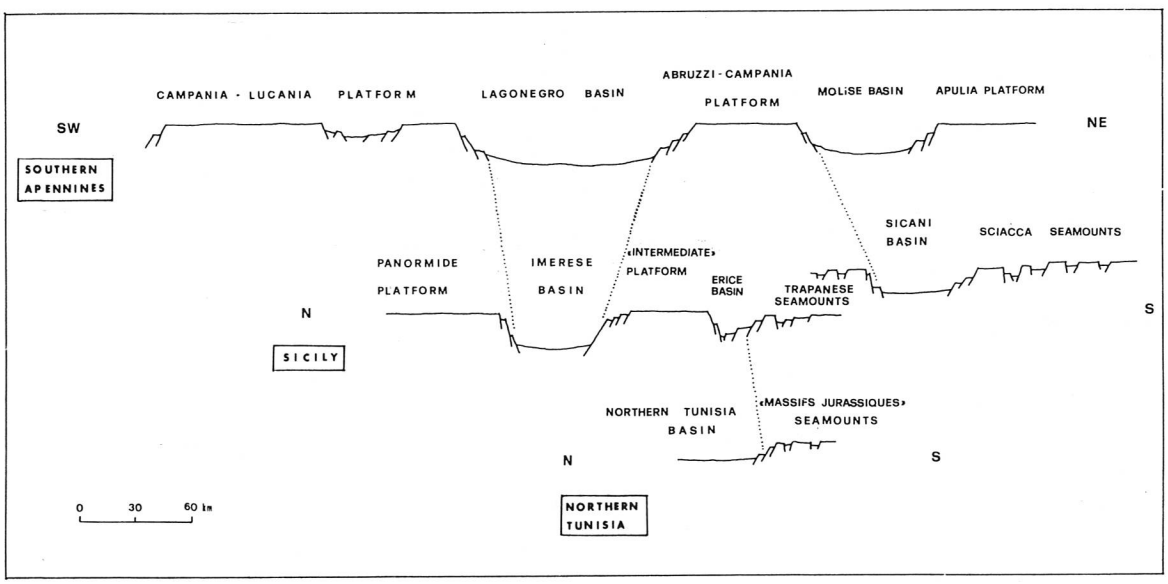
The connection between the Apulia and the Sahara continental margins in the Southern Apennines and in Sicily

by

P. SCANDONE, G. GIUNTA et V. LIGUORI
Istituto di geologia, Università, Palermo (Italie)

Present status

Sicily, Calabria and the Campania-Lucania Apennines are a very interesting portion of the Maghreb-Apennines-Dinarides system, in which the Maghreb E-W direction of the main units become N-S in Central Calabria, and finally NW-SE in the Southern Apennines. In Tunisia the pile of the Maghreb nappes overlie the Northern part of the Atlas.



The so-called Ragusa platform has been classically assumed as African foreland for the Sicily nappes. The palinspastic connections between this belt and the more internal zones affected by tectogenesis are not yet completely clear. It is probable that the Ragusa zone is connected with Sahel and Northern Libya trough Malta and the Sicily Chanel. These areas seem to belong to a less stable, marginal belt of the Sahara plate, the Pelagian sub-plate, separated from the Atlas sub-plate by the Zaghouan fault system.

CIESM,

Rapp. Comm. int. Mer Médit., **23**, 4a, pp. 99-103, 3 figs., (1975).

The Pelagian sub-plate southwards become more and more stable, gradually passing into the Sahara platform *sensu stricto*. The Apulia platform is the foreland of the Apennines. The connections between this belt and the more internal zones affected by tectogenesis are well known. Sismic profiles in the Ionian area distinctly show that the internal margin of the Apulia platform bends towards Greece, and disappears, plunging beneath Peloponnese. Moreover several geophysical data suggest a crustal composition of the Ionian area quite different from that of the Adriatic zone.

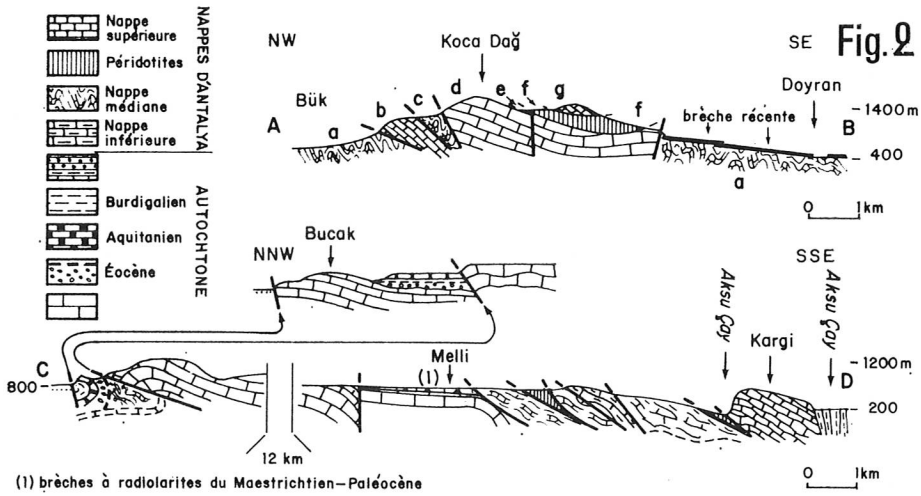
It is not possible to exclude that the Ionian area was a belt characterized by thinned crust during the Alpine cycle; the geochemical data on the Aeolian recent volcanism suggest the existence of a slab of oceanic composition subducing beneath the Calabria-Peloritani arc.

In conclusion, the foreland of the Maghreb-Apennines system may be divided in three main parts :

a. the African element *sensu stricto*, actually moving northwards, as shown by compressional features at the foot of the Algeria continental slope;

b. the Ionian element, actually moving in NW direction (subduction beneath the Calabria-Peloritani arc and consequent Aeolian calc-alkaline volcanism);

c. the Apulia element, actually tectonically inactive.



Development since upper triassic

Fig. 1 shows a restoration of our area in Jurassic times. During Upper Triassic a remarkable seaway existed between shallow water carbonate platforms. In Sicily we recognize two branches.

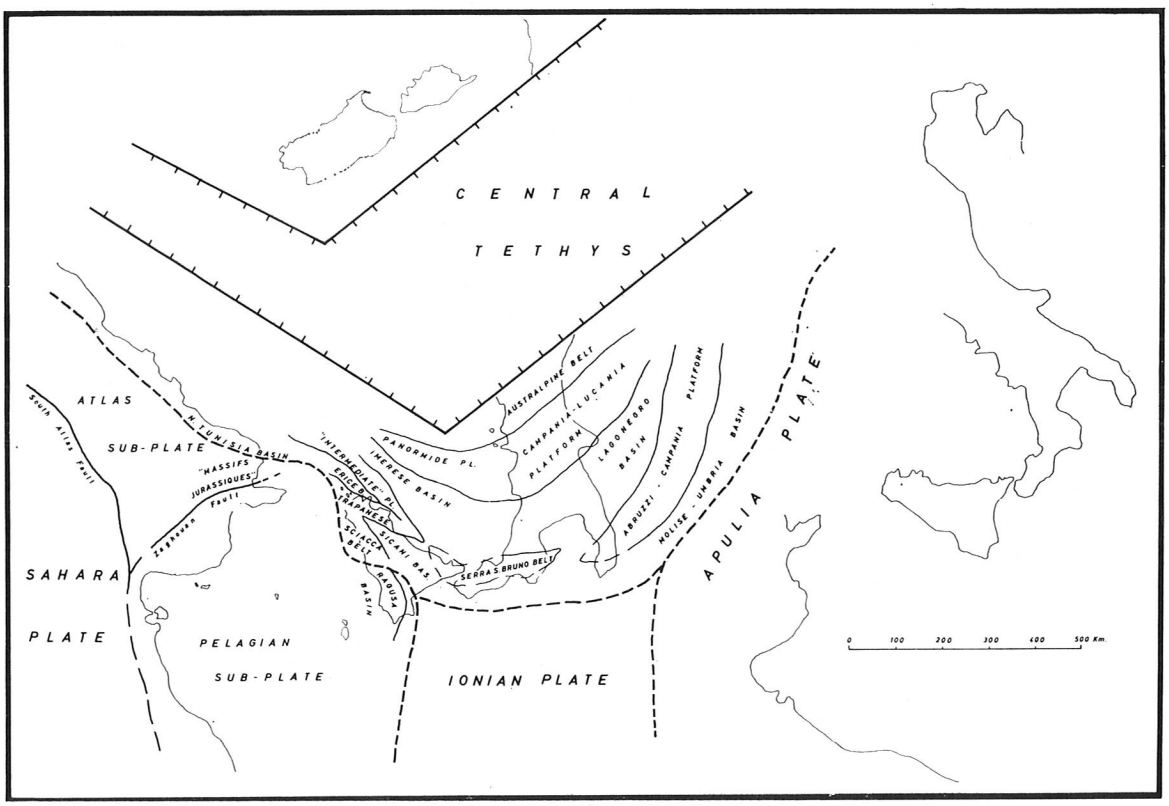
During Middle Liassic a widespread tectonic phase intersects the carbonate platforms : new subsiding basins are created, large fragments of platform sink below the photic zone and become places of condensed pelagic sedimentation. The Imerese basin lengthens westwards, in the direction of the Maghreb. In Sicily the dissection of the platforms and the deepning of the basins are accompanied (Upper Liassic-Lower Dogger) by volcanic activity (acid tuffites in the platform areas, basalts and hyaloclastites in the basins). In Dogger-Malm the outline sketched by the Middle Liassic tectonics become sharper; in the basins the sea floor generally exeeds the compensation depth of the carbonates. During Cretaceous the characters are slightly different; the margins of the basins are more active, and the deepsea conditions are generally less pronounced.

In the carbonate areas local emersions occur. In the Paleogene a lot of the carbonate platform areas emerge. At the end of the Paleogene and at the beginning of the Miocene, flysch deposition begins in the Imerese-Lagonegro basin. During Burdigalian the subduction of the Southern continental margin of the Tethys reaches our isopic zones. The first nappes of the Maghreb-Apennines system are piled up, and contemporaneously the Paleogene Alps system partially overthrusts the Neogene Maghreb-Apennines nappes. In Middle-Upper Miocene the Maghreb-Apennines building is constructed in the main lines.

In this time the most convex part of the Maghreb-Apennines nappes arc is thrusted towards the foreland more than the other parts of the chain; the Calabria-Peloritani arc is thus clearly drawn. Continuing the subduction, in the Pliocene the chain as a whole is thrust upon the foreland for at least 30 kilometres; the Calabria-Peloritani arc is of course strongly emphasized. The most internal parts of the Maghreb-Apennines system and the greatest part of the Paleogene Alps system collapse in the actual Tyrrenian Sea area.

During Quaternary the Apulia margin becomes inactive, while the Sahara and mainly the Ionian margins are still active.

In conclusion, looking at the palinspastic map we see that the sector under discussion, about 1000 kilometres long, of the Southern continental margin of the Tethys has been affected by compression across 250-400 kilometres in width from Burdigalian up to the present time (18 million years). This corresponds to an average subduction rate of about 1,4 - 2,2 cm/year. But the nappes which make up the Maghreb-Apennines system represent only the skin of the corresponding litospheric plates : a lot of crust disappeared in the asthenosphere. This is a general fact in mountain buildings, as LAUBSCHER (1970-74) has clearly demonstrated.



In a two-dimensional calculation, assuming a continental margin affected by compression across an average of 30 kilometres, we obtain in our area 300.000 square kilometres of paleogeographic realms which took part in the deformation. If we average the width of the chain at 130 kilometres, we can deduce that 170.000 square kilometres — that is, more than half of the original surface — have been subtracted from the system.

In a three-dimensional calculation, assuming at the beginning of the Alpine cycle an average thickness of continental crust of 30 kilometres, we obtain 9 million cubic kilometres of continental crust affected by deformation. Seeing that the actual width of the chain is 130 kilometres, and assuming here an average

depth of the Moho of 40 kilometres, we can calculate a volume of 4,8 million of cubic kilometres. About half of the original volume of crust is lost, having been subtracted from the system. In effect, the lower crust, more dense, takes part in the subduction with the mantle, and only the upper crust is packed in the roots of the chain.

This must induce us to remember, when we play with plate motion in the Mediterranean area, that our chess-board is not a closed kinematic system.

*
* *

Discussion

Caire A. : Vous avez figuré une plaque ionienne entre le plateau de Raguse et l'Apulie. Quels sont les caractères de cette plaque et de ses limites?

Au Mésozoïque, le plateau de Raguse et l'Apulie ont des caractères de plateforme carbonatée. Les faciès peuvent se modifier d'un point à l'autre d'une plateforme. Pourquoi donc voulez-vous séparer ces deux régions par une plaque distincte? Dans leur qualité d'avant-pays (resté à l'abri des dislocations tangentielles alpines), le plateau de Raguse et l'Apulie ont pour équivalent maghrébin le Sahara, et non pas l'Atlas tunisien plissé. Votre limite de la zone orogénique alpine devrait donc joindre aussi le bord interne du plateau de Raguse à l'accident sud atlasique.

Giunta : 1. Some good seismic profiles show that Apulia is in continuity with Greece. Otherwise Ragusa is a basin with pelagic sedimentation and not a plateform. Sediments are not calcarenites but turbidites occur.

Biju-Duval B. : Il y a deux ans à Athènes, B. RYAN a présenté un schéma de reconstruction de différentes plaques et sous-plaques en Méditerranée au cours du Mésozoïque et du Cénozoïque, repris récemment dans l'article de DEWEY *et al.* Vous avez reconstruit un schéma valable pour la Méditerranée moyenne en définissant différentes plaques. Avez-vous des arguments qui permettent de définir ces plaques par la présence soit de zones de divergence (medio-oceanic ridge) soit de zones de convergences (subduction zones) au cours du Mésozoïque entre les plateformes saharienne et pélagienne, la zone ionienne et la plateforme apulienne?

Deuxième question : il me semble que les données pétrolières publiées par l'AGIP montrent qu'au Sud du plateau de Raguse existe au Lias et au Jurassique inférieur une zone plus profonde suggérant une marge au Sud de Raguse. Avez-vous tenu compte de ces données dans votre reconstruction?

Réponse du présentateur : I am not a geologist but our conclusions are different from official data, there are no evidence of compressive features.

Flores G. : The current interpretation of the Iblei plateau indicates that with the exception of an interval in the Mesozoic, particularly in the Jurassic, with pelagic sedimentation, the area has represented a platform Triassic throughout miocene times. This point is based on the study of hundreds of well sections. I refer in particular to a paper by F. BARBIERI.

P. Scandone. Reply to the questions put by G. FLORES, A. CAIRE and B. BIJU-DUVAL :

I think it right to concentrate my answers in a single reply, as several questions put to me have common elements. Let us begin from the Ragusa " platform ". The available data from the drilled wells and from surface information allow to reconstruct the following geological history.

Late Triassic : deposition of shallow water sediments, represented by dolomites and evaporites. At the end of Triassic, tectonic fragmentation of this shelf in several blocks, which underwent different subsidence.

Liassic : deposition of calcareous turbidites, generally dolomitized, currently interpreted as shallow water dolimites; deposition of allodapic limestones, currently interpreted as " epicontinental " pelagic limestones, and of black shales (Streppenosa Formation), with rare intercalations of real pelagic lime mudstones. The sudden and great variation of the thicknesses, mainly in the Streppenosa Formation, are indicative of active synsedimentary faulting.

Dghger-Malm : deposition of pelagic lime mudstones, with rare turbidite levels. The intensity of the syn-sedimentary tectonics is reduced.

Cretaceous : deposition of pelagic lime mudstones in the basin, deposition of shallow water limestones on volcanic seamounts. In the upper part of the sequence the turbidite content increases, with diffuse slump phenomena.

Paleogene : gradual transition from pelagic to neritic deposits. The synsedimentary tectonic activity stops.

Neogene : deposition of shallow water calcarenites, marls and clays upon a stable platform area.

The Ragusa " platform ", therefore, evolved from an unstable shelf to an active and moderately deep basin, and finally to a stable platform. I think we may make a great mistake in minimizing or ignoring the role of the Mesozoic synsedimentary tectonics.

Let us consider now the connection between the Ragusa and the Apulia platforms. The basinal facies of the Ragusa zone pass eastwards (Siracusa area) to platform margin and to seamount facies. In the Ionian Sea seismic explorations suggest very thick sedimentary sequences below the Messinian evaporites, but their facies are not known. In the Apulia platform the Mesozoic facies are indicative of shallow water environment. I think that the affirmation made by prof. CAIRE that the Mesozoic facies of the Ragusa and Apulia zones are comparable, is inexact. Seismic surveys in the Ionian Sea, on the other hand, clearly indicate that the Apulia platform does not bend towards the Ragusa zone, but towards Greece, where it plonges beneath Peloponnese. Deep seismic and gravimetric data indicate different crustal composition in the Apulia, Ionian Sea and Southern Sicily. Finally, if we accept the interpretation, proposed by BARBERI and others in 1973, of the deep focus earthquakes below the Tyrrhenian Sea and of the Aeolian volcanism, we must admit that the Ionian plate still plays an independent kinematic role.

We distinguished the three areas for the above reasons. All three areas, of course, belong to the northern margin of the African continent, as we have demonstrated in our palinspastic reconstructions. They must be considered, of course, microplates, that is, minor elements of the great Africa plate. In this scheme the foreland of the Maghrebide-Apennine system undoubtedly extends from Sahara to Apulia, crossing different elements.

I do not agree at all that the Apulia, Ragusa and Sahara zones represent kinematically equivalent zones. We can relate the building up of the Maghrebide-Sicilian part of the chain to the northward component of the African movements, with consequent subduction of the Sahara continental margin beneath the Iberian block. On the other hand, we can relate the building up of the Apenninic part of the chain to the westward component of the African movements, with consequent subduction of the Apulia margin beneath the Corsica-Sardinia block. The amount of the westward motion seems to have been greater than the northward one. Besides, along the African margin *sensu stricto* (Atlas and Pelagian subplates) the front of the movement could have fragmented in several segments. These progressed differently across the external areas, and were connected by transform segments. Because of the above, the front of the movement of the Sicilian nappes can be individuated in the Sciacca zone, while the same front of the movement in Tunisia passes along the southern margin of the folded Atlas mountains. Similar differential motions of the fronts of the movement within the foreland are described, for instance, by LAUBSCHER [1974] in the Alps. From the kinematic point of view the Tunisian folded Atlas mountains may be regarded as the equivalent of the folded Jura mountains. The Sicilian nappes may represent an equivalent of the Helvetic nappes south of the tabular Jura, where the front of the movement lies in a more internal position compared with that of the folded Jura mountains.

Au cours de la discussion un participant ayant signalé que le bassin de Trapani ne correspondait pas à un facies jurassique mais tertiaire, les auteurs précisent " We do not speak about Trapani basin, but about Trapani belt and seamounts. We have to compare the elements which are comparable. Taormina dolomite is manily a turbidite facies. In Ragusa basins we found slumping ".

*
* *