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The Oligo-Miocene Rift of Southern Sardinia, Italy

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Data here reported are summarised from a recent paper by the same authors (Casula *et al*., 2001); they represent the main result of a long established collaboration (1996-2000) between researchers from the Earth Science Dept. of Cagliari University, Italy (A. Cherchi & M. Murru), the Institut Français du Pétrol and the Beicip Franlab, Rueil-Malmaison, France (L. Montadert) and Progemisa S.p.A., Cagliari, Italy (G.. Casula & E. Sarria); Progemisa S.p.A. sponsored most of the field-work and seismic studies.

The structural evolution of the Oligo-Miocene Rift system of Southern Sardinia is linked to the general geodynamic evolution of the Western Central Mediterranean. Thus, the extensional late Oligocene-Lower Burdigalian event is a consequence of an "Apenninic" westward subduction process associated with a volcanic arc (29-30 My to 15-16 My). Following the deposition of subaerial clastics, the sea invaded the rift depression at the beginning of the Aquitanian. Subduction terminated in the opening of the oceanic Provençal Basin and the rotation of Sardinia-Corsica during the Burdigalian (20-21 My to 15-16 My). Within the complex system of Oligo-Miocene rifts of the Western Mediterranean Sea, the Sardinian rift represents the most eastern branch (Cherchi & Montadert, 1982); it crosses Sardinia longitudinally and continues offshore into the Gulf of Asinara to the North and the Gulf of Cagliari to the South.

THE SEDIMENTARY AND VOLCANIC RECORD FROM OLIGOCENE TIME TO MIOCENE

During the Mesozoic and Paleocene Sardinia and Corsica formed an integral part of the southern margin of the European plate, but separated from it during the Burdigalian because of the oceanic opening of the Provençal Basin and the following anticlockwise rotation of Corsica-Sardinia. Thus, Sardinia and Corsica shared the geological history of Western Europe (Iberian Peninsula-Southern France) up to the Lower Burdigalian.

Syn-rift sedimentation reflects the initial evolution; it began with continental environment, marked along the margins by the continental to transitional clastic deposits (Oligocene ?) of the Ussana Formation (Pecorini & Pomesano Cherchi, 1969; Cherchi & Montadert, 1982, 1984) overlaid by a transgression which invaded the middle parts of the Island. This heterochronous transgression started in the Lower Aquitanian or in the Lower Burdigalian, in different areas; it was controlled by both tensional tectonics and pre-transgressive volcanic morphology. In central-southern Sardinia the earliest marine sediments are represented by limestones containing early forms *Miogypsina gunteri* and *Miogypsinoides bantamensis*, overlaid by marls with *Globigerina ciperoensis*, *Globigerinoides primordius* and rare *Globoquadrina selli*, of early Aquitanian age; *Globoquadrina dehiscens*, which F.O. is more or less synchronous with *G. selli*, is not present here (Cherchi *et al.,* in progress).

Marine sedimentation in the basin continued into the Upper Miocene. The most recent marine sediments are of Upper Tortonian - Lower Messinian ages. The rapid Messinian regression, with its lagoonar and evaporitic facies (carbonate with anhydrite nodules) alternating with continental episodes was accompanied by erosional processes and the deposition of paleosoils (Cherchi *et al*., 1978). Upper Miocene outcrops are very limited due to intensive erosion during the Messinian regression and the Middle-Upper Pliocene continental phase (hills of Cagliari, Sinis Peninsula, Campidano Graben, etc.).

Several volcanic events punctuated the evolution of the Sardinian Oligo-Miocene Graben system

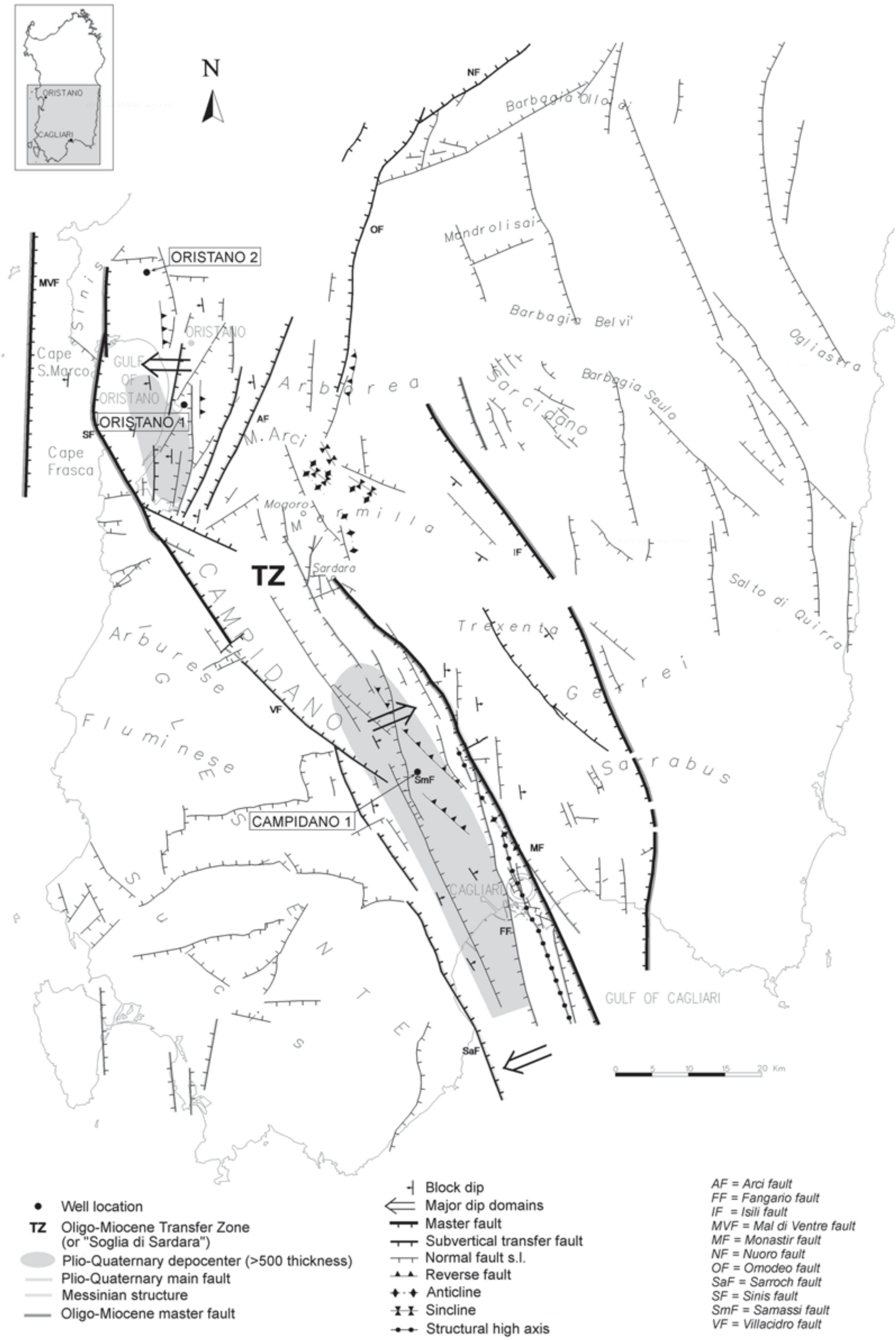

Fig. 1 - Structural sketch map (after Casula *et al.*, 2001).

(Lecca *et al.*,1997). To begin, an important calc-alkaline Oligo-Miocene volcanism preceded the transgression (28 My) and continued in a marine environment up to the Middle Miocene (15 My).

Structural data

The internal structure and deformation of the South Sardinia Oligo-Miocene Rift, like most intracontinental extensional systems, such as: the Suez Rift, the East African Rifts, the Rhine Graben, the North Sea, the Oslo Graben, is controlled by major normal faults and tilted blocks, and by transverse structures. The South Sardinia Oligo-Miocene Rift is a complex Graben system characterized by a clearly asymmetric inner structure, with opposing-polarity half-grabens, each including several tilted blocks with an average 10°-15° dip, separated by a transfer zone (Fig. 1). The latter is characterized by a transfer fault system and a central uplift with a complex structure that involves a 'horst-type twist zones (Maillard & Mauffret, 1993).

The schematic structural map shows the major normal fault trends. A major longitudinal trend NNW-SSE, parallel to the rift axis, and a transverse N-S to NNE-SSW oblique trend, both control the structure and morphology of the rift. The former trend is mostly developed in the southern part, whereas the latter is more evident in the northern region, where it again adopts the N-S regional trend of the Oligo-Miocene Sardinia Rift (Cherchi & Montadert, 1982). Other fault sets are scarce and generally display minor throw; other N90°E and N110°-130°E and pure cross-faults, perpendicular to the rift axis (N40°-N70°E) are sparse and generally have minor throws.

The principal master faults (i.e.: the Sinis, the Sarroch and the Monastir faults, etc.) have original dips between 60° and 80°, probably related to their listricity. These faults propagate along the entire rift zone though segmented and offset by transfer faults. The basin kinematics and the strong asymmetry of the basin are controlled by these faults emphasizing the change of polarity of the half-grabens. Longitudinal normal faults, both antithetic and synthetic, are also associated with the master faults (Fig.2).

Minor transverse faults are steeper, almost vertical, and show limited extension, as they do not cross the entire rift zone. However, their role in rifting is important as they act as transfer faults between the major longitudinal normal faults.

Several dip domains characterize the Southern Sardinia Oligo-Miocene rift. A W-SW dip domain occurs in the northern part, including the offshore of the Gulf of Oristano. The E-NE dip domain is dominant onshore in the central-eastern and southern parts of the rift. Following rift polarity swithes, the dip direction changes twice along the South Sardinia Oligo-Miocene Rift, defining three major rift and transfert segments each 40-60 km long:

- The Northern Oristano segment, a west-dipping half-graben;
- The complex Transfer Zone, located in the central Campidano (Sardara) and Marmilla region.
- a Southern Cagliari Region, an east-dipping half-graben;

During the Messinian, the N140°-160° shortening, which affected the whole region produced inversion structures in the Southern Sardinia Oligo-Miocene rift (Fig. 2). In fact, the main Messinian structures are sub-parallel to the Oligo-Miocene NNW-SSE fault trend, with variations of the structural trends resulting from local rotations within the shear system. As a result, the main NNW-SSE Oligo-Miocene longitudinal faults were reactivated as oblique normal faults. The effects of the Messinian tectonic inversion increase progressively southwards. In the Northern Oristano segment there is minor evidence of Messinian structures, documented only at a micro-scale, while in the Southern Cagliari segment several types of meso- and macro-scale structures can be related to this tectonic event.

The main Messinian structures in the study area are related to the reactivation of the NNW-SSE Oligo-Miocene Monastir master fault and the associated fault set.

Several N-S striking east-dipping normal faults developed in this system. These 'en echelon' synthetic structures have a normal component with ENE dip direction opposite to that of the main fault dip; the fault plane dip decreases southward from 80° to 40°.

Within this kinematic system an uplifted wedge, that strikes N160° and is 1 to 5 Km wide and 50-60 km long in the offshore area, is identified in the southern branch of the Monastir Fault. The maximum uplift is reached in the Cagliari hills with about 1000 m total vertical displacement. In the offshore Gulf of Cagliari, seismic profiles also show the southward continuation of the uplifted zone.

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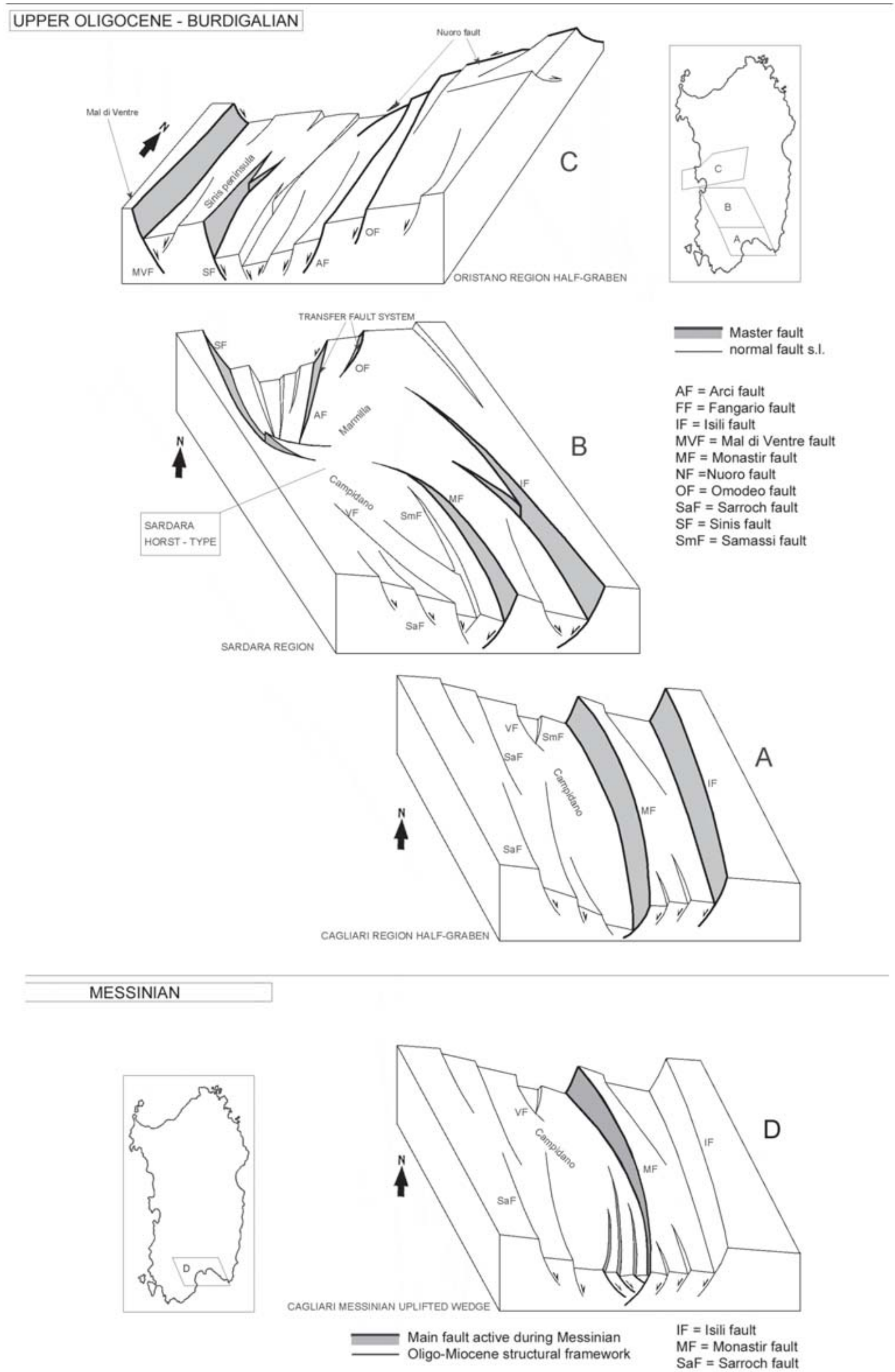

Fig. 2 - Schematic block diagram of the Oligo-Miocene structure in the Campidano area: A) Southern Cagliari Region; B) Sardara region; C) Northern Oristano Region; D) Messinian structure in the Southern Cagliari Region (after Casula *et al*., 2001).

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