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A Study of Bytownites in Amphibolites of the Ivrea-Zone (Italian Alps) and in Anorthosites: a New Unmixing Gap in the Low Plagioclases

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For a long time the low plagioclases were believed to be a continuous solid solution series. However, optical discontinuities had been reported already by v. FEDOROW (1898, cf. WENK 1967) and structural discontinuities were described first by CHAO and TAYLOR (1941). In 1951, LAVES proved the existence of an unmixing gap in the low plagioclases of the peristerite range, i. e. for bulk compositions between approx. 1 and 17 mol-% An. In this note observations will be reported suggesting the existence of a second unmixing gap in the low plagioclase series.

The plagioclases with fine lamellae in bytownite-pyroxene-amphibolites from Anzola (Valle d'Ossola) described first by JÄGER and HUTTENLOCHER (1955) have been reinvestigated, and similar bytownites have been found in the surrounding rock units of the Ivrea-Zone as well as in anorthosites e. g. of the Lewisian at Roneval (South Harris, Outer Hebrides), the Precambrian of Minnesota, Essex County (N. Y.), Norway, the Black Forest, the Bushveld Complex and (as inclusions in labradorite) in anorthosites from Tabor Island, Labrador.

Electron microanalyser and optical measurements show that the composition of the bytownite grains varies between approx. 65 and 85 mol-%. The lamellae appear in areas with approx. 66.5 mol-% An and there have a distance around 6 μ. This distance becomes smaller with increasing An content and reaches the resolution limit of the polarisation and phase contrast microscopes near 80 mol-% An, so that the margins of grains with inverse zoning appear optically homogeneous. However, several specimens show blue schiller colours along these margins when observed in thin sections. This is interpreted as Bragg diffraction from submicroscopic lamellae, which have been observed in electron transmission by virtue of their diffraction contrast. The lamellar boundaris are oriented near $(\bar{6}01)$.

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From the following experimental results it can be inferred that the lamellae are exsolved bytownite with approximately 83 mol-% An composition:

1. Interference microscopy shows that the refractive index of the lamellae is considerably higher than that of the matrix (observed in the plane normal to the lamellae and to (010)).

2. The optical extinction differences between the matrix and the lamellae are the same as between the matrix and the homogeneous parts of the grains which have over approx. 80 mol-% An.

3. In the electron probe microanalyser a scan of Ca and Na across the lamellae shows rhythmic changes indicating higher Ca and lower Na contents in the lamellae as compared to the matrix which has 65—70 mol-% An composition.

4. If the thicknesses of the lamellae are taken as statistically constant at varying compositions, the distance of the lamellae is a measure of the volume proportion of An-rich to An-poor material. This leads to the assumption that materials with less than approx. 67 and more than approx. 83 mol-% An are homogeneous. The distance of the lamellae is a function of the An content.

5. Precession photographs of the lamellate material show b reflections typical for bytownite and anorthite as well as "b-split" reflections typical for intermediate low plagioclases.

6. Electron transmission micrographs of the lamellae in particles where they have submicroscopical thicknesses show a pronounced diffraction contrast between lamellae and matrix.

7. Selected area electron diffraction patterns including at least one lamella show a doubling of certain Kikuchi lines which is interpreted as minute differences between the lattice constants of the matrix and those of the lamellae (cf. NISSEN and BOLLMANN 1968). The doubling is not observed if the selecting aperture is shifted so that only matrix material contributes to the diffraction pattern.

8. If particles with lamellae are observed under extreme magnifications in dark field electron microscopic observation using only the diffracted intensity of a pair of "b-split" reflections, regular alternating dark and white stripes with approx. 28 Å periodicity interpreted as antiphase domains[1]) (cf. GLOSSOP and PASHLEY 1959, MCCONNEL and FLEET 1963) can be observed in the entire powder particle with the exception of the lamellae which must therefore lack this antiphase domain texture and thus have a different atomic structure.

The existence of an unmixing gap between approx. 67 and 83 mol-% An is concluded from these data. Lattice constant measurements by GRUNDY and

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[1]) Due to satellite extinction rules the antiphase domains must have twice the thickness as that observed in the electron microscope.

BROWN (1967) show that lattice angles for these substances are practically identical at $650 \pm 100°C$, when the material is supposed to have unmixed producing a minimum of phase boundary strains. — Theoretical considerations to be published on changes in geometric and physical properties of the low plagioclases are compatible with the proposed end members of unmixing.

This is an abstract of a talk presented at the "Symposion Ivrea-Verbano", 30. III. to 3. IV. 1968, Locarno. I am very indebted to Mr. R. Gubser for electron probe microanalysis of bytownite from Anzola and to Mr. R. Wessicken-Buchta for help with phase contrast and interference microscopy. Many colleagues from Zürich, Bern and Basel kindly contributed rock specimens. A full account of this subject is in preparation as part of a habilitation thesis.

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