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Dating U-rich inclusions in garnet using U-Pb ID-TIMS: a new technique to overcome the challenge of constraining pegmatites crystallization ages

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In pegmatites, zircon is usually very rich in U. In some cases such zircon grains yield concordant to near concordant ages, but in other cases pegmatites have strongly altered zircon grains that yield complex and discordant U-Pb data. There are also pegmatites with no zircon crystals or only with zircon xenocrysts. Examples of all four situations occur in pegmatites cutting the Pavia pluton, western Ossa-Morena Zone (Portugal). Four out of seven dated pegmatites cutting granites ($s.l.$) yield concordant and coherent ages (328, 324 and 319 Ma). Two ages are constrained using the data provided by monazite (322 and 317 Ma) as, in these samples, all the zircon grains are found to be xenocrystic or intensely metamict. Zircon grains of another pegmatite are interpreted to be all xenocrystic but in the absence of another suitable geochronometer we are unable to determine its crystallization age. Another pegmatite, cutting discordantly the amphibolitic facies schists of the Moura Schists Formation, presented a new challenge. Only one non-metamict zircon crystal was found and that gave an age of 329.4 $\pm$ 1.2 Ma, from a slightly normally discordant analysis suggesting a probable mixture with an older component. As no other common geochronometer was found, the occurrence of U-rich inclusions in garnet represented the only possibility for constraining the crystallization age of this pegmatite using U-Pb systematics.

Garnet is euhedral, light orange and translucent, usually $<$1 mm in size. Its average composition is $Sps_{56.7}Alm_{39.3}Py_{2.6}Gros_{1.3}And_{0.1}$. Although the exact identity of the inclusions is unknown we suspect that they represent mainly uraninite, as seen in EDS of selected inclusions, and as suggested by their prominent phleocroic haloes in the surrounding garnet grain and high U contents, which are likely in the percentage range. Based on 5 out of 8 analyses an age of 318.36 $\pm$ 0.32 Ma was obtained and interpreted to represent the crystallization age of this pegmatite. This age is validated by the occurrence of other pegmatites with the same age of $\sim$318 Ma in the area that could be dated using zircon and monazite.

Although this technique is not necessarily restricted to garnet and other minerals may be suitable hosts, garnet presents two main advantages: it is virtually free of common Pb and most crystals and fragments show excellent optical transparency and are free of internal fractures. Furthermore, garnet is a common accessory mineral in pegmatites that originate from aluminous sources. However, there are also two important considerations when selecting the grains and interpreting the data: (i) damage to the integrity of the host directly affects the integrity of the inclusion (as it allows communication between the interior and exterior of a grain facilitating Pb loss and/or resetting), as proven by the strongly discordant ages obtained by two of the analyzed inclusions; (ii) garnet may host different mineral phases with different ages or, even if contemporaneous, having different responses to U-Pb resetting processes, which can contribute to the occurrence of mixed ages.