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An improved single grain OSL chronology for the sedimentary deposits from Diepkloof Rockshelter, Western Cape, South Africa

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ABSTRACT

The single grain optically stimulated luminescence (OSL) chronology for the sedimentary deposit at Diepkloof Rockshelter, reported by Jacobs et al. (2008c), has recently been critiqued and several reasons proposed for why the OSL ages for the Intermediate and Early Howieson's Poort (HP) and Still Bay (SB) techno-complexes might be inaccurate. Tribolo et al. (2013) presented a series of OSL and thermoluminescence (TL) ages that were in agreement with each other, but, for some part of the sequence at least, were much older than the OSL chronology of Jacobs et al. (2008c). In this paper, we have tested the criticisms of Tribolo et al. (2013) and colleagues related to both the equivalent dose (D_e) estimates and the beta dose rates by performing a series of targeted experiments, combined with updates and re-assessments of our error calculations. We show that the D_e estimates are stable over a range of alternative measurement conditions and also over time. We also demonstrate the reproducibility of our measurement procedures for the beta dose rates, and their accuracy tested against a range of independently obtained estimates. We show that, for the stratigraphic units (SUs) where there are major discrepancies in age between Jacobs et al. (2008c) and Tribolo et al. (2013)—notably the Intermediate HP and Early HP—and for which both studies had single grain OSL ages, the estimation of potassium (K) in the sediment surrounding the dated grains is critical. We provide new and updated D_e and dose rate estimates, and final ages which we compare with our previous age estimates and those of Tribolo et al. (2013). The differences in the size of the errors associated with the ages reported in the two independent studies are also addressed. We can show that our ages are robust and consistent with the original chronology, but we cannot satisfactorily explain why the TL and OSL ages provided by Tribolo et al. (2013) might be wrong. So, the dating conundrum at Diepkloof Rockshelter remains. As a result, we caution against the development of HP and SB age models based on only one of the chronologies for this site. At this stage, extrapolation of the Tribolo et al. (2013) chronology to a re-interpretation of the southern African MSA would appear to be premature, especially as the ages do not differ systematically between the two studies and as differences between TL and OSL ages are not an issue at other sites in southern Africa where both dating methods have been applied. Further work is needed to resolve the question of the Diepkloof chronology.

1. Introduction

In a recent compilation of papers in a Special issue of this journal, the previously published single grain optically stimulated luminescence (OSL) chronology for Diepkloof Rockshelter, presented in Jacobs et al. (2008c), was called to question. Tribolo et al. (2013) proposed a new chronology based on measurement of both thermoluminescence (TL) and isothermal TL (ITL) dating of burnt stones, and single grain OSL dating of sedimentary quartz grains. They obtained consistent results between their TL/ITL and OSL chronologies, but some of their results—notably those within the middle of the technological and lithological sequence—are inconsistent with the single grain OSL chronology of Jacobs et al. (2008c). The latter chronology was, therefore, dismissed by all papers in this Special Issue, and excluded from the new chrono-stratigraphy proposed for the site, which was then used to interpret all aspects of the site, including its technological and typological sequences and the implications for understanding the MSA of southern Africa.

Tribolo et al. (2013) and Guérin et al. (2013) made a number of suggestions as to why the single grain OSL chronology of Jacobs et al.

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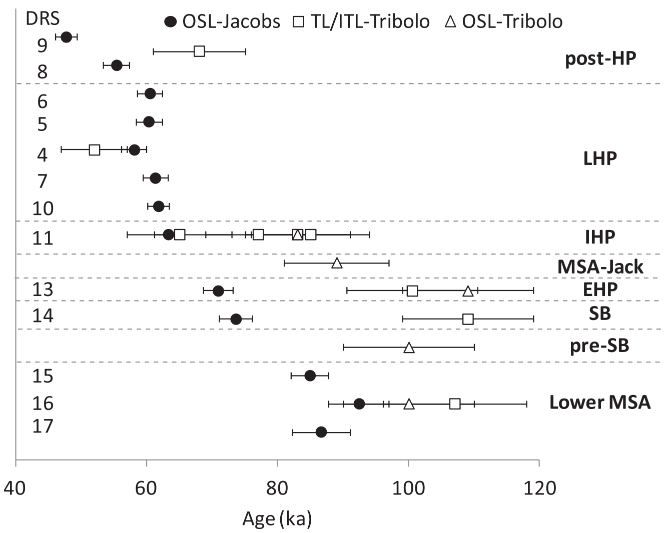

Fig. 1. Summary of ages with 1σ errors for samples collected from Diepkloof Rockshelter and published in Jacobs et al. (2008c) and Tribolo et al. (2005, 2009 and 2013). The filled circles represent the ages for individual samples obtained from OSL dating of single quartz grains by Jacobs et al. (2008c). The DRS numbers at the left are the sample names used by Jacobs et al. (2008c). The open symbols denote the weighted mean TL and/or ITL ages on burnt stones (squares) and individual OSL ages on single quartz grains (triangles) by Tribolo et al. (2013). The technological phases at the right are those provided by Porraz et al. (2013). Note that DRS13 was previously assigned to the SB, but is now associated with the EHP (Porraz et al., 2013, p. 3386).

(2008c) may be wrong. Tribolo et al. (2013) expressed concerns that the single grain equivalent dose (D_e) estimates may have been in error because 'dose recovery tests' were conducted on multi-grain aliquots and not on single grains. Such tests are routinely carried out to establish the most suitable measurement conditions for the samples under investigation (Galbraith et al., 1999). Guérin et al. (2013) raised some objections about our application of the finite mixture model (FMM) to single grain OSL measurements. They also criticised our methods for estimating the beta-particle dose rate, in particular 1) the small size of the uncertainties attached to the beta-particle contribution to the environmental dose rate for some of the samples, including those from Diepkloof; and 2) the details of implementation of a model proposed by Jacobs et al. (2008b) to adjust the beta dose rate in specific circumstances. Tribolo et al. (2013) also commented on these two issues, but indicated that these were insufficient to explain the age discrepancies. Tribolo et al. (2009) had previously also criticised our use of laboratory measurements to estimate the gamma dose rates at Diepkloof, but showed that this was not the source of the age discrepancy.

All of these criticisms and their potential effects on the calculated ages of the samples are testable. In this paper, we scrutinise the effects that the issues raised may have on our single grain OSL chronology for Diepkloof, and re-assess our previously published ages. We also present new D_e and dose rate data for all of the samples to explicitly test the criticisms raised. In the light of our new results, we compare our updated chronology with that developed by Tribolo et al. (2013).

2. Current luminescence chronologies for Diepkloof Rockshelter

In 2008, we published single grain OSL ages for 13 samples from Diepkloof (Jacobs et al., 2008c). These are shown in Fig. 1 together with the weighted mean TL or ITL and individual OSL samples presented in Tribolo et al. (2005, 2009, 2013). The samples of Jacobs et al. (2008c) were collected by the first author from two different sectors (Fig. 2). In the absence of stratigraphic connections between the different excavated sectors in the site (Parkington et al., 2013),

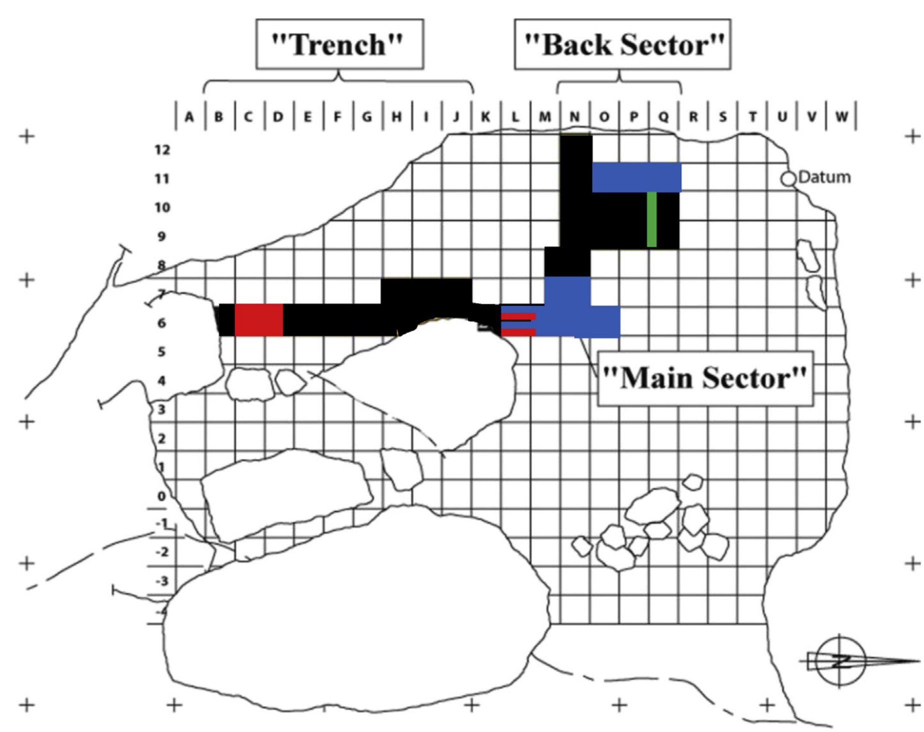

Fig. 2. Schematic of Diepkloof Rockshelter and the excavation plan marked in black (modified from Parkington et al., 2013). Each square represents 1 m^2. The two red areas represent those parts of the excavation from which OSL samples were collected for the study of Jacobs et al. (2008c) and this study. The blue areas represent the excavated areas from which samples were collected for the TL and OSL studies of Tribolo et al. (2013). The red and blue shading in squares L6 and M6 indicates an overlap in sampling area between the two studies. The green shading in the 'Back' sector indicates the approximate position of the section wall from which samples were collected by Feathers and Woodborne (Tribolo, 2003). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)