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for management of future coastal change

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Amplitude of sea level changes and rapid uplift between 128 and 58 ka from stepped marine terraces of Reggio Calabria area, Southern Italy

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Abstract

Frequency and amplitude of the sea level changes can be determined from the built-up marine terraces which have been raised in a tectonic pattern of continuous uplift rate.In the Reggio Calabria area, the uplift rate is 1.3 m/ka (+0.06 - 0.09). It is one of the most favourable raised areas in the world for generating a great number of stepped marine terraces. A new method to estimate the amplitudes of the sea level oscillations has been applied to the marine deposits of terraces. A diagnosis of the relative sea level, at the time of deposition, is provided by shallow water marine deposits,such as beach sands and gravels. A "characteristic height" of these deposits has been defined (Dumas et al., 2002; Dumas et al., 2003, submitted): it is the difference in height between the top of the beach deposit,at the inner edge of the terrace(= the shoreline), and the lower point from the base of the same deposit located at the outer edge.

On the present beaches of the coastline, this interval constitutes a “critical height"(C_h), depending on the current shore processes. According to our measurements, it ranges from c.a 3 to c.a 5 m. Every outpassing from these values means a sea level rise. A suborbital mean periodicity of the so-detected glacio-eustatic terraces has been found; the frequency was, for instance, 2.1 ka during the orbital cycle beginning at 128 ka (substages 5.5 and partly 5.4, following the oxygen isotopic chronology). The amplitude of the sea level oscillations is estimated from the"characteristic height" of the beach deposits. For each oscillation, the amplitude of the sea level rise is evaluated thanks to the following equation:

$$S_r=H_c+A_r-C_h$$

where S_r is the amplitude of the sea level rise, H_c the "characteristic height" of the deposit, A_r the amplitude of the uplift which occurred during the time interval separating low from high stand, and C_h the maximal "critical height" (5 m). The value of A_r is calculated from the uplift rate (1.3 m/ka), assuming that the duration of each sea level rise is equal to one third of the mean periodicity of the whole glacio-eustatic cycle.

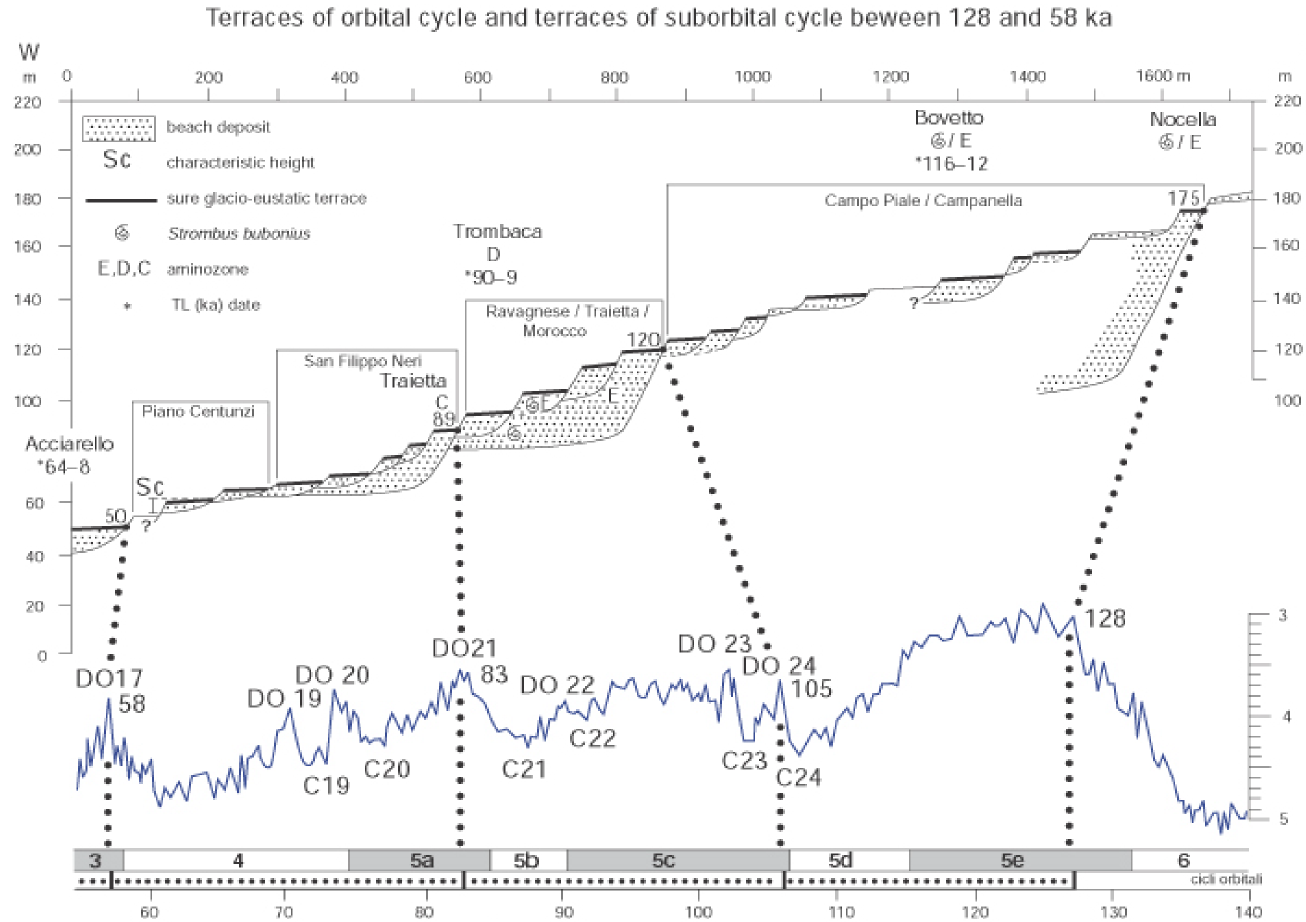
As the "characteristic height" depends on the available outcropping marine deposits, the result is to be considered a minimum one.

Very slight values of the sea level rise are detected with respect to the suborbital cycles (so-little as 1m), while the largest estimated amplitude of sea-level rise related to a suborbital transgressive event, which occurred during substage 5.3, is 12.1 m. This value remains yet smaller than that of the three orbital events at c.a 128, c.a 105 and c.a 83 ka, whose sea level rise can be estimated at least at respectively c.a 112, c.a 39 and c.a 27 m.

As the amplitude of uplift occurring during the transgression is to be added in the calculation of the amplitude of the sea level rise, a threshold appears, which is proportional to the uplift rate; so, with a 1.3 m/ka uplift rate, Calabria, near Reggio, is a very suitable region for the detection of small amplitude oscillations, more than any other area submitted to higher uplift rate.

As regards to the estimate of the sea level fall, the equation is: $S_f=H_c-C_h+I_v-A_f$, where S_f is the amplitude of the sea level fall, I_v the vertical interval between both successive paleoshorelines, at the limits of the suborbital glacio-eustatic cycle, and A_f the amplitude of uplift which occurred during the sea level falling, which is estimated, conventionally, equal to two thirds of the mean periodicity of the cycle.

The falling sea level has caused sometimes the down-cutting of a valley, which was invaded by the sea during the subsequent transgression, such as a "ria" of Galicia, and partly covered with the corresponding beach deposits. In this case, the total amount of down-cutting is only partly due to the regional uplift and mostly depends on falling sea level, which is another evidence for the global sea level change.



B. Curva MD95-2042 delta 18O benthique (Shackleton, 2001; Hinnov et al., 2002; Shackleton et al., 2002)

As for the whole glacio-eustatic cycle, the vertical interval between two consecutive paleoshorelines is $D=A_u+(z-z')$, where A_u is the total amplitude of uplift which occurred during the cycle, $(z-z')$ being the difference in elevation between two successive past sea level high stands.

With such a combination, it is possible to distinguish two successive shorelines which are very close together, if the uplift rate is rapid.

But A_u must be greater than $(z-z')$, in order to locate the preceding paleoshoreline higher than the subsequent one; if not, some marine terraces may have been destroyed, because the amplitude of sea level rise was greater than the falling sea level change, and the amplitude of uplift is smaller than the difference between both successive highstands. Such a scenario may have occurred before the beginning of substage 5.3, on account of the great amplitude of the warming preceding DO24 (105 ka).

The same scenario is perhaps not to be excluded between two suborbital sea level changes, by seeing the pattern of suborbital oscillations especially during substage 5.3, as evidenced by some delta ^{18}O benthic or planctonic records (Oppo et al., 2001). So, every small sea level change could not be detected, for this second reason, from raised marine terraces.

Nevertheless, rapid but not excessive uplift is a good condition to detect many sea level oscillations and especially their magnitude. Moreover, the morpho-structural setting must be convenient for down-cutting valleys to be involved by global regressions combined with uplift, and for providing a great deal of debris which contributes to built up marine terraces.

Taking into account that the measurement of H_c gives a minimum value of each sea level rise, the amplitudes of sea level rises are as follows: between 10.7 and 1.2 m for 11 suborbital oscillations during substage 5.5 and partly 5.4, between 12.1 and 7.5 m for 3 oscillations during substages 5.3 -5.2, and between 5.9 and 2 m for 7 oscillations during substage 5.1 and stage 4.

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