Terraces on a Rising Coast

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Abstract- **It is unlikely that terraces along a rising coast, whether submerged or exposed, can be assigned to certain sealevel positions in the past. Instead, the terraces probably represent functions of histograms of sums of positions through time, on a vertically moving background.**

I. INTRODUCTION

The marine geologist K. O. Emery (1958) and many since, have made surveys of shallow submerged marine terraces of Southern California. The abstract of Emery's paper (1958, p. 39) begins as follows: "Profiles across the mainland shelf, island shelves, and bank tops of southern California show five separate flatternings that are interpreted as erosional marine terraces cut during times of low sea level of the Pleistocene Epoch. Similar terraces have been discovered recently in widely separated parts of the world; this supports the interpretation of their relationship to eustatic changes of sea level." Also, Emery correlated the various terraces over long distances and ascribed differences in elevation to differences in vertical motion.

The concept that terraces were cut during a certain stand of sea level is widespread still. This can only be true for coastal regions that are not moving vertically, or moving very slowly with respect to changes in sea level. In fact, differences in vertical motion are likely to produce different sequences of terraces, not similar sequences offset vertically.

II. TERRACES

Terraces can be recognized along many portions of the coast of California, both as features of the landscape above the water, and as flat or gently sloping areas offshore, embedded into steeper slopes above and below (Figs. 1-3). One of the more puzzling features is an extended terrace near sea level, in many areas (Fig. 2). It is puzzling, because sea level has been at the present position for only some 7000 years. In most areas, at present rates of cutting into the cliff, a relatively narrow ledge would be expected for a stationary coast attacked during this time span.

Between Pt. Conception and Santa Monica, terrace depths near –20 m are common, as well as depths near –60 m. At Palos Verdes, one finds levels at +36 m, just below sea level, near –22 m, near –57 m, and near –80 m. (All taken from Emery, 1958, Pl. 1.)

Fig. 1. Terraced coastal landscape
Palos Verdes, CA

Fig. 2. Wave-cut terrace at sea level,
Pt. Conception, CA

II. SEALEVEL VATIATIONS

The variations in sea level were especially large within the last 900,000 years or so, generally spanning 100 m or more through a full 100-kyr cycle. Detailed information is available on the variation of oxygen isotopes in seawater for this period (Fig. 4). However, the exact transformation of this index into sea level is still somewhat speculative, although the principle is well established (e.g. Pirazoli et al., 1993). We have assumed a 110 m range for the sealevel change from 18 kyr ago to the present. It is most probably within 10 percent of the true range.

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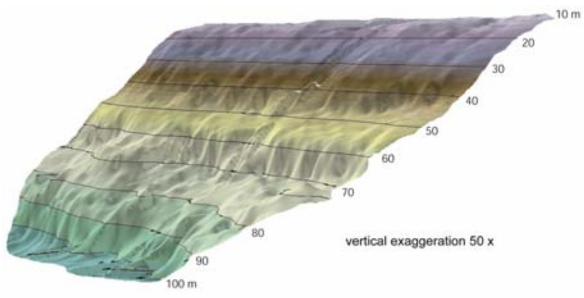

Fig. 3. Subsurface topography off San Onofre, CA [GIS image from D.L. Inman and P.M. Masters using data from R.L. Kolpack (ed.), 1991]

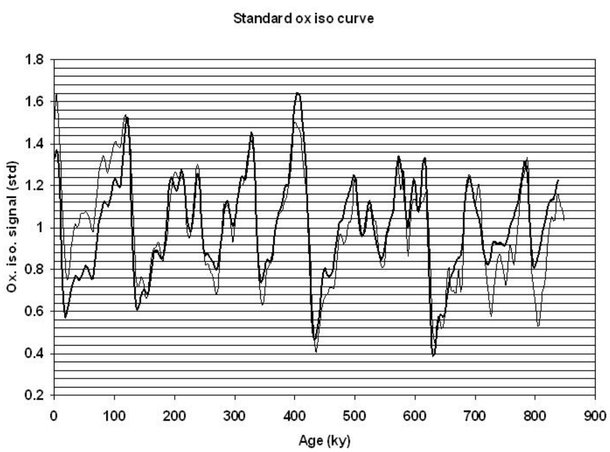

Fig. 4. Oxygen isotope stratigraphy.
Thin line: Ojsx96 from Berger et al., 1996, based on measurements for ODP Leg 130. Thick line: Global curve, stacked signal from various sources, unpublished.

III. SEALEVEL POSITIONS ON A RISING COAST

Using the series describing sealevel fluctuation over the last 700 kyr, as shown in Fig. 4, we have calculated percent time spent at sea level for the various elevations along the coast. In the calculation, we have assumed (arbitrarily) that no effect will be visible if more than a million years have passed. The effects of wave-cutting between then and now, for the last 700 kyr, were adjusted linearly according to age. Times before 700 kyr were ignored.

What emerges are histograms of sealevel positions relative to present elevations (Figs. 5 to 7). Distribution of terraces expected from the histograms is as follows:

For uplift = 0 mm/ decade, –18 m, –35 m, –70 m and –85 m.

For uplift = 1 mm/ decade, +40 m, 0 to –10 m, ca. –30 m, –48 m and –80 m.

For uplift = 2 mm/ decade, +50 m, +20 m, 0, –15 m, –35 m and –70 m.

(The range of uplift values was set according to advice by Douglas Inman, pers. comm. May 2003; see also Bradley and Griggs, 1976.)

IV. CONCLUSION

It appears that the known profiles of elevations of the coast of Southern California can be used as targets for modeling sealevel positions in the Pleistocene, during uplift. Some experimentation will be necessary, with varying assumptions about the nature of sealevel variations (that is, the range of the last 20 kyr), and the deterioration, with time, of the signal left by the terracing process on land and below water. Other considerations include the different resistance of formations to wave-cutting, and the difference in force of waves between glacial and interglacial conditions. The resulting model matrices will be large, but not too large to handle at the PC level.

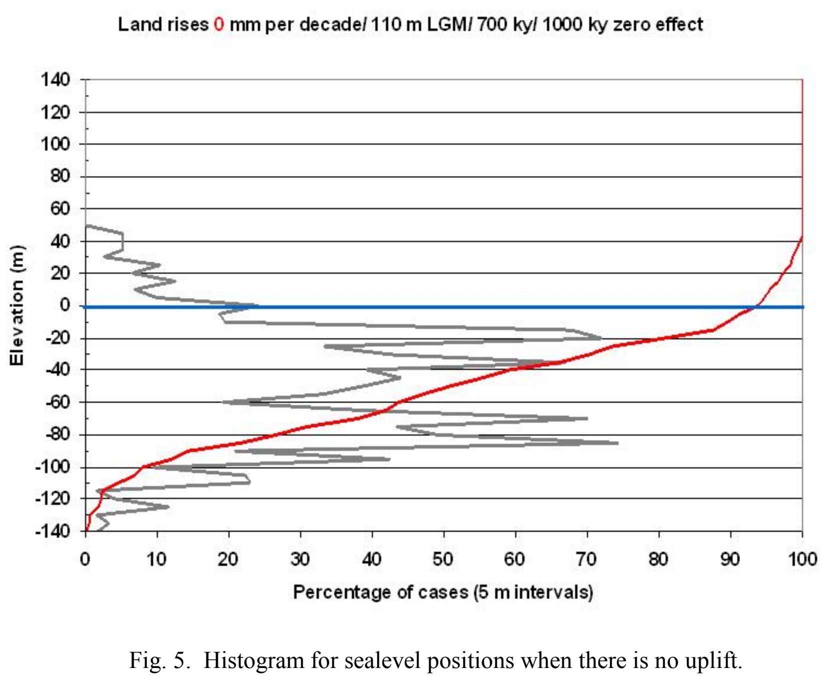

Fig. 5. Histogram for sealevel positions when there is no uplift.

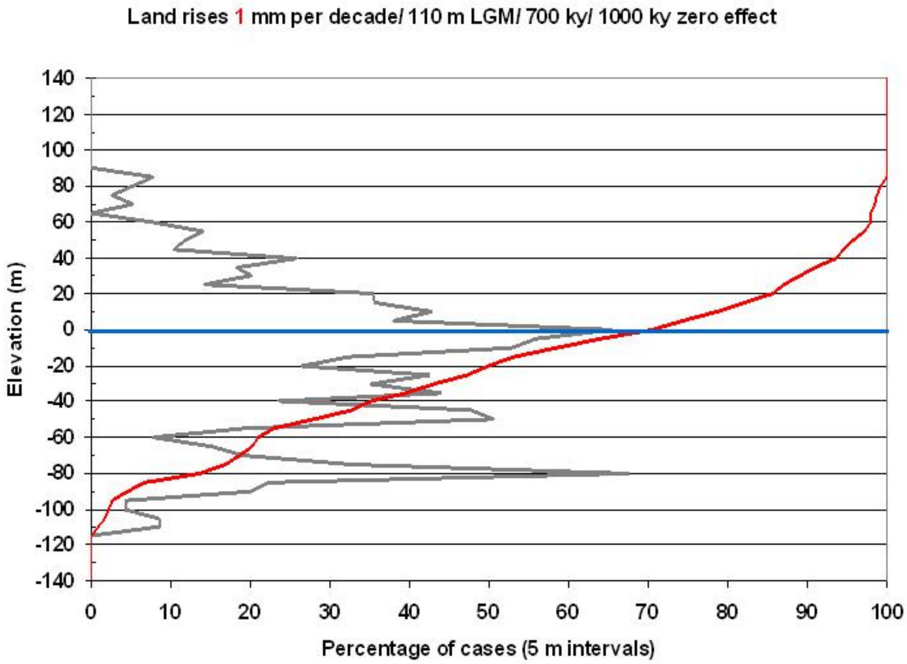

Fig. 6. Histogram for sealevel positions when uplift is 1 mm/decade.

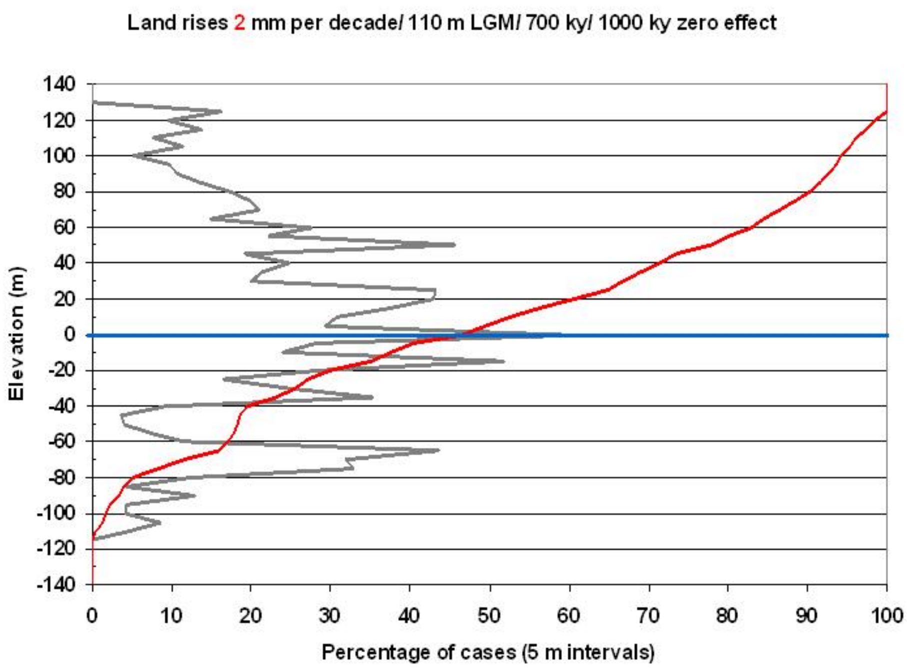

Fig. 7. Histogram for sealevel positions when uplift is 2 mm/decade.

Acknowledgments

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