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AOJ of Histoarchaeology & Anthropological Exploration

Volume 2 Issue 1 - 2026

Short Communication

Uranium-thorium dating: the race towards the earliest rock art

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Received: March 13, 2026 | **Published:** March 20, 2026

Citation: Sauvet G. Uranium-thorium dating: the race towards the earliest rock art. *AOJ Hist Archaeol Anthropol Explor.* 2026;2(1):13–15.

Abstract

In recent years, Uranium-thorium dating of the calcite crusts covering prehistoric cave drawings has yielded increasingly older dates. However, this method suffers from a bias that tends to overestimate the age of the samples and is difficult to detect, so many researchers are inclined to accept these very old dates without questioning their validity. It is imperative to exercise the utmost caution by conducting a physicochemical analysis of the samples and performing cross-dating using the carbon-14 method (or another method) on the same samples.

The paleolithic rock art lasted almost 30,000 years[1] and the chronology of the tremendous number of art works is very difficult to assert. This gives rise to many interpretations. The most reliable dating method is radiocarbon (14C) but only paintings made with charcoal are concerned.[2] Uranium-Thorium (or U-series) has been known for a long time to date corals and speleothems[3] and the method has been extended more recently to the dating of thin layers of calcite covering rock art, though the results are questionable.[4] In recent years, prehistorians seem to have been engaged in a quest to find the oldest date.[5] This was induced by an award of 35,000 euros by the National Geographic Society for the project "*U-series dating of Palaeolithic cave paintings in Europe - in search of Europe's oldest art*".

In 2012, Pike *et al*.[6] announced in grand style that a red disc from the El Castillo cave (Cantabria, Spain) had just been dated to 40.8 ka. This date was 4,000 years older than that of the Chauvet Cave (Ardèche, France), and the authors suggested that "*it cannot be ruled out that the earliest paintings were symbolic expressions of the Neanderthals*." In 2018, Hoffmann *et al*.[7] smashed this record by publishing dates found in three Spanish caves that were around 65 ka (64.8 ka at La Pasiega (Cantabria); 66.7 ka at Maltravieso (Cáceres) for a hand stencil; 65.5 ka at Ardales (Málaga). The authors authoritatively stated that "*This cave art is the earliest dated so far and predates, by at least 20 ka, the arrival of modern humans in Europe, which implies Neandertal authorship*."

But Europe would not hold onto its record for long, because in 2026, Oktaviana *et al*.[8] published an age of 71.6±3.8 ka for a negative hand on the island of Sulawesi in Indonesia (a minimum age of 67.8 ka). Very quickly, the news spread across the websites and social networks. "*The oldest figurative painting known to date worldwide*" read the highly reputable website of the National Museum of Natural History in Paris.[9]

Unfortunately, most of these dates are likely to be artificially aged due to a methodological bias.[10] The method is based on the radioactive decay of uranium into thorium. When a layer of calcite is deposited on prehistoric paint, it incorporates a small amount of uranium that is soluble in water. Uranium-234 then decays into thorium-230, and the ratio of 230Th/234U can be used to calculate the age of the deposit, provided that the calcite behaves as a closed system (i.e., without exchange with the external environment). This is the crux of the matter, as numerous examples show that the system is sometimes "open," meaning that water percolating through the calcite causes some of the uranium to leach out, to the point that the 230Th/234U ratio can become greater than 1,[11] which is strictly impossible in the case of a closed system (the 230Th/234U ratio tending towards 1 after an infinite period of time called secular equilibrium). Even Dirk Hoffmann, the proponent of the Neanderthal age of Spanish cave paintings, was confronted with a stalagmitic floor that, for a short period of time, showed a loss of uranium incompatible with secular equilibrium.[12]

In the Indonesian islands (Borneo, Sulawesi, Timor), Maxime Aubert's team, using the uranium series method,found increasingly older ages over the years. [24 ka in Timor,[13] 32 ka in Sulawesi, then 43.9 ka,[14] then 51.2 ka[15] and finally 67.8 ka],[8] each of these articles punctuated with superlatives intended to pique the reader's curiosity ("*the earliest known surviving example of representational art*," "*The earliest known representational work of art in the world,*" "*This hunting scene is currently the earliest figurative artwork in the world,*" "*The newly discovered Liang Metanduno hand stencils are the oldest archaeological evidence*").

To demonstrate that their results are valid, the authors dated separately thin layers of calcite accumulated over time to show that they coincide with their stratigraphy. For example, in Timor, three successive layers 0.1 mm thick yield ages of 6.3 ka, 24 ka, and 29.3 ka, which is consistent with the deposition of these layers in a closed system.[13] However, this is not always the case. Sometimes anomalies occur. For example, at Leang Balangajia, the surface layer is apparently older by 7.8 ka than the layer in contact with the pigment. The authors acknowledge that, in this case, there has probably been partial leaching of uranium from the surface.[14] One wonders why the same hypothesis is not considered in all cases.

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At another site, LeangTedongnge, four slices taken from the thickness of the calcite give almost identical ages of around 45 ka.[14] This would mean that the entire layer formed in less than a thousand years and that no further deposits occurred during the next 45,000 years. It seems more likely that the leaching of uranium affected the entire thickness of the calcite over time, which calls into question the age of the underlying paint.

In the case of the hand stencil at Liang Metanduno, three layers of the calcite crust have also been dated, ranging from 35.8 ka for the outermost layer to 62.7 and 67.8 ka for the lower layers (Figure 1). To date, this is the only evidence available to support the claim that it is "the oldest hand stencil in the world." It is virtually impossible to know why calcite sometimes behaves like a closed system and sometimes like an open system. The only answer to this question is to date the same sample using two different methods, for instance using both U/Th and 14C. Unfortunately, measuring 14C in a calcite sample is not very accurate, as it is necessary to take into account a proportion of carbon of geological origin called "dead carbon," which can vary between 5 and 20%. However, the results obtained by this cross-dating method have proven useful in the case of a negative handprint from Borneo covered by a calcite drapery.[16] For the inner layer close to the pigment, the agreement between the two methods is very satisfactory, but for the outer edge, U/Th gives a much older age than 14C (27,320 years versus 9,900-8,770 years), evidence of an open system.

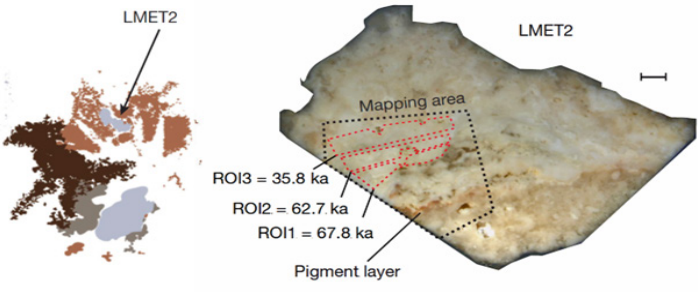

Figure 1 Negative hand of Liang Metanduno (Sulawesi). Location of the three samples dated by U/Th. According to Oktaviana et al. 2026.[8]

More recently, the same method was used in the Nerja Cave (Málaga, Spain). A charcoal mark was directly dated to 19,162±532 cal BP;[17] it was overlaid with a layer of calcite dated by 14C to between 14,621-13,217 cal BP (depending on the "dead carbon" content of between 0 and 10%). Although not very accurate, this measurement is completely at odds with the age given by U/Th, which is 118,880±1,930 years.[18] In this case, there is no doubt that the calcite behaved as an open system allowing the leaching of a significant part of the uranium. One can imagine the media success the authors would have achieved if they had published a paper in *Nature* entitled: "*Neanderthals were painting in Nerja 119,000 years ago.*" Moreover, Pons-Branchu *et al*.[19] showed that the samples that gave the highest ages were systematically those with the lowest uranium content. This is particularly the case for the dates of around 65,000 years found in the Spanish caves of La Pasiega, Maltravieso, and Ardales, which casts doubt on their accuracy.

Calcium carbonate exists in two polymorphic forms, aragonite and calcite. However, aragonite has a much higher uranium content than calcite.[20] When aragonite transforms into calcite through diagenesis, a large part of the uranium is released, promoting its leaching, which explains why calcite always appears much older than aragonite.[21] The coexistence of both phases in the stalagmites sampled for U/Th dating at La Pasiega explains the abnormally high values found in this cave.[22] The partial presence of aragonite at Ardales is probably responsible for the same effects.[23]

All of these results should prompt the utmost caution. The rule should be to reject results obtained by U/Th until a complete physicochemical study using Raman spectroscopy has been conducted and until consistency with another method (14C) has been demonstrated. Of course, 14C is limited to ages younger than 45,000 years. However, if 14C measurements were made on the calcite samples used in Indonesia and Spain and if the results indicate ages higher than 45,000 years, then the data found by U/Th could be acceptable. This sound professional ethics would prevent prehistorians from being seduced by the uncontrolled claims of physicists who are reluctant to apply methodological doubt to their own research and get carried away by the thrill of publishing in *Nature* the "oldest date in the world". This race for media records seems to have become the main objective of certain research teams, to the detriment of a reasoned contribution to archaeological knowledge. In the dehumanized world we live in today, besieged as we are by fake news, let us at least try to ensure that Prehistory remains, in the literal sense, a "human science."

Acknowledgments

None.

Conflicts of interest

Author declares that there is no conflict of interest.

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