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## The Timing of the Palaeoproterozoic Great Oxidation Event using Dykes, Sills and Volcanics of the Ongeluk Large Igneous Province, Kaapvaal Craton

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The Neoproterozoic to Palaeoproterozoic Transvaal Supergroup of the Kaapvaal Craton, southern Africa, is one of the best-preserved and most complete stratigraphic records across a critical juncture in the Earth's history. This time interval witnessed the growth and emergence of the Earth's first large continents, as well as the first significant rise in atmospheric oxygen, an event known as the Great Oxidation Event (GOE). This series of events was accompanied by several documented ice ages, of which at least one was global, a Snowball Earth. Finally, one of the largest seawater carbon isotopic excursions is documented during the latter part of this time, the so-called Lomagundi-Jatuli Event. A key lithologic correlation line for interpreting the Transvaal Supergroup stratigraphy has been to equate the two main basaltic formations within the predominantly sedimentary succession: the submarine Ongeluk Formation (Postmasburg Group) basalts in the western Griqualand West sub-basin and the subaerial Hekpoort Formation (Pretoria Group) basalts in the more eastern Transvaal sub-basin. Based on Rb-Sr and Pb-Pb whole rock age dating, these volcanic formations have long been considered to be ca. 2.22 Ga in age, specifically ca. 2222 Ma for the Ongeluk basalts (Cornell et al., 1996). However, basalts remain difficult targets to date with U-Pb geochronology on zircon and baddeleyite, and experience has shown that Pb/Pb isochrons are easily reset, typically yielding ages that are too young. Modern instrumental techniques however, combining the capabilities of scanning electron microscopy and high spatial resolution U-Pb dating using the secondary ion mass spectrometer can overcome these difficulties by

dating small, but otherwise well-preserved micro-baddeleyites on relatively coarse-grained mafic volcanics in-situ. Using these techniques on the volcanic rocks in conjunction with isotope dilution thermal ionisation mass spectrometry geochronology on coarser-grained feeder dolerite sills within the Transvaal Supergroup and a N-trending dolerite dyke swarm, we have dated the Ongeluk-related magmatism to a precise age of ca. 2426 Ma. This magmatic event is now a newly identified large igneous province (LIP), which is at least ~1000 km wide, and is supported by ages and palaeomagnetic studies (Evans et al., 1997) defining a near-equatorial key palaeopole at ca. 2426 Ma. Even more importantly, as the Ongeluk basalts overlie and interfinger with the glacial Makganyene diamictites, quite possibly a global glacial event, and straddle the onset of GOE. Our new age thus also dates the termination of the first of four possible Palaeoproterozoic glaciations and the commencement of the GOE. In conjunction with other critical observations, our new Ongeluk LIP age invalidates the Ongeluk Formation to Hekpoort Formation correlation and forces a reinterpretation of the iconic Transvaal Supergroup stratigraphy. We propose that the Postmasburg Group of the Griqualand West sub-basin is entirely older than the upper part of the Transvaal sub-basin, i.e. older than the Duitschland Formation and lower Pretoria Group. If the entire Postmasburg Group ever extended east into the Transvaal sub-basin, its record has been erased by erosion seen below the base of the Duitschland Formation. This boundary is marked by a significant angular unconformity that represents the demise, folding, and subsequent uplift and karstification of the underlying Ghaap and Chuniespoort Group depositional system in both sub-

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basins. Following this tectonic disturbance, there was a shift in depocentre to the north-east, and the initiation of a lithologically different sub-basin represented by the Duitschland Formation and the overlying lower Pretoria Group. By combining this new stratigraphic framework with that of published record of redox indicators suggests that the onset of GOE was not characterised by a monotonic rise of atmospheric oxygen concentration. Rather, oxygen concentrations oscillated before the final complete oxygenation of the atmosphere and the first appearance of red-bed sandstones at ca. 2308 Ma (Rasmussen et al., 2013). Our new Ongeluk LIP age eliminates the ~200 million year hiatus below the Makganyene Formation diamictites and argues for an essentially continuous depositional record leading up to the Makganyene global glaciation in the Griqualand West sub-basin. This leads us to interpret the Makganyene glaciation as the first Palaeoproterozoic glaciation which

was most likely correlatable with the Ramsay Lake Formation of the Huronian Supergroup in Canada. Cap carbonates are lacking above this first glaciation. We correlate the lower Duitschland Formation glaciation with the Bruce Formation glaciation in the Huronian Supergroup, identifying it as the second global glaciation. It is overlain in both basins by a unique level of cap carbonates of potentially global significance.

#### References

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