AL-RICH PYROXENES: METASTABLE FORMATION IN SUPERCOOLED LUNAR BASALTIC AND TERRESTRIAL IMPACT MELTS

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Clinopyroxenes with 4 - 12 weight% Al_2O_3 have been observed in Apollo 15 samples only in mare basaltic rocks with vitrophyric or px-phyric textures: 15118 (qz-normative, px-phyric); 15125 (qz-normative, px-phyric); 15256 (ol-normative impact melt breccia); 15486 (qz-normative, vitrophyric); 15499 (qz-normative, vitrophyric);15597 (qz-normative, vitrophyric); 15666 (qz-normative, px-phyric); 15682 (qz-normative, px-phyric). (Chemical and petrological data of 15256 from own investigations, of the other rocks from the literature, referred by Ryder 1985).

Al-rich pyroxenes in these rocks are phenocrysts, often of skeletal shape, in vitreous or microcrystalline matrix, indicating rapid growth in supercooled melts.

In comparison to normative pyroxenes, calculated from analyses of the parent rocks, Al-rich pyroxenes are higher in Ca and lower in Fe; average Mg:Fe:Ca is 37:46:17 in normative pyroxenes, and 37:33:30 in Al-rich pyroxenes. The largest part of Al replaces Si in tetrahedral coordination (Al^{IV}); charge balance is maintained by Ti^{4+} and Al^{3+} (Al^{VI}), to a lower degree by Cr^{3+} in octahedral sites. The composition of a pyroxene with 8.5% Al_2O_3 from 15256 is ,e.g.:

$(Si_{1.73}\ Al_{.27})(Al_{.12}\ Ti_{.08}\ Cr_{.01}\ Fe_{.74}\ Mg_{.50}\ Ca_{.53})\ O_6.$

With fourvalent Ti and trivalent Cr, Al^{IV} should be equal to Al^{VI}+ 2 Ti + Cr. Fig. 1 shows that this is not the case, indicating some Ti^{3+} and/or Cr^{2+} in octahedral coordination. These pyroxenes are apparently metastable phases which formed under conditions of rapid cooling, favouring the uptake of Ca, and slowly diffusing Al and Ti by the pyroxene lattice. Depletion of the melt in Ca and Al impeded or retarded the crystallisation of plagioclase.

Al-rich pyroxene was synthezised by annealing a melt of 15555 composition for up to 115 hours at various temperatures and f_{O2} close to the FeO/Fe equilibrium. Olivine appeared between 1300 and 1050°C and pyroxene between 1050 and 950°C, below 1000°C together with ilmenite, but no plagioclase was formed. The average pyroxene composition (8% Al_2O_3) is:
$(Si_{1.74}Al_{.26})(Al_{.11}Ti^{4+}_{.06}Ti^{3+}_{.02}Fe_{.48}Mg_{.57}Ca_{.74})O_6$.

We suppose that no plagioclase crystallized in these experiments because rapidly nucleating pyroxene captured too much Al and Ca.

Trichitic crystals of Al- and Ca-rich pyroxene and microspherulitic plagioclase are components of vitrophyric impact melt glass in suevite breccias of the Ries crater, Germany. The average of 13 pyroxenes in one glass sample contains 9% Al_2O_3 and corresponds to
$(Si_{1.83}Al_{.17})(Al_{.24}Ti_{.01}Fe_{.45}Mg_{.79}Ca_{.42}Na_{.02}K_{.02})O_6$,

with Mg:Fe:Ca = 48:27:25; normative pyroxene, calculated from the composition of the granodioritic impact melt, has Mg:Fe:Ca = 51:33:16. Areas of pyroxene and feldspar crystallisation are, in general, distinctly separated in these glasses. We assume that also in this case feldspar nucleation was impeded in areas of pyroxene growth by the depletion of the melt in Al and Ca.

Reference: Ryder, G. (1985), Catalogue of Apollo 15 rocks. Curatorial Branch Publication 72, Lyndon B.Johnson Space Center, Houston, Texas.

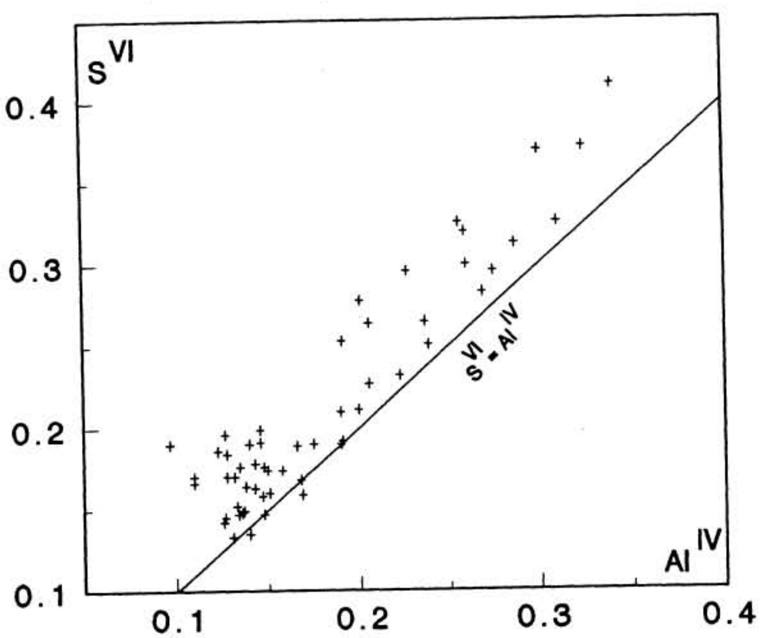

Fig.1 55 Al-rich Apollo 15 rocks: Al^{IV} versus $S^{VI} = Al^{VI}+Ti+Cr$