Significant Lunar Minerals

Mineral Names

The compositions of minerals naturally fall into certain groups. A group shares a common anion and similarities in how the lattice of the minerals are structured. Plagioclase, olivine and pyroxene groups are silicates. Other groups of importance on the Moon are the oxides, of which the spinel group is a specific subset, the sulfides, the phosphates and the native (no anions) metals.

In many cases within a group individual crystals may have quite a range of compositions. So for example a specimen in the olivine group may actually be half way between pure fayalite (Fe_2SiO_4) and pure forsterite (Mg_2SiO_4), or anywhere in between the end members. For mineral groups where this happens, geologists frequently will refer to the group name, rather than the mineral name. In such cases geologist will indicate the relative amount of each end member by giving the ratio of one end member to the total. For example an olivine that is half forsterite and half fayalite is described as Fo_{50}, where Fo refers to the forsterite end member. This approach is also used for the plagioclase group, where the two end members are anorthite ($CaAl_2Si_2O_8$) and albite ($NaAlSi_3O_8$). The relative amounts of these two end members in a crystal are expressed as An_{90}. This is saying that 90% of the plagioclase is the anorthite end member.

Lunar Abundance

The terms indicating relative abundances in Table 1 are not formally defined. For this table the general concepts are as follows. Something that is **A**bundant is wide spread and usually more than ~33% of the material. A **M**ajor constituents will be present at levels >5%. A **m**inor mineral will usually fall in the range 0.1 to 5%. A **t**race mineral is usually less than 0.1% of a sample.

The Moon is dominantly composed of silicate minerals. Typically, plagioclase is by far the most abundant and there commonly are substantial amounts of pyroxenes and olivines. Together, these three mineral groups usually, but not always, make up >95% of the crystalline material in the rock and the regolith.

There are varying amounts of other minerals on the Moon. The non-silicate minerals included in Table 1 are designed to capture specific minerals or types of minerals that are either locally significant or representative of specific engineering concern.

Other Information

To prevent ambiguity as to what is meant be a specific mineral name, a standard called the Dana Number is given. With this number a mineralogist can ascertain exactly what is meant when the mineral name is used.

Mohs hardness is a standard way of comparing the “hardness” of minerals. 304 stainless steel has a hardness of approximately 4.5 on the Mohs scale. 440C Stainless Steel (HRC60) falls just over 6. Clearly, many if not most of the engineering materials used will be susceptible to abrasion from the majority of the lunar minerals.

The specific gravity compares the density of the mineral to water. This will have significant in situations such as computation of inertia and blocking of radiation.

The chemical formula for each mineral is also listed. These are the ideal formulas. Real minerals always depart to some extent from these ideals. Usually the departure is of no great significance for engineering purposes. Geologists commonly report chemical analyses of rocks as weight percent oxides. It is important to realize that for the most part such oxides simply do not exist. Rather the minerals, as listed, or glasses made from these minerals are what exist.

TABLE 1. Significant Lunar Minerals..

	Mineral	Dana #	Mohs Hardness	Spec Gravity	Chemical Composition	%*
Plagioclase	Anorthite	76.1.3.6	6	2.75	$CaAl_2Si_2O_8$	A
	Bytownite	76.1.3.5	6.0-6.5	2.73	$(Ca,Na)(Si,Al)_4O_8$	M
	Labradorite	76.1.3.4	7	2.71	$(Ca,Na)(Si,Al)_4O_8$	M
Olivine	Fayalite	51.3.1.1	6.5-7.0	4.39	Fe_2SiO_4	m
	Forsterite	51.3.1.2	6.5-7.0	3.24	Mg_2SiO_4	M
Pyroxene	Clinoenstatite	65.1.1.1	5.0-6.0	3.4	$Mg_2\,[Si_2O_6]$	M
	Pigeonite	65.1.1.4	6	3.3	$(Mg,Fe^{+2},Ca)_2[Si_2O_6]$	M
	Hedenbergite	65.1.3a.2	6	3.5	$CaFe^{+2}[Si_2O_6]$	m
	Augite	65.1.3a.3	5.5-6.0	3.3	$(Ca,Na)(Mg,Fe,Al,Ti)[(Si,Al)_2O_6]$	M
	Enstatite	65.1.2.1	5.0-6.0	3.4	$Mg_2[Si_2O_6]$	A
O	Ilmenite	4.3.5.1	5.5	4.72	$Fe^{+2}TiO_3$	m
Spinel	Spinel	7.2.1.1	7.5-8.0	3.56	$MgAl_2O_4$	m
	Hercynite	7.2.1.3	7.5-8	3.93	$Fe^{+2}Al_2O_4$	m
	Ulvospinel	7.2.5.2	5.5-6.0	4.7	$TiFe^{+2}{}_2O_4$	m
	Chromite	7.2.3.3	5.5	4.7	$Fe^{+2}Cr_2O_4$	m
S	Troilite	2.8.9.1	4	4.75	FeS	t
PO4	Whitlockite	38.3.4.1	5	3.12	$Ca_9(Mg,Fe^{+2})(PO_4)_6(PO_3OH)$	t
	Apatite	41.8.1.0	5	3.19	$Ca_5(PO_4)_3(OH,F,Cl)$	t
	Native Iron	2.9.1.1	4.5	7.87	Fe	t

* - Typical relative abundance, A-abundant, M-major, m-minor, t-trace.