A glacial isostatic adjustment origin for double MIS 5.5 and Holocene marine notches in the coastline of Italy

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Abstract

Modern tidal notches on rocky coastlines are well developed in the Mediterranean Sea because of its microtidal regime, and occur around much of the coast of Italy. Uplifted fossil notch couplets (here called “double notches”) are well developed in some sites. The two notches within a couplet have an average vertical separation of 2–4 m, and are systematically observed at an elevation of a few metres above present sea level on tectonically stable coastal sites of western Italy. The upper notch has a morphology similar to that of the notch developed at present-day mean sea level in the modern tidal regime. However, the lower notch has a smoother morphology and larger vertical dimension than the upper one, and is pervasively bored by \textit{Lithophaga} activity. Although the upper notch is attributed to the MIS 5.5 stage (last interglacial, \(\sim 125\) ka), the origin of the lower one has so far remained enigmatic. Based on a quantitative assessment of the glacial isostatic adjustment (GIA) expected at each single site from updated models, we argue that both notches within a couplet were formed during a single highstand of the MIS 5.5 substage, and the superposed morphology resulted from isostatic motion and tidal erosion. The lower notch of the couplet is argued to be formed during the earlier part of the highstand and its smooth vertically extended morphology is attributed to glacio-hydro-isostatic vertical movements (= crustal subsidence) that extended tidal erosion over a large vertical distance as the crust slowly subsided. In contrast, the upper notch of the couplet is considered to develop in the later part of the highstand due to tidal action at times when eustatic and isostatic movements almost ceased. The ridge between the two notches in a couplet was the site of organic encrustation, protecting the rock there, but subsequently removed by subaerial erosion when the notch couplet was uplifted. Observations of double notches formed on the present coastline show that a similar process has been active also during the late Holocene transgression.

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1. Introduction

This paper describes and interprets the peculiar morphology of fossil notches that almost adjoin each other at few metres elevation above the present sea level along the coastlines of central-western Italy. Whereas the upper notch is well sculpted and is unambiguously recognized as having been carved during the last interglacial highstand (MIS 5.5), the lower notch is smoothed and placed closely beneath the MIS 5.5 notch. Although the lower notch does not apparently resemble a tidal notch, we surmise that the composite morphology is formed by notch couplets, but the origin of the lower notch in a couplet remains enigmatic. Our research is based on observations and new measurements of the notch couplets carved in limestone promontories in 5 different coasts of the Tyrrhenian Sea (Fig. 1). Here we introduce “double notch” as a new term into notch terminology, and use it throughout this paper to indicate this composite coastal morphology.

The double notch has been commonly interpreted as composed by two chronologically distinct forms which were attributed, from the highest to the lowest, to MIS 5.5 and MIS 5.3 (Dai Pra and Ozer, 1985; Iannace et al.,...
A recently published isostatic model (Lambeck et al., 2004a), documents that relative sea-level changes along the Italian coast and adjacent seas—the combined result of eustasy, glacial-hydro-isostasy and vertical tectonic motion—exhibit considerable spatial and temporal variability throughout the Holocene. In addition, the Late Holocene notch shows a morphology similar to the MIS 5.5 double notch at the observed sites, suggesting that the history of Holocene sea-level changes may be applied to the last interglacial highstand. As the sampled sites lie in stable areas with respect to faulting and folding, we argue that differential motion and development of the double notch morphology is related to isostatic adjustments during the last interglacial and modern highstand.

2. Hypothesis

Tidal notches (Pirazzoli, 1986) form principally in limestone, and develop around mean sea level in microtidal regimes such as the Mediterranean or Barbados. They have also been called marine notches, but “tidal” is more appropriate to their mode of formation (range of tide), because notches may also be created by mechanical erosion below tide level on high-energy coasts, (Fig. 2). Surf processes form vertically broad notches which are difficult to relate to mean sea level, and form a continuum with tidal notches along an energy gradient (Pirazzoli, 1986; Rust and Kershaw, 2000).

A recent model of marine terrace formation (Trenhaile, 2002) interprets tidal notch formation as a result of physical (inorganic) processes. Others view biological abrasion and dissolution as principal factors, with lesser effects of physical abrasion and dissolution processes such as wetting fronts and salt weathering (Carobene, 1972; Pirazzoli, 1986; Spencer, 1988, 1992), or mixing when spring water plus marine water form an aggressive mix (Forti, 2003). Whatever the process of formation in any particular setting, tidal notches are especially well developed in many coastal zones of the Central Mediterranean Sea because of its microtidal regime: 0.3 ± 0.4 m for sea-wave and air-pressure changes except for Tunisia and the Trieste area, which have larger (1–1.20 m) tidal ranges (Istituto Idrografico della Marina, 2002). Tidal notches therefore indicate episodes of sea-level relative stillstand. At many Italian tectonically active coasts, where evidence exists of large current uplift (eastern Sicily) and subsidence (Trieste, north Adriatic sea), the present-day marine notch is lacking because the tectonic rates are faster than the rate of carving (Antonioli et al., 2004a; Kershaw and Antonioli, 2004). Due to its representation of the sea level in microtidal regimes, tidal notches have been efficiently used to measure palaeo-sea level changes in the Mediterranean Sea (Kershaw and Antonioli, 2004; Kershaw and Guo, 2001; Pirazzoli, 1986).

As described in a later section, we observed in several sites the occurrence of a smoothed form interpretable as an enlarged marine notch lying between the MIS 5.5 and Holocene tidal notches. Lambeck et al. (2004a) demonstrated throughout the Mediterranean the effects of Holocene transgression and isostatic adjustment related to the Fennoscandian and Alpine ice sheets, using modelled parameters of mantle isostasy. In the case of the western Mediterranean Sea there has been isostatic subsidence and relative sea-level rise. Within the Mediterranean Sea, the Holocene eustatic sea-level rise accompanied coastal subsidence as a result of mantle
viscoelastic deformation particularly during the decreasing rate of sea level rise at 6–7 ka. Substantially different amounts of subsidence are predicted at different coastal sites during any time slice. For instance, 4–6 m different elevation of the relative sea-level is predicted at 7 ka between the Adriatic and Tyrrenhian Sea in eastern and western part of the Central Mediterranean Sea, respectively (Lambeck and Chappell, 2001).

Lambeck et al. (2004b) have subsequently proposed that glacio-hydro-isostatic adjustments occurred also during the MIS 5.5 sea-level rise. Thus the hypothesis put forth in this paper is that the double notch morphology is the product of the predicted postglacial isostatic rebound during the final stage of both the MIS 5.5 and Holocene highstand.

3. Methodology

In order to test our hypothesis, we firstly ascertained that the studied coasts were tectonically stable at least since the MIS 5.5. It is documented that during this last interglacial period the global sea level rose higher than since the MIS 5.5. It is documented that during this last interglacial period the global sea level rose higher than since the MIS 5.5 (Lambeck and Chappell, 2001; Potter and Lambeck, 2004). On the Mediterranean coasts, the average level attained by the sea during the MIS 5.5 is inferred to be 3 m, which is the marker shoreline elevation in southern Sardinia (Ferranti et al., this volume; Lambeck et al., 2004a). This shoreline is situated at a coast which is considered to be tectonically stable since the Early Miocene (Patacca et al., 1990), but affected by crustal loading and unloading during a glacial-interglacial cycle (Lambeck et al., 2004b).

Thus, we limited our observation to the coasts of the Tyrrenhian Sea (western Italy) where the MIS 5.5 tidal notch is found close to the expected eustatic elevation (Fig. 1). Age attribution and altitude of the notches in the studied sites have been discussed in several papers (Orosei Gulf: Antonioli and Ferranti, 1992; Antonioli et al., 1999; Carobene, 1972; Capo Caccia: Antonioli et al., 1996, 1998a, b; Capri Island: Antonioli and Ferranti, 1997; Gaeta: Antonioli et al., 1999, 2002; Capo San Vito; Antonioli, 1991) and a comprehensive review is given in Ferranti et al. (this volume). The tidal notches were attributed to the MIS 5.5 using: (i) the occurrence at the same altitude of fossils boreholes, whereas the fossil tidal notch is not or is only marginally bored. Measurements were performed of the modern tidal notch and were compared to the known tide excursion. Underwater investigations were performed with the aid of scuba dive equipment. Submerged notches that have a form similar to the smooth fossil notch have been recognised at Gaeta (Fig. 6) and Orosei (Fig. 7) and...
Capri sites, but not at St. Vito lo Capo and Capo Caccia. These submerged notches were measured and referenced to the top of the modern algal rim (Fig. 6).

We are aware that, although emerged notches have forms that can be easily measured, submerged notches cannot be surveyed with equal accuracy.

4. Results

4.1. Capri

The MIS 5.5 tidal notch is mapped at Capri Island (Fig. 1) at an elevation which varies from 5.4 to 8.1 over a 30 km long coastline (Figs. 5B and C). This notch was dated through correlation with a similar-elevation beach deposit containing Cladocora on the nearby Sorrento Peninsula, which provided a MIS 5.5 U/Th age (Brancaccio et al., 1978).

The smoothed fossil notch was observed in several locations, and has a better developed concavity on the southeastern side of the island (Figs. 5B and C). The modern notch appears well developed (width: 45–70 cm), and very smoothed notches submerged beneath the present one have been measured on the southeastern side of the island (width 1.9 m).

4.2. St Vito

At the St Vito lo Capo promontory (northwest Sicily, Fig. 1), the MIS 5.5 tidal notch is found at elevation of 8–11 m on a 30 km stretch of coast. In contrast to Capri, this site has morphological limitations due to the lack of a steep seaciff, so no double notch is apparent. However, we found a well-developed double notch inside a cave (Fig. 5D). The notch was attributed to MIS 9 by Antonioli et al. (2002). The modern notch is very well developed (width: 50–75 cm) but the submerged notch was not observed, perhaps due to the same morphological limitation outlined above.
4.3. Gaeta

The Gaeta promontory displays a 150 m high limestone cliff. The altitude of the MIS 5.5 notch varies between 4.9 and 4.8 m on a 3 km coastline stretch. The fact that the limestone is stratified does not allow the best preservation of fossil notch forms. MIS 5.5 fossil double notches are observed only in sheltered bays or in caves. On the contrary, the modern notch (width: 45–70 cm) and the smoothed notch (width 3.4 m, Table 1) below sea level are clearly visible throughout the whole promontory (Fig. 6), also in exposed areas.

4.4. Capo Caccia

Capo Caccia (Fig. 5A) located on the Balearic Sea side of Sardinia, shows a 40–60 m high wall directly along the coast, which is characterized by exposure to...
prevailing winds. Due to the high-energy environment, the MIS 5.5 double notch was preserved mainly in sheltered bays, where the tidal notch is found at elevations ranging between 3.75 and 5.45 m on a 4 km long coast. Modern notches are well developed (width: 50–75 cm). The submerged notch has been observed in several dives, but detailed measurements were hampered due to the thick algal overgrowth.

4.5. Orosei

The site that shows the best-preserved MIS 5.5 tidal notch is the Orosei Gulf (Fig. 1), on a high cliff, with a lateral continuity of 60 km (Fig. 5E). At this location, the notch elevation ranges between 7.8 and 10.5 m above the sea level over a 55 km long stretch of coast. 

Antonioli and Ferranti (1992) hypothesised that this notch was so well preserved because of its burial underneath a thick continental talus cover during younger glacial stages (dated MIS 4–2), today largely eroded but partially visible below sea level. Marine notches at the Orosei Gulf are of particular importance for comparison of the measurements and description of the different parameters (altitude, width and depth). The vertical dimensions (h of Fig. 3) of the fossil tidal notch show values ranging in all sites between 62 and 120 cm, and depth of concavity (p of Fig. 3) between 48 and 215 cm. In general, the altitude of the notch is higher in sites where the tide reaches higher elevations.

The form of the fossil as well as of the Modern tidal notch is well developed (the Modern notch has width of 55–80 cm, depth of concavity up to 2 m, see Fig. 3). We think that the reason lies in the presence of an efficient karst system close to the shoreline, which produced a powerful and sustained spring water flow (often of the order of 1–10 m$^3$/s). The continual presence of continental water (that floats on the marine water) has arguably increased the chemical dissolution processes at tide level. The submerged smoothed notch is clearly visible throughout the whole promontory (Fig. 7), also on exposed, high-energy locations.
5. Discussion

The fossil tidal notches were found at variable altitudes (between 3.8 and 10.8 m, Table 1) in different sites along the Tyrrhenian Sea coastline (Fig. 1). Nonetheless these elevations are very close to the uncertainty range for the eustatic elevation of the MIS 5.5 highstand. Thus we conclude that the studied sites are tectonically almost stable.

In each studied site, the lower and smoothed fossil notch has a width that shows a spatial variation (depending on latitude) between 3.8 up to 6.4 m, and a depth of the concavity (Figs. 4 and 8) that varies (1.5–4 m) also at the same site, depending on the local exposure conditions. Table 1 shows the complete parameters measured in all sites.

Pirazzoli (1986) and Woodroffe (2003) described coastal morphologies similar to those illustrated here. Woodroffe (2003, p. 243) described some smoothed submerged notches at Curacao (Fig. 9), which were interpreted by Focke (1978), as built by high-energy waves on a very exposed coast. Thus, the smoothed fossil notch might be interpreted as due to the wave action on a very exposed cliff. Alternatively, it is possible that corrosion processes below sea level shaped the smoothed notch. In a further scenario, the smoothed notch might be related to a sea-level highstand during stages or substages younger than MIS 5.5 (Carobene and Pasini, 1982; Dai Pra and Ozer, 1985; Iannace et al., 2001). Obviously, the smoothed notch cannot be attributed to a highstand older than MIS 5.5, otherwise it would have been wiped away during the MIS 5.5 transgression.

These hypotheses, to different degrees, appear unlikely in light of our observations at the studied sites. Note the following points:

1. Because of the steep cliffs beneath the MIS 5.5 tidal notch, and variable depth of the sea floor at the surveyed sites, we can exclude the suggestion that the fossil smoothed notch could have been carved by

<table>
<thead>
<tr>
<th>Site</th>
<th>MIS 5.5 tidal notch altitude (m)</th>
<th>Smoothed notch width (m)</th>
<th>Predicted rsl from 7 cal ka BP to the present (m)</th>
<th>Predicted rsl from 2 cal ka BP to the present (m)</th>
<th>Submerged smoothed notch width m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gaeta</td>
<td>4.9</td>
<td>3.8</td>
<td>11.6</td>
<td>1.32</td>
<td>3.4</td>
</tr>
<tr>
<td>Capri</td>
<td>7.3</td>
<td>4.6</td>
<td>11.6</td>
<td>1.37</td>
<td>1.9</td>
</tr>
<tr>
<td>St. Vito</td>
<td>8</td>
<td>4.9</td>
<td>14.1</td>
<td>1.66</td>
<td>—</td>
</tr>
<tr>
<td>Orosei Gulf</td>
<td>8.8</td>
<td>6.4</td>
<td>15.4</td>
<td>1.85</td>
<td>3.6</td>
</tr>
<tr>
<td>Capo Caccia</td>
<td>5</td>
<td>3.4</td>
<td>12.2</td>
<td>1.47</td>
<td>—</td>
</tr>
</tbody>
</table>

Fig. 8. Morphological sketch of the 5 sites studied with the indication of the width (m) of the smoothed notch.

Fig. 9. From Woodroffe (2003), coastal morphology on tropical limestone coasts around the island of Curacao in relation to biodegradation and water turbulence, which is a function of wave energy: 1, sheltered; 2, leeward; 3, lateral (intermediate); and 4, windward.
crosion (abrasion by particles moved by waves) during the MIS 5.5 highstand. The cliff just under-neath the MIS 5.5 tidal notch is at all sites very steep and dips continuously beneath the sea level to water depths ranging from −10 to −25 m, where it is concealed by loose deposits. More significantly, the difference in elevation between the fossil tidal and smoothed notch is broadly similar at all the sites. Corrosion (by the action of water turbulence using loose sediment to erode the cliff) cannot have produced the notches, because the position of notches in the steep cliff profile is too far above the local sea floor where loose sediment could be actively moved by currents to erode the cliff.

(2) The notches are found both in exposed and sheltered coastal areas (e.g. Gaeta and Orosei sites), and therefore, their formation is unrelated to the fetch or wave processes, in contrast to the arguments of Focke (1978). Woodroffe (2003) wrote: “similar cliff morphology occurs on other Pleistocene limestone coast in the West Indies … but is not convincingly related to wave energy. In the most protected areas, recession takes place subtidally primarily as a result of marine bioerosion”.

(3) We also exclude the suggestion that the smoothed fossil notches were formed during a younger stage or substage highstand. In this hypothesis the width of the smoothed fossil notch should represent the tidal range existing during the younger highstand. However, it is documented both at a global scale (Siddall et al., 2003; Waelbroeck et al., 2002), and within the Central Mediterranean sea (Antonioli et al., 2004b), that the eustatic sea level during substages 5.3 and 5.1 rose no higher than −18 to −20 m below the present sea level. In addition, the width of the smoothed notch can reach high values (up to 4 m as at the Orosei site, Table 1), much higher than the modern, and by inference, the MIS 5.5 tidal range. This would require unrealistic variations in tidal ranges with a dramatic increase between MIS 5.5 and 5.3–5.1, and again a dramatic decrease between the latter and the current highstand.

Thus, the most plausible hypothesis is that the two notches (tidal and smoothed) were formed during the same MIS 5.5 highstand. In recent work by some authors, propositions have been put forth that two different highstands occurred during the MIS 5.5. In the central Mediterranean Sea, Kindler et al. (1997) hypothesized the occurrence of two different highstand during MIS 5.5. This inference was supported by petrographic and sedimentological analyses on fossil beaches in 4 sites that show a transgressive surface bounding two marine deposits. The chronological interpretation was based on published AAR and a few $\alpha$-U/Th ages. Jedoui et al. (2003) hypothesized two high sea levels (at 5 and 3 m) during the Last Interglacial in south-eastern Tunisia coast based on $U$-series analyses on gastropod shells. Chronological support for the two-highstand model is weak. Kindler et al. (1997) do not report any ages with an error bar to support the two highstands. The $U$/Th analyses on gastropods reported by Jedoui et al. (2003) have a wide scatter between 39 and 180 ka, and an age on Strombus bubonius was 50 ka, in marked contrast with the enormous evidence of a MIS 5.5 age for the Strombus (see the review in Ferranti et al., this volume). Our opinion is that the double MIS 5.5 highstand model remains controversial, and updated $\delta^{18}$O data from deep sea cores (Siddall et al., 2003; Waelbroeck et al. 2002) did not report two isotopic peaks during MIS 5.5.

Based on our observations, we propose an alternative interpretation, in which glacial-hydro-isostatic move-ments played an important role in building the double notch, and only a single highstand is required, in better agreement with the regional and global observations. The fact that the smoothed notch is bored by Lithophaga holes, whereas the tidal notch is virtually devoid of boreholes, is of particular relevance to the following discussion. This would suggest that the smoothed notch was gradually submerged but the tidal notch was only partially submerged from the tide but not colonized by Lithophaga.

In addition, at Gaeta and Orosei the submerged forms were observed (Figs. 3, 6, 7) with a high-morphological continuity on exposed coasts but especially on sheltered sites with Holocene smoothed notch dimensions comparable to those of MIS 5.5 (Fig. 8, Table 1). So it appears that these morphologies were formed also during the Holocene transgression (Gaeta, Capri and Orosei), and possibly also during older Marine Isotope Stages, as was recognized at St. Vito Lo Capo for MIS 9 (Antonioli et al., 2002).

Lambeck et al. (2004a) proposed that relative sea-level changes along the Italian coast during the Holocene were the combined result of eustasy, glacio-hydro-isostasy and vertical tectonic motion. When the tectonic contribution is evaluated, eustatic and isostatic contributions can be predicted from models of ice sheets and earth rheology. The model predicts also large spatial variability of relative sea-level changes. In the Tyrrenhian Sea the predicted sea level values are higher from north to south toward the centre of the basin. Using the 7ka time slice, when resolution of the glacio–hydro–isostatic contribution is good (e.g. Lambeck et al., 2004a), different position for the coeval sea level are predicted for the individual sites studied in this paper (Gaeta, 11.6 m; Capri, 11.6 m; St Vito, 14.1 m; Orosei, 15.4 m; Capo Caccia, 12.2 m). The elevation differences remain when different time slices are evaluated. The 2 and 7ka sea-level contour lines relative
to the present one on the Italian seas are drawn in Fig. 10. When we compare the altitude of the fossil smoothed notch in the different sites, with the predicted (Lambeck et al., 2004a) relative sea-level change, specifically calculated for each site (metres of relative sea level rise, or land subsidence), it is possible to note a remarkable spatial correlation in variation (Table 1 and Fig. 10). The spatial variation in smoothed notch elevation ranges from 3.8 m at Gaeta to 6.4 m at Orosei (Table 1), and mimics the same spatial trend predicted for the Holocene sea level rise. Based on the updated model (Fi_W7_5) for ice sheet thickness during MIS 6, Lambeck et al. (2004b) noted similar spatial variation on sea level in the Tyrrhenian Sea during MIS 5.5 respect to whose published for the Holocene.

We propose that the double notch records the combined action of eustatic rise and glacio-hydro-isostatic subsidence. Fig. 11 shows our interpretation of the sequence of events that carved the double notches. At about 135 ka, the sea level rose rapidly and notches could not have been built (Fig. 11a). No tectonic vertical motion was induced, as tectonic stability was already attained. At about 127 ka, onset of the MIS 5.5 stillstand is recorded by carving of the notch in the intertidal zone (Fig. 11b), but hydro-isostatic loading caused a slow subsidence of a few metres, resulting in a smoothing of the notch due to both dissolution and Lithophaga borings (Fig. 11c). At about 119 ka, hydro-isostatic subsidence slows down, and a coralline or Dendropoma algal rim is built at the intertidal level (Fig. 11d). As isostatic subsidence stopped, the upper tidal notch formed above the algal rim (Fig. 11e), until the following sea level fall (Fig. 11f). Thus, the smoothed notch represents indeed the enlargement of a former tidal notch carved during the same highstand, and the position of the tidal notch migrates upward (relatively to the land) during the MIS 5.5 highstand (Fig. 12).

This model may be applied to the Holocene rise as well, and explains why notches older than 1–3 ka have never been found in stable sites of the central Mediterranean coasts, since they are likely smoothed and submerged beneath the modern notch. Although age constraints are not available for the proposed model of double notch formation, we suggest that it might explain the unconformity-bound MIS 5.5 marine deposits described by Kindler et al. (1997) in the stable Sardinia sites (and also in other localities as Red Sea or Caribbean, Bruggemann et al., 2004; Neumann and Hearty, 1996) as due to glacio–hydro–isostatic adjustments.
6. Conclusions

Although we are aware that only firm age constraints can confirm its feasibility, we believe the following lines of reasoning support an isostatic model for the genesis of the double notch:

(1) There is a clear correlation between the heights of uplifted MIS 5.5 double notches, reported in this paper, and the isostatic behaviour of the Tyrrenian Sea crust predicted by Lambeck et al. (2004a); and there is arguably a similar behaviour between MIS 5.5 and MIS 1.

(2) The notches are found both in exposed and sheltered coastal areas, and therefore, their formation is unrelated to the fetch or wave processes. Also, corrasion processes are unlikely due to the almost consistent elevation difference between the upper and the lower (smoothed) MIS 5.5 notch, regardless of the morphology of the sea bottom which is evidently different at different sites.

(3) Whereas the smoothed notch is bored by Lithophaga holes, the upper tidal notch is not, suggesting the smoothed notch was gradually submerged while the upper notch was only partially submerged from the tide but not colonized by Lithophaga. The smoothed notch was cut back more deeply and enlarged horizontally into the bedrock respect to the upper notch because of continued action by Lithophaga under the sea surface. Since Lithophaga can live in water of \(-20\) m (Antonioli and Ferranti, 1992), there is no reason for its boring action to stop in the steadily deepening water as isostatic subsidence progressed. In addition, the different width of smoothed notches at different sites allows us to exclude that only sea-level movements carved these forms.

(4) The lip between the upper and the smoothed notch represents the site where a Dendropoma or Lithophyllum rim developed, and protected the bedrock from dissolution. Subsequent subaerial weathering in exposed cliffs removed the organic rims, leaving only the lip.

(5) The existence of double notches in examples of different ages testifies to a repeated process of formation driven by deep causes (as the one controlling the local isostatic response to melt water loads), and it is difficult to attain if random processes (i.e. different highstand during an interglacial) are acting. The fact that these morphologies are found in different Marine Isotope Stages suggests that isostatic movements were active also in stages older than the Holocene.

(6) If supported by future radiometric ages, this novel interpretation of the double marine notches may represent a valuable tool to understand future relative sea level changes in relation to coastal movements.

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References


References


