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Stratigraphy, fluids and ecology: the genesis of bio-concretionned rocky outcrops (Tegnùe) of the northern Adriatic shelf

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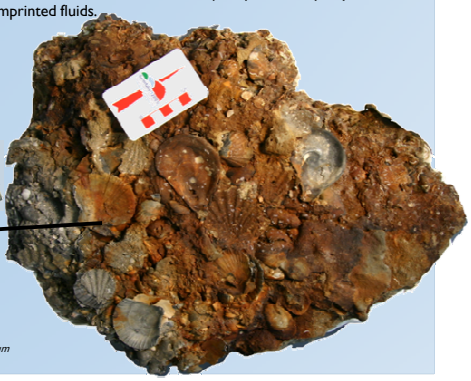
In the north-western Adriatic Sea the siliciclastic inner shelf is interrupted by localized rocky outcrops up to 2-3 m high. Such 'rocks', grouped under the dialectal name of *tegnùe*, are known by fishermen for their fishing value but also as a threat to trawling. Their ecology is a subtype of coralligenous habitat.

A project undertaken in 2013 by the municipality of Chioggia has been addressed to study a marine area, where these outcrops are particularly prolific, by means of high-resolution seismic stratigraphy, oceanographic measurements and bottom sampling.

These outcrops are rich in marine fauna and coralline algae. Their nature, however, could not be understood by ecology alone since such epifaunal and algal component is mainly a later exploitation rather than a genetic cause of this peculiar habitat.

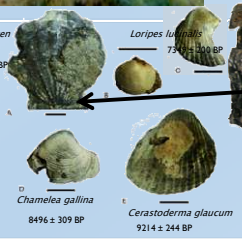
A running hypothesis for years was that these rocks represented Holocene beachrock deposits formed at a very early stage of the post-glacial transgression. However, a better understanding of the processes has been always hampered by the difficulty in getting samples of diagnostic value.

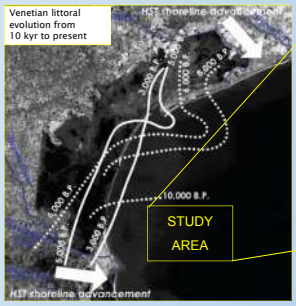
More recently, convincing arguments have been put forth supporting that part at least of the northern Adriatic *tegnùe* are linked to calcium carbonate precipitation by hydrocarbon-imprinted fluids.

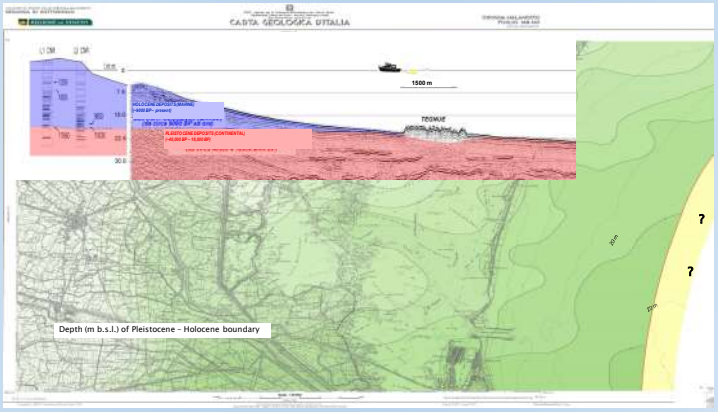


A metric stratoid collected at 23 m water depth proved to be an excellent archive registering the various steps that led a shelly sand sediment to turn into a rock first and then a coralligenous habitat at present. The sample embeds a variety of disarticulated and oriented shell remains, mainly bivalves, sourced by lagoonal to shallow marine environments.

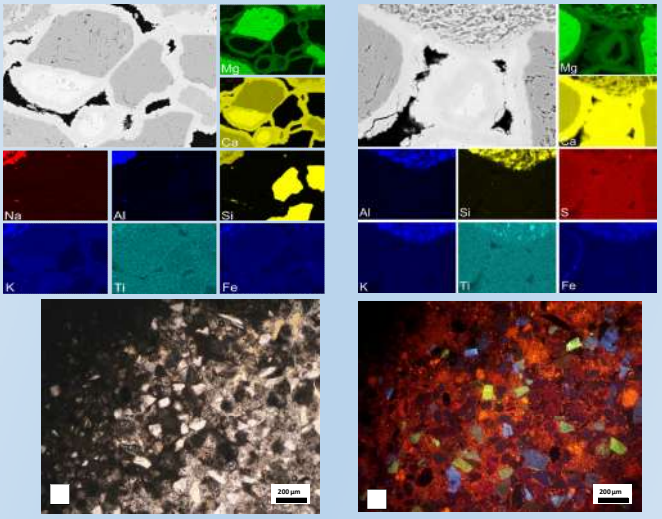
AMS ^{14}C dating of some bioclasts reveals that they have an age comprised between ca. 7.3 and 9.2 kyr cal BP.



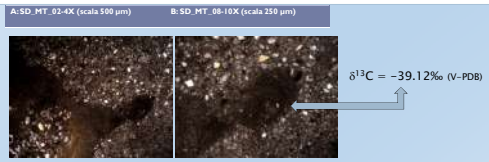




Such ages are consistent with the proposed time when the post-glacial sea level rise reached this depth. The shelly sand is therefore interpreted as a condensed section above the ravinement surface.



SEM-EDS, cathodoluminescence and geochemical mapping document that this highly porous sandy deposit got cemented by only one generation of calcium carbonate identified as scalenohedral calcite coating individual clasts. As suggested by the chronology of the fossiliferous calcarenite, this process took place under marine conditions but the typology of the cement suggests the interaction between saline and brackish fluids, likely related to onshore freshwater discharge at sea by a sealed water-table.



Our research thus documents a new modality for the formation of at least one typology of these Adriatic outcrops. Calcarenites thus formed may keep buried or get exhumed by oceanographic causes. In this latter case, they can become site of faunal and algal colonization. Although our study does not identify hydrocarbon-seepage as one of the main drivers for the genesis of *tegnùe* here, nevertheless our lastroid contains small pebbles of a dark mudstone whose bulk $\delta^{13}C$ depleted composition is a signature of hydrocarbon seepage. We suggest that hydrocarbon-seepage was conducive to lithification of fine grained estuarine sediments quickly eroded by the transgression and embedded together with the shells in the chaotic condensed deposit which is core to the *tegnùe*.

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