BADDELEYITE — ZrO_2 — FROM LOVASJÄRVI DIABASE, SOUTHEASTERN FINLAND

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Baddeleyite is described from a basic intrusion from southeastern Finland. Microprobe analyses resulted in the following chemical composition besides ZrO_2: HfO_2 0.9—1.5, FeO 0.2, $TiO_2 < 0.1$ and $Al_2O_3 < 0.1$ percent. The mineral occurs together with zircon and quartz. Comments concerning this mineral paragenesis are presented.

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Introduction

Baddeleyite, ZrO_2, has been described as an accessory mineral from very different types of occurrences most of which are silica-free or -poor rock types. It has been recorded in ultrabasic rocks (kimberlite, ilmenitenorite), carbonatites, alkali syenites, sanidine lavas and granitic pegmatites. It has also been reported from placers, impact glasses, tektites, and especially from lunar rocks (basalts). Recently, baddeleyite has been described also from terrestial gabbroic rocks by Keil and Fricker (1974).

In Finland baddeleyite has formerly been identified from the Sokli carbonatite (Paarma, 1970), and lately from the Porttivaara albite diabase, northeastern Finland (Dr. O. Kouvo, pers. comm., 1976) and from the Jotnian diabases from Säppi and Sorkka, southwestern Finland and from Norrgrunnan, western Finland, (Dr. O. Kouvo and Mr. M. Vaasjoki, pers. comm., 1976).

This note is concerned with an occurrence of baddeleyite in a diabase from southeastern Finland. Microscopic determinations and heavy mineral separations confirm that in this case baddeleyite appears to be the major Zr-bearing phase.

Geological environment

A differentiated basic intrusion, here called the Lovasjärvi diabase, is situated between the large Wiborg and the smaller Suomenniemi rapakivi massifs in southeastern Finland, (see Geological Map of Finland, Pre-Quaternary Rocks. Sheet 3132-Savitaipale. Simonen and Tyrväinen, 1965). The trend of the diabase »dike» is N 45° W. Thus it coincides with the general trend of the diabase dike set described by Laitakari (1969). The length of the intrusion is about 5 km and the width does not exeed 1 km. The diabase is in contact with both rapakivi granites mentioned above. Geologically it is clearly older than the rapakivi intrusions. This fact is verified by the eruptive breccias and rapakivi veins in diabase which are met with at the both ends of the Lovasjärvi diabase »dike». The radiometric age of the diabase (1650 M.a., U-Pb age from zircon) agrees with that of the rapakivi within the limits of error. The petrographic description of the Lovasjärvi diabase will be given elsewhere in near future.

Mineral description

Baddeleyite was first detected optically in a polished thin section of the Lovasjärvi diabase. The identification was confirmed by using the electron microprobe and X-ray diffraction methods. Afterwards, the heavy mineral separations made for the dating proved that baddeleyite predominates over zircon.

Baddeleyite occurs as inclusions in slightly sericitized plagioclase (An 40—50), in fractures between other mineral grains and in contact with quartz and zircon (Figs. 1—4). Sometimes baddeleyite grains have a zircon

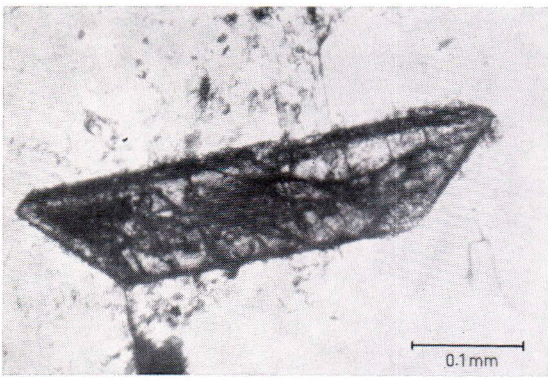

Fig. 1. Euhedral baddeleyite as an inclusion in slightly sericitized plagioclase. Photo E. Halme.

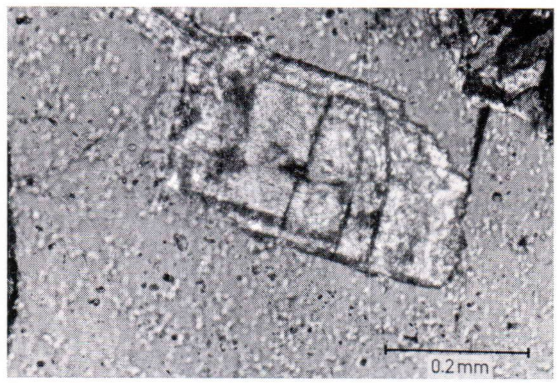

Fig. 3. Zircon mantled anhedral baddeleyite. Cf. the X-ray scanning images in Figures 5. Photo E. Halme.

Fig. 2. Twinned baddeleyite between quartz and apatite. Cf. the X-ray scanning images in Figure 6. Photo E. Halme.

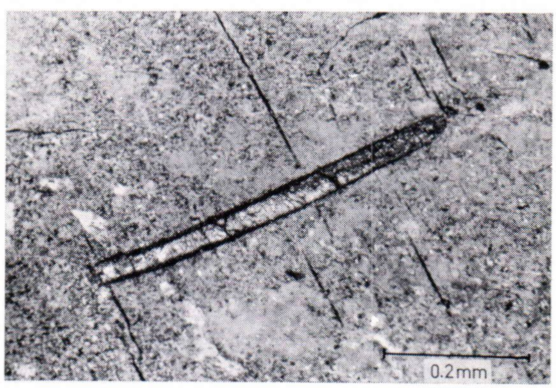

Fig. 4. Rodlike baddeleyite in plagioclase. Photo E. Halme.

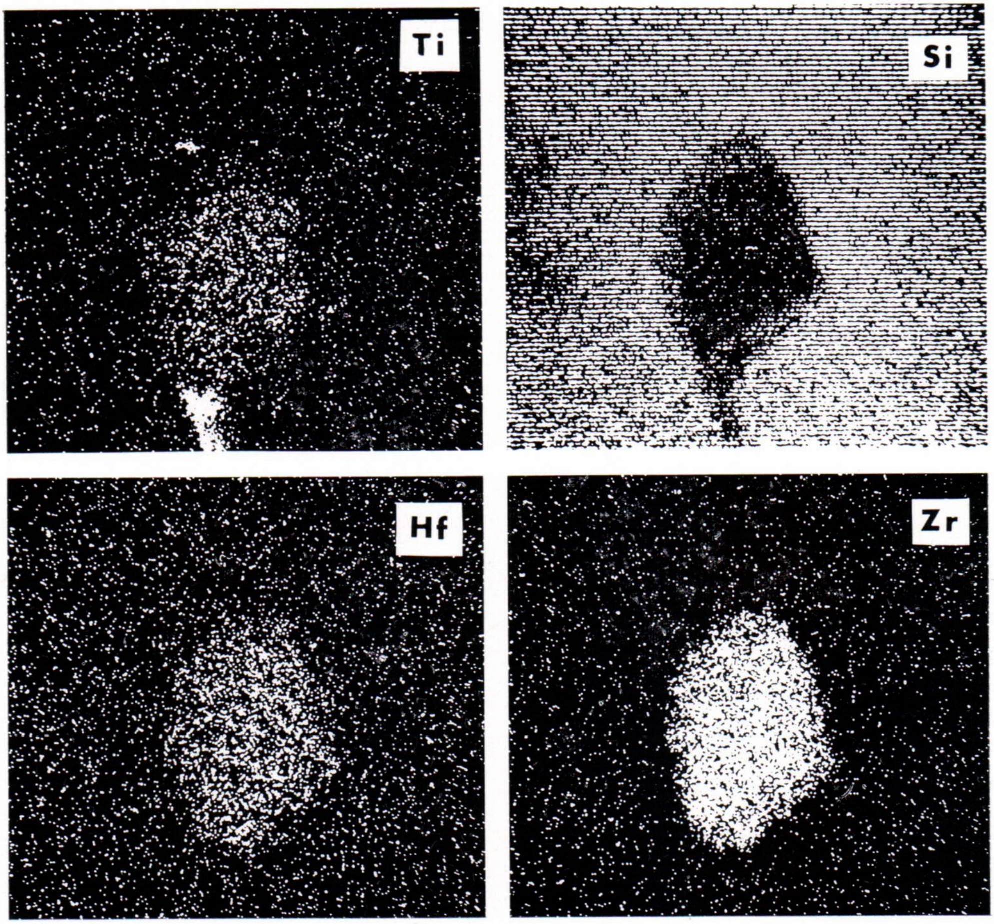

Fig. 5. $TiK\alpha_1$-, Si $K\alpha$-, Hf $L\alpha_1$-, and Zr $L\alpha_1$- scan-ning images. Same mineral grain as in Figure 3. Si- and Zr- images show markedly the zircon mantle around baddeleyite.

mantle as shown in Figure 3 (cf. X-ray scanning images of the same mineral grain in Figure 5.). The mineral commonly shows a euhedral habit (Fig. 1) but, on the other hand, subhedral to anhedral grains are not rare (Figs. 2—4). Maximum length of the euhedral baddeleyite crystals measures up to 0.4 mm. Prismatic baddeleyite is polysynthetically twinned on the monoclinic (100) plane (Fig. 2). Untwinned grains are not very common. The colour of the mineral is yellowish with a faint pleochroism from yellowish to pale brownish.

Microprobe analyses, performed on several mineral grains, resulted in the following chemical composition (besides ZrO_2): HfO_2 0.9—1.5, FeO 0.2, $TiO_2 < 0.1$ and $Al_2O_3 < 0.1$ weight percent. No other elements were detected. The chemistry of the Lovasjärvi baddeleyite is also depicted by the X-ray scanning pictures in Figures 5—6. Zr and Hf are not always evenly distributed in baddeleyite. This is depicted by the X-ray scanning images in Figure 6. Baddeleyite grains, intimately intergrown with zircon, sometimes show small silica contents due to zircon.

The crystal habit of baddeleyite is shown

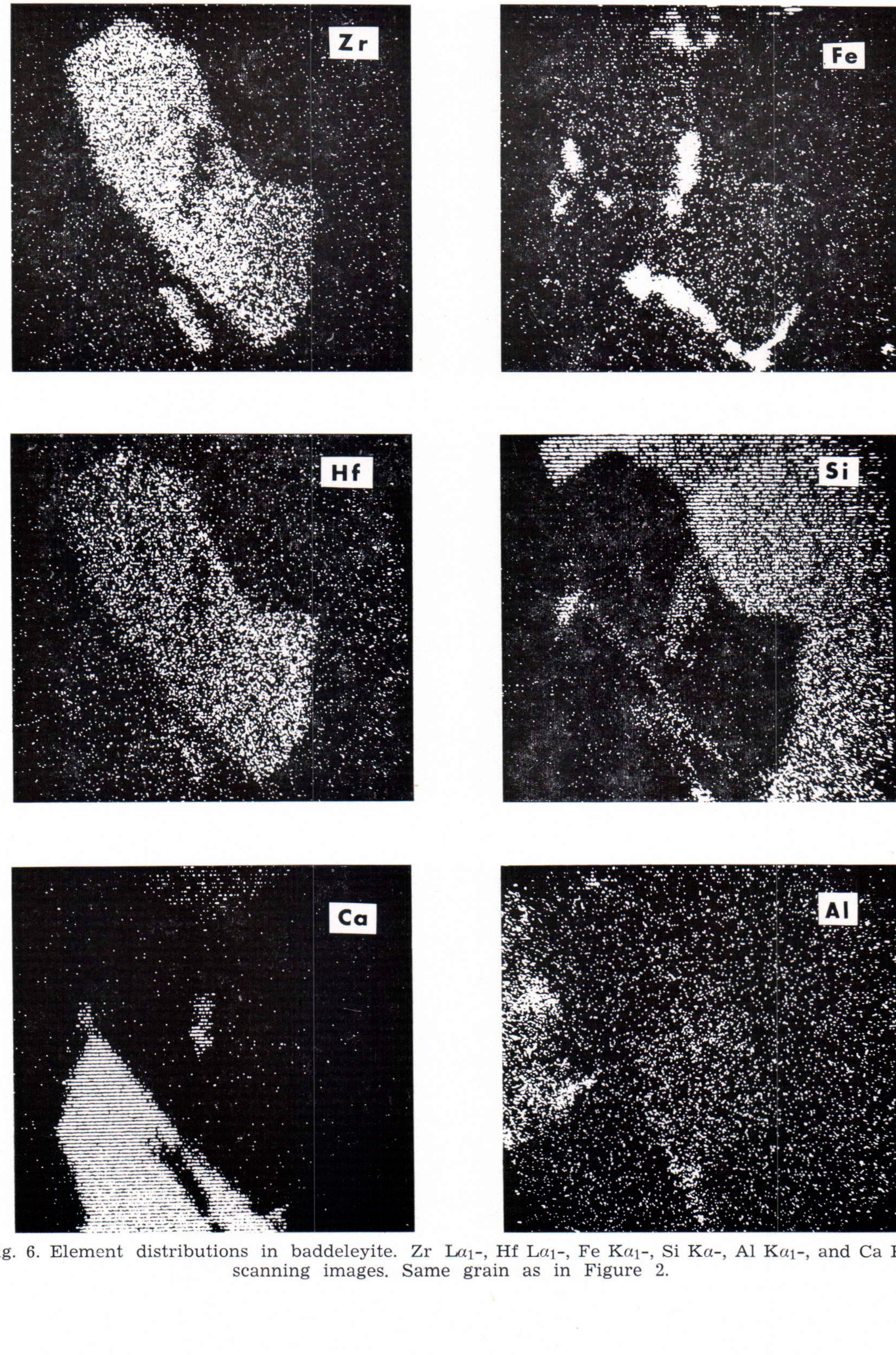

Fig. 6. Element distributions in baddeleyite. Zr $L\alpha_1$-, Hf $L\alpha_1$-, Fe $K\alpha_1$-, Si $K\alpha$-, Al $K\alpha_1$-, and Ca $K\alpha_1$-scanning images. Same grain as in Figure 2.

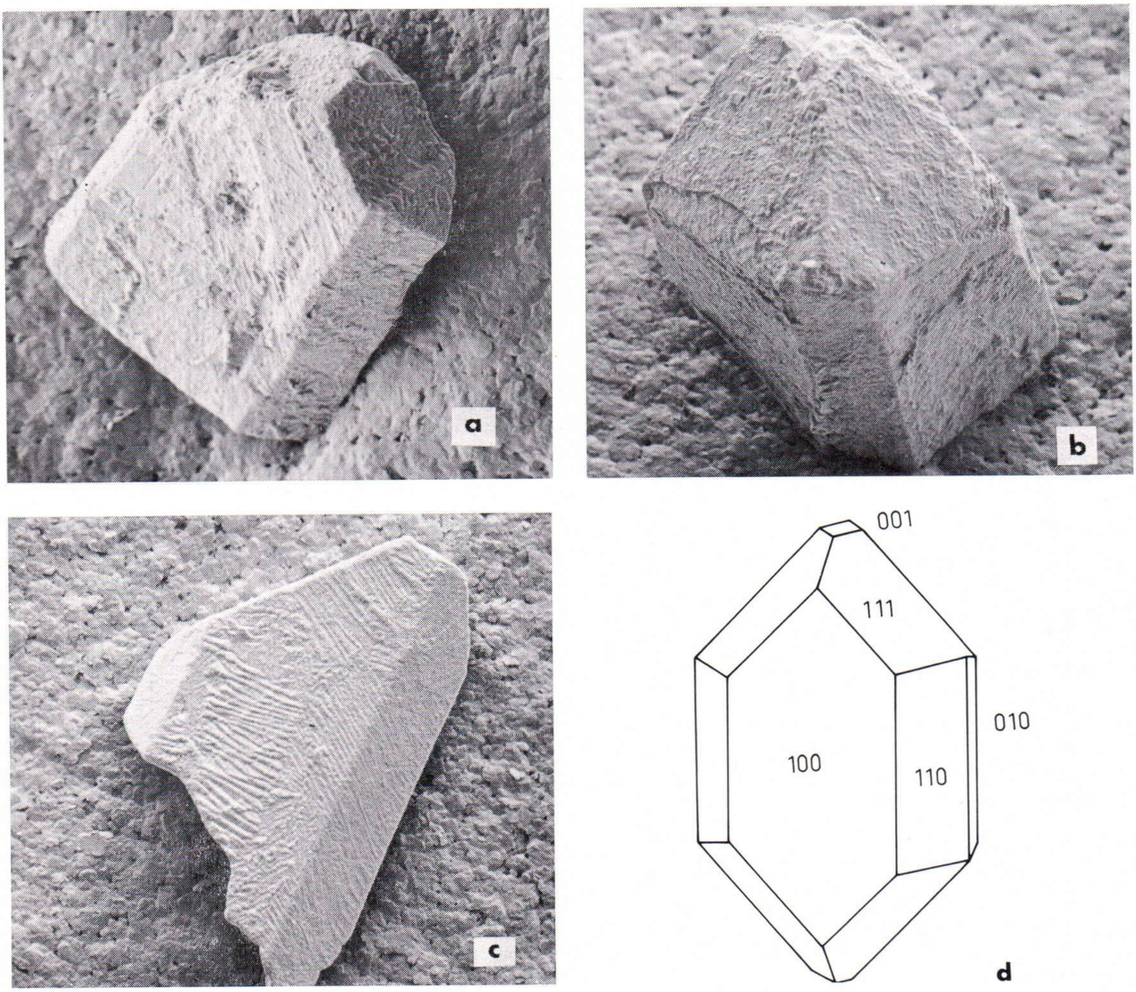

Fig. 7. SEM-images (a — c) showing the tabular habit (d) of baddeleyite. × 260.

in Figures 1—4, and the general morphology in Figures 7 a—d. X-ray single crystal determinations by Dr. M. Lehtinen and X-ray powder diffraction studies by Mr. P. Kallio gave the following unit cell parameters for baddeleyite (space group $P2_1/c$): a_0 = 5.143 Å, b_0 = 5.213 Å, c_0 = 5.312 Å (± 0.01), β = 99°15', $a_0 : b_0 : c_0$ = 0.986 : 1 : 1.019, with V = 140.56 Å^3.

Concluding remarks

The work of Butterman and Foster (1967) suggests that in a silica-poor system baddeleyite (monoclinic ZrO_2) is stable with zircon below 1170° C. At Lovasjärvi the crystallization of the basic, iron rich magma commenced with the formation of iron oxides and of the olivine-bearing ($Fo_{57}Fa_{43}$) rock and continued on decreasing temperature to more silica-rich rocks. During this sequence the Zr-rich mineral phase appeared in the form of baddeleyite. With increasing silica content in the melt baddeleyite crystals were at least partly coated with zircon mantle. This phase of crystallization is also characterized by baddelyite grains which are in contact with quartz. In the baddeleyite-bearing rock olivine ($Fo_{13}Fa_{87}$) is still present as a minor constituent. The final stage of the crystallization of the Zr-rich mineral phase is the formation of zircon. It is worth while mentioning that zircon crystals are transparent with beautiful, tetragonal habit.

It may be concluded that the mineral sequence baddeleyite, zircon and free quartz is closely associated with the crystallization of the primary basic magma.

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