

Sea level change and the relationship with the volcanic load: the Sardinian Volcanism.

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RIASSUNTO

Variazione della linea di costa in relazione al carico vulcanico: il vulcanismo Sardo

In un contesto di stabilità regionale la Sardegna presenta, nel Golfo di Orosei (Sardegna orientale), un solco di battente marino continuo e lungo 30 km circa, attribuito al Tirreniano, posto ad una quota superiore (10.5-7.6 m) rispetto al livello atteso (6 ± 3 m), per una zona tettonicamente stabile.

Per analizzare il problema, si è studiata la risposta flessurale della crosta, a carichi crostali. Tali carichi possono essere interni ed esterni all'isola, ma devono essere posteriori alla formazione della linea di costa Tirreniana. Si offre pertanto un quadro generale delle età delle vulcaniti recenti presenti nell'isola e degli eventuali depositi vulcanici a mare. Successivamente, in base ad una modellazione isostatica multiparametrica, si analizza l'influenza sulla linea di costa di un carico vulcanico tipo. Un ulteriore modello analitico ha simulato la presenza di un batolite/laccolite ubicato nelle aree limitrofe al golfo. I test sintetici hanno dimostrato che i carichi continentali non riescono a spiegare l'anomalia, che sembra invece ben correlata con una spinta dal basso verso l'alto legata alla presenza di attività vulcanica limitrofa.

Key words: fissural activity laccolith, batholith, MIS 5.5, Orosei Gulf, Tyrrhenian notch.

The level of the Tyrrhenian coast line (125 Ma) in Sardinia is known from the observation of 58 geomorphological measuring sites (Ferranti *et al.*, 2006). The low variability of the height of the markers, in comparison with other regions, makes this piece of coast the eustatic reference of MIS 5.5 (M.I.S = Marine Isotopic Stage) for all of the Mediterranean region, this level being at 6 ± 3 m above present sea level (LAMBECK *et al.*, 2004a, b). Along a segment of the eastern Sardinia coast though, there is an elevated segment of the Tyrrhenian notch, which extends for 30 km, near the Gulf of Orosei, where the level changes from north to south from 7.6 to 11.5 m (fig. 1b, c), (FERRANTI *et al.*, 2006).

Generally a height deviation of the notch from the predicted value is due to tectonic activity, volcanic activity,

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isostatic movements and anthropogenic activity.

The Sardinia coast is considered to have too low tectonic activity, no effect of anthropogenic activity, and also too small post-glacial rebound in order to explain the anomaly (GUEGUEN *et al.*, 1998). The remaining candidate is the Neogenic-Quaternary continental and submarine volcanic activity, which we investigate as possible cause for the observed anomalies.

We offer a review on the volcanic deposits (fig. 1a) and their timing in Sardinia and investigate to what extent volcanic loads can influence a coastline from a theoretical standpoint, considering the isostatic flexure model. We investigate the parameter space defining synthetic load models, employing a geometric solid to reflect the morphology of volcanic deposits (fig. 2b). We consider the flexural response for different cases and we change the shape of the load (radius, height, density of load, eccentricity of base of solid), the distance from the centre of the load to the coast and the crustal flexural rigidity. The synthetic models show that the volcanic loading produces upward and downward movements of the coastline in the order of a few meters. The upward movements are connected to the flexural bulge, and appear only in a limited distance range from the source.

Finally, we load the crust with the existing volcanic deposits of Sardinia and demonstrate that the observed notch height-anomaly cannot be explained by the volcanic loading, but must be produced by an upward welling due to the emplacement of volcanic material, as produced for instance by a laccolith or batholith (fig. 2a). We use the model of the flexure of an elastic plate supported at the edges (TIMOSCHENKO & WOINOWSKY, 1959) at the bottom of which a force is applied. The upward movement could be related to the submarine volcano only recently detected or to a source located on the Sardinia coast near Orosei.

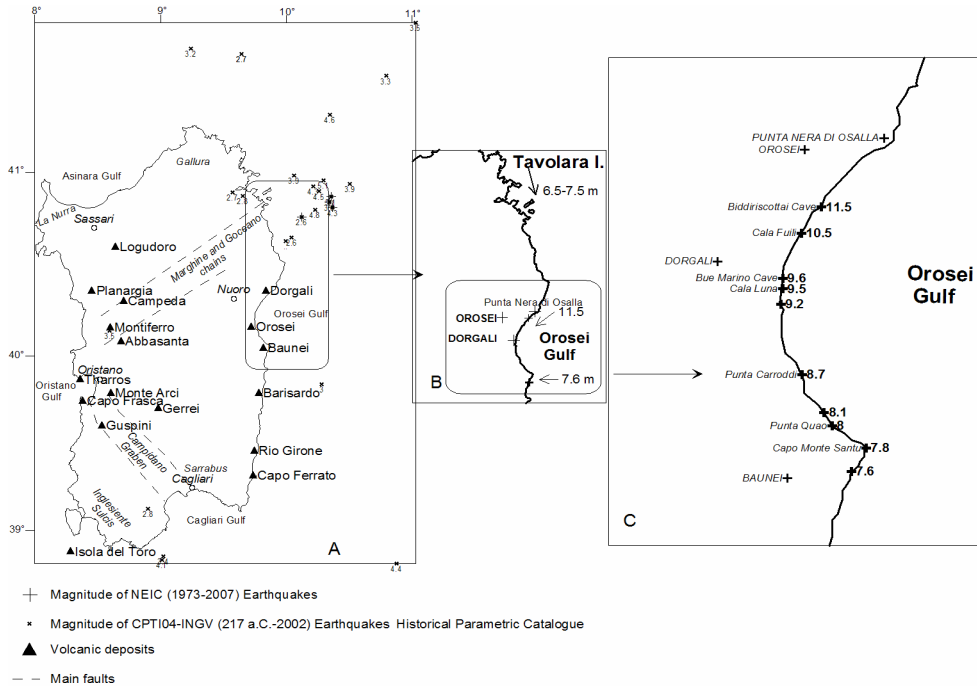


Fig. 1 – Sketch of Sardinia Island: A) Main faults, volcanism and seismicity, magnitude of the seismic events is shown below the epicentre; rectangular area show the coastal segment reported in Fig. 1b); B) Height of tidal notch of Tyrrhenian age (125 ky) along the north-eastern coast; rectangular area shows the coastal segment reported in Fig 1c); C) Coastal segment with elevated height of tidal notch along the Orosei Gulf. Height-values given in m above sea level (FERRANTI et al., 2006). *Schema della Sardegna: A) Principali faglie, depositi vulcanici e sismicità. La magnitudo degli eventi sismici è contrassegnata da crocette (vedi leggenda); l'area rettangolare individua il settore costiero rappresentato in Fig. 1b); B) Altezza del solco di battente Tirreniano (125 ka) lungo il settore nord-orientale dell'isola; l'area rettangolare segnala la Fig. 1c); C) Settore costiero e altezze del solco di battente lungo il Golfo di Orosei. I valori delle altezze sono dati in metri sul livello del mare (FERRANTI et al., 2006).*

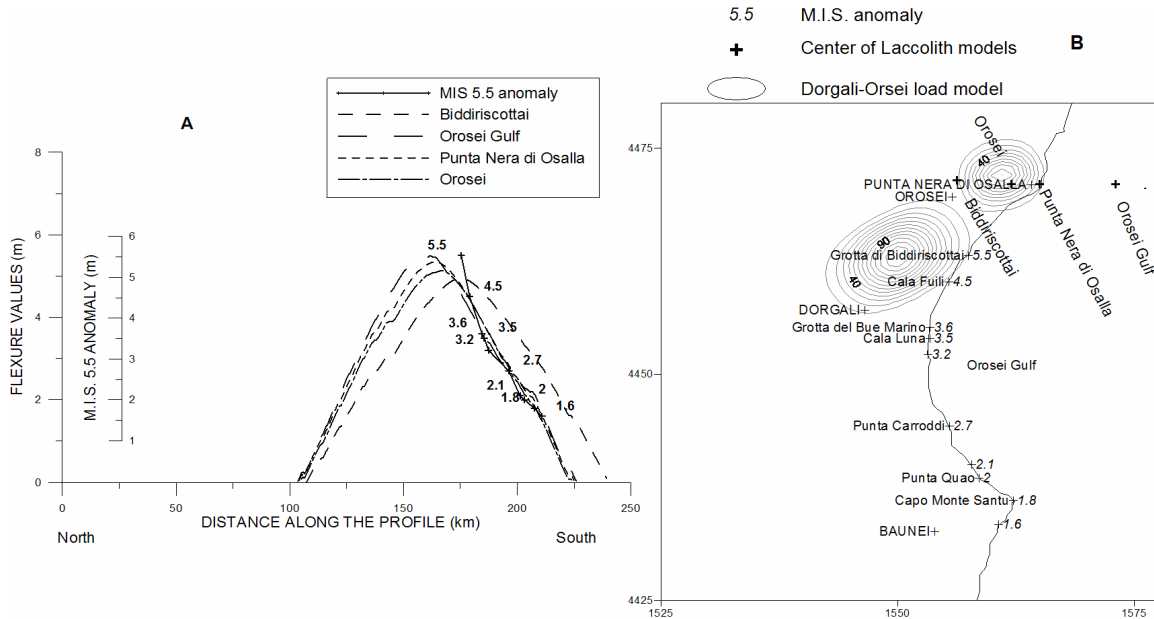


Fig. 2 - A) Plot of upward deformation due to the laccolith model for different points of application; B) Geographic location of the models along the Orosei Gulf. The numbers are the height of anomaly MIS 5.5 (FERRANTI et al., 2006) and with nearest towns added to the left in small block. Main towns are added (capital letters) for orientation; the crosses in black color indicate the centre of load application of laccolith models; the grey ellipse shows the Dorgali-Orsei load model. *A) Profilo della deformazione verso l'alto dovuta al modello laccolite per diversi punti di applicazione; B) Localizzazione geografica dei modelli. I numeri in corsivo sono le altezze anomale del MIS 5.5 (FERRANTI et al., 2006) e sulla sinistra, in minuscolo, le cittadine limitrofe, in maiuscolo le città principali; le croci nere indicano il centro di applicazione nella modellazione dei laccoliti; in grigio invece il modello Dorgali-Orsei.*

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