ANN. INST. GEOL. PUBL. HUNG. | vol. LXX. | Budapestini, 1987

Proceedings of the VIIIth RCMNS Congress

NEOGENE GEODYNAMICAL EVOLUTION OF A PYRENEO-MEDITERRANEAN GRABEN: THE ROUSSILLON EXAMPLE (SOUTHERN FRANCE)

by

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The Roussillon graben is located to the extremity of the Pyrenean "axial zone". It extends over the margin of the Gulf of Lion. As such, it is a structure that conjointly affects the marine and the continental domains.

Two major faults delimit this graben: to the north, the Prades' fault (N 60° E) and to the south, the Albéres' fault (N 85° E). Near the shoreline, in the heart of the basin, the well Canet 1 (GOTTIS, 1958) has rediscovered the Paleozoic basement underneath a sedimentary filling 1800 meters thick. That graben depth diminishes toward the West where this same Hercynian basement reappears.

The Neogene age of this tectonic unit is attested by the faunas delivered by this sedimentary filling. This one is organized in two superposed and inconformable detritic sequences:

— underneath, a Miocene series that outcrops along the edges of the basin and that was rediscovered in depth by the drills;

— over it, a Pliocene series, wildly outcropping on the surface.

These two stratigraphic units have also been recognized off-shore, in the Gulf of Lion: as well as by the sea drills (CRAVATTE and al., 1974) and by the sismic cross sections (GENNESSEAUX et LEFEVBRE, 1980).

The Miocene rifting

During this period, this rift showed two characteristics:

— an orientation at right angle to the shoreline,

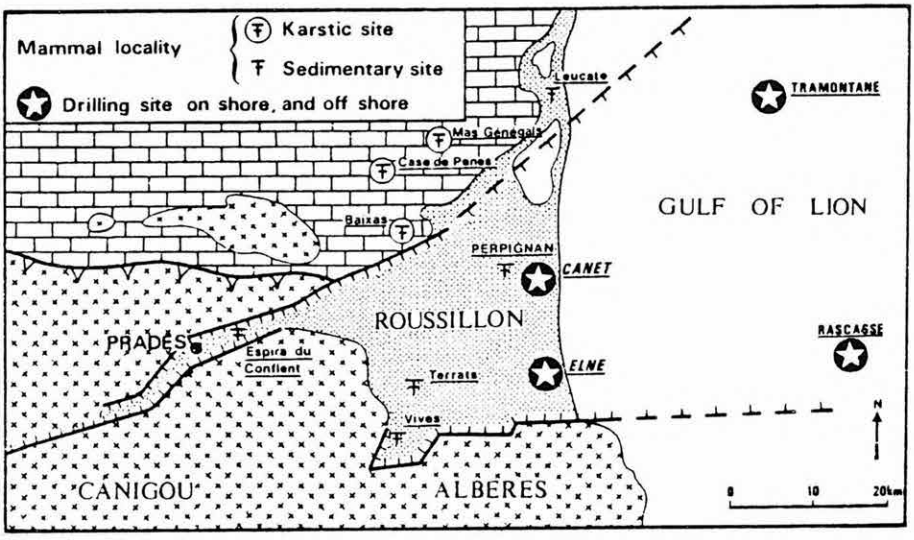
— an amphibious disposition.

The Miocene facies. First, one observes a major opposition: to the East of the basin, the facies are exclusively marine (CRAVATTE et al., 1974) while, to the west, they are exclusively terrestrial (BANDET, 1975; CLAUZON et al., 1982, 1986).

Furthermore, within every one of these domains, one notices sedimentologic gradients. Within the marine domain, this gradient strikes west—east: it opposes sandy littoral formations with benthonic Foraminifera to the west, to the siltic deposits with pelagic faunas from the eastern open sea. Within the continental domain, it is an opposition between proximal (megabreccias) and distal (arkoses) facies which are disposed after a submeridian fashion, i.e. at right angle with the bordering accidents of the basin.

Chronostratigraphy of the Miocene series. On shore as well off-shore, this Miocene series is enframed by two unconformities:

— at the bottom of the graben, it rests in plane unconformity over the Palaeozoic basement;


Mammal locality
Karstic site
Sedimentary site
Drilling site on shore, and off shore
Leucate
TRAMONTANE
Mas Genegals
Case de Penes
Baixas
GULF OF LION
PERPIGNAN
CANET
ROUSSILLON
PRADES
Espira du Conflent
RASCASSE
ELNE
Terrats
Vivès
N
CANIGOU
ALBERES
0 10 20km

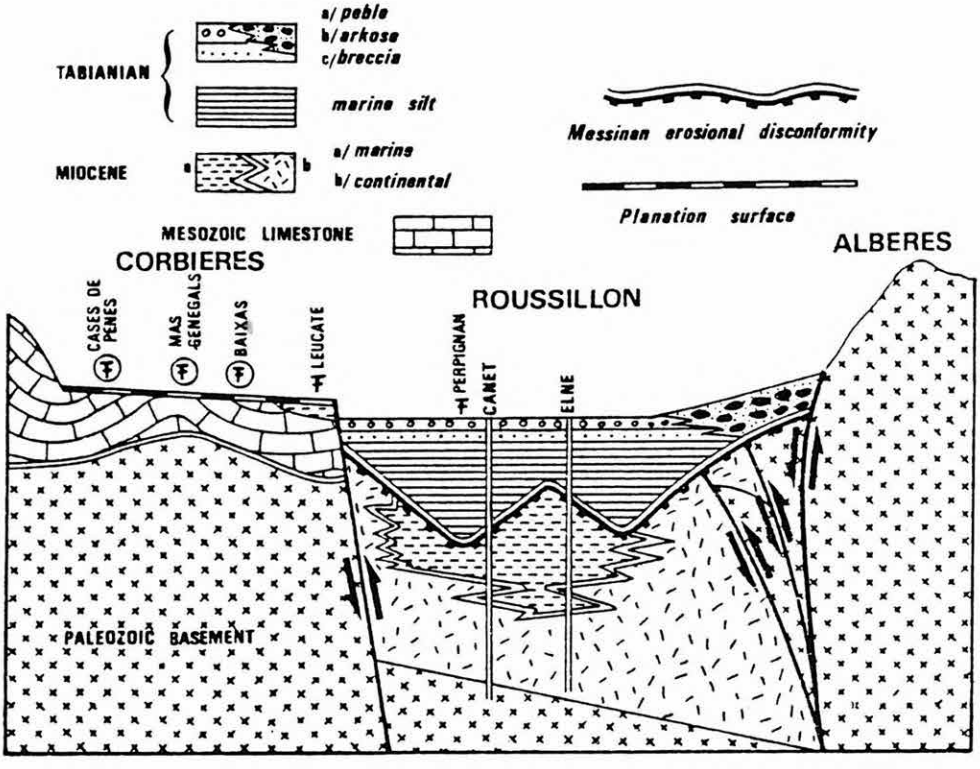

TABIANIAN
a/ peble
b/ arkose
c/ breccia
marine silt
MIOCENE
a/ marine
b/ continental
Messinan erosional disconformity
Planation surface
MESOZOIC LIMESTONE
CORBIERES
ROUSSILLON
ALBERES
CASES DE PENES
MAS GENEGALS
BAIXAS
LEUCATE
PERPIGNAN
CANET
ELNE
PALEOZOIC BASEMENT

Fig. 1.

— at the top, it is truncated by the Messinian gullied unconformity which separates it from the overlaying Pliocene unit (BUROLLET et BYRAMJEE, 1974; BURRUS, 1984; CLAUZON et CRAVATTE, 1985).

Within the marine domain, the chronostratigraphic attributions rest upon Foraminifera and/or nannofossils (Canet, Rascasse, Tramontane and Autan drills) while, with respect to the littoral or continental domains, they rest upon rodents (BAUDELOT et CROUZEL, 1974; AGUILAR et MAGNÉ, 1978; CLAUZON et al., 1982, 1986; MICHAUX et AGUILAR, 1985).

In the off-shore drills, the Miocene series begins as early as the lower Aquitanian and ends—at the latest—within the Serravallian (CRAVATTE et al., 1974). On shore, within the satellite graben of Conflent, the rodent locality of Espira du Conflent (BAUDELOT et CROUZEL, 1974) provided a lower Burdigalian age, which allowed the datation to the Aquitanian of the 200 meters of arkosic deposits over which it rests (BANDET, 1975). To the upper limit of the series, included in a core sample cut off right under the Mio—Pliocene unconformity, the drill Canet delivered *Globigerinoides sicanus*, the Langhian planktonic marker (CLAUZON et CRAVATTE, 1985).

These results allow to say that—over the whole rift—the first levels of the filling belong to the lower Miocene while the upper part of this series is not older than the Serravallian. The chronological gap between the Miocene and Pliocene units corresponds to a duration of around 10 m.y. (CLAUZON et CRAVATTE, 1985).

The planation surface of the northern basin border. The Roussillon basin is overlooked to the north by a horst crowned by a Mesozoic carbonated cover: the Corbières unit. The folded structures which affect these Mesozoic carbonates are truncated by a planation surface which average elevation is around 200 meters (CORNET, 1975). This surface rises up, westward, very progressively. On the eastern side, it goes under marine deposits of a recognized Miocene age (DONCIEUX, 1903; MAGNÉ, 1978).

The geological testimony of this planation surface is twofold: palaeogeographical and geochronological. After the palaeogeographical point of view, this level—transgressed by the Miocene seas—makes up an excellent hypsometric landmark of the shorelines. Following the chronostratigraphic point of view—thanks to the numerous rodent karstic localities it delivered (MEIN et CORNET, 1973; CORNET et al., 1976; AGUILAR et MICHAUX, oral indication)—it is also a priceless landmark. Therefore, the datations provided by these karstic microfaunas are widely heterochronous, ranging from the Stampian to the Upper Pliocene.

Motionless in space (at least during the Miocene) and permanent in time (at least during the Neogene), that planation surface thus demonstrates that the horst —upon which it rests—has not been uplifted during Neogene times. Hence, the important throw (2000 m), which put it out of level with respect to the Roussillon graben, is to be exclusively imputed to the subsidence of this graben.

Chronology of the rift subsidence. Within the heart of the basin (Canet drill), the Hercynian basement has been reached at – 1837 meters (GOTTIS, 1958). Out of that value, 200 meters are due to the Plio—Quaternary subsidence (CLAUZON et al., 1986). Thus, the Miocene subsidence is settled at about 1600 meters. An isochronous datum line—implanted on one hand in the basin and, on the other hand, upon the horst—permits to follow its chronological evolution during the Miocene. It is question, in the basin, of the already mentionned presence of the Langhian marker (Globigerinoides sicanus) from the Canet drill. Its faunistic association indicates a very shallow depth. On the other hand, on the Corbières horst, the locality of Leucate (AGUILAR et MAGNÉ, 1978) is concerned. This rodent microfauna (equally of Langhian age) has been delivered by a littoral deposit so its bathymetry have the same value than the preceding.

At the time of their setting, these two levels were localized at the same elevation. Today not including the Plio—Quaternary subsidence), a difference of 600 meters is recorded between them. It took place between the Langhian and the Messinian unconformity and gives the value of the subsidence in this apace of time. Accordingly, the subsidence belonging to the lower Miocene can be appreciated: its value is around 1000 meters (CLAUZON et al., 1986).

The Upper Miocene compressive episode

The southern edge of the basin (at leat, to the east of Maureillas) is marked out by a reverse fault. Following a simple or a repetitive superposition (Le Boulou thrust slices), the Palaeozoic basement is overlying the Tertiary material. Against the fault the layers are vertical and they have a megabrecciae facies. Their elements are issued from the southern Albères horst. They show a progressive unconformity.

These compressive structures are sealed by the Pliocene series that begins as early as the lower Tabianian (CLAUZON et CRAVATTE, 1985). Hence they are older. On the other hand, they are posterior to the Lower and Middle Miocene subsidence. Consequently this event occurred within the Upper Miocene.

The Messinian gullying episode

The geometry and the chronology of this gullying event are well-known (CLAUZON et al., 1982, 1985, 1986). During this episode—synchroneous of the Messinian salinity crisis—the three Roussillon rivers (Agly, Têt, Tech) have deeply cut through the Miocene filling series. Following a north—south cross section, established to the right of the present day shoreline, drops of several hundreds of meters are recorded between the palaeothal wegs of these rivers and the intermediate palaeocrest-lines (CLAUZON et al., 1986).

The dislevelments, meseared along the longitudinal profiles of these same rivers, are not less. Estimated along the whole lenght of the basin, they check around 600 meters, value corresponding to the average slopes plotted at 15 to 16‰, i.e. 4 to 5 times greater than the present-days.

The gullied topography—so obvious on the continental domain—extents offshore until the evaporites of the abyssal plains (MAUFFRET et al., 1973; BUROLLET et BYRAMJEE, 1974; RYAN, 1976; CITA et RYAN, 1978; MONTADERT et al., 1978; GENESSEAUX et LEFEBVRE, 1980; BURRUS, 1984).

Connecting the continental data and the submarine's, one succeeds restituting the continuity of the "Messinian erosional surface" (CITA et RYAN, 1978) from the Pyrenean mountain to the abssyal plains, over a distance of a hundred kilometers.

The Pliocene ria filling

Two major phenomenons occurred during the Pliocene:

— first one, the ingression of the Messinian canyon,

— second one, the following filling of these rias.

Geometry and facies of the Pliocene filling up. The top of this filling corresponds to the terminal level of the alluvial piedmont built by the Roussillon three rivers. This piedmont slopes eastward following the basin axis. It is exclusively made up of continental material: coarse (gravels) to the west, finer (arkoses and silts) to the east.

On the contrary, the bottom of this series is only made up of marine sediments. They are littoral to the west and epibathyal to the east.

The thicknesses of this filling series are, paradoxically, less important in western proximal position (300 meters) than in eastern distal situation (908 meters).

Finally, one notices a singularity in the stratigraphic relationship between the Miocene and Pliocene series: to the south—west of the basin, the latter is inset within that one (CLAUZON et CRAVATTE, 1985). One knows that such a setting cannot be explained by tectonics.

The Pliocene tectonics. Nevertheless, the Roussillon basin has not been spared by the Pliocene tectonic activity. In order to appreciate the undergone deformation, one disposes of a convenient reference—known as being stable during the studied time (VAIL and HARDENBOL, 1979)—the limit marine/continental. During the Tabianian, this limit has prograded over the whole length, today emerged, of the basin (CLAUZON et al., 1986). The curve of the Tertiary eustatic changes of sea level (VAIL and HARDENBOL, 1979) give a height of +80 meters to that reference level. Today, in the western part of the basin, the Tabianian coastal beds are laying between +130 and +200 meters while they are buried at −150 meters, right facing the shoreline (CLAUZON et CRAVATTE, 1985). So, we have an evidence that, during the Plio—Pleistocene, the basin has undergone a rocking motion: it went down around 250 meters to the east. The numerical ratio of the sedimentary accumulation (900 meters) and of the subsiding (250 meters) as well as the attenuation of these values westward, demonstrate that a loading subsidence is the prime cause of this movement.

Age and geodynamics of the Pliocene filling up. That loading subsidence is synchronous with the up lifting of the Albères horst, conjointly proved by the recurrent faulting of its northern accident and by the Villelongue dels Monts cyclopean breccia.

Still recently, this Roussillon Pliocene series was ascribed to the Plaisancian. Actually, it belongs only to the Tabianian stage (CLAUZON et CRAVATTE, 1985) of which it covers only the lower and middle parts since the Perpignan vertebrates beds, located at its roof, seem to be aged of 4 m.y. (MICHAUX et AGUILAR, 1985).

Thanks to the combined use of marine (planktonic Foraminifera) and terrestrial (rodents) pointers (CLAUZON et al., 1986), one has been able to demonstrate that:

— the marine transgressive levels, at the bottom of the Pliocene series, were isochronous and ascribed to the lowest Tabianian;

— the continental roof of the same series was also isochronous and dated of around 4 m.y.

Hence, between this two chronostratigraphic horizons, the building of the marine sedimentary prism, completed by the progradation of the alluvial piedmont that covers it (progradation carried out according to the west—east axis of the graben), have been realized within a lapse of about 1 to 1.5 m.y.

It follows that—from the geodynamical point of view—the Pliocene filling up of this basin has been determined: not by the volume generated by the subsidence of the graben (as such was the case during the Miocene) but by the volume eroded during the Messinian event and submerged at the outset of the Pliocene.

Conclusion

The Neogene geodynamical evolution of the Roussillon basin records the three classical events recognized everywhere else in the French Mediterranean south:

— the compressive and orogenic phase of the Upper Miocene,

— the Messinian erosional surface,

— the filling up of the Pliocene rias.

The Roussillon originality does not lie in this ordinary sequence but in the previous rifting phase which, during the lower and middle Miocene, created this basin, stretched at right angle to the shoreline, allowing thus the further episodes to take advantage of an extraordinary recording.

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