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Current achievements and challenges of a multiple dating approach (14C, 230Th/U and 36Cl) to infer tsunami transport age(s) of reef-top boulders on Bonaire (Leeward Antilles)

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The deposition of supratidal coarse-clast deposits is difficult to date, limiting their value for inferring frequency-magnitude patterns of high-energy wave events. On Bonaire (Leeward Antilles, Caribbean), these deposits form prominent landforms, and transport by one or several Holocene tsunamis is assumed at least for the largest clasts. Although a large dataset of 14C and electron spin resonance (ESR) ages is available for major coral rubble ridges and ramparts, it is still debated whether these data reflect the timing of major events, and how these datasets are biased by the reworking of coral fragments. As an attempt to overcome the current challenges for dating the dislocation of singular boulders, three distinct dating methods are implemented and compared: (i) 14C dating of boring bivalves attached to the boulders; (ii) 230Th/U dating of post-depositional, secondary calcite flowstone and subaerial microbialites at the underside of the boulders; and (iii) surface exposure dating of overturned boulders via 36Cl concentration measurements in corals. Approaches (ii) and (iii) have never been applied to coastal boulder deposits so far. The three 14C age estimates are older than 37 ka, i.e. most probably beyond the applicability of the method, which is attributed to post-depositional diagenetic processes, shedding doubt on the usefulness of this method in the local context. The remarkably convergent 230Th/U ages, all pointing to the Late Holocene period (1.0–1.6 ka), are minimum ages for the transport event(s). The microbialite sample yields an age of 1.23±0.23 ka and both flowstone samples are in stratigraphic order: the older (onset of carbonate precipitation) and younger flowstone layers yield ages of 1.59±0.03 and 1.23±0.03 ka, respectively. Four coral samples collected from the topside of overturned boulders yielded similar 36Cl concentration measurements. However, the computed ages are affected by large uncertainties, mostly due to the high natural chlorine concentration resulting in low AMS ratios. After correction for the inherited component and chemical denudation since platform emergence (inducing additional uncertainty), the calculated 36Cl ages cluster between 2.5±1.3 and 3.0±1.3 ka for three of four boulders whilst the fourth one yields an age of 6.1±1.8 ka, probably related to a higher inheritance. These 230Th/U and 36Cl age estimates are coherent with a suggested tsunami age of <3.3 ka obtained from the investigation of allochthonous shell horizons in sediment cores of northwestern Bonaire. While 230Th/U dating of post-depositional calcite flowstone appears to be the most robust and/or accurate approach, these results illustrate the potential and current limitations of the applied methods for dating the dislocation of supralittoral boulders in carbonate-reef settings.