Baddeleyite $^{206}Pb/^{238}U$ age change as a function of crystallographic orientation analyzed by SHRIMP

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Baddeleyites (ZrO_2) are found in ultramafic and alkaline rocks and suffer low Pb diffusion compared to zircon and therefore, they are extremely favorable for dating by U-Pb method. For these experiments were utilized Phalaborwa baddeleyite - Africa (donated by Wingate, M.T.D - Australia) and Kovdor - Russia (donated by Radionov, N.V). $^{206}Pb/^{238}U$ ratio measured in baddeleyite by ion microprobe change significantly (up to ±10% or more) and systematically with the relative orientation of the baddeleyite crystal structure, therefore, the $^{206}Pb/^{238}U$ age change significantly (1). According to crystallographic orientation, normal or reverse discordance may occur. Therefore, it is difficult to establish a baddeleyite standard by ion probe due the $^{206}Pb / ^{238}U$ ratio variation with the crystallographic orientation. Here, in this experiment, Temora zircon standard will be used to obtain mass bias correction factor. For baddeleyite, like zircon, LN(Pb^+/U^+) correlate with variations LN(UO^+/U^+) by discrimination factor. Data fit reasonably well to calibration lines (with mean slope = 2.12) that relate the natural logarithms of radiogenic $^{206}Pb^+/U^+$ and UO^+/U^+ (Wingate and Compston.,2000), therefore this value is very close for zircon that slope = 2.0. On the other hand, the $^{207}Pb / ^{206}Pb$ ratio fractionation is very small and therefore age doesn't need correction.

Methodology: To study the behavior of the variation in the $^{206}Pb / ^{238}U$ ratio according with baddeleyite crystallographic orientation, it will be analyzed by four steps. Step (a): the mount will be marked north-south direction and after analyzes set done, the mount will be repolished with 3 microns diamond paste; step (b): before starting 2nd analysis session the mount will be rotated 90 degrees in relation step 1 position; step (c) mount repolishing and rotating 270 degrees relative step (a); step (d): mount repolishing and rotating 180 degrees. For each rotation step, U-Th-Pb isotopes are analyzed for baddelyite sets by SHRIMP and thus we can to compare $^{206}Pb / ^{238}U$ ratio values in different crystallographic orientations.

After hundreds of analyzes performed in different crystallographic orientations, we observed that the $^{206}P/^{238}U$ and $^{207}Pb/^{235}U$ ratios fit along the same discordia line. Age with reverse discordance of a given crystallographic orientation may have normal discordance age after rotating the crystal, but aligned on the same discordia line. If $^{207}Pb/^{206}Pb$ age is constant and does not change with crystallographic orientating, this implies that the discordia line crosses the concordia curve at the same point for random orientation. For the Palaborwa baddeleyite standard the discordia line intersects with the concordia curve always close to 2063 ± 2 Ma age, therefore close to TIMS value (2060 Ma). The slope value = 2.0 (LnPb$^+$/U$^+$) x LN (UO^+/U^+) was obtained by Temora zircon standard and applied $^{206}Pb/^{208}U$ ratio matrix correction at baddeleyite. The correct value of this slope should be obtained through several analyzes of baddeleyite. For Kovdor baddeleyite from Russia, the concordia age obtained indicated an age of 375 ± 6 Ma, therefore very close for concordia age = 379 ± 3.7 Ma (2). Reverse discordance also may occur at high U zircon (>2000ppm) and in this case it is not related to crystallographic orientation, but may be associated for metamitic crystal with U loss/add (3).

(1) Wingate and Compston (2000). Chemical Geology 168: 75–97.
(2) Rodionov et al. (2012). Gondwana Research 21: 728–744.
(3) Sato et al. (2003). IV SSAGI. Salvador, Brazil.

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