Rapid cooling of the Bushveld Complex layered mafic intrusion

JACOB B. SETERA[1], JILL A. VANTONGEREN[1], BRENT D. TURRIN[1], CARL C. SWISHER III[1]

[1]Department of Earth and Planetary Science, Rutgers University, Piscataway, NJ, USA
jacob.setera@rutgers.edu

The distinctive layering and large cumulate grain sizes of large layered mafic intrusions, such as the Bushveld Igneous Complex (BIC), has commonly been thought to form as a result of slow cooling rates. However, recent chronologic data has begun to suggest the contrary [e.g. 1, 2] and indicate that the BIC cooled rapidly to temperatures well below the solidus. This study focuses on the low temperature (~350-200°C) thermal evolution of the Rustenburg Layered Suite (RLS) associated with the BIC in northern South Africa. We report $^{40}Ar/^{39}Ar$ ages for plagioclase and biotite mineral separates from a combination of 11 stratigraphic horizons from the Eastern Limb of the RLS encompassing a total of ~6.5 km of stratigraphy. We also report diffusion parameters and closure temperatures for the plagioclase mineral separates from 7 of these stratigraphic horizons.

Biotite $^{40}Ar/^{39}Ar$ plateau ages throughout the stratigraphy overlap at 1σ and range from 2051.0 to 2055.3 Ma. This lack of systematic variation in biotite ages throughout the stratigraphy is similar to that previously observed in U-Pb zircon ages [2] and indicates that the entire body cooled rapidly from zircon crystallization temperatures of ~750-850°C [2] to the ~350°C Ar closure tmperature of biotite [3]. Plagioclase plateau ages range from 2007.4 to 2041.5 Ma and yield variable diffusion parameters corresponding to a wide range of closure tempartures (208.8°C to 296.5°C for 10°C Ma^{-1}). The significantly younger plagioclase ages suggest that the RLS cooled much slower below the Ar closure temperature of biotite (<350°C). We interpret this change in cooling rates as a shift to primarily conductive cooling of the RLS and cessation of the hydrothermal system associated with the emplacement of the BIC. Variable plagioclase ages and closure temperatures are a product of the diminishing thermal anomaly accompanying the emplacement of the BIC and a protracted return to the original geothermal gradient.

[1] Cassata et al. (2007) *Geochim. Cosmochim. Acta* **73,** 6600-6612. [2] Zeh et al. (2015) *Earth Planet. Sc. Lett.* **418**, 103-114. [3] McDougall & Harrison (1999) *Geochronology and Thermochronology by the 40Ar/39Ar Method*. Oxford University Press.