We report a study of carbonates from the Campbellrand-Malmani carbonate platform of the Neoarchean (2.68-2.50 Ga) Kaapvaal Craton, South Africa. This sequence preserves the least altered late Archean rocks known to exist, with maximum metamorphic temperatures that range from 110°C to 150°C and 130°C to 170°C based on greenalite-quartz-magnetite-hematite and greenalite-quartz-minnesotaite equilibrium, respectively, in the overlying Kuruman Iron Formation [Miyano and Beukes, 1984].

For this study, we analyzed nine outcrop specimens from multiple members of the Gamohaan Formation. The strata are comprised primarily of stromatolitic limestone with localized early diagenetic dolomitization. Hand specimens have been micro-sampled according to mineralogy and carbonate textures to interrogate the most homogeneous material for analysis. These textures include sparry and “herringbone” calcite as well as lamellar micrite and dolomite. Additionally, spatial variability was investigated by sampling three different drill cores that have been described previously by Klein and Beukes [1989]. The three cores (AD-5, WB-98, and DI-1) cover a distance of 212 km and are located approximately along strike. A single, characteristic crytalgal limestone layer has been targeted in the cores and outcrop to ensure the most valid spatial comparison possible.

In addition to clumped isotope analysis, sample investigation also included petrographic and electron microscopy as well as electron backscatter diffraction of thin sections. Apparent temperatures determined by clumped isotope thermometry range from 102°C to 178°C for sparry calcite, 89°C to 151°C for micrite and “Herringbone” calcite, and 104°C to 153°C for dolomite. The average values for the aforementioned textures/minerals are 143°C, 131°C, and 124°C (±21°C), respectively. Systematic differences are not observed for samples collected from different locations along strike or stratigraphically in the outcrop samples. Apparent clumped temperatures are in good agreement with burial temperatures estimated by metamorphic mineral assemblages. Clumped isotope thermometry has allowed us to go a step further and determine a likely diagenetic and burial history of these samples based on geochemistry, mineralogy, petrology, and modeled isotope-exchange reactions by solid-state diffusion [Stolper and Eiler, 2015].