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MS-13-P-2502 Characterization of twin domains in Phalaborwa baddeleyite xenocrysts by EBSD and TEM

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Baddeleyite is an important mineral which undergoes a martensitic phase transformation from cubic through tetragonal to monoclinic at room temperature for low pressure (<4Gpa)1. A number of high pressure crystalline phases (5-50GPa), including an orthorhombic phase, have been reported for shock recovery experiments of small baddeleyite crystallites (1-30 micron)2. It was also suggested that Phalaborwa baddeleyite xenocrysts are possibly metaminct due to the absence of cathodoluminescence (CL) response3. The presence of twin domains in natural baddeleyite has been reported for twinning in monoclinic baddeleyite (zirconia) occurring along {001} planes and more predominant than along {011} planes and very rarely along {012}4. The volume change (5%) and strain energy (8-14%) during the transformation results in crystal twinning and/or cracking due to catastrophic changes in temperature and pressure as a result of the emplacement process. Twin boundaries in baddeleyite could provide valuable information on the thermal history of the material1 as well as distinguish growth twins from transformation and deformation induced twins. The characterization by transmission electron microscopy (TEM) of twins in baddeleyite from the Mbuji Mayi kimberlite has been previously reported5. However, twin boundaries analysed by electron back scatter diffraction (EBSD) have not been reported for baddeleyite. In this paper we will present results for the analysis of twin domains observed in baddeleyite from the Phalaborwa carbonatite complex by EBSD and TEM.
Polished sections of Phalaborwa baddeleyite were analysed in a JEOL 7001F scanning electron microscope (SEM) and crystal orientation analysis was performed by using am Oxford EBSD system. FIB lamellae using a FEI Helios Nanolab 650 FIBSEM were cut perpendicular to the twin boundaries observed in the polished sections. The FIB lamellae were imaged using the bright field (BF) TEM mode in a JEOL ARM 200F TEM.
The twin bands for baddeleyite are revealed by channelling contrast in the BSE image (Figure.1). Two sets of polysynthetic twins can be identified in the EBSD image shown in Figure 2. Analysis of the EBSD data reveals both 90o and 180o twin boundaries. TEM images showing three distinct twin domains and the corresponding diffraction patterns are shown in Figure 3. The specimen was tilted away from the zone axis shown in the SADs to improve contrast in the BF image.

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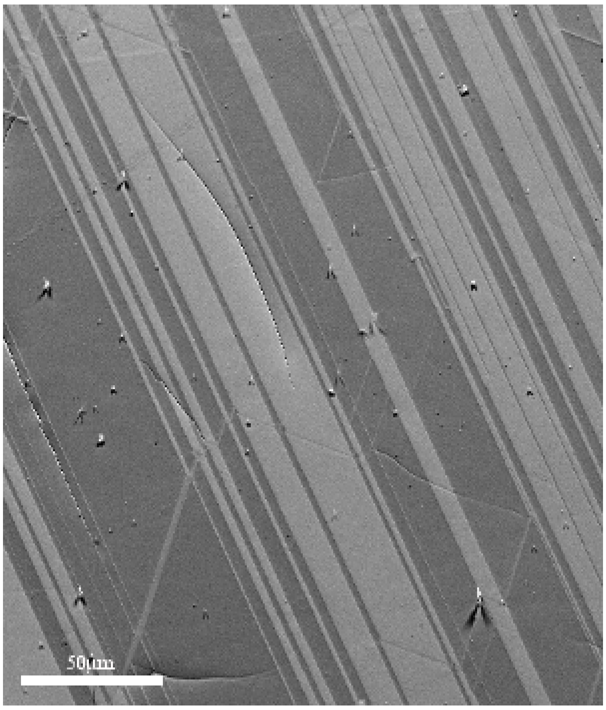

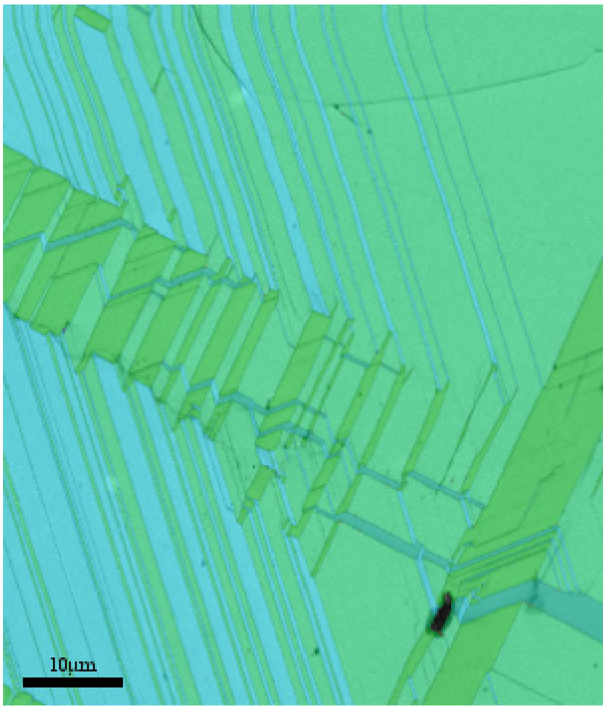

Fig. 1: SEM-BSE image showing channeling contrast for the twin domains

Fig. 2: All euler map overlaid on a band contrast image of baddeleyite showing the various twin bands

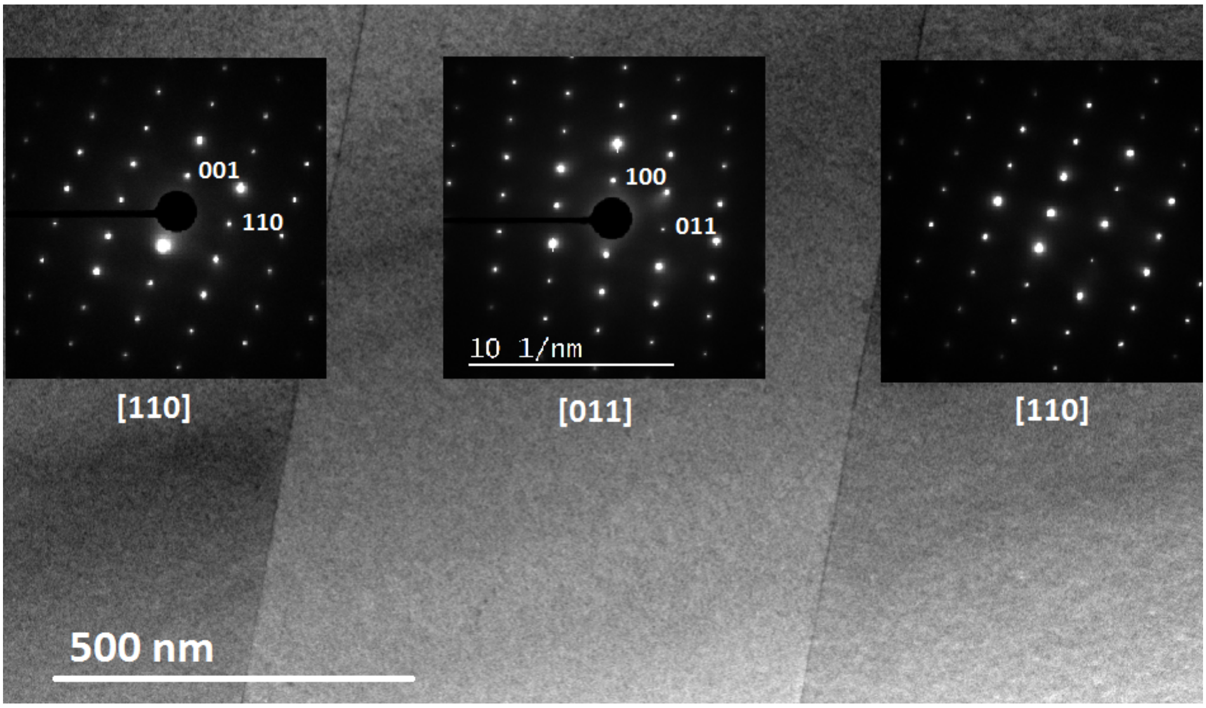

Fig. 3: BF TEM micrograph of a twin in baddeleyite with superimposed SAD patterns of the three regions.