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Salt diapirism during basin inversion: inferences from analogue modelling

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The development of diapirs is generally correlated with the activity of normal faults developed in extensional regime, which is considered the most efficient mechanism triggering diapirism (e.g. Jackson & Vendeville, 1994). The influence of contractional settings on diapir growth is doubtless considered a less efficacious mechanism (or an opposing mechanism to diapirism growth; e.g., Vendeville, 1991). As far as we are concerned, in spite of numerous works on analogue modelling exploring salt diapirism mechanisms (i.e. Cotton & Koyi, 2000; Costa & Vendeville, 2001; Sans & Koyi, 2001; Bonini, 2003; Brun & Fort, 2004), analogue models have never explored the influence of positive fault inversion on diapirism.

In this work we present the results of the modelling built to understand the relationships between fault reactivation and their orientation in respect to the maximum horizontal stress axis (Del Ventisette *et alii*, 2004). The models is performed at the Tectonic Modelling Lab of the CNR-IGG and of the Department of Earth Sciences of Florence using a pure-shear/simple-shear deformational apparatus.

Scaling of analogue models to the natural prototype requires the geometrical, rheological, kinematical and dynamical similarities to be satisfied (e.g., Hubbert, 1937; Ramberg, 1981; Weijermars & Schmeling, 1986; Weijermars *et alii*, 1993).

The models had initial dimensions of 45.5cm × 42cm × 7cm and consisted of a pure brittle system representing the crystalline basement of a natural prototype.

The models were extended at a constant velocity of 10 mm/h for seven hours up to the bulk extension (BE) of about 16.5%. After 1 hour of deformation (approximately 2.3% BE), when the graben was 1 cm deep, a mixture of silicone and oleic acid (Newtonian behaviour, ρ=1060 kg m^{-3}, η=10^{3} Pa s) was placed into the graben to simulate the ductile behaviour of salt layers that are generally associated whit this geodynamic context. The successive syn-tectonic sedimentation consisted of dry quartz sand layers (Fontainebleau sand with grain dimension <250 mm) with different colours sieved at regular time intervals (1 mm every 30 minutes).

The following deformation phase simulated a compressive stress field ($\sigma_1 \cong \sigma_h$) that was applied at the constant velocity of 10 mm/h for seven hours.

The deformation of these models was mostly accommodated by the dip-slip reactivation of pre-existing extensional structures (fig. 1a), both in the basement and in the basin fill, without the development of important newly-formed structures away from these reactivated normal faults.

The results of analogue models reported here suggest a new triggering mechanism for diapiric rise during basin inversion. This mechanism relates the localization of ductile diapirs in correspondences of early normal faults inverted during shortening. In this case, diapiric growth is related to the strong dip-slip reactivation component along the fault extruding upwards the silicone-simulating salt.

In many places around the world, diapiric rise locally developed along the reactivated extensional fault system. For example, in the Nzala des Oudayas area (Saiss Basin, Morocco), which is characterized by a Tertiary and Quaternary shortening phases reactivating the Mesozoic extensional structures (e.g. Ait Brahim *et alii*, 2002 and references therein), the Triassic salt diapirs are directly located above the inverted normal faults. The comparison between the overall features of Nzala des Oudayas diapirs (fig. 1b) with the model geometries (fig. 1a) allow us to suggest that the triggering mechanism for this diapiric structure could be most likely related to the syn-shortening fault reactivation.

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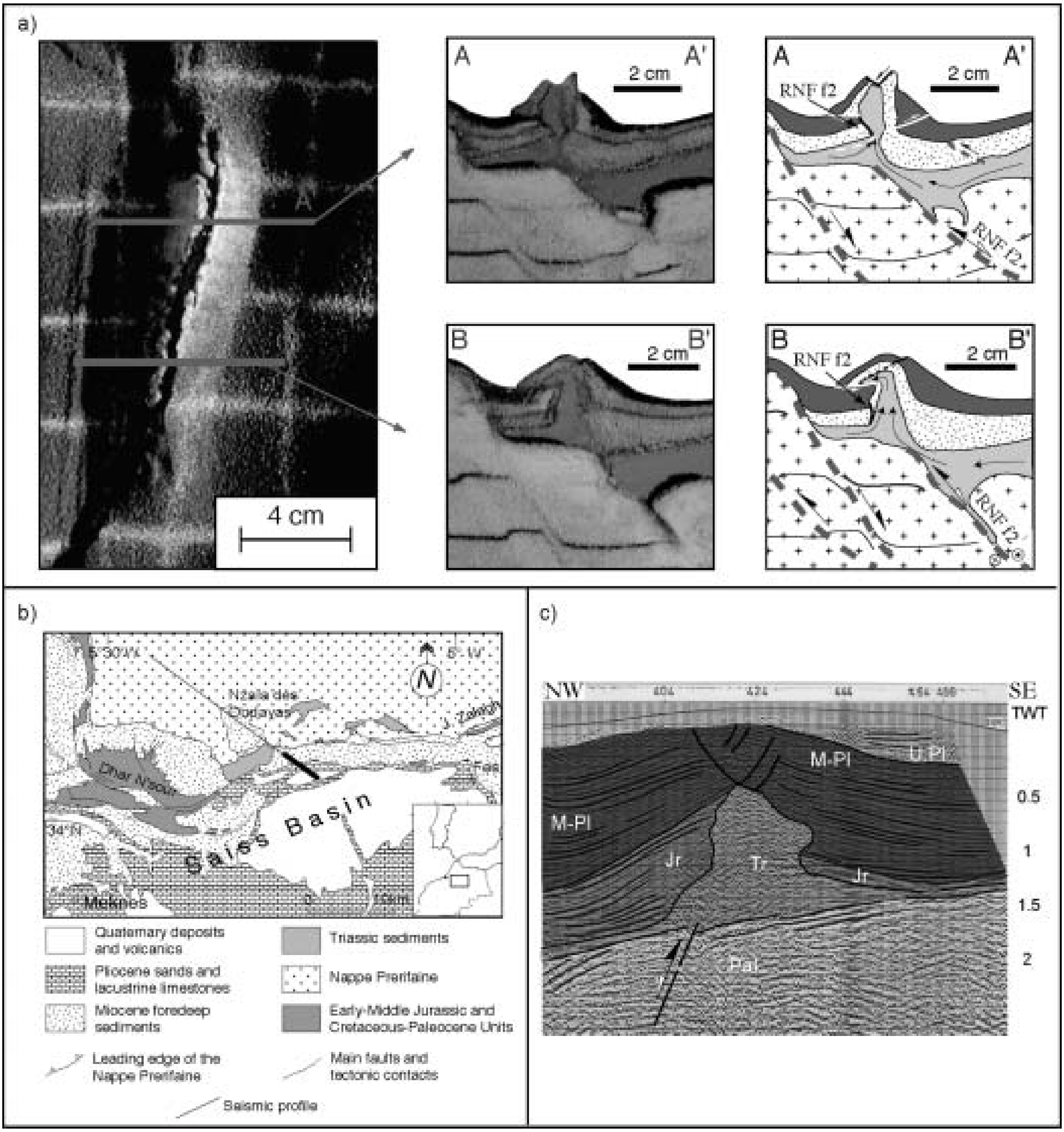

Fig. 1 - *a*) Diapiric structures developed during shortening in models. The diapir grew directly above the early reactivated normal faults f2. RNF=Reactivated normal fault. *b*) Schematic geological map showing the main tectonic elements of the Saiss Basin (Morocco), including the location of seismic line. *c*) Close-up of the seismic profile and its interpretation showing diapiric structures; Pal = Paleozoic basement; Tr = Triassic salt; Jr = Jurrassic deposits; M-Pl = Miocene-Pliocene sediments; U.Pl = Upper Pliocene sediments (Lacustrine limestones).