[PS]Benefits of New Offshore Seismics on the Understanding of a Western Mediterranean Continental Shelf Geodynamics and Eustatic Controls During the Neogene (Provence Margin, SE France)*

Aurelie Tassy[1], Francois Fournier[1], Jean Borgomano[1], Bruno Arfib[1], Philippe Munch[1] and Isabelle Thinon[2]

Search and Discovery Article #50643 (2012)**
Posted July 3, 2012

*Adapted from poster presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

[1]ix-Marseille University, Marseille, France (auretassy@gmail.com)
[2]BRGM, GEO-GBS, Orléans, France

Abstract

Outcrops in Provence have been exhaustively studied, however few studies focused on the marine geology and the possible offshore continuity of onshore structures. It is a complex geological domain situated between the Alpine arc and the continental margin of the Liguro-Provençal back-arc basin, which was also influenced by the high amplitude Neogene eustatic changes, especially during the Messinian Salinity Crisis (MSC). To improve our knowledge on this key domain within the context of the characterization of coastal karst system, it is critical to integrate data from onshore geology and offshore seismics. A major asset of this study has been the acquisition since 2007 of high-resolution offshore seismic lines and shallow coring. Given the lack of offshore wells in this area, the seismic lines have been mainly interpreted based on the stratigraphical and structural comparisons to the near-by outcrops (qualitative seismic inversion) and locally with the support of shallow coring. Onshore-offshore geological cross-sections help to validate the seismic interpretations. A variety of seismo-facies has been interpreted in terms of stratigraphic and structural characteristics, sedimentary and diagenetic heterogeneities of the formations and rock properties measured on outcrop samples. We propose a new geological map of the offshore Provence Continental margin, a completed depth map of the Messinian Erosional Surface, and a new land-sea depth map of the top Mesozoic carbonate Formation that is the main karstic aquifer in the area. Such results imply new considerations for the tectonic, stratigraphic and hydrographic framework of the Provence area. We integrate the present day bathymetry and altimetry, the surfaces of the Messinian erosional unconformity and the top Mesozoic carbonate in a 3D onshore-offshore surfacic model. Successive sea-level changes of the Mediterranean since the Burdigalian period are modeled and compared to the altitudes of sedimentary deposits and marine erosional surfaces on land. This method evidences anomalies between altitude of Tertiary deposits and corresponding sea level, relative to the actual topography and structures. This implies significant differential vertical movements of the Provence margin during the Plio-Quaternary. The causes of these tectonic movements are debated, probably gravity alpine tectonics, isostatic rebound after the MSC, or subduction and slab detachment under the Corsica and Sardinia.

Outcrops in Provence have been exhaustively studied, however few studies focused on the marine geology, and the possible offshore continuity of onshore structures. It is a complex geological domain situated between the Alpine arc and the continental margin of the Liguro-Provençal back-arc basin which was also influenced by the high amplitude Neogene eustatic changes, especially during the Messinian Salinity Crisis (MSC). To improve our knowledge on this key domain within the context of the charaterisation of coastal karst systems, it is critical to integrate data from onshore geology and offshore seismics. A major asset of this study has been the aquisition since 2007 of high resolution seismic lines and shallow coring. Given the lack of offshore wells in this area, the seismic lines have been mainly interpreted on the basis of stratigraphical and structural comparisons to the near-by outcrops (qualitative seismic inversion) and locally with the support of shallow coring. A variety of seismo-units have been interpreted in terms of stratigraphic and structural characteristics, sedimentary and diagenetic heterogeneities on the formations, and rock properties measured on outcrop samples. We propose a new geological map of the offshore Provence Continental Margin and a completed depth-map of the Messinian Erosionnal Surface (MES). Such results imply new considerations for the tectonic, stratigraphic and hydrographic framework of the Provence area.

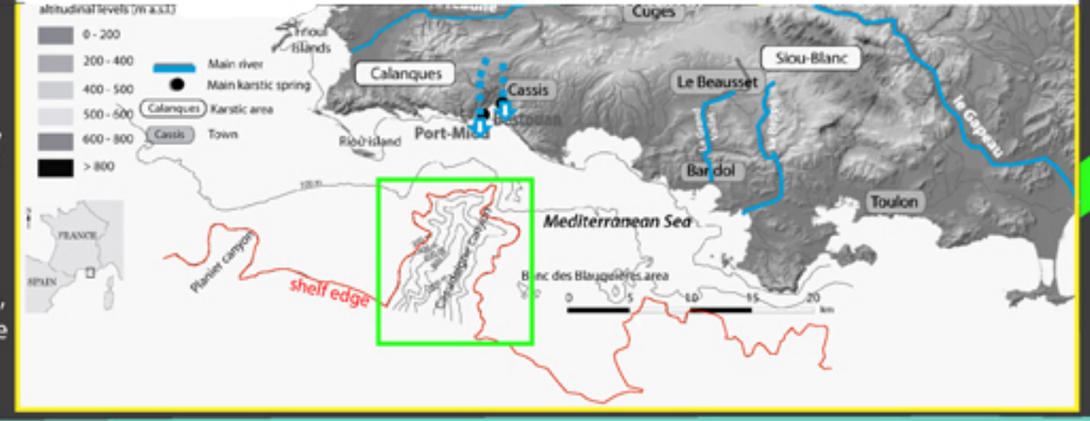
Main geological onshore structures prolonge towards the continental shelf. Cassidaigne Canyon deeply incises the Provence Margin. Its development is strongly influenced by lithological and structural controls. The western head of the canyon develops into the soft Aptian marls, displaying a bad-land erosive structure. During the MSC, an other canyon ("Bandol Canyon") was connected to theCassidaigne Canyon eastern head. Bandol Canyon incises the shelf at the limit between Hercynian basement and Mesozoic slice thrusts. During the Pliocene, it was totally filled with marine sedimentation, contrary to Cassidaigne, wich is deeper and only partially filled by the Pliocene turbiditic deposits coming from the Bandol Canyon.

The depth-converted map of the MES evidences a 500 m Messinian incision in Bandol Canyon, which is not visible on a bathymetric map, and seems connected with coastal rivers onshore. It also evidences the absence of incision of the Huveaune River offshore Marseilles. We propose a land to sea Messinian hydrographic network, both on surface and deep phreatic karst inherited from the MSC.

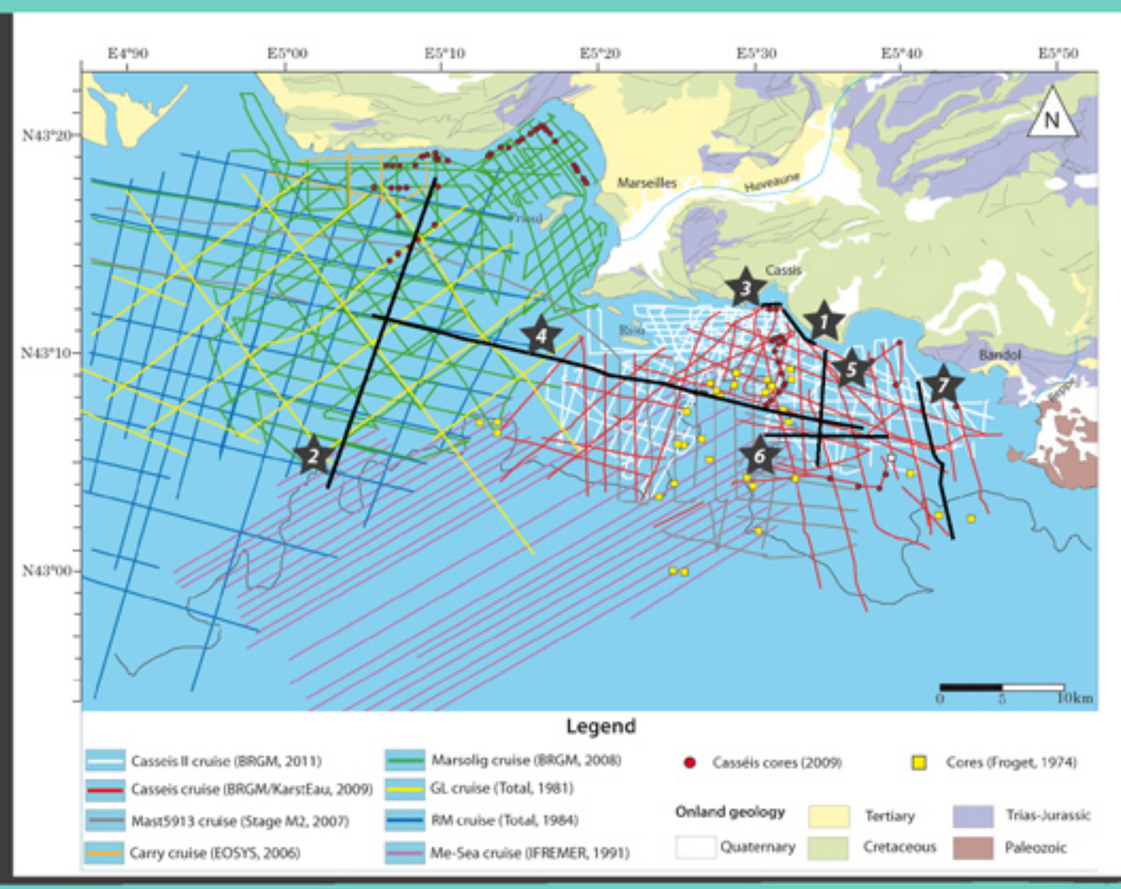
We integrate the present-day bathymetry and altimetry and the MES in a 3D onshore-offshore surfacic model. Successive sea-level changes of the Mediterranean since the Burdigalian period are modeled and compared to the altitudes of sedimentary deposits and marine erosionnal surfaces onland. This method evidences anomalies between altitude of Tertiary deposits and corresponding sea-level, relative to the actual topography and structures. This implies significant vertical movements of the Provence Margin during the Plio-Quaternary. The causes of these tectonic movements are probably gravity alpine tectonics, isostatic rebound after the MSC, or subduction and slab detachement under the Corsica and Sardinia.

Large coastal karstic springs, coastal rivers, carbonate area, karstic features

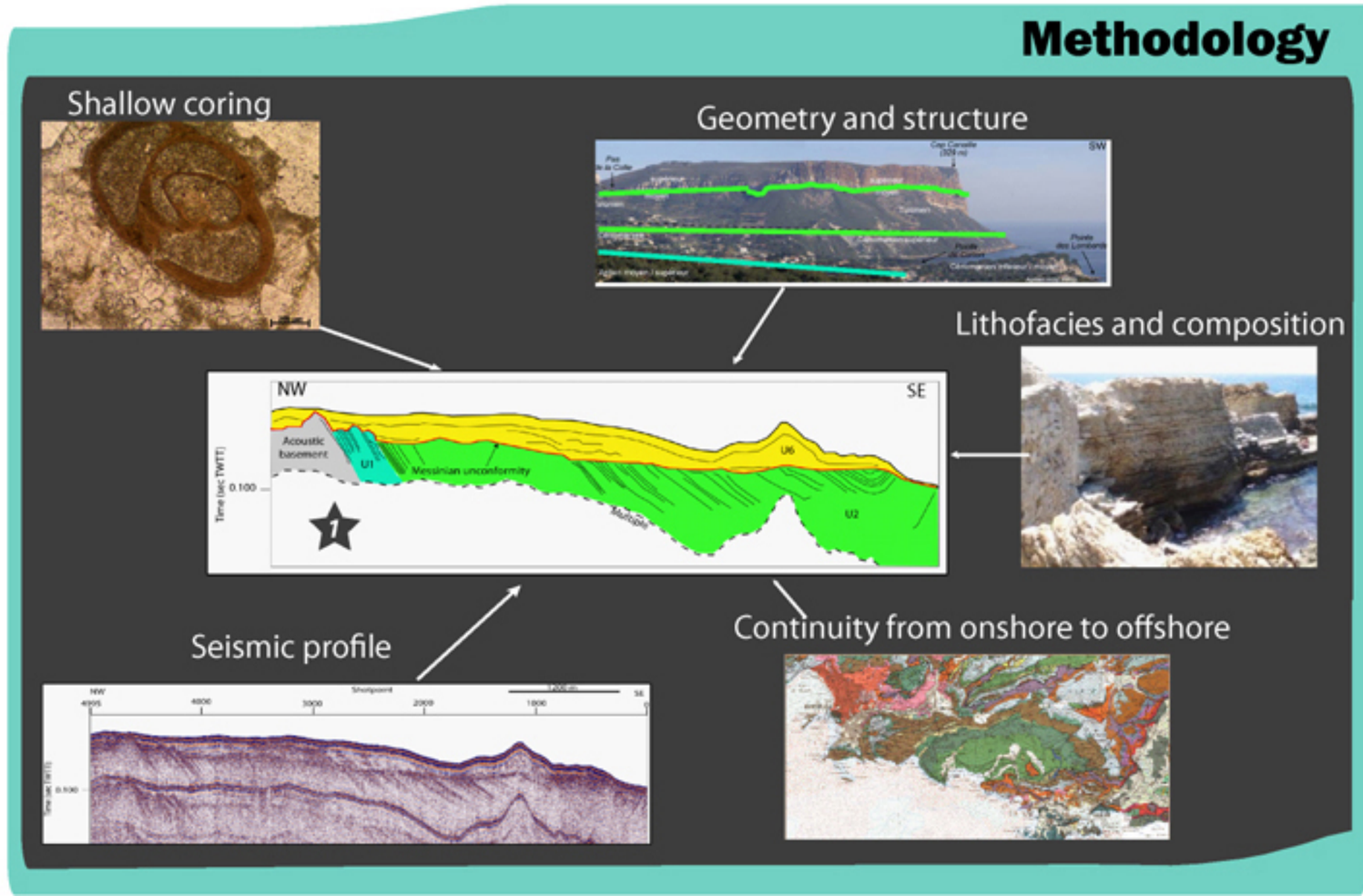
Offshore: shallow margin, large submarine canyons

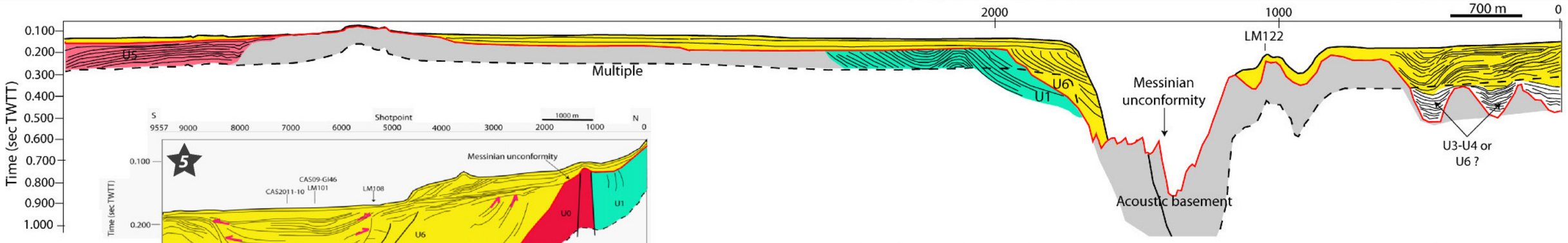


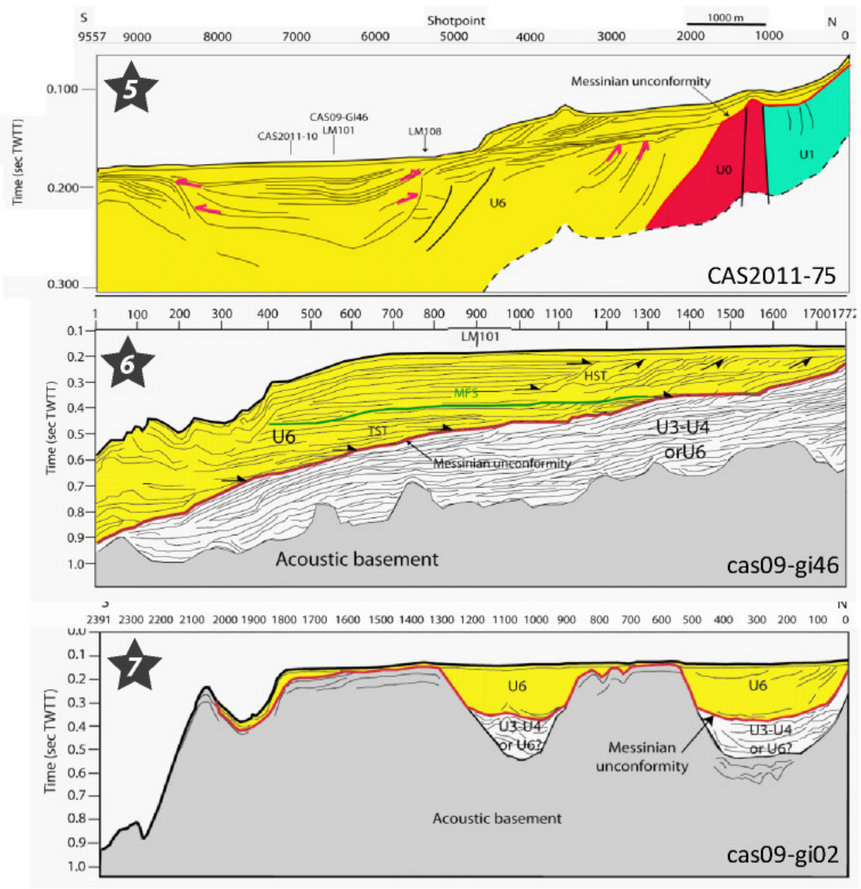
Database and Onshore Geology



Methodology



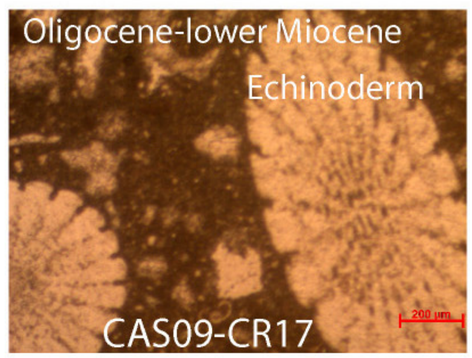


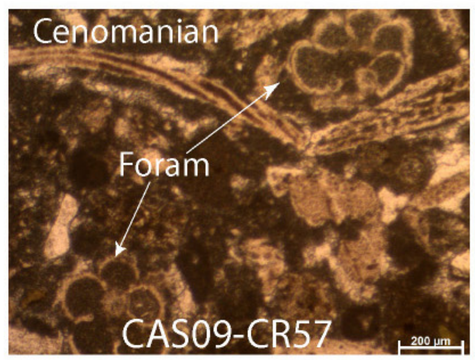


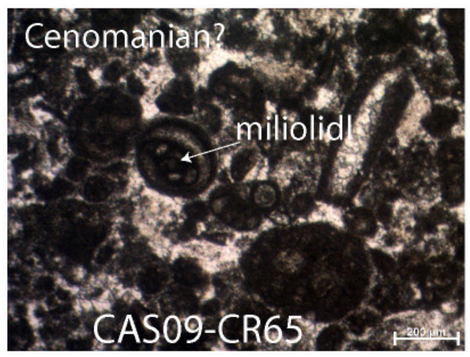
Seismo-stratigraphic units

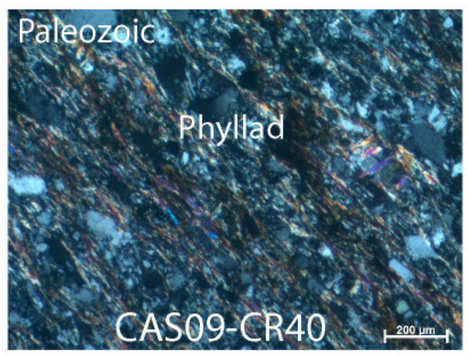
Sismo-stratigraphic unit	Reflection configuration	Reflection continuity	Reflection amplitude and frequency	Bounding relasionship	Age interpretation	Example
Unit 6	Parallel to sigmoidal	Continuous to semicontinuous	HR and LR: Low amplitude low frequency VHR: High amplitude	Draping the underlying topography. Onlaps at the base, truncations at the top	Plio-quaternary	100 ms HR
Unit 5	Semiparallel	Semicontinuous	Variable amplitude high frequency	Onlaps above the underlying unit. Thinning out towards the coast. Troncations at the top.	Miocene (post-rift: Burdigalian to Tortonian)	50 ms
Unit 4	Semiparallel	Semicontinuous	Variable amplitude high frequency	Faulted and folded unit filling paleo-topography structured in half grabens	Miocene (syn-rift: Aquitanian to Burdigalian)	50 ms VHR
Unit 3	Oblique	Semicontinuous	High amplitude, very high frequency	Laterally limited by oblique or vertical surfaces. Top truncated by flat angular unconformity or drapped by Unit 2	Oligocene	50 ms VHR
Unit 2	Semiparallel	Semicontinuous	Variable amplitude high frequency	Limited at the base by U1 Top truncated by a flat angular unconformity	Cenomanian to Coniacian	50 ms VHR
Unit 1	Semiparallel	Continuous	High amplitude, high frequency	Restricted in the central area syncline. Top truncated by flat angular unconformity	Aptian	200 ms HR
Unit 0	Chaotic or oblique	Discontinuous	Low amplitude high frequency	Top truncated by flat angular unconformity Laterally bounded by faults	Berriasian to Hauterivian	50 ms HR
Accoustic basement	Chaotic	Discontinuous	Low amplitude	Top limited by an unconformity	Hercynian or Mesozoic	50 ms VHR

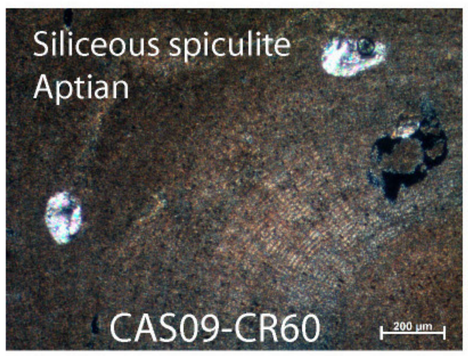
Core data

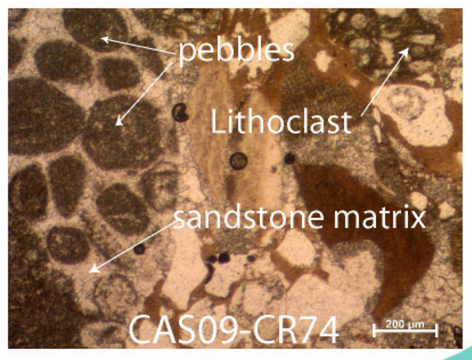




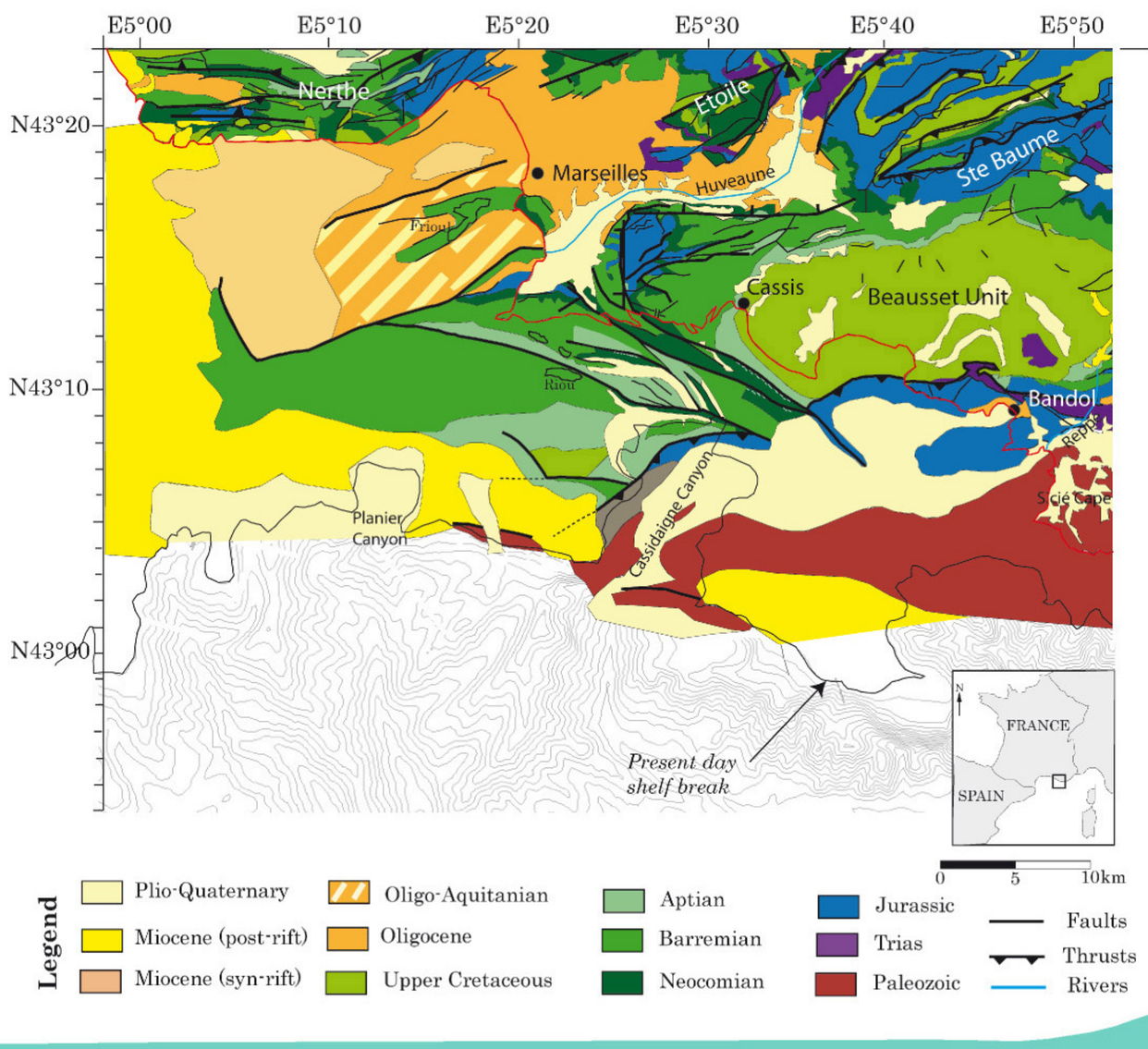




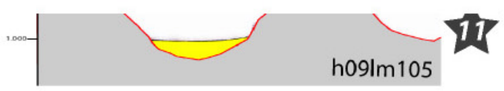




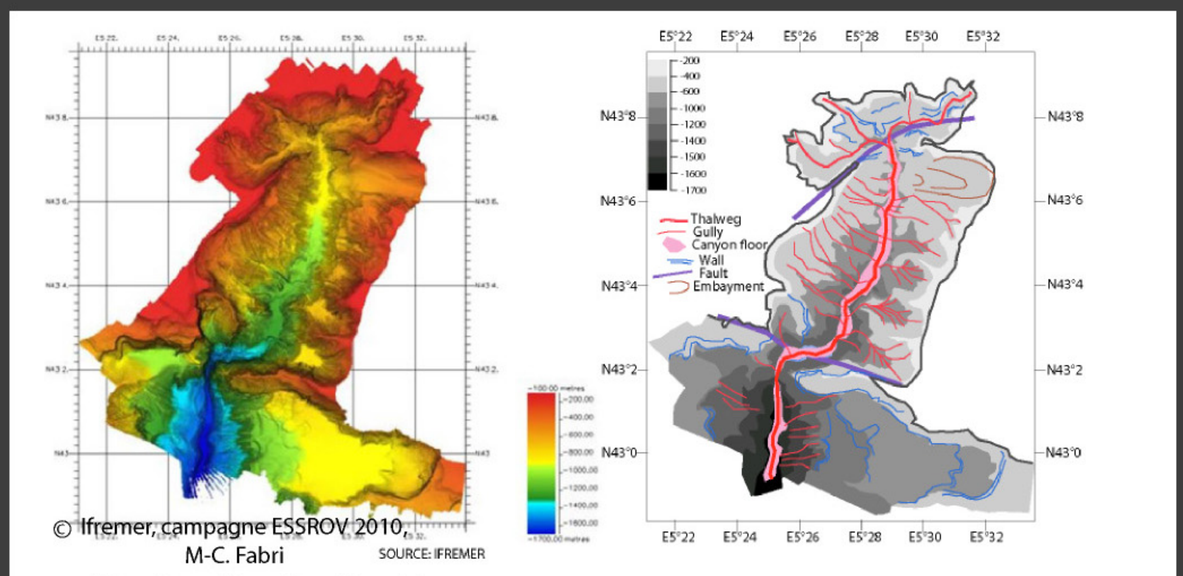
Onshore-Offshore geological map

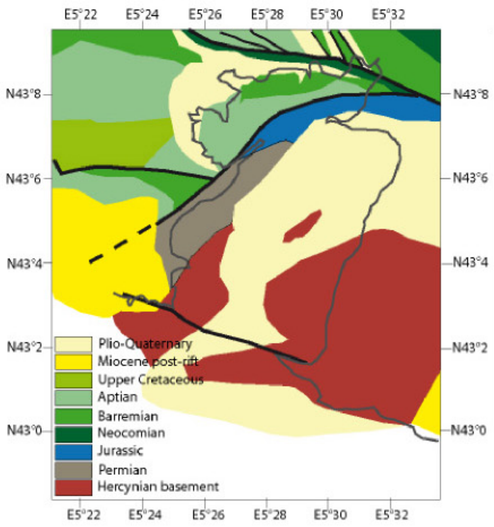


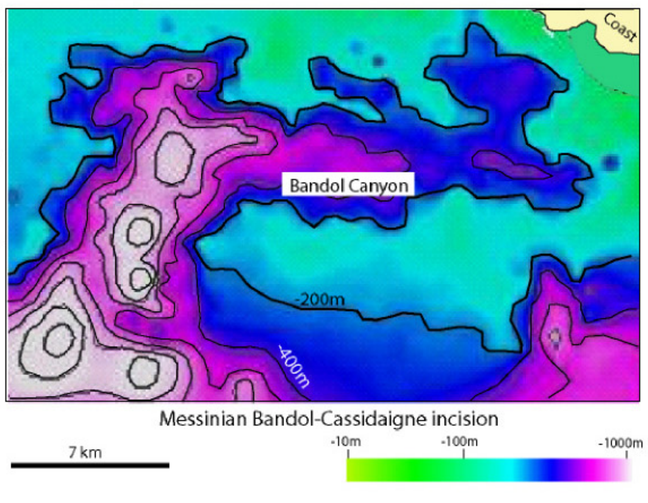
downstream, is only partially filled by turbiditic deposits coming from the Bandol Canyon.



Morphology, Geology, Messinian Incision



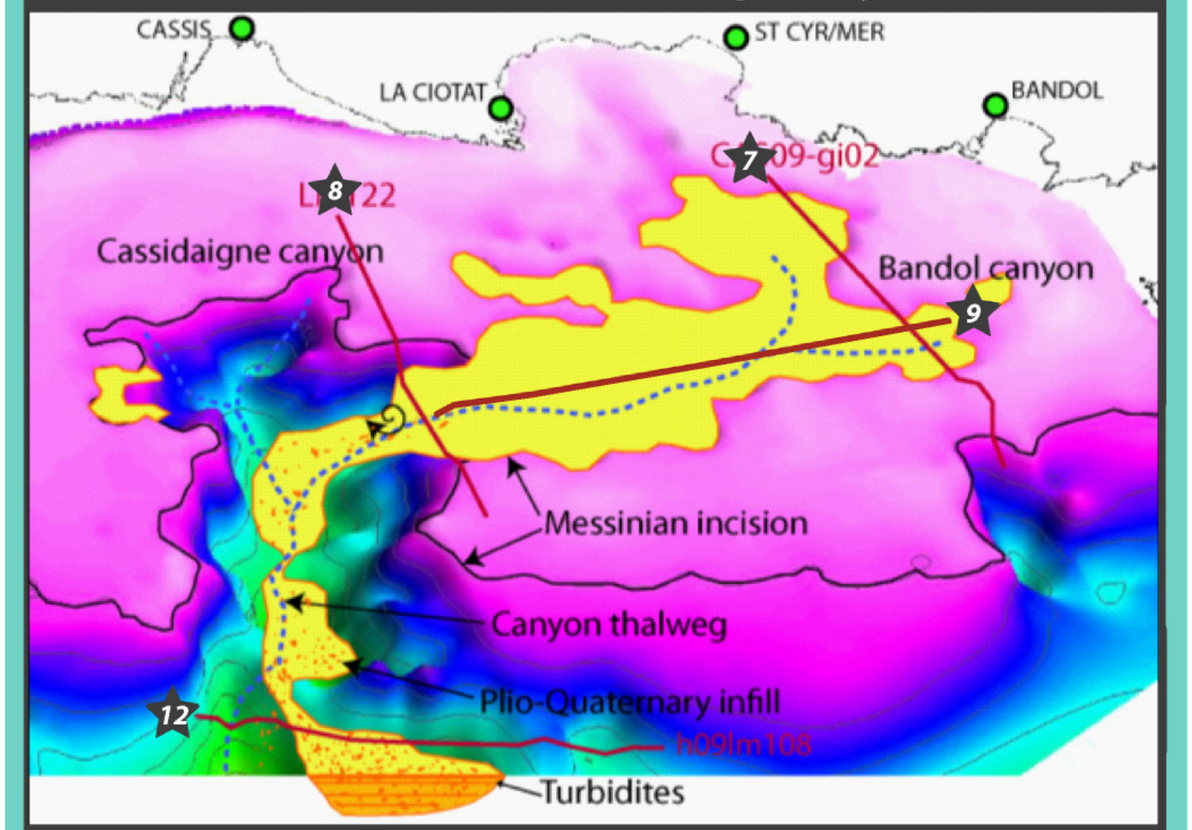




Messinian Bandol-Cassidaigne incision

Pliocene-Quaternary Canyon fill

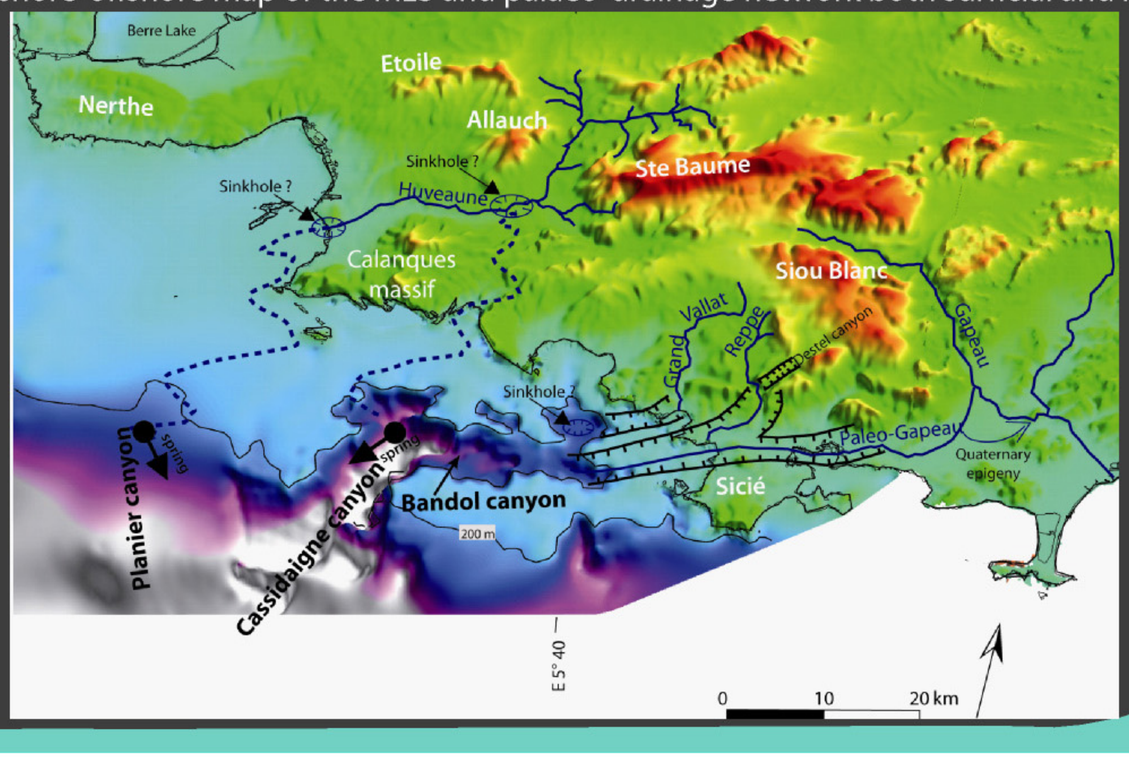
Prograding-agrading system in the Bandol Canyon
vs
turbiditic in the Cassidaigne Canyon



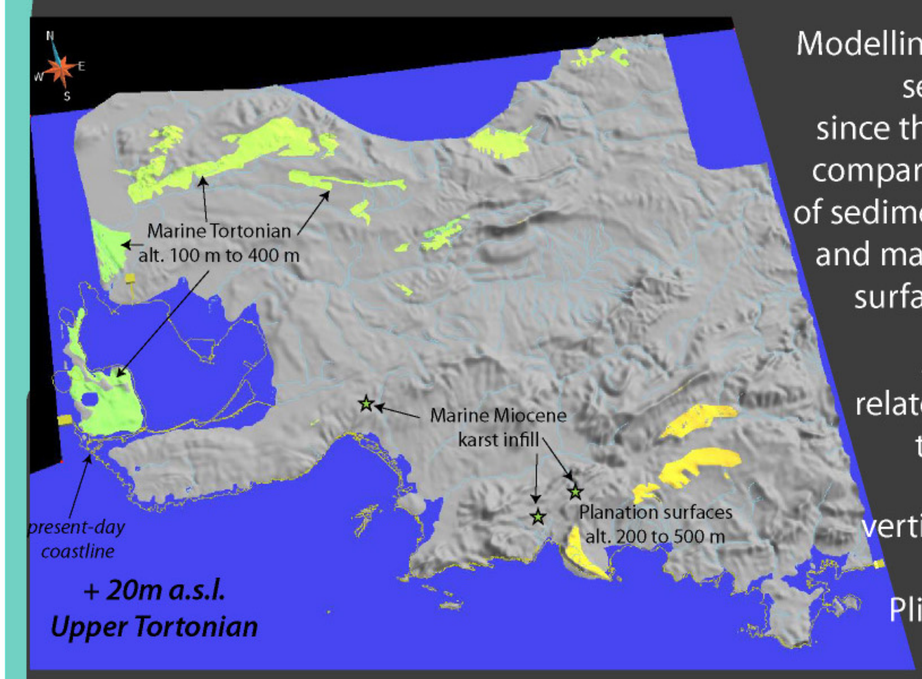
The same Plio-Quaternary sediments thickness is observed within the two canyons (0.5s TWTT; 12 & 4). Bandol Canyon is totally filled in contrast to Cassidaigne Canyon, which is deeper, and erosive downstream (12).

Messinian hydrographic network?

Onshore-offshore map of the MES and palaeo-drainage network both surficial and karstic



Uplifted Tertiary marine transgressions



Modelling of successive sea-levels since the Burdigalian compared to altitudes of sedimentary deposits and marine planation surfaces onland.

↓

Anomalies related to the actual topography

↓

vertical movements during the Plio-Quaternary