by Dominique Frizon de Lamotte and Pascale Leturmy

The Structural Map of the Arabian Plate and Surrounding Areas

Université de Cergy-Pontoise, Département Géosciences et Environnement, F 95000 Cergy-Pontoise, France. E-mail: dominique.frizon-de-lamotte@u-cergy.fr

With contributions from: Philippe Agard (Univ. Pierre-et-Marie-Curie), Jean-Claude Ringenbach (Total), Alexandra Robert (Univ. Cergy-Pontoise), Shahram Sherkati (Iranian National Oil Company) and Jean-Christophe Wrobel-Daveau (Univ. Cergy-Pontoise).

The project of a Structural Map of the Arabian Plate and Surrounding Areas was supported by CGMW in order to bridge the gap between the Tectonic map of Africa (Milesi *et al.*, 2010) and the International Tectonic Map of Asia (*in progress*) and because the Arabian Plate is a very critical area to understand the geodynamic processes which led to the collision between Africa and Eurasia. From an educational point of view, the map can also help teachers to illustrate a variety of tectonic styles and features for undergraduate and graduate students.

The Arabian plate (*see a recent synthesis in* Al Hosani *et al.*, 2013) is a well-defined geological domain located between a south and south-western divergent boundary (the Gulf of Aden and Red Sea) and a north-eastern convergent boundary (the Zagros Fold-Thrust Belt). Laterally, the plate is flanked by two major transform fault zones: the left-lateral Levant Fault to the west and the right-lateral Owen Fault to the east; the Levant Fault being an outstanding example of intra-continental transform faulting.

As the aim of the map is to focus on the Phanerozoic evolution. The Panafrican basement cropping out in the Arabian and Nubian Shields is not differentiated. In the northeastern corner of the map, the Turan epi-Variscan Platform, pertaining to the Eurasian Plate, is also undifferentiated. A chart listing the main geodynamic events occurring in the area has been added to the legend. Two major supercycles (the Tethyan and Gondwanan supercycles, respectively) are recognized above and below the pre-Middle Carboniferous major unconformity. This unconformity is frequently mentioned in the literature as the “Hercynian Unconformity” but, in our opinion, it is unrelated to the Hercynian (*i.e.* Variscan) orogenic system. Our interpretation is that it results from an important Late Devonian thermo-mechanical event accompanied by vertical movements and diffuse extensional deformation. This major, possibly worldwide, episode could be one of the causes of the top-basement “Arch-and-Basin” geometry, which is frequently observed in the old (Precambrian) continental areas and in particular in northern Gondwana (Frizon de Lamotte *et al.*, 2013).

The center of the map is occupied by the Arabian Platform (Konert *et al.*, 2001; Johnson, 2008; Faqira *et al.*, 2009; Al Hosani *et al.*, 2013) for which the thickness of the weakly deformed sedimentary domains (intra-continental basins, continental margins) resting on the Panafrican basement is represented by isopachs. The blue color of the isopachs in the Levant margin and the yellow color of the isopachs in the Red Sea and Gulf of Aden margins highlight the Early Jurassic and Early Miocene ages respectively of the main rifting episodes giving birth to these deep and partly oceanic basins. To the

east the age of the oceanic strip underlying the Arabian Sea is not precisely known and this is highlighted with a specific pattern. In the Arabian Platform, two series of isopachs are drawn above and below the major pre-Carboniferous unconformity discussed above. A N-NE trending inherited structural grain dominates all over the Arabian Platform. It controls not only Paleozoic and Mesozoic depot centers and arches in the Platform, but also the structural style in the Zagros. In addition it is associated with major hydrocarbon fields (Qatar Arch, Ghawar). The imprint of this structural grain is as old as Late Precambrian. The paleogeographic limits of Late Precambrian (Hormuz, Huf and Ara formations) and Miocene salt deposits are indicated. The map shows that Precambrian salt is confined between normal faults suggesting deposition controlled by a Late Precambrian extensional episode. On the other hand, the outline of the limit of Permian deposits allows delineation of the south-eastern and north-western regions where the Mesozoic cover rests over the pre-Carboniferous Paleozoic rocks or directly over the basement. It is, in particular, the case for the Yemen rift system, which developed during a Late Jurassic rifting event. The Arabian Shield and Platform are intruded by Cenozoic alkali basalt bodies connected to the Afar volcanic province and related to a mantle plume located at the triple junction between Red Sea, Gulf of Oman and East African rift systems.

At the northern edge of the Arabian Platform, the Zagros Fold-Thrust Belt represents the Phanerozoic cover of the Arabian Plate detached over the Late Precambrian Hormuz salt and folded into a succession of broad anticlines and synclines [*see a recent synthesis in* Leturmy and Robin (2010) and *in* Lacombe *et al.* (2011)]. The whole system is cut out by late and presently active basement faults, which are responsible for the present day seismicity. In the Zagros, the colors represent the age of the main deformation. This representation helps to visualize the presence of “Cretaceous Nappes”, made up of mantle rocks (serpentinized peridotite) associated with gabbros and sedimentary rocks (radiolarite, pelagic carbonate) coming from the distal margin of the Neo-Tethys and in some places with occurrences of HP-LT metamorphic rocks (indicated on the map with their age by red dots) (Agard *et al.*, 2007). The Campanian-Santonian age of emplacement of these thrust sheets is synchronous with the emplacement (“obduction”) of ophiolitic nappes in Oman and Cyprus. The whole system forms together the “peri-Arabic ophiolitic crescent” defined by Ricou (1971).

In the Zagros, after the emplacement of the Cretaceous Nappes, the closure of the Neo-Tethys Ocean occurred at the end of Eocene times [*see a review in* Frizon de Lamotte *et al.* (2011)]. The map illustrates with different colors the propagation of the deformation

front from the Eocene suture to the foreland. Following Wrobel-Daveau (2011), four successive deformation fronts are recognized. The faster propagation of the deformation in the easternmost Zagros (Fars province) is linked to the presence of a very pronounced décollement level, the Hormuz salt, at the bottom of the sedimentary pile (the main salt plugs are depicted on the map). North of Oman, it is likely that the triangle of oceanic crust wedged between the front of the Makran accretionary prism and the Oman margin represents a remnant of the Neo-Tethys Ocean yet to be subducted. This configuration provides a snapshot of the margin of the Arabian Plate at the beginning of Cenozoic, i.e. after the emplacement of the Cretaceous Nappes but before the collision with the Sanandaj-Sirjan Zone, which pertains to the Cimmerian Domain (see below).

A set of continental micro-blocks are displayed between the Zagros suture and the undifferentiated Eurasian domain outcropping in the north-eastern corner of the map (the Turan epi-Variscan Platform). Two categories of blocks are distinguished: the Cimmerian blocks to the east and the Taurus-Lesser Caucasus blocks to the west. On the map, these blocks are subdivided in three colors symbolizing the intensity of deformation and the nature of material (cover and/or basement) involved in deformation. The Cimmerian Domain drifted from Gondwana by the Late Permian, as a consequence of Neo-Tethys opening and accreted to Eurasia during the late Triassic, as a consequence of Paleo-Tethys closure (see a recent synthesis in Brunet *et al.*, 2009). By contrast, the Taurus-Lesser Caucasus Domain drifted towards Eurasia by the Middle(?) Jurassic when the East Mediterranean oceanic or hyper-stretched deep basins developed (see a recent synthesis in Sosson *et al.*, 2010). The Cimmerian and Taurus-Lesser Caucasus Domains are ornamented by subduction-related magmatic rocks of Upper Triassic to Neogene age (with a massive occurrence during the Eocene), indicating that they must be interpreted as the active margin of the Neo-Tethys. Accordingly, minor sutures within the two Domains are interpreted as deep back-arc basins opened during the Late Jurassic-Lower Cretaceous and closed during the Upper Cretaceous, probably when the Cretaceous Nappes emplaced.

The Alborz and Kopet Dagh are currently active Cenozoic Belts marking the boundary with the Eurasian Plate. The South-Caspian Basin, classically interpreted as a back-arc basin related to Neo-Tethys subduction, is filled by up to 24 km of sediments resting upon an oceanic basement. The age of the basement is not precisely known (Upper Jurassic-Lower Cretaceous?) and is represented, as in the Arabian Sea, by a specific pattern. It is, however, recognized that the age of sedimentary filling is mainly Cenozoic (illustrated by the yellow color of the isopachs). The bending of the Alborz Belt around the South-Caspian Basin is interpreted to be related to the rigidity of the underlying oceanic basement acting as a buttress during compressive deformation.

Currently, the entire domain sandwiched between the Turan epi-Variscan Platform and the Arabian Platform is included in the Alpine Orogenic System and remains the site of diffuse but significant tectonic activity.

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