TAUNG……………. A RIVER RAN THROUGH IT

Brian F Kuhn[1,2], Philip Hopley[3], Andrew I.R. Herries[4], Stephanie E. Baker[1,2], Colin G. Menter[5], Matthew Caruana[6], Alexandra Bountalis[1,2]

Abstract

In 1924 The Taung Child fossil was recovered from the Buxton Limeworks in South Africa. Raymond Dart designated this fossil as the type specimen of *Australopithecus africanus* in 1925, which spurred 85 years of fossil discoveries that would indicate that Africa was the cradle of humankind. Renewed scientific endeavours at the Taung palaeoanthropology site, Northwest Province, South Africa, took place in 2010 and have yielded results that will allow us to more precisely reconstruct the age provenience and context of the Taung Child. Initial sedimentological analysis has identified riverine tufa deposits overlying the pink calcretes and palustrine deposits of the Dart and Hrdliĉka Pinnacles. Palaeomagnetic analyses indicate that the older pink calcrete (PCS) has a normal magnetic polarity at its base and a reversed polarity at its top suggesting it formed over quite a long period of time, perhaps around 2.6 Ma. The younger yellowish-red (YRSS) deposit has a reversed magnetic polarity and may suggest deposition between 2.58 and 1.95 Ma based on associated fauna. Here we discuss the latest results in relation to previous hypotheses and how these new discoveries can be used to reinterpret the depositional and environmental influences on the Dart and Hrdliĉka Pinnacles at Taung and potentially the age of the *Au. africanus* type specimen.

Introduction

The Buxton Limeworks at Taung (Figure 1) commenced quarrying operations in 1916 (McKee, 1994). In 1924 mining activities unearthed the Taung Child, *Australopithecus africanus* (Dart, 1925). On the instruction of the director of the quarry company, two pinnacles were left in place recording the original thickness of the deposit on either side of the fossil deposit and slightly to the north of the suspected discovery site (Partridge, 2000). Hrdliĉka (1925), Young (1925), Cipriani (1928) and Broom (1934) all made a number of trips to the Taung fossil sites and all agreed that the type site for the *Au. africanus* specimen had in all probability been destroyed during mining operations. In 1982-84 Tobias excavated the base of the Dart Pinnacle and surmised that the Dart deposits were possible remnants of the type-site for the Taung Child (McKee, 1993a, b; 1994; McKee and Tobias, 1994). Further excavations took place in 1988 by Toussaint and from 1988-1993 by Tobias and McKee (McKee, 1994). Excavations and examination of bore cores by Partridge (Tobias *et al.*, 1993) indicated that two lithologies occur across the Dart and Hrdliĉka Pinnacles. The first has been described as a pale reddish brown to pink clay and siltstone deposit (PCS aka 'Pink Fill') and the second as a yellowish-red sand and siltstone deposit (YRSS aka 'Red Fill') (Tobias *et al.*, 1993).

Since the initial sedimentological work of Young (1925), the Dart and Hrdliĉka deposits have been interpreted as cave sediments that formed within the Thabaseek Tufa; either as a younger cave-fill or as contemporaneous carapace caves (e.g. McKee, 1993b; McKee and Tobias, 1994; McKee, 2010). Numerous cave-fills are exposed within the tufa deposits of the Buxton-Norlim quarry at Taung (McKee, 1994), so it is reasonable to assume that the poorly exposed sediments of the Dart and Hrdliĉka pinnacles were also cave-fills. However, sedimentological studies of the Dart and Hrdliĉka deposits (e.g. Partridge *et al.*, 1991) have focused on the provenance of the "Taung Child" through minor element geochemistry, rather than taking a more basic lithological approach. Utilizing the new exposures produced by the excavations of McKee *et al.* (1994), we have undertaken an initial sedimentological analysis to further our understanding of the depositional context of the "Taung Child" and associated fauna. The results of the most recent expedition reveals that the PCS is a landscape deposit and not a cave infill as previously suggested. This makes Taung the oldest hominin landscape deposit in southern Africa.

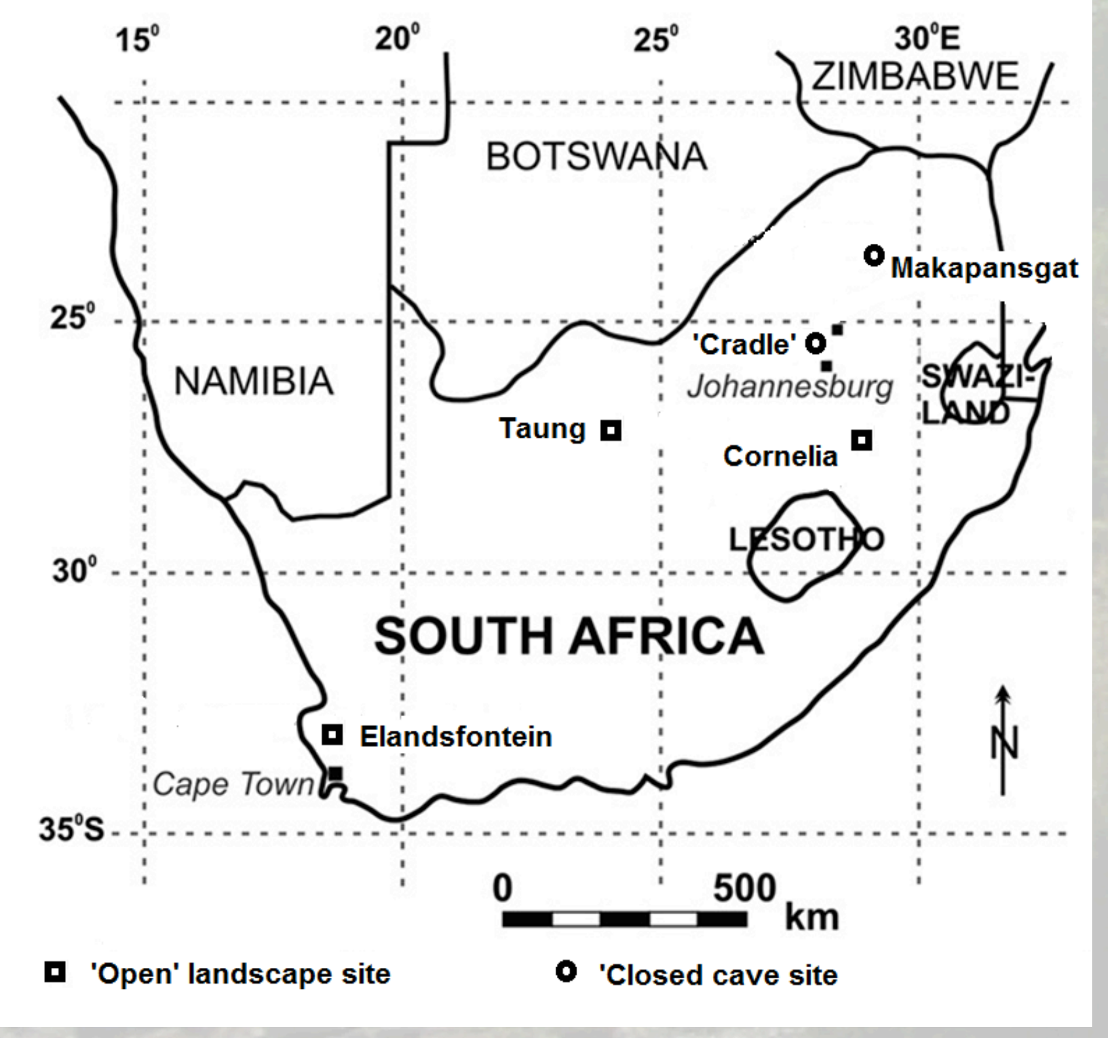

Figure 1: Location of the Buxton Limeworks (Taung) in relation to hominin localities in South Africa.

Methods

Utilizing the exposures produced by the excavations of McKee (McKee *et al,.* 1994), geological samples were taken from the sediments outcropping at the base of the Dart Pinnacle, the southern face of the Hrdliĉka Pinnacle and in the intervening area (Figure 2). The exposure at the base of the Dart Pinnacle is 2.5 m deep and offers the potential for sampling vertically within the sedimentary sequence. Samples were taken from both the eastern and western parts of this exposure. A second series of samples were taken from the 4 m thick exposure on the southern face of the Hrdliĉka Pinnacle. A series of samples were collected laterally, both east-west and north-south across the exposed area of the mined tufa. The near vertical dip of the carapace tufa in this area meant that more than a 20 m thickness of the Thabaseek tufa flow was exposed. A series of smaller isolated sediment fills were also sampled from the area between the two pinnacles where Peabody (1954) suggested the skull originated. Routine sedimentological analysis was undertaken on hand specimens, polished blocks and thin sections. Palaeomagnetic analysis followed procedures outlined by Herries and Shaw (2011) and Herries *et al.* (2006).

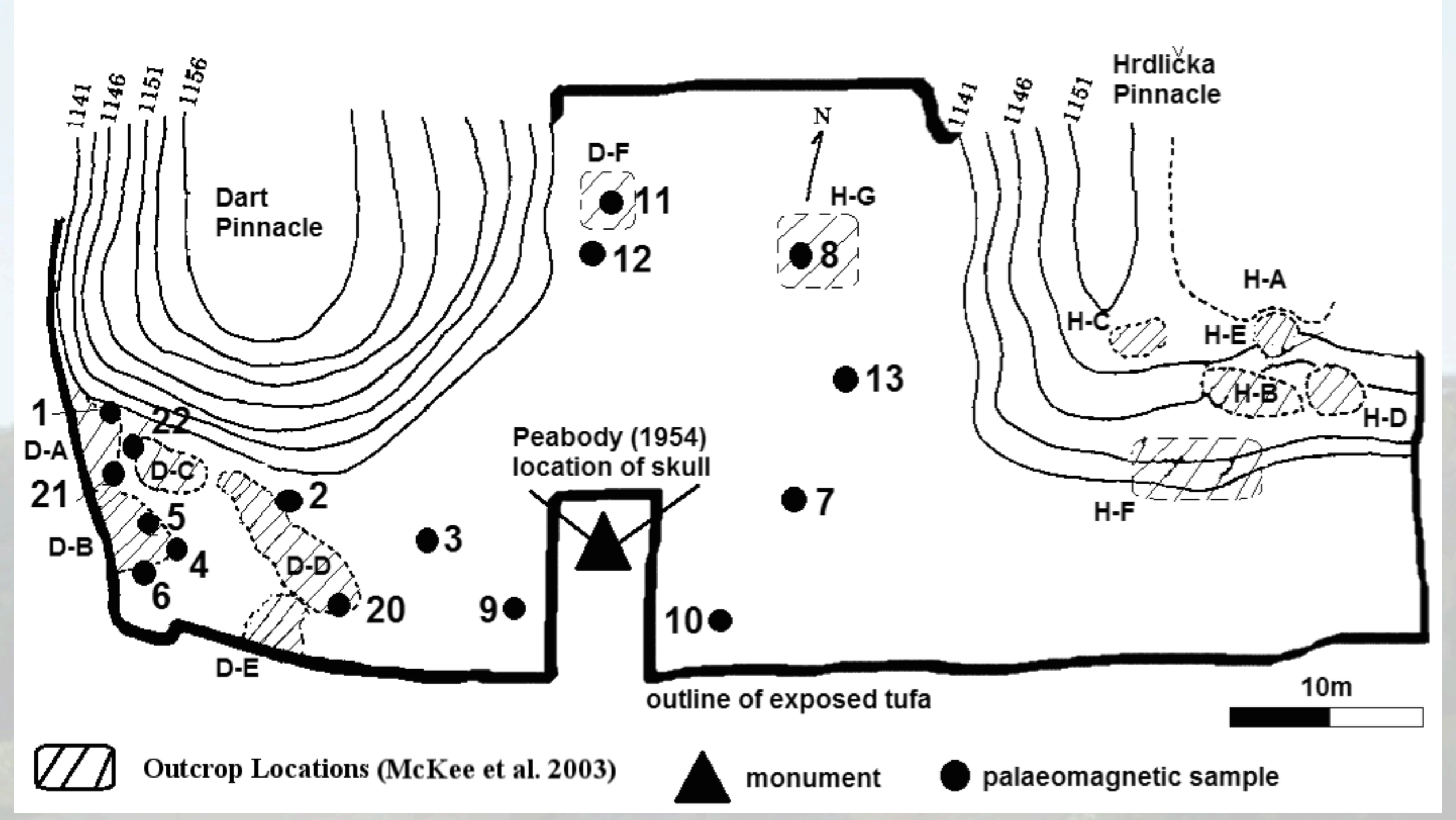

Figure 2: The location of outcrops (dotted lines) and palaeomagnetic sampling localities (1-23) around the two Pinnacles (after McKee, 1995b).

Results

The PCS deposits of the Dart and Hrdliĉka Pinnacles display a number of sedimentological characteristics typical of massive calcretes. Rhizoconcretions (Figure 3c), root mats (Figure 3b,d) and trace fossils belonging to the *Coprinisphaera* ichnofacies, *Celliforma* sp. (Figure 3g) and *Coprinisphaera* sp. (Figure 3h), are all indicative of palaeosol development. Holes between 1 mm and 3 mm in the rhizoconcretions and root mats indicate the position of the roots prior to decay. In thin section, the calcified root mats resemble the alveolar septal fabric of root growth within the soil (Figure 3f). Much of the PCS deposits are composed of peloidal micrite (Figure 3a) cemented by at least one phase of carbonate cement. The PCS contains silt-sized quartz grains "floating" within the micrite matrix (Figure 3e), as is typical of the expansive growth of calcretes.

The PCS deposits at the base of the Dart Pinnacle is characterised by rhizoconcretions, *Coprinisphaera* sp., *Celliforma* sp. as well as fragments of fossil eggshell (Figure 3 & Figure 4). This association of plant and animal trace fossils is characteristic of the *Coprinisphaera* ichnofacies and represents calcrete growth in a semi-arid environment. *Coprinisphaera* and *Celliforma* are nesting traces (calichnia) constructed in the soil by adult insects (dung beetles and solitary bees, respectively) for breeding purposes (Genise *et al.*, 2000). The larvae are confined to cells provisioned with different kinds of organic matter, such as pollen, dung and plant material. Unlike some social insects (e.g. ants and termites), most solitary insects cannot transport their eggs or larvae to more favourable sites should conditions become unfavourable, nor can they construct nests to produce a favourable microclimate. Instead, they construct their nests at ideal sites where larval physiological requirements match the local soil microenvironment.

The *Celliforma* tracemaker, solitary bees (hymenoptera), construct their nests on bare, light and dry soil exposed to sun with access to angiosperms which provide pollen to the bees. The *Coprinisphaera* ichnogenus is strongly associated with terrestrial herbaceous communities such as savannahs, grasslands and prairies (Sanchez *et al.*, 2010). Because the *Coprinisphaera* tracemaker, Scarabaeinae, provision their nests with the excrement of vertebrate herbivores, it is common to find their trace fossils in association with herbaceous trace fossils such as rhizoliths (Genise *et al.*, 2000). The *Coprinisphaera* ichnofacies has been observed at a number of African early hominin palaeosol localities in Tanzania, Kenya and Chad (e.g. Thackeray, 1994; Duringer *et al.*, 2007; Krell and Schawaller, 2011) and is indicative of savannah grassland environments.

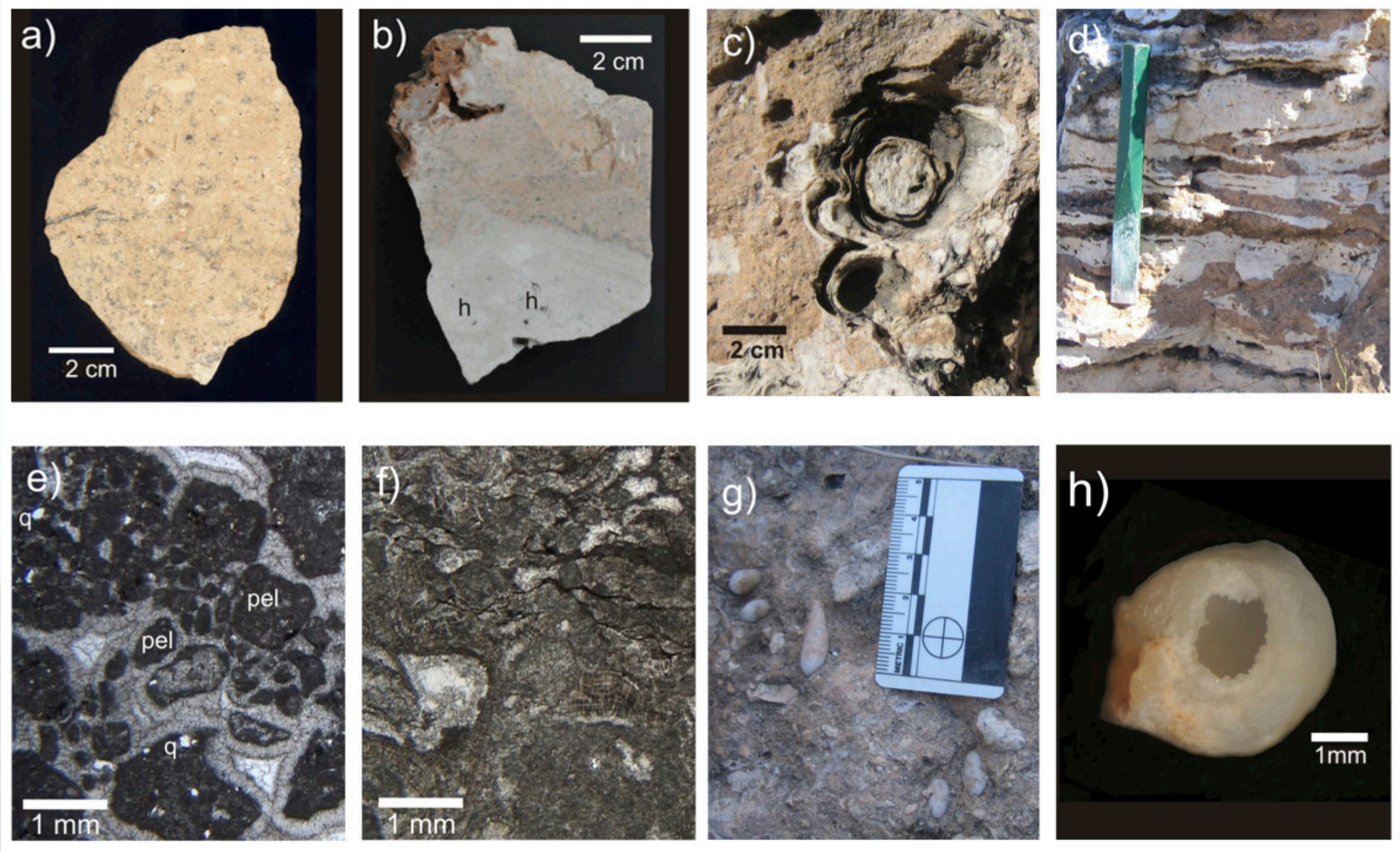

Figure 3. Pedogenic features of the PCS deposits from the Dart and Hrdliĉka Pinnacles. a) Polished block of PCS from the base of the Dart Pinnacle. Massive pink calcrete with typical mottled appearance. B) Polished block of PCS from the base of the Dart Pinnacle with calcified root-mat. Note the 1 mm diameter root holes (h) surrounded by concentric calcite growth. c) Rhizoconcretion in PCS from the base of the Dart Pinnacle. Note the root holes in the centre of the concretion. d) Calcified root mats in PCS deposits, Hrdliĉka Pinnacle. Chizel length is 25 cm. e) Thin section of a) showing micritic peloids (pel) and floating silt-sized quartz grains (q) surrounded by an isopachous rim cement and a drusy spar cement; p.p.l., 5 mm field of view. f) Thin section of the cream coloured root mats shown in d). Note sparite in-fill of root casts surrounded by and layers of speleothem-like fibrous calcite, as observed in other Kalahari calcretes (e.g. Watts, 1978; 1980); p.p.l., 5 mm field of view. G) Five solitary bee cells belonging to the *Celliforma* ichnogenus; PCS deposit, base of the Dart Pinnacle. h) Dung beetle brood ball belonging to the *Coprinisphaera* ichnogenus; PCS deposit, base of the Dart Pinnacle. Note the small size of this specimen.

Palaeomagnetic Results

Mineral magnetic measurements and demagnetisation spectra indicate that magnetite is the dominant carrier in the deposits due to detrital inputs and behave similar to speleothem samples from the palaeocave sites (see Herries and Shaw, 2011). Samples record weak, but extremely stable remanence. In most cases, the samples have only a small overprint that is removed by 250°C or 10-12mT. Both reversed and normal polarity directions are recorded from the site. All of the tufa deposits record a normal polarity direction, while the PCS deposits record normal polarity at its base and reversed polarity at its top (Figure 4 & Figure 5). This indicates that this deposit may have formed over quite a long period of time to have incorporated a reversal during its formation. It is unlikely to be a short polarity reversal as identified in some cave deposits in South Africa (Herries and Shaw, 2011), because there is a sharp, rapid change between normal and reversed polarities suggesting slow deposition. The purportedly younger YRSS deposits record a reversed polarity. This indicates that the top of PCS and YRSS were deposited at a different time to the Thabaseek Tufa and that the base of PCS and YRSS are not contemporary.

The reversed polarity YRSS deposits most likely date to the beginning of the early Pleistocene, Matuyama Chron between 2.58 and 1.95 Ma, given the faunal age estimates based on the primates from this deposit, making them contemporary with Sterkfontein Member 4 between 2.6 and 2.0 Ma (Pickering and Kramers, 2010; Herries and Shaw, 2011). The clearly older PCS deposits record a normal to reversed polarity which may suggest deposition either side of the Pliocene-Pleistocene boundary and centred at the Gauss-Matuyama boundary at 2.58 Ma. This would make the deposit and the Taung Child skull roughly intermediate in age between the australopithecine-bearing Member 3 at the Makapansgat Limeworks between 3.0-2.6 Ma and Sterkfontein (Herries *et al.*, 2010). The only other option is that the PCS deposits are older than 3 Ma. Based on the current evidence, a good estimate for the age of the skull is ~2.6 Ma at the very end of the Pliocene.

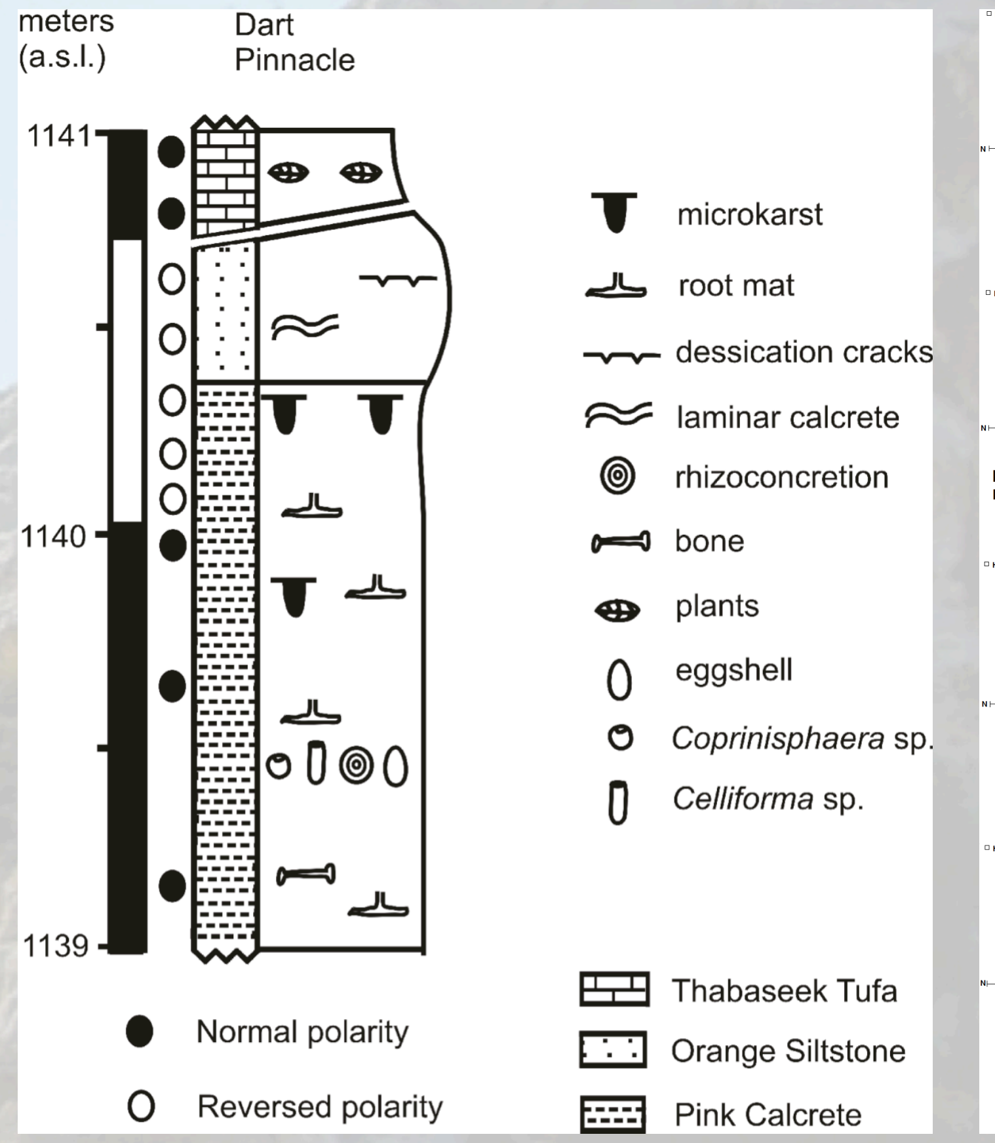

Figure 4: Sedimentological log and magnetostratigraphy of the Dart deposits, Taung

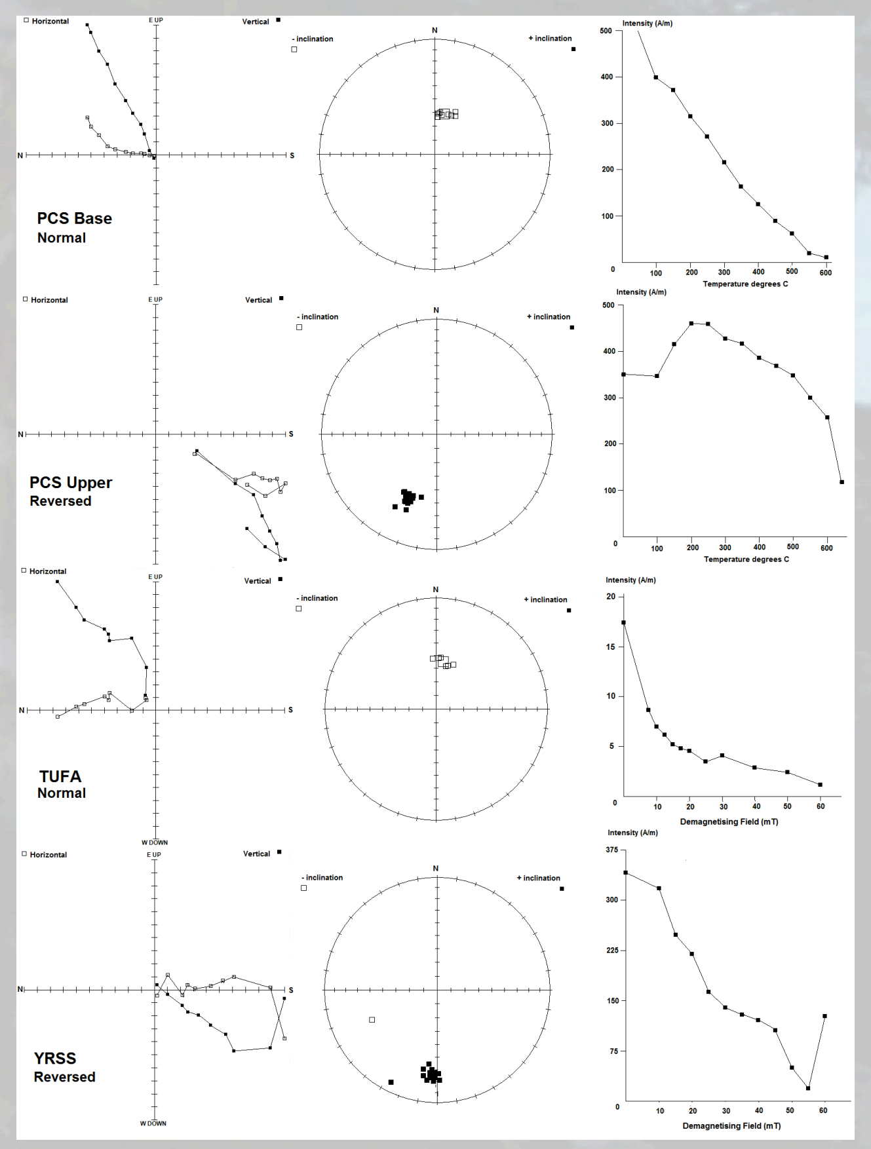

Figure 5: Palaeomagnetic vector plots for normal and reversed polarity PCS, YRSS and Tufa deposits from Taung.

Conclusions and Future Research

The evidence presented in this study demonstrates that the PCS fossil-bearing deposits of the Dart and Hrdliĉka deposits were not sedimentary infills of a tufa-cave. Instead, we have demonstrated that the hominin-bearing pink carbonate deposit is a calcrete that formed on the Plio-Pleistocene land surface. This is the earliest hominin-bearing landsurface deposit to be recognised from southern Africa; hominin fossils from the Elandsfontein Calcrete and Dune system and the Cornelia fluvial system date to less than 1.1 Ma (Herries and Shaw, 2011). We have demonstrated that the Dart deposits share a number of sedimentological characteristics with the hominin-bearing paleosols of eastern and central Africa (e.g. Hay and Reeder, 1978; Cohen, 1982). Our re-interpretation of the stratigraphy and depositional environment at Taung has implications for future research at the site. Under the previous tufa-cave depositional model, it seemed likely that there were no significant *in situ* fossil deposits remaining at the two pinnacles, as they had been largely destroyed by the combination of mining activities and palaeontological investigations. To the contrary, we believe it is likely that there are laterally extensive fossil-bearing palaeosol deposits underlying the Thabaseek Tufa that is currently exposed on the floor of the Buxton-Norlim quarry. Planned geophysical investigations and targeted palaeontological excavations will determine the extent and depth of the hominin-bearing calcrete in the subsurface.

[1] Institute for Human Evolution, University of the Witwatersrand, Johannesburg, Private Bag 3, Wits 2050, South Africa
[2] School of Geosciences, University of the Witwatersrand, Johannesburg, Private Bag 3, Wits 2050, South Africa
[3] Department of Earth and Planetary Sciences, Birkbeck College, University of London, Malet Street, London, WC1E 7HX
[4] Archaeomagnetism Laboratory, Department of Archaeology, La Trobe University, Melbourne, VIC, Australia
[5] Centre for Language and Culture in Africa (CCLA), University of Johannesburg, PO Box 524, Auckland Park 2006, South Africa
[6] School of Geography, Archaeology, and Environmental Studies, University of the Witwatersrand, Johannesburg, Private Bag 3, Wits 2050, South Africa

REFERENCES

Broom, R., 1934. On the fossil remains associated with *Australopithecus africanus*. S. Afr, J. Sci. 31, 471-480.
Cipriani, L. 1928. Skull "*Australopithecus africanus*", Dart. Arch. Anthrop. Etnol. LVII, 1- 29.
Cohen, A.S., 1982. Paleoenvironments of root casts from the Koobi Fora Formation, Kenya. J. Sed. Petrol. 52, 401-414.
Dart, R.A., 1925. *Australopithecus africanus*: The man-ape of South Africa. Nature 115, 195-199.
Duringer, P., Schuster, M., Genise, J.F., Mackaye, H.T., Vignaud, P., Brunet, M., 2007. New termite trace fossils: Galleries, nests and fungus combs from the Chad basin of Africa (Upper Miocene-Lower Pliocene). Palaeogeogr. Palaeoclimatol., Palaeoecol. 251, 323-353.
Genise, J.F., Mángano M.G., Buatois, L.A., Laza, J.H., Verde, M., 2000. Insect Trace Fossil Associations in Paleosols: The Coprinisphaera Ichnofacies. Palaios 15, 49-64.
Hay R.L, Reeder, R.J., 1978. Calcretes of Olduvai Gorge and the Ndolanya Beds of northern Tanzania. Sedimentology 25, 649-673.
Herries, A.I.R., Shaw, J., 2011. Palaeomagnetic analysis of the Sterkfontein palaeocave deposits: implications for the age of the hominin fossils and stone tool industries. J. Hum. Evol. 60, 523-539.
Herries, A.I.R., Adams, J.W., Kuykendall, K.L., Shaw, J., 2006. Speleology and magnetobiostratigraphic chronology of the GD 2 locality of the Gondolin hominin-bearing paleocave deposits, North West Province, South Africa, J. Human Evolution. 51, 617-631
Hrdliĉka, A. 1925. The Taungs Ape. Am. J. Phys. Anthropol. 8, 379- 392.
Krell, F.T., Schawaller, W., 2011. Beetles (Insecta: Coleoptera). In: Harrison, T. (Ed.), Paleontology and Geology of Laetoli: Human Evolution in Context. Volume 2: Fossil Hominins and the Associated Fauna. Springer, New York. pp. 535-548.
McKee, J.K., 1993a. The faunal age of the Taung hominid deposit. J. Hum. Evol. 14, 252-265.
McKee, J.K., 1993b. Formation and geomorphology of caves in calcareous tufas and implications for the study of Taung fossil deposits. Trans. R. Soc. S. Afr. 48, 307-322.
McKee, J.K., 1994. Catalogue of fossil sites at the Buxton Limeworks, Taung. Palaeont. Afr. 31, 73- 81.
McKee, J.K., Tobias, P.V. 1994. Taung stratigraphy and taphonomy: preliminary results based on the 1988-89 excavations. S. Afr. J. Sci. 90, 233-235.
McKee, J.K., 2010. Taphonomic processes of bone distribution and deposition in the tufa caves of Taung, South Africa. J. Taphonomy 8, 203-213.
Partridge, T.C., 2000. Hominid-Bearing Cave and Tufa Deposits. In: Partridge T.C., Maud, R.R. (Eds.), The Cenozoic in Southern Africa. Oxford Monographs on Geology and Geophysics 40. Oxford University Press, pp. 100-125.
Partridge, T.C., Bollen, J.F., Tobias, P.V., McKee, J.K., 1991. New light on the provenience of the Taung skull. S. Afri. J. Sci. 87, 340-341.
Pickering, R., Kramers, J.D. 2010 Re-appraisal of the stratigraphy and determination of new U-Pb dates for the Sterkfontein hominin site, South Africa. J. Hum. Evol. 59. 70-86.
Sánchez, M. V., Laza, J.H., Bellosi, E.S., Genise, J.F., 2010. Ichnostratigraphy of middle Cenozoic *Coprinisphaera* from central Patagonia: Insights into the evolution of dung beetles, herbivores and grass-dominated habitats. Palaeogeogr., Palaeoclimatol., Palaeoecol. 297, 633-648.
Thackray, G.D., 1994. Fossil Nest of Sweat Bees (Halictinae) from a Miocene Paleosol, Rusinga Island, Western Kenya. J. Paleontol. 68,795-800.
Tobias, P.V., Vogel, P.C., Oschadleus, H.D., Partridge, T.C., McKee, J.K., 1993. New isotopic and sedimentological measurements of the Thabaseek deposits (South Africa) and the dating of the Taung hominid. Quat. Res. 40, 360-367.
Young, R.B., 1925. The calcareous tufa deposits of the Campbell Rand, from Boetsap to Taungs Native Reserve. Trans. Geol. Soc. S. Afr. 28, 55-67.