

# The olive tree-ring problematic dating

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We are glad to see that our paper has stimulated a lively debate, and we acknowledge the appreciation of our work by Bietak, Kuniholm and MacGillivray as well as that of those who oppose our hypothesis (Bruins & van der Plicht, Friedrich *et al.*, all above). The enigma of the dating of the Santorini eruption is a long-lasting one, and because of its bearing on the dating of several eastern Mediterranean civilisations, has attracted significant attention. The potentially great importance of the Santorini olive branch used by Friedrich *et al.* (2006) was that it came from the site itself, and possibly belonged to the destruction layer. As such, the sincere and serious attempt to date it made by Friedrich *et al.* (2006) should be appreciated. Unfortunately, large olive branches may exist as dead limbs for a very long time and thus represent earlier periods.

We are dendrochronologists and tree biologists and we therefore focus our response on the tree-rings. Moreover, if the Santorini olive tree-ring data is not reliable there is therefore no *in situ* dating. All other indirect archaeological data emerging from sites outside Santorini, such as Crete and Egypt, and used for indirect dating of the Santorini eruption have their own inherited dating problems, as discussed by many others. We posit again that we consider the date of the Thera eruption based on the putative tree-ring sequence of a single olive tree (Friedrich *et al.* 2006) with great caution. As stated by Kuniholm (above), “[f]or successful radiocarbon wiggle-matching, if the radiocarbon laboratory is not given the precise ring-count between sampled sub-sections of the piece, any reported wiggle-match is immediately suspect. An approximation of the count just will not do. One or two or three or more missed (or missing) rings will skew the results by years or even decades”, and so also will false or double rings, often found in Mediterranean trees (Cherubini *et al.* 2003, 2013).

The critical remarks by Bruins and van der Plicht and Friedrich *et al.* (above) indicate that publishing our original olive tree-ring findings (Cherubini *et al.* 2013) is of utmost importance. The fact that an evergreen Mediterranean tree species may form annual rings in one climatic area but not in another (e.g. Cherubini *et al.* 2003) is not always understood, and may cause confusion. Bruins and van der Plicht (above) didn't consider the flexible and very variable biology of cambial activity (and the resulting wood anatomy) in Mediterranean evergreens (e.g. Liphshitz & Lev-Yadun 1986) and therefore cited papers that the first author of Cherubini *et al.* (above) published as a co-author (Rossi *et al.* 2013) or evaluated as the editor of the journal *Dendrochronologia* (Arnan *et al.* 2012) as contra evidence. However, the olive trees studied by Rossi *et al.* (2013) grew in a region with very low winter temperatures for cambial activity (2–3°C), a temperature known to arrest cambial activity in Mediterranean evergreens (Liphshitz & Lev-Yadun 1986 and citations therein).

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In Santorini, the low winter temperatures are around 10°C, a much milder climate that allows for more flushes of growth and results in less pronounced seasonality (more false growth-rings). The study by Terral and Durand (2006) cited by Bruins and van der Plicht (above) does not prove anything concerning the possibility to determine whether olive growth-rings are indeed annual, but rather assumed that it is indeed so. As for Arnán *et al.* (2012: 11), they describe the problematic nature of olive tree-rings: “[t]ree-rings did not cross-date well, neither within nor between individuals”, and only estimated the ages, a result that does not require safe identification of each and every growth-ring as needed for wiggle-match dating, the critical process in Friedrich *et al.* (2006).

The dendrochronological analysis of olive trees growing on Santorini (Cherubini *et al.* 2013) showed that the determination of their tree-ring number is impossible. Accordingly, caution should be taken with the dating by Friedrich *et al.* (2006) and their proposal cannot be used to discount a date range for the eruption of 1525–1490 BC as proposed by numerous other radiocarbon studies.

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