The travertine hand and footprints at Qiusang, Tibet

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The proposed sensational Middle Pleistocene dating of the hand and footprints found at the Qiusang site in Tibet has involved a method that numerous authors have considered unsuitable for poorly crystallised reprecipitated carbonate deposits. This is an open-air site, and precipitation should be expected to severely affect its travertine's U–Th ratio, especially by removing uranium. Such an open system inevitably results in age estimates that are significantly greater than the precipitate's actual age. There is no evidence that hominins occupied the central Tibetan Plateau at the time proposed, and none of modern humans in Eurasia, yet the footprints are of Moderns. Recent U–Th analysis applications in China have shown that results from speleothems and similar deposits can be as much as a hundred times or so too high. They have also confirmed that multiple samples from the same deposit may provide vastly different age estimates. Moreover, sample splits processed by different labo-

ratories yielded entirely different results.

This paper responds to the article by Zhang D. D. et al. (2021), reporting the discovery of a panel of ancient hand and foot impressions on mineralised travertine at the Qiusang Hot Spring site in central Tibet. Dating the travertine unit to the late Middle Pleistocene, the research team confidently announced that the Qiusang site presents the earliest known rock art in the world and the first evidence of hominins on the Tibetan Plateau (previously attributed to the Nwya Devu site dated to ~40–30 ka BP by OSL; Zhang X. L. et al. 2018; Zhang J.-F. and Dennell 2018). The eighteen authors of this new report have provided a comprehensive description and discussion of this fascinating phenomenon. They carefully explain their reasoning, and we emphasise that we accept most of their propositions. For instance, we agree that the traces on the Qiusang panel were made by pressing hands and feet into the soft medium and were not created with tools. We also concur that the marks were made deliberately, so they are a form of palaeoart. Moreover, we have no hesitation in accepting that juveniles made them. Children have been responsible for much rock art production, and specifically for most body part impressions found on soft or formerly soft cave deposits in Europe and Australia (Bednarik 2008). We also concur that the markings were made when the travertine was soft and still being precipitated, so they should be of an age matching that of the medium.

We disagree with these authors in just one detail: we question the basis of their claim that the rock bearing the ichnological traces is of the Middle Pleistocene and in the order of 169 to 226 ka old. The uranium-thorium method they used to arrive at this result has been shown numerous times to provide unreliable Pleistocene age estimates of reprecipitated carbonate deposits. Carbonate speleothems, formed by a similar process, have in all cases yielded significantly more recent radiocarbon ages than the U–Th dates when these were checked (Bednarik 1984, 1997, 2001; Bard et al. 1990; Holmgren et al. 1994; Labonne et al. 2002; Plagnes et al. 2003; Taçon et al. 2012; Quiles et al. 2014; Sanchidrián et al. 2017; Valladas et al. 2017). While the ages obtained by the two methods have usually matched reasonably well if they were of the Holocene, the U–Th ages of Late Pleistocene samples increase exponentially with age until they can be many times their actual ages (Bednarik 2022: Fig. 1). In the worst of the many cases reported before the Qiusang example, a reprecipitated carbonate film that can only be a few centuries old at most provided a U–Th raw age of 134.6 ka, i.e., hundreds of times its realistic antiquity (Tang et al. 2020).

The stochastic distribution of the dates suggests that the distortion is not systematic but seems to be a random function of taphonomic processes distorting the U–Th ratios. Most notably, U is soluble in water and can be readily removed when the deposit is subjected to moisture. This occurs with speleothems frequently and even more so with travertine fully exposed to precipitation. Travertines are not dense crystalline formations like stalagmites; they have varying degrees of porosity which assists the reaction with carbonic acid, reverting to their soluble (bicarbonate) state. In addition to effecting U depletion, moisture may also remove or add detrital Th; there may be a transformation of aragonite to calcite, or components of the support rock may contaminate samples.

Two other factors are of even greater concern. First, the significant variations of U concentrations in coeval calcite skins, even on a millimetre-scale, can be >100% (Hoffmann et al. 2009; Tang et al. 2020). Samples taken from the same deposit, only millimetres apart, can produce significantly different results. Second, a recent blind test of the method's reliability by submitting several split samples to two U–Th laboratories yielded entirely different results for all samples (Tang and Bednarik 2021). One of these two laboratories has provided the analyses for Zhang D. D. et al. (2021). If we know and expect that multiple samples taken of the same deposit generate such disparate analytical results, and if, in addition, we discover that different laboratories can report vastly different findings from the same samples, using even entirely different reporting protocols, such outcomes are dubious.

However, there is still one more impediment to accepting U–Th 'dates' from non-crystalline reprecipitated carbonates. Science demands the testability of falsifiable propositions, yet those concerning the age of samples sacrificed during their analysis are not testable; the procedure cannot be repeated. Another sample can be secured adjacent to the first, but as noted, it may provide a very different outcome. An example of a rock art dating method offering full testability that has been extensively applied in China is microerosion analysis (e.g. Tang et al. 2017, 2018, 2020; Jin and Chao 2019, 2020, 2021). The micro-wanes measured can be re-located by any analyst, even centuries from now, and can be re-measured. Conversely, the dating of rock art by physical intervention, especially by methods of debatable reliability, needs to be discouraged (Tang et al. 2020; Tang and Bednarik 2021).

Because of these many concerns about the credibility of the U–Th method when applied to porous carbonates, an intensive debate about it has developed since 2012 (Bednarik 2012, 2017; Clottes 2012; Pons-Branchu et al. 2014; Sauvet et al. 2015; Aubert et al. 2018; Pons-Branchu et al. 2020; White et al. in press) — although the problem has been known for about forty years (Bednarik 1984). The sensational data reported by Zhang D. D. et al. need to be considered in the context of that debate. A proposition of Middle Pleistocene rock art in Tibet is extraordinary, and it requires correspondingly extraordinary evidence. However, the results of a controversial application of U–Th analysis of porous reprecipitated calcium carbonate is the only support it has. As the authors correctly note, the hand and footprints at Qiusang were made by 'modern' humans, yet they contradict themselves by proposing that the tracks derive from Denisovans. Whilst the detailed physiology of these robust humans is not yet available, they were likely to have had thicker fingers, and their feet would have also differed from those of gracile hominins. Their footprints would likely have resembled those of *Homo sapiens neanderthalensis*, so the reported specimens could not be of the Middle Pleistocene in any case.

The age of the travertine at Qiusang could easily be checked by ^{14}C analysis, but like their colleagues working in Spanish caves (Pike et al. 2017) committed solely to U–Th, Zhang D. D. et al. (2021) might reject that option. It is correct that the accuracy of radiocarbon essays can also be challenged for several reasons (Bednarik 2001), but the argument that when the results of the two methods differ significantly, the ^{14}C dates must be wrong is logically flawed. The chronology of the Upper Palaeolithic is primarily based on that method and is not likely to be entirely false. Moreover, the authors who presented the Spanish U–Th 'dates' aspire to demonstrate that their data prove Neanderthals made the cave paintings. However, if we discount the radiocarbon dates for these robust humans post-MIS 5 because they are 'wrong', we lose all justification to attribute the paintings to them.

The sensational claims that the oldest known rock art in the world has been discovered in central Tibet — a region that is not even known to have been occupied by humans at the time proposed — is based on nothing other than a controversial dating method (specifically the application of U–Th analysis to porous carbonates) that many dozens of authors have rejected over the past decade. We suggest that ^{14}C age estimates from the same travertine would help resolve the issue. Despite issues such as potential dead carbon contamination, recent ^{14}C inheritance or non-atmospheric components of dissolved inorganic carbon, it offers a significantly better-proven approach to estimating the age of porous reprecipitated carbonates. Another possibility would be to try determining the detrital contamination, possibly using isochron methods. We especially suggest the need for core-sampling the Qiusang travertine to determine its variability of apparent age relative to weathering zones, which would clarify the degree of uranium leaching. Conversely, we should point out that the term 'parietal art' in the title of the target paper is misleading: this word denotes cave art ('parietal' refers to a cavity wall, as in anatomy), whereas Qiusang is an open-air site.

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