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The stratigraphy,chronology and palaeoenvironment of The Pleistocene Cave Fill, Gladysvale Cave, South Africa

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ABSTRACT

The South African hominin bearing caves have yielded a wealth of early hominin and other faunal material, which has been the subject of many studies. Little work, however, has been undertaken on the cave fills themselves, as the breccias are complex, poorly stratified, highly calcified, inadequately exposed and too old to date by conventional radiometric means (Partridge, 2000). Gladysvale Cave is an exception to this, as the younger, internal deposits are well exposed from mining, are extremely well stratified, and are preliminarily dated to between 200 and 250 kyr, making this an ideal location to document the three dimensional stratigraphy and sedimentology of a cave fill fan and to test other models of cave sedimentation.

The chronostratigraphic approach of Moriarty *et al*. (2000) was used to divide the deposit at Gladysvale into flowstone bounded units (FBU). The younger, internal deposit at Gladysvale was shown to consist of six major FBU and two minor ones, which in general occur throughout the cave. Binding flowstones are not always present, and are limited to areas directly below and in close proximity to major palaeodrip sources. The majority of sediment entered the cave through a single, central entrance and then split into two lobes around a number of stalagmitic bosses. This entrance eventually choked, and final stage sedimentation entered through a slit-like entrance across the front wall of the cave. As accommodation space inside the cave is fixed, the morphology of the units is defined by their relative position in the cave and the topography of the underlying units. Six major facies types are described, and facies changes from the proximal to distal portions of the deposit are described. Facies changes in time were controlled by the sediment supply rates.

A number of intercalated flowstones and stalagmites were dated via ICP-MS Uranium-series dating, and despite problems with detrital contamination, ten reliable and robust dates were acquired, only three of which required correction for excess ^{232}Th. The internal fan deposit is between ~570 and 7 kyr, making it both older and younger than previously thought. The dated speleothems all grew in the recovery period following a full interglacial or major inter stadial, indicating that these were periods of increased effective precipitation, during which the cave entrance was restricted to incoming clastic sediment. The dated flowstones show good concordance with the rainfall record of the Tswaing Impact Crater, and this record was used to generate an age model for the undated flowstones and intercalated breccia units.

Carbon and oxygen isotope analysis of the breccias and flowstones provided further climatic control. Oxygen isotopes are invariant between flowstone and breccia, and any original signature was most likely overprinted by the residence time of the groundwater in the dolomite host rock. Carbon isotopes show more variation, and there is clear partitioning between flowstone and breccia, and $\delta^{13}C$ values are interpreted as representing changing amounts of C_3 and C_4 vegetation respectively. The C_4 signal for the breccias is confirmed by the presence of granular soil micropeds seen in thin sections.

The succession of flowstones and breccias, the U-series dates and the stable light isotope data provide a ~600 kyr record of terrestrial climate change, which is, to date, the oldest such record for southern Africa, and shows excellent concordance with various other climate change records, both global, local and marine. The synchronicity of these records suggests a strong allocyclic control, which is attributed to changes in atmospheric circulation, in particular the size and position of the circumpolar vortex above Antarctica.

A climatically controlled model for the nature and rate of sedimentation at Gladysvale Cave is proposed, in which flowstones grow during the warm, wet recovery period following full interglacials, during which C_3 vegetation dominates and cave entrances are restricted. Sediments are washed into more open caves, during arid, C_4 dominated conditions, corresponding to glacial periods. As this model is climatically controlled, and the Cradle of Humankind World Heritage Site is a relatively small area, the other caves in the area would have experience the same conditions, and if open at the time should contain fills of similar ages.

This study has shown the value of the cave fills themselves, which are often understudied. The breccias at Gladysvale are strongly climatically controlled, being deposited only once certain climactic thresholds are crossed, hence producing a highly punctuated record. The hominin and other faunal remains from these caves should be viewed within this context. Gladysvale Cave also contains a ~600 kyr record of climate change, which will contribute to our understanding of terrestrial climatic changes and the landscape's response to them.