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Proposal to undertake ESR analysis in Australia on bovid teeth from fossil bearing sites in South Africa

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The dating of the southern African hominin and other fossil bearing palaeocave sites remains a difficult task. In recent years advancements in uranium-lead dating, coupled with palaeomagnetic research has allowed the establishment of the age of many sites (Herries et al., 2010; Herries and Shaw, 2011; Pickering et al., 2011; Herries et al., 2013; Herries and Adams, 2013; Hopley et al., 2013; Herries et al., 2014). However, there are many sites where either the precise relationship of the U-Pb and palaeomagnetic dates, often restricted to siltstone sequences, to the hominin and fossil bearing breccias is difficult to access. At other sites suitable material does not exist for these methods or suitable conditions do not exist (i.e low uranium concentrations or very short stratigraphic sequences). As such, it is beneficial for a range of dating methods to be developed that can date all aspects of a fossil site, from the speleothem, to the siltstone to the breccias and fossils themselves. Only then will we gain a comprehensive understanding of the sites and be able to confidently date all the fossil sites in S. Africa. This is a crucial step for wider South African Palaeontology and Archaeology as the vast majority of sites throughout S. Africa that are older than the Middle Stone Age have been dated by ESR (Herries, 2011). It is therefore critical to evaluate the method more closely given recent advancements in the technique. This work will require ESR to be undertaken at sites where chronological control is very good or well developed (e.g Drimolen and Haasgat) to compare the ESR dates versus other methods as well as sites where no ages currently exist, but from which dates from various methods can potentially be recovered (e.g Taung and Bolt's Farm). In a number of cases these localities also have areas where ESR is currently the only hope for dating some of the deposits.

Electron Spin Resonance (ESR) is a method that can be used to date the breccia deposits in which we find most of the hominin remains as well as directly date non-hominin fossils in the same deposit by directly dating bovid tooth enamel. ESR has been used on South African sites previously and while largely dismissed initially, a reanalysis of the data shows that the ESR ages obtained are often very consistent when compared to other dating methods (Herries and Shaw, 2011; Herries and Adams, 2013). Our ability to Plio-Pleistocene teeth from South Africa appears to be due to the extremely low background radiation values at the sites. In April and May 2014 Dr Andy Herries and Dr Renaud Joannes-Boyau visited a number of Plio-Pleistocene cave sites at Taung (with Dr Brian Kuhn), Bolt's Farm (with Ms Stephanie Potze and Dr Dominique Gommery), Drimolen (with Dr Colin Mentor) and Haasgat (with Ms Stephanie Potze and Dr Justin Adams) with the aim of identifying suitable material and deposits to re-evaluate ESR dating as part of a multi-disciplinary Australian Research Council Funded Project granted to Dr Herries. During this trip they undertook in-situ, non-destructive dosimetry measurements to ascertain the suitability of the sites and deposits. This work indicates that all the sites visited have low levels of background radiation and so are extremely suitable for ESR analysis. They also identified a range of teeth from each site that were suitable based on context and preservation.

The aim is to export these teeth to Dr Joannes-Boyau at the Dept. Geoscience at Southern Cross University in NSW, Australia. Dr Joannes-Boyau is a recognised world leader in the field of ESR and undertook his PhD in helping to understand some of the early problems with the method (Joannes-Boyau, Grün, 2009; 2010; 2011; Joannes-Boyau et al., 2010; 2011; Joannes-Boyau, 2013). He has built the first laboratory specifically built for working on palaeontological and archaeological samples. This new method also means that the analysis is minimally invasive to the tooth. No such ESR laboratory exists in South Africa and as such the material needs to be exported to Australia for this analysis. The specifics of each sample and its context are outlined in the separate applications for each locality.

References

Herries, A.I.R., Kappen, P., Kegley, A., Paterson, D., Howard, D.L., de Jonge, M.D., Potze, S., Adams, J.W. 2014. Palaeomagnetic and Synchrotron analysis of >1.95 Ma fossil bearing palaeokarst at Haasgat, Gauteng. South African J. Science. 110 (3/4; March/April) 1-12.

Herries, A.I.R., Adams, J.W. 2013. Clarifying the context, dating and age range of the Gondolin hominins and *Paranthropus* in South Africa. J. Human Evolution. 65, 676–681.

Herries, A.I.R., Pickering, R., Adams, J.W., Curnoe, D., Warr, G., Latham, A.G., Shaw, J. 2013. A multi-disciplinary perspective on the age of *Australopithecus* in southern Africa. In: Reed, K.E., Fleagle, J.G., Leakey, R. (Eds.) Paleobiology of *Australopithecus*: Contributions from the Fourth

Stony Brook Human Evolution Symposium and Workshop, Diversity in *Australopithecus*: Tracking the First Bipeds. Vertebrate Paleobiology and Paleoanthropology series. 21-40.

Herries, A.I.R. 2011. A chronological perspective on the Acheulian and its transition to the Middle Stone Age in southern Africa: the question of the Fauresmith. International Journal of Evolutionary Biology Key Evolutionary Transformations in Homo sapiens. Volume 2011, ID 961401, 25pp doi: 10.4061/2011/961401.

Herries, A.I.R., Shaw, J. 2011. Palaeomagnetic analysis of the Sterkfontein palaeocave deposits; age implications for the hominin fossils and stone tool industries. J. Human Evolution 60, 523-539.

Hopley, P., Herries, A.I.R., Baker, S., Kuhn, B., Menter, C. 2013. Beyond the South African Cave Paradigm – *Australopithecus africanus* from the Pliocene palaeosol deposits of Taung. American J. Physical Anthropology. 151, 316-324.

Joannes-Boyau, R. 2013. Detailed protocol for accurate non-destructive direct dating of human remains. Geochronometria 40, 322-333. (2012 ERAID 1790 – FOR 0402)

Joannes-Boyau R., Grün R. 2011. A comprehensive model for CO_2^- radicals in fossil tooth enamel: Implications for ESR dating. Quaternary Geochronology 6, 82-97.

Joannes-Boyau R., Grün R. 2011. Decomposition of B-induced ESR spectra of fossil tooth enamel. Radiation Physics and Chemistry 80, 335-342.

Joannes-Boyau R., Bodin T., Grün R. 2010. Decomposition of the angular ESR spectra of fossil tooth enamel fragments. Radiation Measurements 45, 887-898.

Joannes-Boyau R., Grün R., Bodin T. 2010. Decomposition of the laboratory irradiation component of angular ESR spectra of fossil tooth enamel fragments. Applied Radiation and Isotopes 68, 1798-1808.

Joannes-Boyau R., Grün R. 2010. Decomposition of UV induced ESR spectra in enamel fragments of a modern and a fossil tooth. Ancient TL 28, 23-34.

Joannes-Boyau R., Grün R. 2009. Thermal behavior of oriented and non-oriented CO_2^- radicals in tooth enamel. Radiation Measurements 44, pp. 505-511.

Pickering, R., Dirks, P., Jinnah, Z.,de Ruiter, D.J, Churchill, S.E., Herries, A.I.R., Woodhead, J., Hellstrom, J., Berger, L.R. 2011. *Australopithecus sediba* at 1.977 Ma and implications for the origins of the genus *Homo*. Science. 333; 1421-1423.