TIMING OF REGIONAL TECTONISM AND Au-MINERALISATION IN THE TANAMI BLOCK: $^{40}Ar/^{39}Ar$ GEOCHRONOLOGICAL CONSTRAINTS

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Existing age constraints for geological events in the Tanami Block come predominantly from U-Pb geochronology of i) detrital zircons in sediments, and ii) magmatic zircons in granitoids. These constraints have been used together with observed and inferred geological relationships to help constrain timing of stratigraphy, magmatism, deformation, metamorphism and Au-mineralisation (e.g. Vandenburg *et al.*, 2001). Ongoing GA/NTGS zircon geochronology is continuing to refine our understanding of the stratigraphy and magmatic history of the Tanami, with attendant implications for tectonic evolution. In this regard it is noteworthy that detrital zircon ages of ~1815 Ma from the Killi Killi formation require either (or both) a revision of existing stratigraphy, or that the so-called Tanami Orogenic Event significantly post-dates ~1815 Ma, in contrast to previous estimates of ~1845 – 1830 Ma. However, detrital and magmatic zircons can provide no direct constraints on timing of deformation, metamorphism and Au-mineralisation, and consequently our current understanding of these processes in the Tanami region is relatively poor, despite being critical to predictive exploration models.

Here we present new age constraints from $^{40}Ar/^{39}Ar$ geochronology. These results complement existing U-Pb zircon isotopic constraints from intrusive rocks and detrital zircons in sediments. Argon retention is, in general, more sensitive to thermal disturbance than Pb in zircons; consequently the $^{40}Ar/^{39}Ar$ results provide timing information regarding regional cooling and the timing of final hydrothermal activity in mineralised zones.

The samples fall broadly into two categories;
1) Micas from Au-bearing veins at the Callie mine.
2) Micas and feldspars from regional Tanami granitoids.

Results from Callie

Gold mineralisation at Callie is hosted in east-northeast striking dilational quartz veins, and is concentrated where these veins intersect F1 fold hinges (Vandenberg *et al*, 2001). Gold-bearing quartz veins contain clots and trails of randomly oriented, relatively coarse biotite (Figure 1). Four examples of this vein-hosted biotite have been carefully separated from surrounding biotite-bearing foliated metasediments, and analysed by the $^{40}Ar/^{39}Ar$ step-heating method. Two of these yield "plateau" ages of ~1710 Ma and the other two give "plateau" ages of ~1735 Ma (Figure 2). At this stage the significance of the difference in ages between these two pairs of samples is unclear, however, the important first order observation is that vein biotites yield $^{40}Ar/^{39}Ar$ ages demonstrably younger than both U-Pb zircon and $^{40}Ar/^{39}Ar$ mica ages from any known Tanami granites (see below). These data therefore strongly suggest that at least some of the hydrothermal activity responsible for vein generation post-dates intrusion of the youngest known Tanami granites (~1795 Ma; Dean, 2001) by several tens of million years. These results are also consistent with structural relationships suggesting that Au-mineralisation occurred late in the deformation history of the region (Vandenberg *et al*., 2001).

The host metasedimentary sequence at Callie is crosscut by biotite-rich lamprophyric dykes, which themselves are cut by quartz veins with a similar orientation and character to auriferous

quartz veins. Biotite from one of these dykes yields an $^{40}Ar/^{39}Ar$ age of ~1760 Ma (Figure 2). If this age is interpreted to approximate the time of dyke intrusion, as would be consistent with generally older regional cooling ages (reported below), the age of quartz veins must post-date ~1760 Ma, consistent with vein-biotite ages of ~1710 and ~1735 Ma.

Results from Regional Granitoids

Biotite and/or K-feldspar was separated from five drill-core samples of Tanami Granitoids, including the Coomarie and Frankenia granitic domes as well as other smaller intrusive bodies not spatially associated with any known gold mineralisation. Argon geochronological results from these samples provides new constraints on the regional thermal history of the Tanami Block, as well as aiding in the interpretation of the results from Callie discussed above. Biotite ages from these regional granitoids range between ~1755 and ~1820 Ma (Figure 3). These ages are best interpreted as representing the time of final cooling through a temperature of between 300 and 350°C - the "closure temperature" for Ar diffusion in biotite. As expected, these ages are slightly younger than U-Pb zircon ages from Tanami granitoids, but are significantly older than the ages reported above for biotite from Au-bearing veins at Callie. It would therefore appear that ambient temperatures in the Tanami Block dropped below ~300°C prior to 1750 Ma, strengthening the interpretation that ages from Callie vein-biotite approximate the time of subsequent hydrothermal activity.

K-feldspars from regional granites yield stair-shaped age spectra preserving age gradients from ~1700 Ma ranging to as young as ~1350 Ma (Figure 4). The younger ages preserved in K-feldspar reflect the lower Ar closure temperature relative to biotite. The large age gradients can be interpreted either as an indication of very slow cooling (<1°C/Ma) through the temperature interval ~280 – 130°C, or as a product of partial thermal resetting and/or recrystallisation of feldspar during the Mesoproterozic. Any such subsequent thermal events were clearly not sufficiently intense to pervasively reset biotite or the more retentive parts of K-feldspar crystals, and must therefore have been of relatively low temperature (<250°C).

In contrast to biotite ages from granites distal to known hydrothermal systems, muscovite from the Bunkers Granite, collected within a few metres of the fault-related ore-zone at The Granites gold deposit, preserves an $^{40}Ar/^{39}Ar$ age of ~1710 Ma. The age is indistinguishable from vein-biotite ages from Callie, and may represent further evidence of localised hydrothermal activity at ~1710 Ma, unrelated to any known local magmatism.

Summary

Argon geochronology from a range of samples reveals significant new details regarding the thermal history, and the likely timing of hydrothermal activity in the Tanami region. Of most potential interest to the mineral exploration industry, the data appear to require that at least some of the hydrothermal activity found in Au-deposits is as young as ~1710 Ma, and is therefore unrelated to any known magmatic activity, which ceased at ~1795 Ma. In addition, the results from K-feldspars provide initial indications of the Mesoproterozic thermal history of the region, hitherto essentially unknown.

Dean, A. A., 2001. Igneous rocks of the Tanami Region. Northern Territory Geological Survey Record – Electronic pre-release.

Vandenberg, L. C., Hendrickx, M. A. & Crispe, A. J., 2001. Structural geology of the Tanami Region. Northern Territory Geological Survey Record – Electronic pre-release.

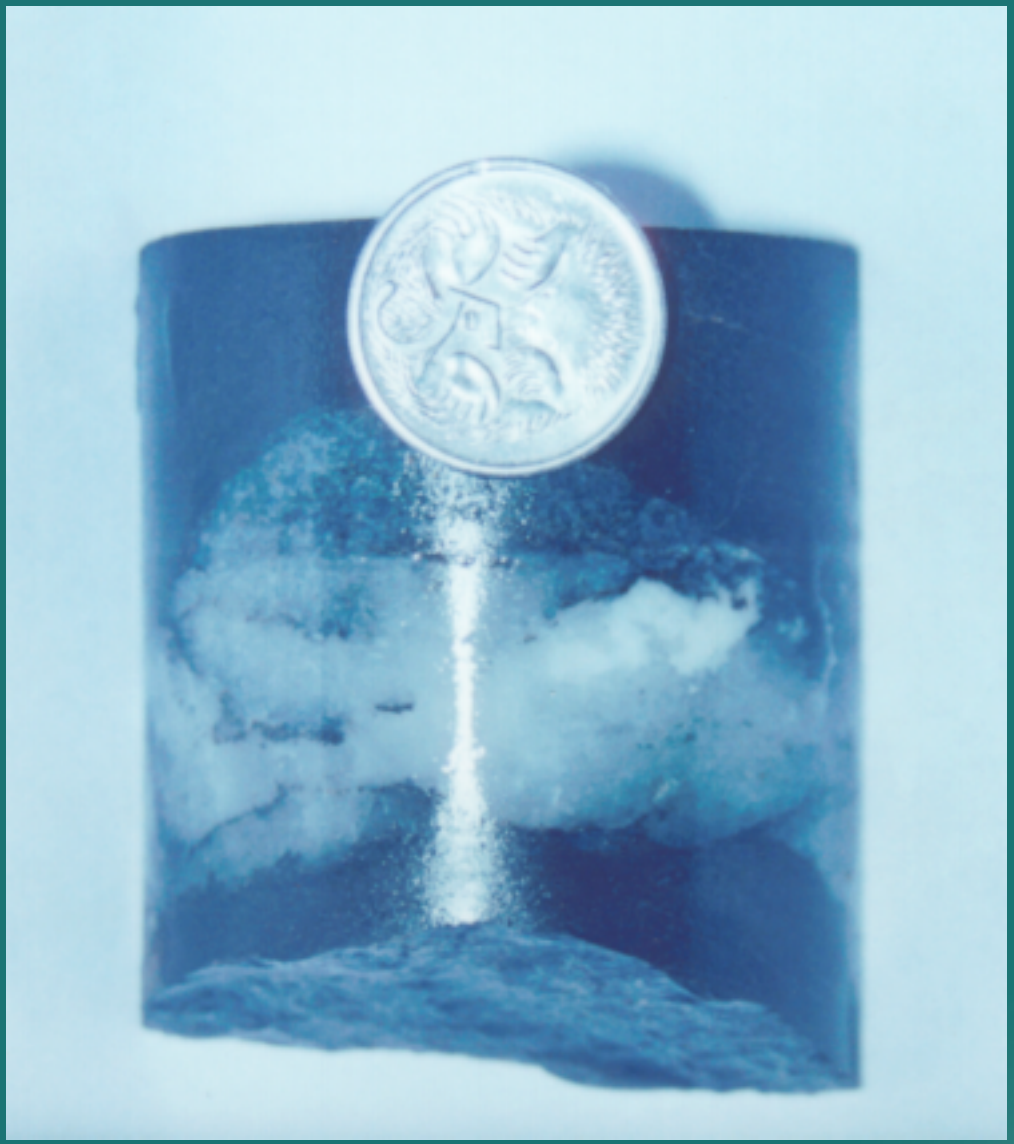
Figure Captions

Figure 1. Drill core from the Callie deposit showing ore-stage quartz vein containing clots of coarse biotite, as dated by the $^{40}Ar/^{39}Ar$ method in this study.

Figure 2. $^{40}Ar/^{39}Ar$ age spectra from the Callie deposit. Age spectrum in bold comes from biotite from a lamprophyric dyke which cross-cuts the host-rock stratigraphy, but itself is cross-cut by quartz veins regarded as synchronous with the ore-stage veins. All other age spectra are from biotite clots in ore-stage veins.

Figure 3. $^{40}Ar/^{39}Ar$ age spectra for biotites from Tanami regional granitoids. These are interpreted as recording regional cooling through ~300 – 350°C, and are significantly older than biotites from ore-stage veins at Callie – see Figure 2.

Figure 4. $^{40}Ar/^{39}Ar$ age spectra for K-feldspars from Tanami regional granitoids, exhibiting large age gradients – see text for discussion.



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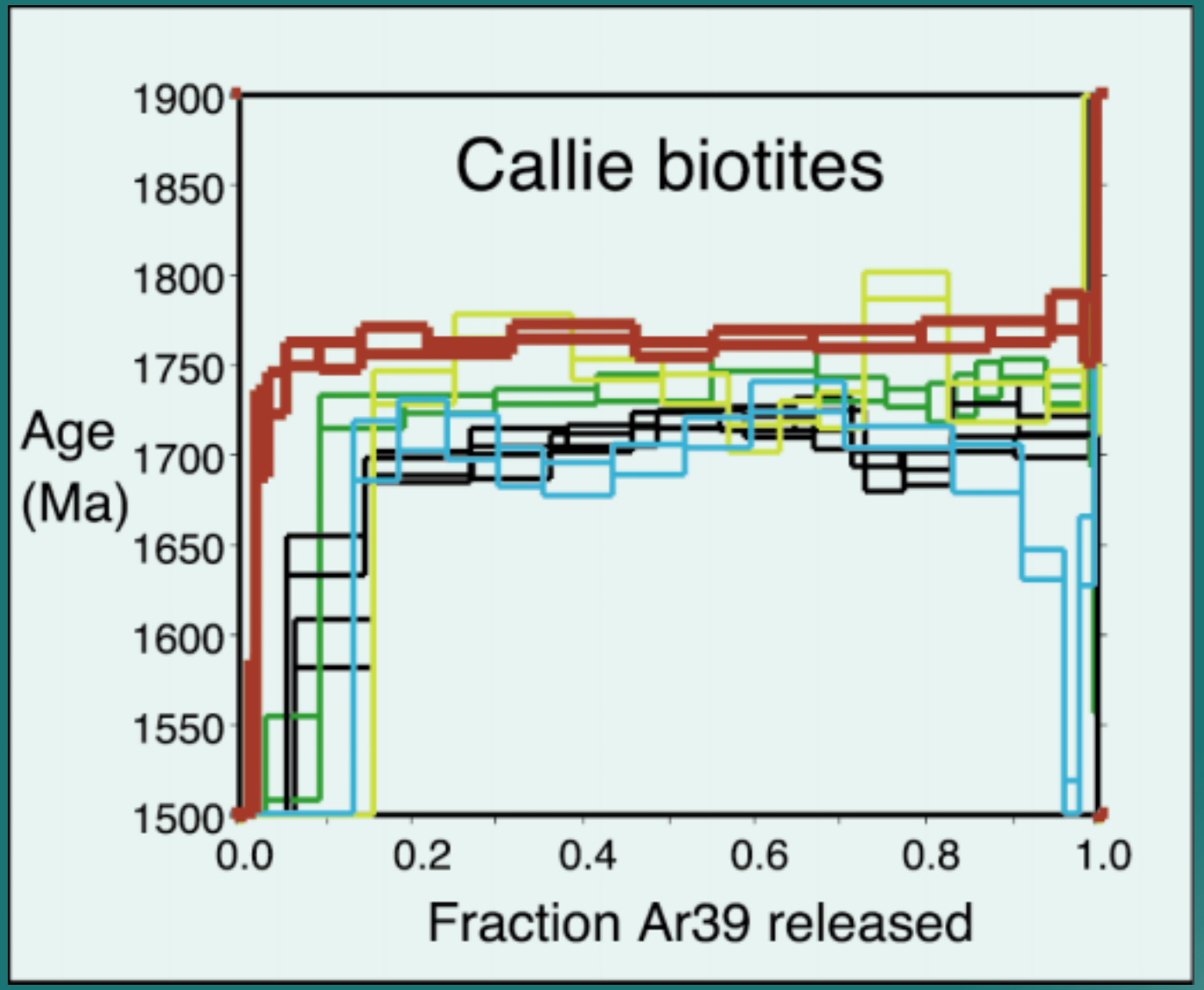

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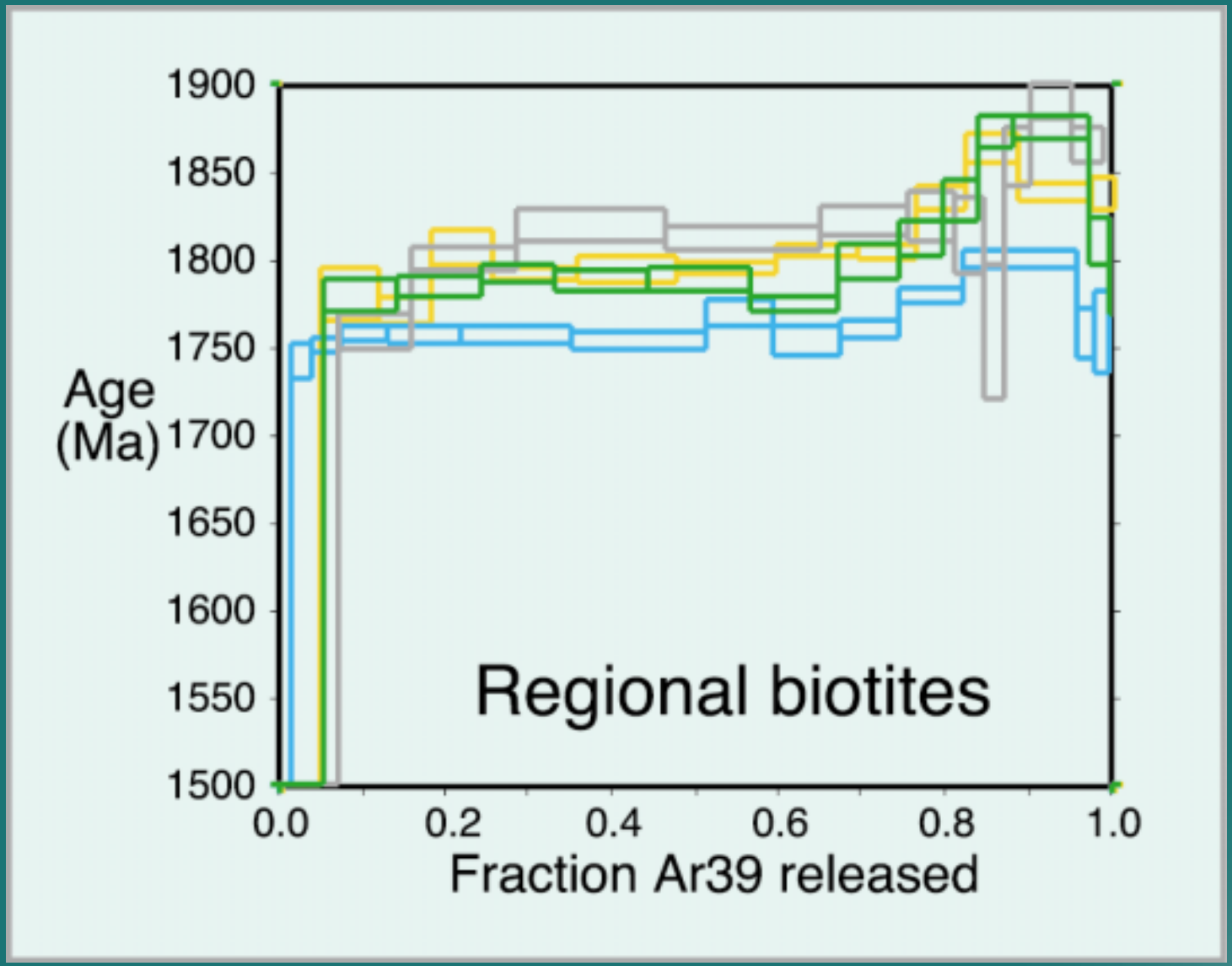

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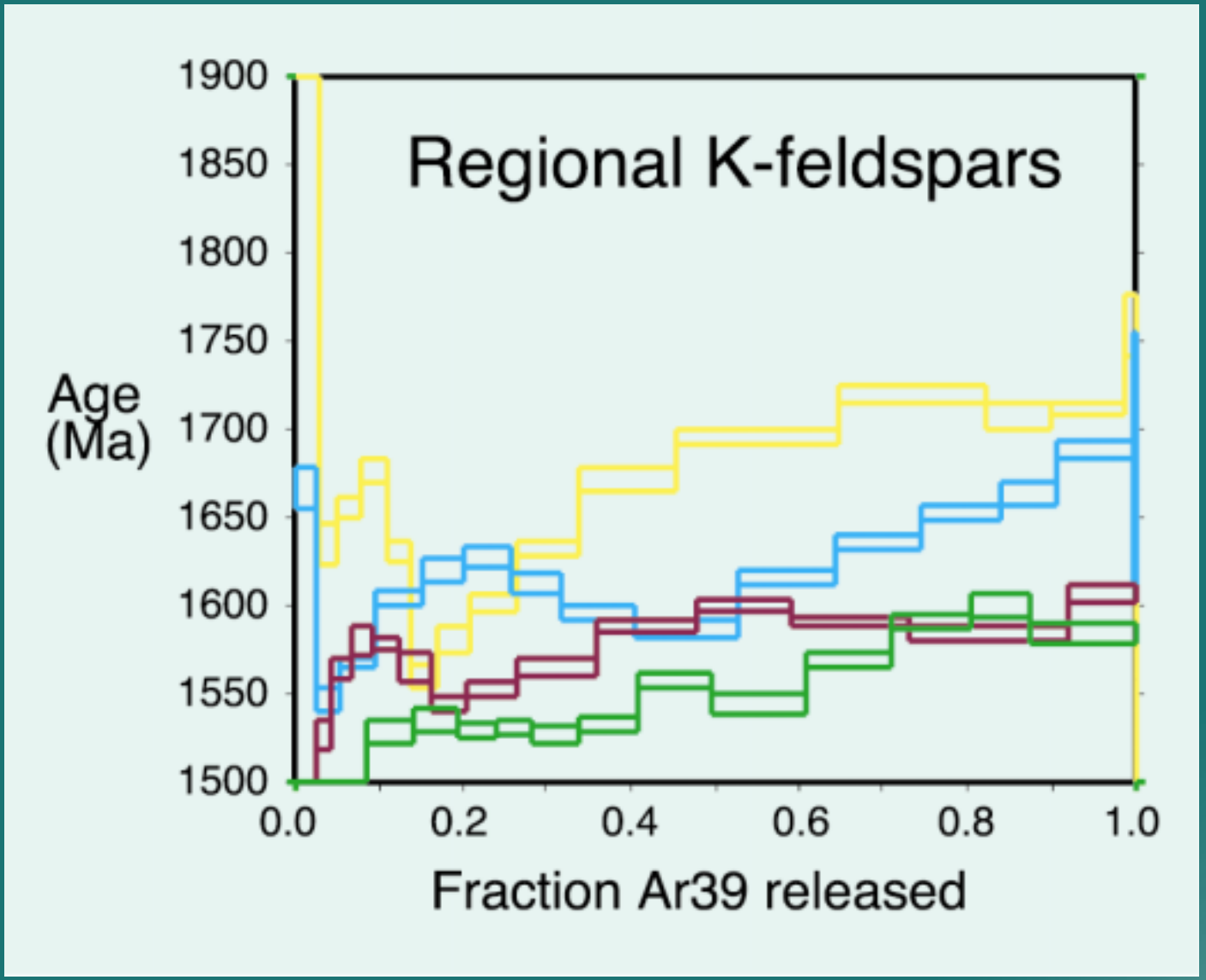

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