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Opinion

The Apparent Age of *Lithophaga*

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Opinion

Stable isotopes may in due course allow *Lithophaga* age/height data to be corrected for apparent age and thus used legitimately in tectonic research. The study of Quaternary sea-level change promised to benefit greatly from AMS 14C dating of *Lithophaga* and other boring molluscs as, unlike shells in beach deposits, they appeared to be unambiguously in situ and, as they live below tide level, they offered to provide a minimum value for the elevation of the contemporaneous waterline. They were soon deployed in the analysis of coastal uplift in the Corinth area of Greece [1,2].

Some of the gilt soon rubbed off. *Lithophaga* can live at depths of up to 20 m, although most of them are found in the 2 m below low tide [3], and burrows can be reoccupied, so that the 14C age need not refer to the time when the boring was executed. But the validity of the ages, after the usual pretreatment, isotopic correction, and adjustment for the local reservoir age (ΔR), seemed not to be in doubt. In any case no one would have wished to waste an expensive AMS determination on proving the nil age of a modern mollusc, especially as mollusc specialists had declared that *Lithophaga* did not ingest any carbonate material in the course of its burrowing activities. Using museum specimens from the Mediterranean and the Red Sea, Shaw et al. [4] have since shown that the radiocarbon age of modern *Lithophaga sp.* may exceed zero by as much as 2000 yr, an effect they ascribe to the incorporation of dead carbon from the rock into which the molluscs excavated their burrows. In their view the ages are of little value in assessing coastal uplift because the extent to which they have been distorted is impossible to determine and the *Lithophaga* burrows that are used to mark the former position of sea level may have been occupied more than once or tenanted for long periods. They prefer to derive average uplift rates for coastal Greece from the present elevation of the shoreline marking the Holocene sea-level maximum of ~6000 yr BP.

One could argue that ^{14}C calibration websites (e.g. http://www.calib.org/) regularly update information on the local reservoir age, including values in excess of 1000 yr, and that in any case the study of uplift rates could continue unfazed as the corresponding plot, though displaced, would remain parallel to the original one. The problem with the *Lithophaga* studies under review was that sample elevations also had to be corrected for sea-level changes during the period in question and thus 'absolute' ages for the various samples were essential. This note outlines an attempt to salvage some of the tectonic information derived from compromised *Lithophaga* sequences in the Gulf of Corinth and Sicily by evaluating the dead carbon effect for different samples with the help of δ^{13}C measurements.

δ^{13}C is generally used to normalise ^{14}C ages to counter isotopic fractionation, but it also serves to identify contamination of mollusc material by dead carbon [5]. The contaminant carbon can occur as carbonate overgrowths but may also be incorporated in the shell structure from what Walker [6] called 'solutional carbonate', the source identified by Shaw et al. [4]. The former may be missed when sampling for XRD (which in any case is of limited value here as mytilids are of mixed mineralogy); the latter cannot be detected by visual inspection. δ^{13}C analysis, however, can be run on an aliquot of the gas or powder representative of the entire sample. Assuming that this has been done for the present samples and that they were not contaminated in some other way the problem remains of calibrating the δ^{13}C signal. The attempt is made in the knowledge that the δ^{13}C of individual marine mollusc species collected live can have a wide scatter even at a single site, and that the three modern specimens from the Mediterranean used by Shaw et al. [4] come from locations which may well have had different reservoir values at the time of collection. The issue of age normalisation is provisionally shelved.

A plot of δ^{13}C vs apparent age (r = 0.94) for the three modern specimens from the Mediterranean is consistent with a positive rate of 2.4 ‰ /1000 yr. In view of the tectonic history inferred by Shaw et al. [4] one would not expect any correlation between sample age and height on Crete except possibly for a *Lithophaga* specimen at 9 m, and here the proposed correction gives a calibrated (CalPal) date of AD 490 which, allowing for a reservoir age somewhere in the Mediterranean range of 280-665 yr [7], is in agreement with the date of the documented earthquake that prompted the study by Shaw et al. [4], viz AD 365. When applied to the *Lithophaga* data for the Eliki fault zone in the Gulf of Corinth [8], after Holocene sea-level correction [9], we obtain at least 14 m of net uplift in the last 8000 yr (r = 0.95) which appears to have resulted from at least three discrete events.

These results, though hardly conclusive in view of the small sample size and all the other caveats, suggests that stable isotopes may in due course allow *Lithophaga* age/height data to be used legitimately in tectonic research. But more museum specimens and expensive AMS dates will first have to be sacrificed.

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