What do in-situ Rb-Sr mica ages tell us? Lessons learned from the Greater Gothenburg area

Thomas Zack

Department of Earth Sciences, University of Gothenburg, Sweden, thomas.zack@gu.se

In the last decade, LA-ICP-MS/MS has enabled the collection of a world-wide data set of Rb/Sr ages of micas that arguably is already larger than all published Rb/Sr ages collected the previous 70 years. While this new technique has already been successfully applied to a wide field of research (from paleoclimate to outer space), one of the most fundamental questions in geochronology is not satisfactorily answered: are we recording cooling ages or formation ages? Almost canonical values for closure temperatures for the Rb-Sr system are widely used in the literature for biotite (ca 350ºC) and for muscovite (ca 500ºC). However, it needs to be stressed that neither experimental calibrations nor field data is very robust, and none of this data is using the high spatial resolution now available by LA-ICP-MS/MS. Instead of invoking thermally activated diffusion as the major mechanism (thermochronology), age systematics can often be equally well explained by mineral recrystallization due to metamorphic reactions and/or fluid infiltration (petrochronology).

The area around Gothenburg is ideally suited to study the behavior of muscovite and biotite in this regard. Being situated in the middle of the Idefjorden terrane, it has been subjected to two high grade metamorphic events, the Gothian and the Sveconorwegian orogenies at ca 1.5 Ga and 1.0 Ga, respectively. In several published and ongoing studies, it can be shown that in-situ Rb-Sr ages of muscovite trustfully record formation ages derived from systems thought to be insensitive to consecutive events (e.g., U-Pb ages from zircon and columbite). For example, Rb-Sr muscovite ages for the Högsbo pegmatite are 1.03 Ga in age (Rösel & Zack 2022) and the pegmatites from the Southern Gothenburg Archipelago are 1.52-1.54 Ga in age (Zorc & Zack, this meeting). The latter example is of relevance, as it demonstrates for the first time that muscovite can survive thermal overprint of up to 650ºC, if thermal conditions along the Göta Alv shear zone are representative (clearly Sveconorwegian migmatites are widespread here, less than 15 km away).

In contrast, Rb-Sr biotite ages are invariably younger compared to concomitant Rb-Sr muscovite ages. Biotites occur in clearly Gothian, Sveconorwegian or in Kungsbacka intrusives (ca 1.3 Ga), yet they all record ages of between 0.90 and 0.93 Ga. The easiest explanation would be that biotite has a lower closure temperature than muscovite. However, there is currently no further evidence that would support this notion. If the Rb-Sr system in biotite would close around 350ºC, clearly resolvable age zonations should be observable within single grains, which is not the case. Furthermore, the analytically significant age range of 5% is not a function of chemical variability which should influence Sr diffusion (Mg# in various biotite range from 5 to 40 but are not correlated with age). Finally, a 1 km continuously cored bore hole (GE-1; see Sjöqvist et al., this meeting) does not reveal a variation in Rb-Sr biotite ages, although a markable decrease in age should be observable. While no comprehensive explanation is currently available, the possibility remains that biotite is more reactive to infiltrating hydrothermal fluids in comparison to adjacent muscovite.

Reference

Rösel, D. & Zack, T., 2022: LA-ICP-MS/MS single spot Rb-Sr dating. *Geostandards and Geoanalytical Research 46*, 143-168.