3c. In the Thrace Evros basin, Early Miocene (22-19.5 Ma) calc-alkaline and K-alkaline rocks occur, suggesting an origin from both lithospheric mantle and crust related to post-collisional extensional processes and core complex exhumation. In the Thrace basin, Na-alkaline basalts occurred at 8.9-4.5 Ma; decompression melting of an asthenospheric source may be related to a westward mantle flow generated by the block movement along the North Anatolian fault system;

3d. The South Moesian block has an N-S line of Na-alkaline basalts that started in the Oligocene and become younger toward the south at 21.4-19.4 Ma. They have an asthenospheric source that may be connected to local fractures related to Tisia-Dacia block rotation movements around stable Moesia.

Thus, the mantle dynamics and melt generation in CPR and surrounding areas are echoes of many subduction, collision, rotation and extension processes of several microplates that acted variably in the convergence between Africa (chiefly Apulia) and Europe since the Cretaceous period until Recent time.

From local geology to global plate tectonics

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There is no plate tectonics modelling without local geological investigations, and a few square meters of well-dated radiolarian cherts can completely change a tectonic model. If ample geological information can be obtained from a given outcrop, the next step consisting in interpreting these in terms of geodynamic environment will often generate contradicting points of view. That is where the larger plate tectonics modelling will bring some constraints.

Most disagreements are rooted in 2D cross sectional approaches of local information, usually considering all the presently juxtaposed geological units as potential actors of a single geodynamic history. Plate tectonics modelling certainly helps in solving the exotic nature of a given unit, and it can be shown that large scale displacement of terranes is rather the rule than the exception.

This can be tested in the Pacific region during the last 250Ma. Terranes have been crossing this large expanse of water, colliding with each other, and then being re-dispersed from tropical to polar regions. Still, these processes are constrained through properly done local investigations. Similarly the Variscan terranes have experienced long distance travelling, from their peri-Gondwana position to their amalgamation along the Eurasian margin. Their final juxtaposition resulted from further displacement during the formation of Pangea. In this instance, the final juxtaposition cannot be used readily to decipher the wander path of these terranes, and only a well constrained plate tectonics model will offer a possible solution.

It is clear from our plate model that the European Variscan terranes occupied the whole border of Gondwana, from South China to South America. The different geodynamic settings along that margin allow defining the former location of the different terranes. The intra-alpine Variscan and Mediterranean terranes were located close to South China, the Iberian terranes were close to the Libyan-Egyptian part of Gondwana, and the Armorican terranes s.l. were located further west. The so-called Rheic margin of Gondwana experienced quite different geodynamic evolutions before the detachment of the Variscan terranes. This can be used as a guideline to put in place this amazing puzzle.

The western Tethyan realm is dominated by the closing of the Paleotethys and the concomitant opening of the Neotethys in the Permo-Triassic times. This process followed the assembly of Pangea and amalgamation of Variscan terranes. However, if continent-to-continent collision took place from the Alleghanian N-American domain to the west Mediterranean area, further east (from Italy to the Middle East) the southern margin of Eurasia remained an active margin. This generated the opening of numerous back-arc basins along that margin from the Late Permian to Late Triassic. The continuing subduction of Paleotethys northward also generated slab pull forces that triggered detachment of the Cimmerian ribbon terrane from Gondwana in the Permian, as did the Variscan terranes in the Devonian.

In that respect the Variscan scenario is quite similar to the Cimmerian one, terranes detached from Gondwana collided with terranes derived from Eurasia, and finally the amalgamated terranes were squeezed between larger continental masses (Gondwana and Laurasia in the Carboniferous for the Variscan orogenic event, Africa-India and Eurasia in the Tertiary for the Cimmerian-Alpine event).

The eo-Cimmerian orogenic event, however, has quite distinct features. The collision was mainly Late Triassic in age corresponding to the final closure of the Paleotethys in Greece, Turkey, Iran, Afghanistan and further east. Jurassic Cimmerian events in the Balkan and Turkey were related to the closure of some Paleotethyan back-arc basins (Maliac, Küre) and to shortening in neighbouring areas such as the Caucasus. The final collision in these areas with larger landmasses occurred only in the middle Tertiary, so the delay between terrane accretion and final orogenic events was locally quite long (up to 200 Ma).

So, the Cimmerian collisional events must be regarded as separate from the Variscan and Alpine ones. The other main difference is that the Variscan terrane accretion was an arc-arc collisional event, resulting in important HT type metamorphism, accompanied by large magmatic pulses related to mantle delamination. For the Cimmerian event, the collision was between a ribbon type passive margin and island arc type terranes, it resulted in soft docking with little metamorphism and magmatism, and limited orogenic processes. In areas where the Cimmerian suture can be studied in details, such as central Iran, the fore-arc series (arc side, upper plate) are found resting directly on the flexural bulge of the passive margin (lower plate), both separated by a few hundred meters of highly sheared flysch-like deposits. The lower plate is hardly deformed, the upper plate presents some imbrication and shortening, and the intervening accretionary prism has nearly completely disappeared, it was totally underplated.

Both upper and lower plates had been previously thinned due to rifting (separation of the Cimmerian terrane from Gondwana on one hand, separation from the Eurasian active margin by back-arc spreading on the other hand). Thus the superposition of both thinned plates in the Triassic did not create much isostatic rebound, and in some areas where the Cimmerian terrane was not very large, sedimentation continued during most of the Triassic, both on the lower plate side, and on the newly created passive margin of the back-arc, to the north of the orogenic zone.

This makes the Cimmerian event difficult to recognize in some areas. The suture zone was not very large, and in Greece and Turkey it hardly outcrops. However, this Late Triassic period was accompanied by widespread clastic influxes in surrounding basins, the Cimmerian collage being surrounded by oceans on its southern (Neotethys) and northern (Eurasian back-arc) sides. Some of these clastic deposits contain olistostroms with blocks clearly pertaining to the disappeared Paleotethys (e.g. pelagic Carboniferous to Early Permian, totally absent outside of the Paleotethys). Some remnant flexural (molassic) basins are also known in Iran (Shemshak). In Turkey they were often interpreted as rift basins. However, a thorough study of the clasts in Late Triassic Turkish conglomerates has shown their exotic nature, and mainly their late Paleozoic pelagic characterictics, showing that they were derived from a suture zone and not rift related; they are commonly followed by a major stratigraphic gap.

In Greece, the remnants of the Cimmerian events are scarce, because of the lack of relevant outcrops. This situation is due to the fact that the final collision with a large landmass (i.e. Africa) has not yet taken place. The Cimmerian remnants are still underplated under the external Hellenides, and/or covered by large carbonate platforms. Our investigation during the last 20 years on this problem has brought to the light that most substratum of the external domain can be attributed to the Paleotethys Permian fore-arc domain, strongly affected by Triassic rifting (somehow quite similar to the present-day Aegean sea area) that led to the opening of the Maliac and Pindos back-arc basins. The latter ceased opening when the arc to the south of it collided with the Cimmerian Apulian terrane. However, the suture zone is not seen, or indirectly, because some Triassic conodonts found in the east Mediterranean basin (Neotethys) are not present in the Pindos north of it. A major barrier prevented these animals and few other species to pass from one basin to the next.

So, in conclusion, the larger geodynamic picture can be derived from the study of suture zones over a large area and from the evolution of margins on both sides of it, but in some areas, only pebbles or microfossils will lead to the solution. It is up to the geologists to use both approaches with some wisdom.

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