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Geoarchaeological and 3D visualisation approaches for contextualising *in-situ* fossil bearing palaeokarst in South Africa: A case study from the ~2.61 Ma Drimolen Makondo

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ABSTRACT

South Africa contains a wealth of palaeokarst deposits that have yielded hominin fossils and Early Stone Age archaeology. Despite the complex nature of deposition within many of these caves there has been a dearth of detailed geoarchaeological studies undertaken on these sites. Many sites in South Africa have been interpreted using an overly simplistic Member System based on simplified sedimentological attributes, rather than chronostratigrahic units. Many of the defined Members thus identify different, but contemporary geological processes occurring in the caves. This has caused serious confusion in reconstructing the life histories of palaeocaves and the ages of the fossil remains interned within them. It is critical to uncover new sites that have not been extensively altered by decades of data collection and destructive mining techniques employed early in their discovery. Although unmined sites present their own problems with regards to extensive colluvium cover and access to fossil-bearing units, analysing strata that is found *in-situ* enhances overall confidence of interpretations drawn. A wealth of geoarchaeological and 3D visualisation techniques can now be employed to aid in the understanding of cave life histories, as well as their excavation. In this paper we present the first attempt to integrate and publish data from a range of such methods on South African fossil bearing palaeokarst using the newly discovered Drimolen Makondo deposit as a case study. This includes the use of ground penetrating radar, 3D visualisation through photogrammetry and multi-scale 3D scanning, micromophology and petrography, palaeomagnetism, mineral magnetism, synchrotron radiation, electron spin resonance, uranium-lead dating and biochronology. Our analysis has allowed us to successfully uncover the full extent of this new ~2.61 Ma fossil bearing palaeokarst deposit and to visualise and interpret its chronostratigraphy.

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1. Introduction

Until the last 20 years almost everything that was known about early hominin evolution in South Africa came from a short (~3 km) stretch of the Bloubank Stream Valley in the Gauteng Province of South Africa (Bolt's Farm to Plover's Lake in Fig. 1b). The sites within the Gauteng exposures of this region are encompassed within the region formally referred to as the Fossil Hominid Sites of South Africa, colloquially termed The Cradle of Humankind (CoH) (Fig. 1a–b). The cave sites of Sterkfontein, Swartkrans and Kromdraai B have yielded the bulk of the early hominin (pre 1.0 Ma) material from South Africa. These caves all have complex multiphase karstification histories where many phases of cave formation and infill have occurred in the same place and on the same palaeokarstic conduits. At Sterkfontein in particular the development of a more recent cave system beneath the palaeokarst has caused material to subside, collapse and be reworked into lower caverns (Stratford et al., 2012, 2014). Many of these caves within the Bloubank Valley are part of the resurgence systems for groundwater out-welling into the Bloubank; of which some may have functioned as primary resurgence caves during the early Pleistocene (Herries et al., 2010). Such caves typically have complex multistage karstification histories as they can function as hydrological outputs for significant periods of time, especially on static landscapes where uplift is minimal (Latham et al., 1999, 2003).

An understanding of the Bloubank Stream Valley sites is further complicated with decades (some sites up to 80 + years) of excavation, the utilisation of various data collection methods by multiple researchers, and lastly, extensive, destructive speleothem mining in the early 20th Century (Herries et al., 2009, 2010, 2013; ; Herries and Adams, 2013). Consequently, many of the fossils recovered from these sites were ex-situ and so their location within the stratigraphy has often been assumed or reconstructed. There has also been an emphasis on how the sediments infilled the caves rather than how the caves themselves formed and evolved, which would help understand deposition within them. Moreover, when this has been attempted, due to the complexities of cave formation this was often misunderstood (Latham et al., 1999, 2003). Many sites in South Africa have been interpreted using an overly simplistic Member System based on simplified sedimentological attributes (Partridge, 1978, 1979; 2000; Bruxelles et al., 2016), rather than chronostratigrahic units. Many of the defined Members thus identify different, but contemporary geological processes occurring in the caves (Latham et al., 2003). This has caused serious confusion in reconstructing the life histories of palaeocaves and the ages of the fossil remains interned within them (Herries et al., 2009, 2013).

It is critical to uncover new sites that have not been extensively

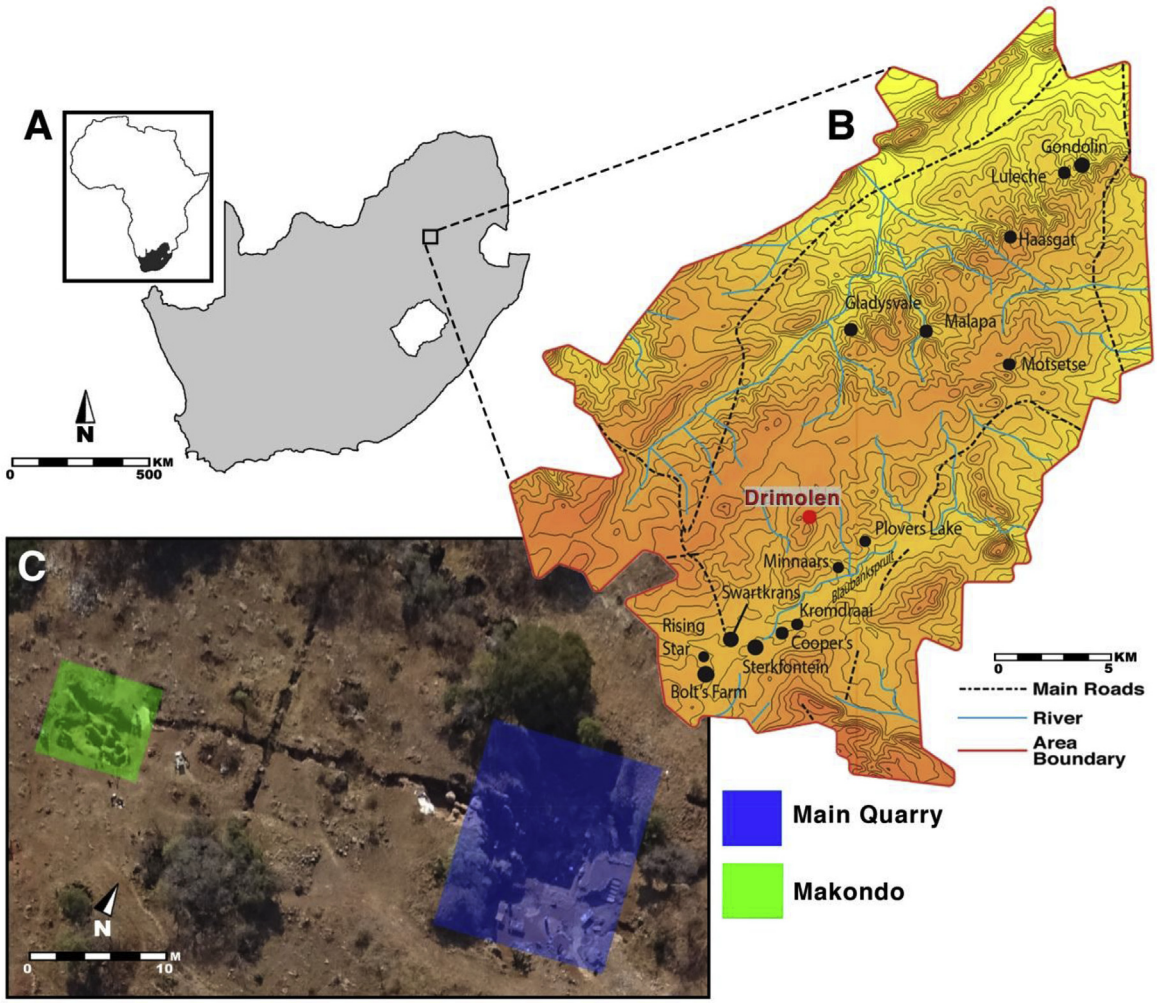

Fig. 1. A) The location of the Hominid Fossil Sites of South Africa UNESCO World Heritage Site (Cradle of Humankind); B) The height and location of Drimolen compared to other fossil bearing cave sites in the CoH; C) The relationship of the Drimolen Makondo to the Main Quarry.

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