X-Ray-Studies of Plagioclases and Pyroxenes
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Plagioclase

16 crystals from Apollo 14 lunar rocks 14310.106 were studied by single crystal X-ray diffraction methods. Besides Weissenberg and Buerger precession cameras a monochromatically focussing single crystal camera with high resolution power (1), (2) was used. Crystal No. 2 shows, that it consists practically of only two individuals described by a complex "albite-Karlsbad" twin law (mirror plane (010) and rotation axis [001]) and crystals No. 5 and No. 15 show also only a pair of twins after the albite law. With these exceptions the other crystals investigated show three or four individuals after albite and "Karlsbad" (rotated around [001]) twin laws.

On precession and Weissenberg photographs 'a' and 'b' or 'a', 'b' and 'c' (diffuse in direction b*) were observed. Crystal No. 5 shows additionally 'e' and 'f' reflections. Weissenberg photographs of the crystal (0.1 x 0.1 x 0.1 mm) were carefully taken with better collimated incident X-rays. On extremely long exposed photographs (200 hours) the following characteristics on the 'a', 'b' and 'e' reflections were observed:

On Okl photographs the position of 'e' reflections is symmetric with respect to 'b' reflections (like satellites). On 4kl photographs the same is not true, additionally 'a' reflections are split into two reflections.

This is characteristic for an "incoherent" two-phase pattern of sub-microscopically intergrown phases with different An-contents.

The analogous position of reflections were observed on the photographs of some corresponding terrestrial specimens An(70)~An(77), in which approximately An(65) and An(80) were determined as exsolution end members (3). An(65) has intermediate structure and An(80) anorthite-like structure with P-lattice. a and c axes of both phases are parallel to each other and the boundary between these two phases is most probably (010). Whether the formation of twins and the exsolution are correlated or not is not yet known.

Single crystal photographs of high resolution power of crystal No. 6
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were taken in a focussing camera. 'a' reflections observed were more diffuse than the corresponding reflections of terrestic specimens. No super-satellite reflections were observed.

Pyroxenes

X-ray studies of 6 crystals of clinopyroxene (pigeonite) and two single crystals of orthopyroxene of lunar sample 14310.106 have been investigated by optical and X-ray methods, applying various single crystal techniques including focussing or semi-focussing devices. The following lattice constants have been determined for the pigeonites

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a = 9.665, \quad b = 8.388, \quad c = 5.\text{2}19, \quad \beta = 108.8^\circ; \quad \text{space group } \frac{2}{1}.\
\]

The lattice constants differ slightly from previous investigations of lunar pyroxenes, indicating a lower Ca- and higher Fe-contents. Most of the crystals showed a more or less pronounced diffuseness of the reflections \((hkl)\) with \(h+k=2n\), which is complementary to the diffuse reflections \(h+k=2n+1\) reported elsewhere (4), (5). On the other hand they were also different from the streaks connecting the pigeonite and augite reflections(6). Diffuse streaks originating from the pigeonite reflections point into the direction where augite reflections are expected, sometimes a very diffuse reflection has approximately the position of the expected augite reflection.

Orthopyroxenes are very rare in sample 14310.106. Although the reflections are generally less diffuse than the corresponding reflections of the pigeonites described above. It could be shown, that the diffuseness of reflections is much more pronounced for reflections with large \(k\) indices when compared with reflections with big values of \(h\). The dependence of diffuseness as a function of \(l\) has not yet been determined. A marked heterogeneity of reflection intensities is correlated with the broadening of reflections.

X-ray photographs with focussing monochromators show the typical effects of "polygonization" in extremely small parts of the crystal. The splitting of Bragg-reflections observed for special values of \((hkl)\) is apparently anisotropic. The polygonization pattern shows very sharp maxima, which seems to be due to curvatures in certain areas of the crystal. All maxima are connected by diffuse intensities. Thus is seems to be improbable, that the effects observed are due to different orientations of mosaic blocks Additional reflections of lower intensity are also observed, the interpretation of which can not yet been given.

The theory of X-ray diffraction of lamellar phase separation (2 phases) has been developed in case of congruent and incongruent planes of intergrowth. If the averaged thickness of lamellae exceeds approximately \(100 \AA\), the calculated diffraction pattern is satisfactorily described by an incoherent superposition of both diffraction pictures.
Thin lamellae cause diffuse scattering, which differs appreciably from the incoherent model: Asymmetric streaks accompany the Bragg reflection, and in case of an averaged thickness of a few lattice constants, the diffraction pattern of the thin lamellae is replaced by diffuse bands, the asymmetry of which is described by the imaginary part of intensity constants. Diffuse streaks connect the reflections of the two phases, they are straight in case of congruent planes of intergrowth, but they may be curved if incongruent planes of intergrowth occur. Lunar An-rich feldspars show exsolution lamellae with incongruent planes and lunar pyroxenes congruent and possibly incongruent planes of intergrowth. We thank Prof. Laves and his coworkers for stimulating discussions.

Literature

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