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Kinematic evolution of the Vena del Gesso (Romagna, Italy), analogue modelling of the interaction between erosion and tectonics

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We present the results of an integrated study between field analyses and analogue modelling approach of the Vena del Gesso Basin in Western Romagna (Italy). This basin is one of the few areas in the Northern Apennines foreland where widely crop out primary evaporites, related to the Messinian Salinity Crisis of the Mediterranean. These deposits give rise to an elongate and well exposed gypsum ridge named «Vena del Gesso», which attains a NE-dipping monoclinal attitude (e.g. MARABINI & VAI, 1985; ROVERI *et alii*, 2003) (fig. 1).

Geological mapping together with the analysis of structures highlighted that the evaporites are completely detached at the base and that back-thrusts repeatedly doubled these deposits, strongly contrasting with the regional forelandward vergence of structures in the Apennines. The tectono-sedimentary architecture, like the angular unconformity exposed spectacularly at Brisighella (e.g. MARABINI & VAI, 1985), allowed us to constrain the timing of deformation.

Analogue modelling techniques were applied to gain a better understanding of the mechanisms responsible for the development of the structural pattern characterising the studied area, specifically the factors favouring the back-thrusts development. Analogue models were performed at the «Tectonic Modelling Laboratory» of the Department of Earth Science and of the CNR-IGG in Florence.

The experiments were geometrically, dynamically and cinematically scaled (e.g. WEIJERMARS & SCHMELING, 1986) in order to simulate the geological boundary conditions of the natural prototype. The models approximated the natural rheological multilayer and had initial dimensions of 24 cm × 25 cm × 2.8 cm. The sand-silicone models were built in a Plexiglas squeeze box and scaled with length ratio $l^*=2\ 10^{-5}$ (1 cm in the model represents about a 0.5 km in nature). The models were then shortened at the constant displacement rate of 0.6 cm h^{-1} (in a normal gravity field) by a rigid wall driven by an electric motor.

Based on the comparison between analogue model results and field data, the overall features affecting the area are interpreted to result from the deformation linked to the sequential activation of an obliquely propagating passive-roof thrust (Banks and Warburton, 1986; and fig. 2) linked at depth to a NE-verging blind thrust anticline in the underlying Marnoso-arenacea Formation. This thrust anticline is in fact almost completely overthrust by the foreland-dipping back-thrust imbricate, which is composed of splays emanated from the main passive-roof thrust localised along the frontal anticline zone.

Moreover, the experimental results evidence the major role played by syntectonic erosion that dictated the deformational style. This is illustrated by two models (VdG04 and VdG 05) sharing the same initial set-up, velocity of deformation and bulk shortening, but erosion was applied to the internal sectors of model VdG-04 only. The comparison of top view photographs and cross sections (fig. 3) between the two models highlights that model VdG-04 developed a quite different structural architecture in respect to the other (model VdG05), thus

Fig. 1 - Panoramic photograph showing the characteristic appearance of the Vena del Gesso monocline.

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confirming that erosion plays a key role controlling the deformation style. Particularly, by eroding the internal part of the model the deformation remained restricted to the area near the moving wall, without propagating outward (compare the cross sections in fig. 2a and b). The most noteworthy divergence is that the structures affecting the models exhibit an opposite sense of the overall vergence. In the model affected by erosion, propagation of shearing along the ductile silicone layer gives rise to passive back-thrusting of the roof sequence, this latter gliding passively over the underlying blind fore-thrust. Model VdG05 (without erosion) exhibits instead mostly a foreland vergence.

In conclusion, we suggest that the dominance of back-thrusting characterising the Vena del Gesso area is consistent with the development of a thin-skinned passive roof duplex, in which the erosion acted as one of the main driving factors.

Fig. 2 - Schematic cartoon illustrating the passive-roof thrusting concept.

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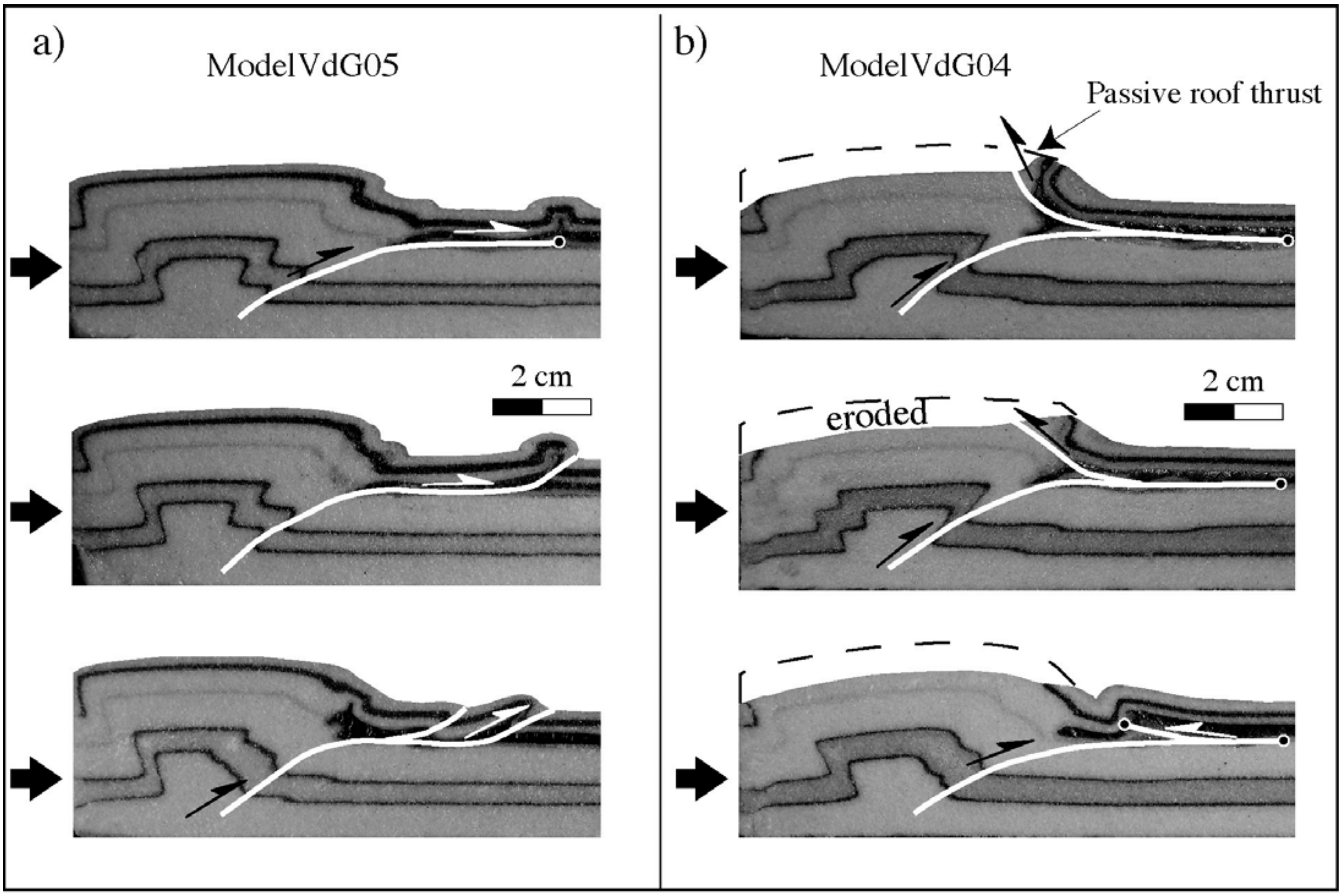

Fig. 3 - Representative model longitudinal cross sections; the comparison between the cross sections highlights the contribution of sin-kinematic erosion in promoting passive roof thrusting geometries.