N 103°W
55	Oasis, Libya	11.5	<120	25°N 24°E
56	Pilot L., N.W.T., Canada	6	<300	60°N 111°W
57	Popigai, USSR	100	38 ± 9	71°N 111°E
58	Puchezh-Katun, USSR	80	183 ± 3	57°N 44°E
59	Ries, Germany	24	14.8 ± 7	49°N 11°E
60	Rochechouart, France	23	160 ± 5	46°N 1°E
61	Rotmistrov, USSR	2.5	70	49°N 32°E
62	Sääksjärvi, Finland	5	490	61°N 22°E
63	St. Martin, Manitoba, Canada	23	225 ± 40	52°N 99°W
64	Serpent Mound, Ohio, USA	6.4	300	39°S 83°W
65	Sierra Madera, Texas, USA	13	100	31°N 103°W
66	Siljan, Sweden	52	365 ± 7	61°N 15°E
67	Slate Island, Superior, Ontario, Canada	30	350	49°N 87°W
68	Steen River, Alberta, Canada	25	95 ± 7	60°N 118°W
69	Steinheim, Germany	3.4	14.8 ± 7	49°N 10°E
70	Strangways, N.T. Australia	24	150 ± 70	15°S 134°E
71	Sudbury, Ontario, Canada	140	1840 ± 150	47°N 81°W
72	Tenoumer, Mauritania	1.9	2.5 ± .5	23°N 10°W
73	Vredefort, South Africa	140	1970 ± 100	27°S 27°E
74	Wanapitei L., Ontario, Canada	8.5	37 ± 2	47°N 81°W
75	Wells Creek, Tennessee, USA	14	200 ± 100	36°N 88°W
76	West Hawk L., Manitoba, Canada	2.7	100 ± 50	50°N 95°W
77	Morasko, Poland	100		52°N 16°E
78	Sobolev, Siberia, USSR	51		46°N 138°E
79	Kjardla, Est. SSR	4	500 ± 50	57°N 23°E
80	Logoisk, Bel. SSR	17	100 ± 20	54°N 28°E
81	Misarai, Lith. SSR	5	500 ± 80	54°N 24°E
82	Obolon, USSR	15	160	50°N 33°E
83	Serra da Canghala, Brazil	12	<300	8°S 47°W
84	Shunak, Kaz. SSR	2.5	12	43°N 73°E
85	Vepriaj, Lith. SSR	8	160 ± 30	55°N 25°E
86	Zeleny Gai, Ukr. SSR	1.4	120 ± 20	47°N 35°E
87	Zhamanshin, Aktyubinsk, USSR	10	4.5 ± 0.5	49°N 61°E
88	Elgygtgyn, Siberia		3.5 ± 0.5	67°N 172°E
89	Cambodia	6×10	—	14°N 106°E
90	Darwin, Tasmania	1.2	—	42°S 145°E

* All are Quaternary in age, i.e. $< 10^6$ y. Most are $< 10^5$ y. Meteorites have been found at these locations.

Source of data: Grieve, R. A. F. and Robertson, P. B. Lunar and Planetary Institute, Houston, Texas. Contrib. No. 367.

APPENDIX VI

Appendix to Table 8.1: Sources of data

1. Mason, B. H. (1971) *Handbook of Elemental Abundances in Meteorites*, Gordon and Breach, London. Orgueil major element analysis by Wiik, Table 3, p. 8, Anal. No. 1. Data × 1.479 to allow for loss of H_2O, C, S.
2. Mason, B. H. (1979) USGS Prof. Paper 440-B-1. Data for Orgueil from Table 84, pp. B111–B112. Values × 1.5 to allow for volatile loss.
3. Weller, M. R., et al. (1978) *GCA*. 42: 999, gives a value (× 1.5) of 2.4 ppm. A more recent determination by Curtis, D. B. (1980) *Meteoritics*. 15, gives a value of 0.4 ppm.
4. From Li/Be = 33. Dreibus, G., et al. (1976) *PLC 7*: 3383.
5. Shima, M. (1979) *GCA*. 43: 353 (× 1.5).
6. Mason, B. H. (1979) Ibid., Average C1 value (× 1.5).
7. Mason, B. H. (1979) Ibid., Ivuna data (× 1.5).
8. Krahenbühl, U., et al. (1973) *GCA*. 37: 1353 (× 1.5).
9. Evensen, N. M., et al. (1978) *GCA*. 42: 1203 (Mean C1 × 1.5).
10. E × trapolated value from neighboring REE.
11. From Zr/Hf = 33.
12. From Th/U = 3.8.
13. Crocket, J. H., pers. comm., 1977.
14. Taylor, S. R. (1979) *PLC 10*, Table 1. Values based mainly on nodule data. Ratio of Al, Ca and Ti to volatile free chondritic values (Col. 1) is 1.36. This ratio is used to obtain mantle abundances for refractory elements from the chondritic data, assuming no relative fractionation.
15. Refractory trace element value from Col. 1, × 1.36 (see [14]).
16. From Ni/Co = 20 (C1 value).
17. C1 value × 1.36.
18. From FeO/MnO = 60. Dreibus, G., et al. (1977) *PLC 8*: 211.
19. K from K-Ar (Taylor, 1979, ibid.) and $K/U = 10^4$.
20. Rb from Rb/Sr = 0.031 [O'Nions, R. K., et al. (1979) *Ann. Rev. Earth Planet. Sci.* 7: 11]. This gives K/Rb = 375. This implies loss of Rb relative to K during accretion of Earth since K/Rb for C1 = 260 (see [25]).
21. From Na/K = 14 [Taylor, S. R. (1980) *PLC 11*: 333].
22. Rb/Cs in crust is ~ 30 compared to 12 in chondrites. Cs will be enriched in crust relative to Rb. Thus 0.016 ppm (from Rb/Cs = 30) is an upper limit.
23. From Tl/U = .022 [Krahenbühl, U., et al. (1973) *PLC 4*: 1325].
24. From Li/Zr = 0.10 (Dreibus, G., et al., ibid., 18).
25. Total crustal data based on Taylor, S. R., and McLennan, S. M. (1981) *Phil. Trans. Roy. Soc.* A301: 381. The uranium abundance has been revised from 1.0 to 1.25 ppm using $K/U = 10^4$. Th has been raised to 4.8 ppm to conform to Th/U = 3.8. Hf has been revised to 3.0 ppm (from 2.2 ppm) to be consistent with chondritic Zr/Hf = 33. Tl from Shaw, D. M. (1976) *GCA*. 40: 73. Rb has been lowered from 50 ppm (Taylor, 1977) to 42 ppm to be

consistent with K/Rb = 300. This ratio implies that Rb is partitioned into the crust preferentially to K (cf. Cs [22]).

26. Major element data, Ba, Co, Cu and Zn from Goodwin (1977) *Geol. Soc. Canada Spec. Paper 16*, 205.
27. REE from Average Archean Sedimentary rock (AAS) [Taylor, S. R., and McLennan, S. M. (1980) *Precambrian Plate Tectonics* (A. Kroner, ed.), Elsevier].
28. Rb from K/Rb = 300, U from $K/U = 10^4$, Th from Th/U = 3.8, Hf from Zr/Hf = 33.
29. Sr, Zr, V, Ni from tholeiite/tonalite – trondhjemite mix (50/50). Tholeiite data from Sun, S. -S., and Nesbitt, R. (1978) *Contrib. Mineral. Petrol.* 65: 301 and (1977) *EPSL.* 35: 429. Tonalite and trondhjemite data from Glikson, A. (1978) *Earth Sci. Rev.* 15: 1.
30. H. Palme, pers. comm., 1980.

APPENDIX VII

Element classification, Condensation sequences

Part A Element classification based on relative volatility and siderophile character.

Refractory		Al	Ba	Be	Ca	Hf	Ir	Mo
		Nb	Os	Pt	REE	Re	Rh	Ru
		Sc	Sr	Ta	Ti	U	V	W
			Y	Zr				
Moderately refractory	Cr	Li	Mg	Si				
Volatile		Ag	Cs	Cu	F	Ga	Ge	K
1300–600° K		Mn	Na	Rb	S	Sb	Se	Sn
		Te	Zn					
Very volatile		B	Bi, Br,	C	Cd	Cl	Hg	I
(< 600° K)		In	Pb			Rare gases		Tl
Siderophile		Fe	Ni	Co	Cr	P	As	Au
		Pt	group					

Part B Sequence of condensations from an oxidized (C/O ~ 0.6) gas of solar composition at 10^{-3} atm. total pressure.

	Temperature °K
Refractory noble metals and hibonite ($CaAl_{12}O_{19}$)	1800–1700
Refractory oxides (Al_2O_3) Perovskite ($CaTiO_3$) Melilite ($CaAl_2Si_2O_7$) Spinel ($MgAl_2O_4$) U, Th, REE in solid solution	1700–1500
Metallic iron (Ni, Co)	1470
Diopside ($CaMgSi_2O_6$) Forsterite (Mg_2SiO_4) Anorthite ($CaAl_2Si_2O_8$) Enstatite ($MgSiO_3$)	1450–1300
Alkali feldspar (NaK) $AlSi_3O_8$, volatile metals, halogens	1000
Troilite (FeS) Pentlandite (Fe, Ni) S	700
Magnetite Fe_3O_4 phyllosilicate minerals (e.g., $Mg_3Si_2O_7 2H_2O$)	400
Ices	< 200

Part C Sequence of condensation from a reduced ($C/O \sim 1.0$) gas of solar composition at 10^{-3} atm. total pressure.

	Temperature °K
Refractory noble metals Os, W, Re, Pt	1800–1700
Reduced high-temperature condensates (TiCSiC, C, Te_3C, AlN Ca S*)	1900–1400
Metallic Fe (with Si)	1350–1200
Refractory oxides	1200–1100
Diopside ($CaMgSi_2O_6$) Forsterite (Mg_2SiO_4) Enstatite ($MgSiO_3$)	1150–1050

Below 10000° K, the sequence is the same as for an oxidized gas.

APPENDIX VIII

Chondritic Rare Earth Element Normalizing Factors.

La	0.367
Ce	0.957
Pr	0.137
Nd	0.711
Sm	0.231
Eu	0.087
Gd	0.306
Tb	0.058
Dy	0.381
Ho	0.0851
Er	0.249
Tm	0.0356
Yb	0.248
Lu	0.0381
Y	2.1

Values from Evensen, M.N., et al. (1978) *GCA. 42*: 1203, for Type 1 carbonaceous chondrites (volatile-free: 1.5 × original data).

APPENDIX IX

The Lunar Sample Numbering System

A total of 2196 samples, weighing 381.69 kg, was collected during the Apollo Missions. The basic numbering system employs a five digit number for the original samples collected on the luanr surface. A different prefix is employed for each mission:

Mission	Prefix
Apollo 11	10—
Apollo 12	12—
Apollo 14	14—
Apollo 15	15—
Apollo 16	6—
Apollo 17	7—
Luna 16	21—
Luna 20	22—
Luna 24	24—

For the Apollo 11, 12 and 14 missions, the remaining three digits have no special significance beyond designating the sampling sequence. For the Apollo 15, 16 and 17 rocks, the remaining digits serve to indicate both sample location and rock type. The Apollo 15 samples are numbered in groups more or less consecutively around the traverses. For the Apollo 16 and 17 missions, the second digit specifies the station on the traverses. The final digit specifies whether the sample is an unsieved soil (0), a sieved fraction of a soil (1 through 4) or a rock (5 through 9). Thus 64826 is a rock from station 4 on the Apollo 16 mission. The main exceptions to this system are the lowest sample numbers (e.g., 70007), which are for drill cores, drive tubes, and other special samples, regardless of location or type. Among the Apollo 15 samples, 15315–15392 and 15605–15689, including numbers ending in 0 through 4, are all rocks. Not all possible numbers were used.

Samples split from the original are identified by additional digits, separated by a comma from the original sample number. Thus 15455,20 is split number 20 from rock 15455.

A total of 69,000 such individual numbers now exists, each representing a documented piece of the Moon.

APPENDIX X

Planetary and asteroidal data arranged in order of increasing distance from the sun.[†]

		Semi-major axis (A.U.)	Inclination to ecliptic	Inclination of equator to orbit	Orbital period	Radius (km)	Mean density (g/cm^3)
	Mercury	0.387	7°00′	0°	86.0 d.	2439	5.435
	Venus	0.723	3°24′	177°	224.7 d.	6051	5.245
	Earth	1.000	0°00′	24°27′	1.00 yr.	6371	5.514
	Moon	-	5°09′	1°32′	-	1738	3.344
	Mars	1.524	1°51′	25°1	1.88 yr.	3390	3.934
8	Flora	2.202	5°89′	-	-	77	-
4	Vesta	2.362	7°13′	-	-	269	2.9
1	Ceres	2.767	10°61′	-	-	510	-
2	Pallas	2.769	34°83′	-	-	269	-
10	Hygiea	3.151	3°81′	-	-	225	-
65	Cybele	3.434	3°55′	-	-	154	-
107	Camilla	3.489	9°92′	-	-	105	-
624	Hektor	5.150	18°26′	-	-	108	-
	Jupiter	5.203	1°18′	3°6′	11.86 yr.	71,600	1.314
	Saturn	9.523	2°29′	26°42′	29.46 yr.	60,000	0.704
	Chiron	13.7	-	-	51.0 yr	175	-
	Uranus	19.164	0°46′	97°	84.01 yr.	25,900	1.21
	Neptune	29.987	1°47′	29°48′	164 yr.	24,750	1.66
	Pluto	39.37	17°10′	-	247 yr.	~1300	~1.0

[†]Sources: Newburn, R. (1978) *PLC 9*: 3; Newburn, R., and Matson, D. (1978) *PLC 9*: 2; Chapman, C., and Zellner, B. (1978) *PLC 9*: 1; Gehrels, T. (ed.) (1979) *Asteroids*, Univ. Arizona Press.

APPENDIX XI

Satellite data, arranged by planet.

Planet	Satellite	Semi-major axis (10^3 km)	Orbital period (r = retrograde)	Diameter (km)	Density (g/cm^3)	Inclination to equatorial plane of planet
Earth:	Moon	384.4	27.32 d.	3476	3.344	18.5° to 28.5°
Mars:	Phobos	9.38	7.65 h.	27×21×19	1.9	1.04°
	Deimos	23.5	30.3 h.	15×12×11	—	2.79°
Jupiter:						
	1979J 3	126	7.1 h.	40	—	—
	1979J 1	128	7.1 h.	35	—	—
J V	Amalthea	182	12 h.	270×170×155	—	0.45°
	1979J 2	223	16.2 h.	75	—	—
J I	Io	422	1.8 d.	3632	3.55	0.02°
J II	Europe	671	3.6 d.	3072	2.99	0.47°
J III	Ganymede	1071	7.2 d.	5276	1.93	0.18°
J IV	Callisto	1884	16.8 d.	4820	1.83	0.25°
J XIII	Leda	11,094	239 d.	10	—	26.7°
J VI	Himalia	11,487	251 d.	170	—	27.6°
J VII	Erala	11,747	260.0 d.	80	—	24.8°
J X	Lysithea	11,861	264.0 d.	25	—	29.0°
J XII	Anake	21,250	r. 1.72 yr.	20	—	147°
J XI	Carme	22,540	r. 1.89 yr.	30	—	164°
J VIII	Parisphae	23,510	r. 2.02 yr.	35	—	145°
J IX	Sinope	23,670	r. 2.07 yr.	30	—	153°
Saturn:	S 15	136	14.3 h.	40×20×20	—	—
	S 14	138	14.6 h.	220	—	—
	S 13	141	15.0 h.	200	—	—
	S 11	151	16.7 h.	180×80	—	—
	S 10	151	16.7 h.	200×180×150	—	—
S II	Mimas	186	22.6 h.	390	1.2	1.52°
S III	Enceladus	238	1.4 d.	500	1.1	0.02°
S IV	Tethys	295	1.9 d.	1050	1.0	1.09°
	S 16	295	1.9 d.	20 ?	—	—
	S 17	295	1.9 d.	30 ?	—	—
S V	Dione	377	2.7 d.	1120	1.4	0.02°
	Dione B	377	2.7 d.	160	—	—
S VI	Rhea	527	4.5 d.	1530	1.3	0.35°
S VII	Titan	1222	15.9 d.	5144	1.9	0.33°
S VIII	Hyperion	1484	21.3 d.	290	—	—
S IX	Iapetus	3562	79.3 d.	1440	1.2	14.72°
S X	Phoebe	12,960	r. 550 d.	240	—	150°
Uranus:	Miranda	130	1.4 d.	300	—	3.4°
	Ariel	191	2.5 d.	800	—	~0°
	Umbriel	266	4.1 d.	550	—	~0°
	Titania	436	8.7 d.	1000	—	~0°
	Oberon	583	13.5 d.	900	—	~0°
Neptune:	Triton	356	r. 5.9 d.	4000	—	159.9°
	Nereid	5567	360 d.	300	—	27.7°
Pluto:	Charon	19	6.4 d.	1300	—	~105°

Sources: Newburn, R., and Matson D. (1978) *PLC 9*: 2;
Science. (1979) 204, 945;
Science. (1979) 206, 925;
Science. (1981) 212, 159.