

Pyroxenes and Olivines in Crystalline Rocks From Ocean of Storms

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Apollo 12 crystalline rocks 12044, 12057 and 12063 have been examined in detail, using optical, X-ray and microprobe techniques, to determine the petrology, chemistry, deformation state and fabric principally of the pyroxenes and olivines. All three rocks have a subophitic texture and are composed predominantly of intermixed pigeonite and augite and calcic plagioclase with olivine content ranging from 0 in 12057 to about 10% in 12063; ilmenite and cristobalite are the major accessories. The euhedral to subhedral olivines are commonly corroded and are strongly zoned both in major and minor elements. The cores are commonly about Fe_{70} decreasing to Fe_{55} at the margins and the crystals are enriched in Cr and depleted in Ca and Ni relative to terrestrial olivines. The pyroxenes consist of intermixed augite and pigeonite commonly elongate parallel to c with a very thin (ca. 10μ) pigeonite nucleus parallel to (100) growth twins and sheathed along the prism planes by augite. The fractionation trend (commonly discontinuous) normal to (100) is pigeonite \rightarrow subcalcic augite \rightarrow Fe-rich pigeonite \rightarrow Fe-rich subcalcic augite \rightarrow hedenbergite. In crystals with thicker pigeonite cores the trend approximately parallel to c from center to end is low Ca pigeonite \rightarrow high Ca pigeonite \rightarrow low Ca pigeonite \rightarrow low Ca, Fe-rich pigeonite. The elements Ti, Al and Cr are enriched in augite relative to pigeonite and the distribution of Ti and Al suggests the low pressure coupled substitutions $2 Al + Ti \rightleftharpoons 2 Si + R^{+2}$.

The diabase chip, 12057, from the regolith has been heavily shocked as indicated by shock mosaicism, shock lamellae, bending, faulting and fracturing. There is very little or no evidence of shock damage to 12044 and 12063. Plagioclase is generally undistorted and olivine, which of the silicates is most susceptible to static and dynamic deformation, shows no deformation whatever. The pyroxenes, apart from (100) twins, are, however, commonly highly distorted generally by rotations about [010]. Thin lamellar features parallel to (001) in the augite appear to be exsolution lamellae but the augite also contains small regular to irregular zones subparallel to (001) having small disorientations and giving rise to a "mosaic" or "stepped" appearance. The lack of evidence of deformation of olivine and the presence of undisturbed plagioclase laths and skeletal ilmenite crystals in highly disoriented pyroxenes indicates that these structures are not due to deformation. The disorientations are ascribed to growth and quenching phenomena and the stepped disorientations in the augite may be related to the transition of pigeonite from $C2/c$ to $P2_1/c$ upon quenching. The fabrics of both olivine and pyroxenes in 12063 are very weak, even though the pyroxene grains are highly inequant, indicating growth in situ with little or no gravitational settling.

All of the primary features discussed above are consistent with rapid growth and quenching phenomena; there is no evidence of post-crystalline static deformation, in agreement with the results from the Sea of Tranquillity.

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