APOLLO 16 LUNAR GLASSES: NORMATIVE COMPOSITION AND ORIGIN.
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Major element compositions have been determined by microprobe analysis of 322 glass particles in the 0.25-0.06 mm size fraction of soil samples from all Apollo 16 stations. To explore mineral compositions of potential source materials of impact glasses, the chemical data have been converted into weight percents of norm minerals anorthite (an), albite (ab), orthoclase (or), enstatite (en), ferrosilite (fs), wollastonite (wo), forsterite (fo), fayalite (fa), quartz (qu), ilmenite (il) and spinel (sp). The results are shown in Fig.1: each glasss particle is represented by a point in triangles pl-px-ol and pl-px-qu, respectively (il and sp are neglected; pl=an+ab+or; px=en+fs+wo; ol=fo+fa;). The 322 glasses form a continuum with some blurred clusters. As usual in other continous complexes, e.g. magmatic rocks, the multitude of glasses must be classified by arbitrary or conventional dividing lines which are boundaries of certain compositional fields. Glass "groups" or "classes" must be defined by such boundaries, not by averages of chemical or normative composition. I tentatively distinguish 12 fields (Fig.1, Table 1). The applicability of this pattern was tested with 270 normative compositions of Apollo 16 individual glass particles and "glass groups", calculated from chemical analyses in the literature.

The glass particles are of different origin and had different histories of formation and cooling. They are either fragments of larger masses or quenched melt droplets and they cooled either rapidly to glass or more slowly to vitrophyric structures. The ratios fragments/droplets and glasses/vitrophyres show characteristic differences for particles of different normative fields. Some of the field I glasses, consisting of more than 95% plagioclase, are diaplectic glasses. Glass particles of field VIII are "green glasses" of volcanic origin. The majority of the analyzed glasses are quenched impact melts. Their normative compositions provide informations on shock-melted mineral aggregations.

Normative compositions of fine fractions of Apollo 16 regolith samples, of agglutinates from Apollo 16 soils and of 119 rock fragments collected at the Apollo 16 site do not cover the whole range of glass compositions: Fines and agglutinate particles occupy a restricted area in the center of glass field III. 85% of all rocks belong to the plagioclase-rich fields I, II, III and XI.

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It follows that glasses of fields IV, V, VI, VII, IX, X and XII, i.e. 47% of the analyzed particles, can neither be derived from the fine fraction nor from the coarse rock components of the local regolith. One possibility would be that these olivine-rich, pyroxene-rich and quartz-normative glasses are exotic components which reached the Apollo 16 site by lateral transport. Another posssibility is based on the observation at terrestrial impact craters that impact melts are formed from rocks deep below the original ground level. Examples are structures like Ries, Popigai, Lake St.Martin and Araguainha where the impact melts were formed from crystalline rocks, overlain by thick sedimentary sequences, whereas fragmental breccias consist mainly of weakly shocked materials from upper levels of the target. The consequence would be that in the Descartes region multiple impacts have produced the weakly shocked fine and coarse components of the regolith, predominately derived from upper levels of the lunar crust below the regolith, whereas impact glass particles represent in the average deeper levels. It follows that anorthosites (fields I, II, XI) and olivine- poor rocks of noritic composition (field III) prevail in upper levels, whereas troctolitic rocks with wo-rich pyroxene (field IV), and pyroxene-rich, ol-normative (fields V, VI, VII) and qu-normative rocks (fields IX and XII), some of them rich in ilmenite, are more abundant at greater depths.

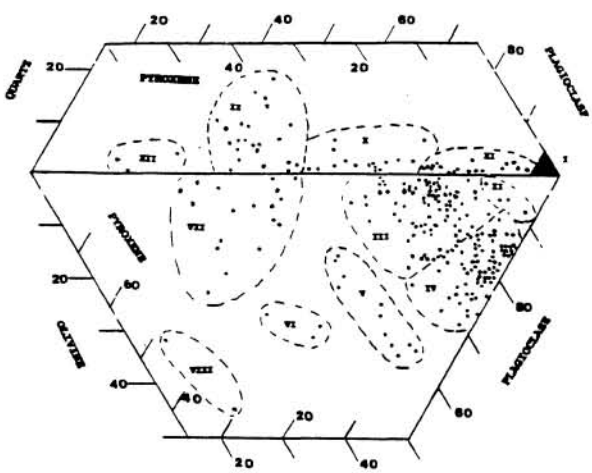

Fig.1. Normative composition of 322 glass particles from Apollo 16 soils.

Field	Pl	Px	Ol	Qu	%
I	95-100	...	...	...	17
II	85-95	0-12	0-10	0	2
III	65-85	10-30	0-15	0	23
IV	65-87	0-15	10-30	0	29
V	50-60	5-30	15-35	0	4
VI	35-50	20-35	25-32	0	1
VII	30-60	40-60	0-25	0	6
VIII	20-30	30-50	30-50	0	0.6
IX	40-60	35-55	0	0-20	7
X	60-75	15-35	0	0-10	5
XI	75-95	5-20	0	0-10	6
XII	25-40	55-70	0	0-5	1

Table 1. Normative fields of Apollo 16 glasses.