Michael A. HAMILTON, 2016. Mafic Dyke Swarms: Their Temporality and Bearing on the Secular Evolution of the Earth. *Acta Geologica Sinica* (English Edition), 90(supp. 1): 12.

Mafic Dyke Swarms: Their Temporality and Bearing on the Secular Evolution of the Earth

Michael A. HAMILTON

Jack Satterly Geochronology Lab, Dept. of Earth Sciences, University of Toronto, Toronto, ON M5S 3B1, Canada

Pioneering U-Pb isotopic studies by a small group of workers in the mid-late 1980s demonstrated the feasibility of using rare accessory mineral chronometers in mafic (gabbroic) intrusive rocks. These examples showed that mafic layered intrusions and diabase/dolerite dyke swarms alike crystallized high-temperature phases such as zircon and baddeleyite, and could be dated to high precision much like their felsic counterparts. While isotope dilution – thermal ionization mass spectrometry (ID-TIMS) blank levels for Pb were steadily reducing, another major advance was achieved by a few laboratories in the efficient mechanical separation and near-consistent recovery of baddeleyite (and zircon), from much smaller sample volumes, and from thin dykes with finer grain sizes. For the last 15 years, this has resulted in a revolution in our ability to date, with high fidelity, major components of large igneous provinces (LIPs) – particularly mafic dykes, sills and layered mafic-ultramafic intrusions. Recent advances in the field of in situ U-Pb dating via secondary ion mass spectrometry (SIMS) are opening new frontiers for dating micro-baddeleyite in even thinner dykes and in basic volcanic rocks, which holds great promise.

Archean cratons represent the surviving fragments of larger continental (and supercontinental) terrains. They are almost always transected by Proterozoic and younger mafic dyke swarms, of variable trend, age and strike length, which are considered to represent the deep vestiges of major extensional events which may or may not have led to eventual rifting and plate fragmentation and dispersal. The last decade has seen a quantum leap in the number accurate and precise U-Pb age determinations in mafic dyke and sill complexes, augmenting ^{40}Ar-^{39}Ar studies in Mesozoic and younger rocks, but largely revolutionizing our understanding of the spectrum of Mesoarchean – Neoproterozoic ages worldwide. The data have started to provide us with a sharper image of 'barcode' events across most cratonic blocks, helped us better understand the areal extent of LIPs, their fanning or converging pattern (locally), and permitted a clearer picture for testing crustal blocks that may once have been joined, or 'nearest neighbours'.

The true power of U-Pb geochronology in these dyke swarms and associated units is more fully realized when the information is coupled with both paleomagnetic and geochemical studies. Experience has shown that a precise age match between LIP components on different crustal blocks is not necessarily a unique solution. Truly robust plate reconstructions must rely upon the ability to measure primary paleomagnetic directions of LIP components on both blocks so that their relative paleo-azimuthal orientations and paleo-latitudes can be assessed. Units that are precisely dated and have demonstrably positive primary paleomagnetic field tests are essential in establishing key poles and meaningful Apparent Polar Wander Paths (APWPs) for inter-cratonic comparisons. Correct continental reconstructions must also satisfy the restored geometries of linear or radiating dyke swarms, as well as aspects of the basement geology. Paleomagnetism has the potential to distinguish between dyke swarms differing in age by a few tens of millions of years based on their different pole positions on an APWP. Moreover, a number of studies with sufficiently high age resolution have been able to determine the precise number, timing and sense of geomagnetic polarity reversals recorded within single swarms. Paired geochronological-paleointensity studies offer the potential to inform us more rigorously about the long-term variability of the Earth's geodynamo, the nucleation of the inner core, and changes in mantle convection patterns due to supercontinent cycles.

Although it is clearly impractical to date all dyke components within a given swarm, considerable leverage in dyke correlation is afforded through high-quality trace element geochemical studies. In this way, ages of undated dyke sets can be predicted on the basis of geochemical correlation with precisely-dated members. Similarly, geochemical fingerprints, particularly in incompatible trace element ratios, can be used to test for magmatic system correlations between cratons and thereby furnish an independent assessment of a proposed reconstruction. Although not definitive on it's own, a significant geochemical contrast between swarms could, alternatively, preclude a direct correlation. In some longer-lived LIPs, geochemical studies have demonstrated a secular reduction both in the degree of crustal contamination and/or depth of mantle melting over the course of plume activity. Tracer isotopic studies (especially Hf on baddeleyite ± zircon) offer tremendous potential to understand the chemical structure of large, long-lived mantle plumes, as well as the temporal evolution of mantle source regions throughout geologic time.

In this contribution, I present many of the concepts cited above, with a review of the evidence using a number of robust examples from several studies.

* Corresponding author. E-mail: mahamilton@es.utoronto.ca