



Prehistory and coastal karst area: Cosquer Cave and the “Calanques” of Marseille

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Re-published from: *Karstologia* 27, 1996, 27-40

Abstract

The Cosquer Cave is a French Palaeolithic painted and engraved cave (27.000-18.500 BP), which is located under the sea, in the Urgonian limestones of Cap Morgiou (“Massif des Calanques”, Marseille). The entrance was submerged at the end of the Last Glacial Stage and is presently 37 m under sea level. A synthesis about the Cosquer Cave environmental studies is presented here. Structural studies show that caves planimetry is determined by Cap Morgiou jointing (mainly NW-SE and N-S vertical faults). Through archaeological studies, a speleothem breaking period can be dated between 27.000 and 18.000 BP. Geomorphologic study of the continental shelf at the foot of the Cosquer Cave area shows fossil shorelines at -36 m, -50/55 m, -90 m, -100 m depth. Radiocarbon dating from shells collected in -100m sediments yielded a date of 13.250 BP. Direct scuba diving observations and submarine cliff profiles sketching show several eustatic still stand levels between -36m and the current sea surface indicating a probable tectonic stability during the last 10.000 years.

Keywords: Prehistory, karst, Cosquer Cave, fossil shorelines, France

1. Introduction

Cosquer cave (Figures 1 and 2) is located at the south-eastern extremity of “Cape Morgiou” in the “Massif des Calanques”, between Marseille and Cassis. With Chauvet Cave, located in Ardèche (Chauvet et al., 1995), it is one of the main archaeological discoveries of those years (Cosquer, 1992; Clottes et al., 1992a; Clottes and Courtin, 1994). Nowadays these two prehistoric sites had proven the general extension of upper Palaeolithic art in south-eastern France.

The lower part of Cosquer Cave, partly submerged, remind us that the story of Palaeolithic man is directly associated with the important changes of the seashore position, which took place from last glacial maximum to present time.

Between Marseille and Cassis, the end of the glacial transgression had submerged a karst area

developed in the Urgonian limestones constituting the main part of the “Massif des Calanques” (Denizot, 1934; Julian and Nicod, 1989; Blanc, 1993b; Nicod, 1995). This arid and hilly area is characterised by deep and narrow coastal creeks (called “calanques” in French) (Photo 1). These coastal creeks and offshore islands constitute the only preserved part of the submerged territories of Cosquer Cave’s artists, presently limited to the south by the -135m contour line.

The aim of this paper is to summarise the results of researches treating of geological environment around and inside this prehistoric site (Collina-Girard, 1992 to 1996). Preliminary, it could be useful to summarise the chronology and characteristics of the prehistoric paintings and engravings observed during the two mains scientific surveys (1992 and 1994), and to consider their significance.

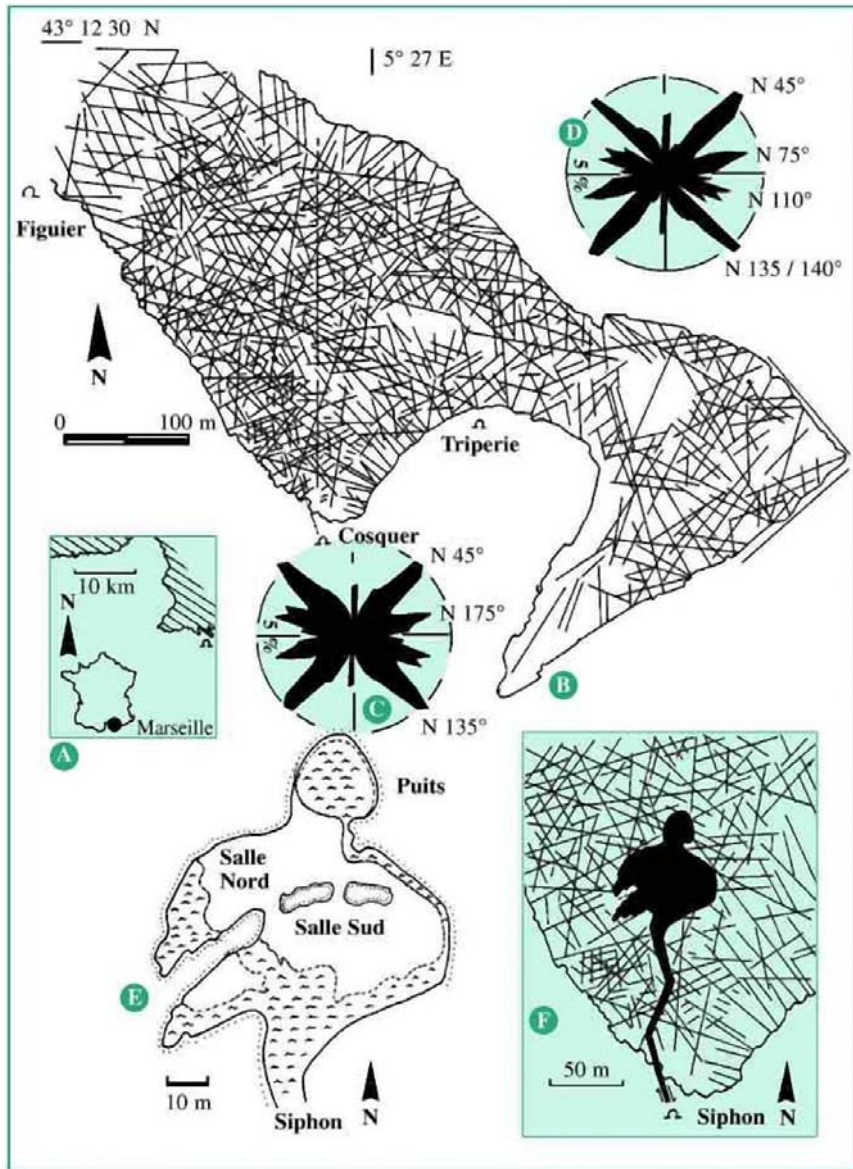


Fig. 1. Geographic and structural location of Cosquer Cave. A = studied area location; B = alignments network on Cap Morgiou area from aerial views (1/3500); C = alignments directional diagram (percentages on 28940km); D = alignments directional diagram (percentages on 540 alignments); E = Cosquer Cave schematic plan; F = cave location and Cap Morgiou jointing (after Collina-Girard, 1995d).

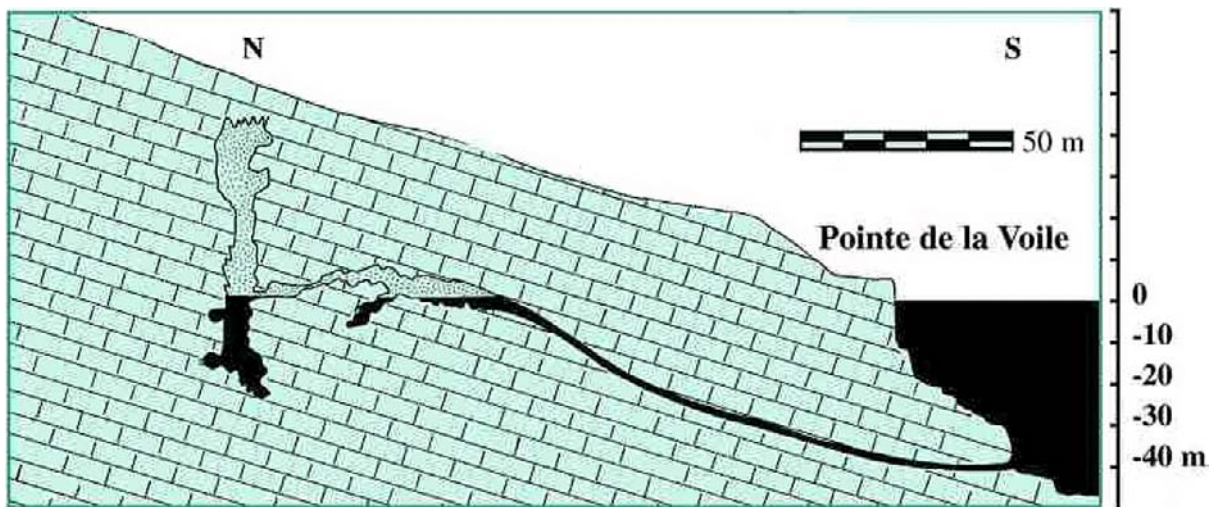


Fig. 2. Schematic profile of Cosquer Cave.



Photo. 1. Cape Morgiou, Cosquer Cave is -37m beneath the sea level (photo: J.Collina-Girard).

2. The Palaeolithic art

Following the scientific survey of 1992, the first isotopic dating (^{14}C) were realised from the charcoal sampled from the hearths and directly from those of paintings (using mass spectrometry, Tandetron, Gif-sur-Yvette Laboratory). Two phases of art painting were pointed out. This result, first supposed from cases of superposition, was confirmed by study of charcoal samples collected during the second scientific survey (autumn 1994). The first occupation took place at 26000 – 29000 BP. After a gap of 10000 years the second period of frequentation occurred between 17.000 and 20.000 BP. (recent phase) (Clottes et al., 1992b). Most of the drawing and painting used mainly charcoal as colouring material. Therefore, and contrariwise with most of prehistoric sites, it is possible, with Tandetron method, to obtain direct dating of the prehistoric art. Consequently, the study of the prehistoric paintings in Cosquer and Chauvet Caves benefit from the most accurate dating.

2.1. The Older period (about 27.000 BP)

During this period, the walls of the cave, weathered by “mondmilch” were covered by meandriform finger marks. These marks were found in the whole cave, even in galleries very difficult in access and on the tops. However, no trace of wooden stairs has been found on the wall as it was observed in Lascaux. In Cosquer cave, this period is characterised by “negative hand print” (n=55). Along the southeast part of the southern main rooms, negative handprints were draw with red clay, but in the eastern part

of the “shaft” (north of the cave, called “puits” in Fig. 1 survey) charcoal were used (and therefore directly dated). These hand prints were made using colouring material directly blow on the hand put on the wall. In these two preferential places, handprints are clearly located above deep area (hypothesis of symbolic use of the topography of the cave).

Most of these handprints show “finger cut” as in the other examples of Pyreneans caves during the Gravettian period (e.g. Gargas, Tibiran). The interpretation differs: real ritual mutilation or printing of folded fingers as suggested by Leroi-Gourhan (1965, 1971, 1980). These “mutilated” negative handprints are quite typical of Gravettian culture known in the caves of Gargas and Tibiran and most generally in the whole “Franco-Cantabric” area.

Some animals (horses) and geometrical signs, draw with the fingers could be contemporaneous of this period (stylistics supposition but lack of direct dating).

2.2. The Younger period (between 19.200 and 18.500 BP)

Most of the paintings (in fact, charcoal drawing) and engravings (n=125) were realised during this period. The animal’s representations are generally engraved, only 1/3 is paintings. Horse is the most represented animal followed by Ibex, bovine (bison and aurochs) and deer. During the campaign of autumn 1994 we found some more exceptional animals such as saïga and megaceros. Marine animals (penguins and seals) are present and contribute to the originality of this prehistoric site. We found a

composite engraving mixing horse head with bison horn associated with schematic figuration (spears?). This unrealistic representation evokes a mythological scheme. A lot of geometric signs were found and the rectangular are specific to Cosquer cave. Some probable vulva representations were observed, and a very realistic phallus was found by J. Courtin in a very narrow part of the cave associated with a lozenge sign, which could be a vulva.

An engraving of seal could be, according to J. Clottes, a mixed representation of human and seal killed by a spear (Clottes and Courtin, 1994). Effectively we know such examples of mixed human-animal representation in southwest of France as the Sorcerer of Sous-Grand-Lac (Dordogne). There are other human representations known in the same area (Roussot, 1994). In Cosquer Cave one of the argument is that one human hand with five fingers prolongs the anterior flipper of the animal.

Presently, Cosquer cave appears integrated in the general context of Upper Palaeolithic art in France. The representations of the older phase (with the typical negative handprints) fit perfectly with the Gravettian rock art, well known in the Pyrénées. The younger phase could be linked to the other Solutrean sites known in the Rhône Valley (caves of Ardèche). For example, the stylisation of ibex is similar to those of Ebbou cave (Collectif, 1984).

3. Cosquer Cave

3.1. Structural context of the cave

Thick beds of the Urgonian limestone, gently dipping toward the south-east, constitute Cape Morgiou. The siphon (116m long) leading to the main cavity is opened at -37m below sea level and 15m away from the present coastline (Fig. 2). The morphology of the cave is linked to the general faulting of the "Massif des Calanques" (Fig. 1F). On Cape Morgiou, we observed a network of subvertical fractures which also guide the emerged and submerged cavities (Collina-Girard, 1995b). Cosquer cave is not the single cave on this area. Triperie and Figuier Caves are known for a long time by divers from Marseille and Cassis and, moreover, sampling in Triperie cave had yielded continental sediments, probably Rissian, according to E. Bonifay, and flint flakes (Courtin, 1978).

3.2. Topography and Geology

The cave includes two main cavities communicating by a narrow passage (Fig. 1E). At the northern extremity of the cave a large shaft, partially submerged, extends vertically from -25m to about +30m above the present sea level (Fig. 2). One of the most important series of negative handprints is located along the eastern part of the shaft. All the cavities communicate in their submarine parts as demonstrated by cavers (L. Vanrell and T. Betton). These very important submerged cavities were certainly ornamented. The Cosquer cave appears clearly as a main prehistoric sanctuary but, unfortunately, only the upper part of the cave had been preserved.

Inside, we observe ancient collapse of the ceiling and three main phases of speleothems deposition (Collina-Girard, 1995b). The older stalactites and draperies are obviously older than Gravettian negative handprints (29.000 - 26.000 BP). The thick orange calcite floors are younger: in some place they cover finger contouring. Finally, white calcite crystallisation covers in some place the painting of the younger phase (20.000 - 17.000 BP). Presently, some tiny helictites and hollowed speleothems are active.

3.3. Speleothems breaking and Archaeology

Neotectonic movements in caves are well known in the French Riviera (Gilli, 1986, 1995). In Italian caves, breaking of stalagmites reveals neotectonic movements (Bini et al., 1992). Collapse of stalactites appears also as a main phenomenon in Cosquer Cave. Locally, stalactites are shifted or crashed (Fig. 3). These observations are common in the karst of Provence (Blanc and Monteau, 1988; Blanc, 1993a, 1993b; Julian and Nicod, 1989). Inside Cosquer cave, the trend of these displacements appears to be oriented toward the South, according to the dip of Urgonian beds and to direction of the edge of the cliff. These observations evoke gravity and roof sliding following the dip (Collina-Girard, 1995b, 1995c). Perhaps earthquakes had activated these movements as suggested by regional observations suggesting collapsing period in some other caves of Provence (Guendon J.-L., oral communication).

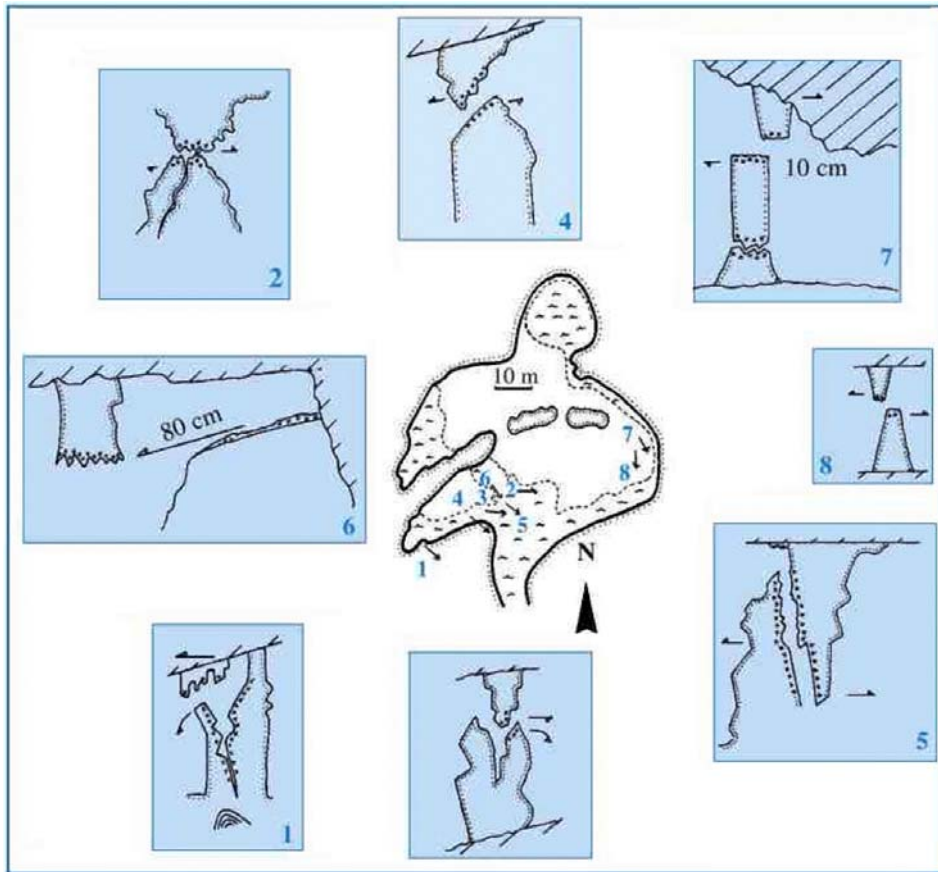


Fig. 3. Location of displaced speleothems and movement directions (after Collina-Girard, 1995b).



Photo. 2. Exploring the submarine access to Cosquer Cave (photo: Luc Vanrell, Comptoir du plongeur, Marseille).

TABLE

Dating of the two samples collected at the entrance of Cosquer Cave

Sample	lithology	Lab. Reference Number	Date BP	Date calibrated BC
94 Cosq-1	carbonated	Ly-7071	8905 +/-75	7740-7734
94 Cosq-2	carbonated	Ly-7072	7160 +/-65	5739-5514

In Cosquer cave we have the possibility to date these movements using rock art dating:

- It was observed that these movements had partially cracked the calcite draperies and the handprint panel (27000 BP) located in the northern part of the “shaft”. The movements are obviously older.

- On the ground, broken stalactites were moved by prehistoric man before welded by calcite to the ground. These broken stalactites support hearth and charcoal of the younger phase of settlement (18000 BP). Therefore the movements are obviously older.

- Therefore, these breakages, collapses and roof movements occurred between the two occupations. It is possible to make the hypothesis that these movements could be the reason of the abandon of the cave during 10.000 years in the period 27000 – 18000 BP, as shown by dating.

3.4. Archaeology and sea level rise

In the upper part of the cave, rock art is well preserved, but the lowest series are submerged. Initially, all these galleries were certainly also ornamented. Sometimes, engraving could still be distinguished below the present sea level. It is important to notice that the paintings and engraving are well conserved immediately above the present sea level. This observation proves that the Holocene sea level never pass over the present one, unless making hypothetical supposition of a very recent subsidence in Marseille area (Bonifay, 1995) not confirmed for this period by other geological observations.

The cave entrance (–37 m below sea level, Photo 2) was closed by the sea during a period to be determined. Taking into account the eustatic curves obtained in Languedoc (Aloisi et al., 1978) and the dating obtained after the submarine excavations near Cassis in the Trémie Cave (Bonifay, 1970, 1995; Bonifay et al., 1971) we could estimate that the flooding of the entrance occurred between 8000 and 6000 BP.

More precisely, two specimen of coastal biogenetic speleothems (algae), in contact with the bedrock, were sampled for dating at the basis of the entrance of Cosquer cave (Sartoretto et al., 1995, 1996; Table). Taking into account the bathymetric distribution of the species

sampled, the submersion of the entrance was estimated around 7000 BC (Mesolithic or beginning of Cardial Neolithic).

4. The submerged territory in the south of Cosquer Cave

4.1. Bathymetric data

The plotting sheets (Hydrographic and Orographic Service of the French Navy) allow to establish a precise bathymetric map between the present coastline and the -200 m contour line. Most of these documents are at the 1/10000 scale (plotting sheets number 77-10-24, 77-10-26, 77-10-27), the others at 1/20000 (77-10-29, 77-10-30, 77-10-31, 77-10-32). A synthetic document was proposed at the 1/25000 scale and a simplified version published at the 1/50000 scale (Collina-Girard, 1995e). The first morphological interpretation proposed (Collina-Girard, 1992; Figures 4 and 6) points out structural trends, fossil shorelines and karst morphologies.

4.2. Thalweg network and structural directions in emerged and submerged areas

The Marseille area is characterised by two main structural faulting directions: NW-SE and NE-SW (Blanc, 1966; Blanc et al., 1967; Guieu, 1968). This structural frame constitutes the framework to the coastline, particularly for creeks and “calanques”, often established on main faulted area. The thalweg network is also structurally determined (Collina-Girard, 1995d). This network was established on topographic maps as it is usually made in morphostructural analysis studies (Prud’homme, 1972; Griboulard, 1980). Concerning the submerged part of this area we studied, in the same way, the submarine thalweg network was drew using details of contour curves (Fig. 5). As it could be supposed, the same structural trend of alignments was observed in emerged (Fig. 5B) and submerged areas (Fig. 5A). These alignments seems to be clearly linked to faults as verified in the south of Riou Island, where a NW-SE faulting escarpment (10 m height) was observed on the map and also on seismic profiles (south-east part of Fig. 6).

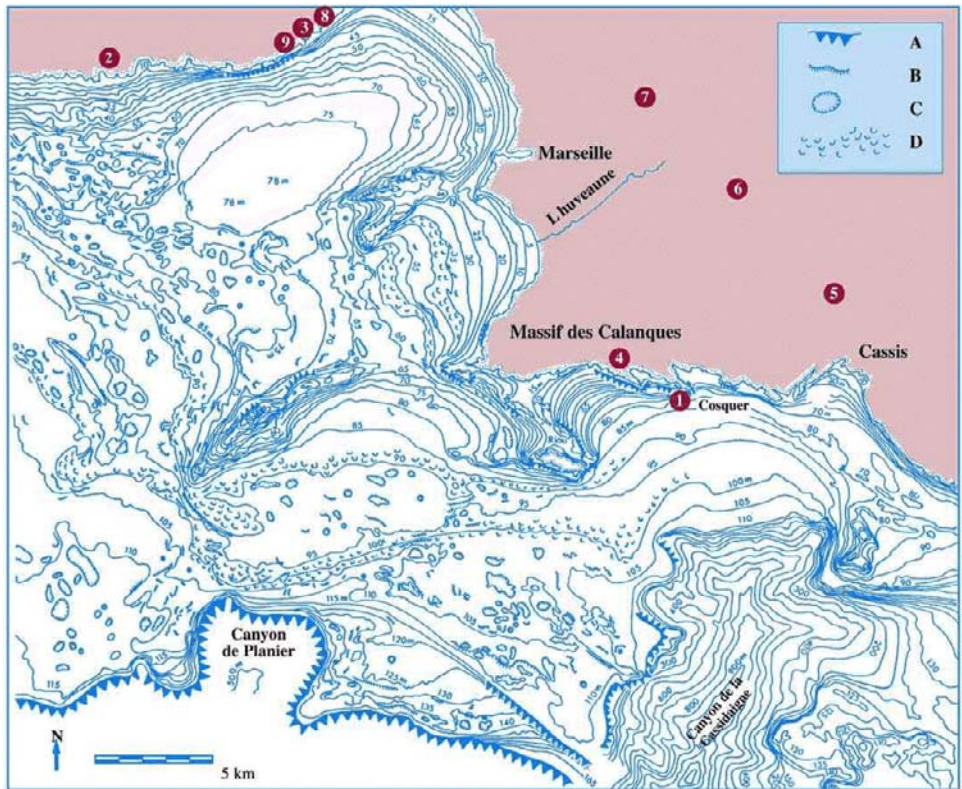


Fig. 4. Bathymetric map of continental shelf around Cosquer Cave (between Carry-le-Rouet and Cassis). A = topographic escarpments and canyons limits; B = escarpments (height <5m); C = sinkholes; D = paleo-shorelines.

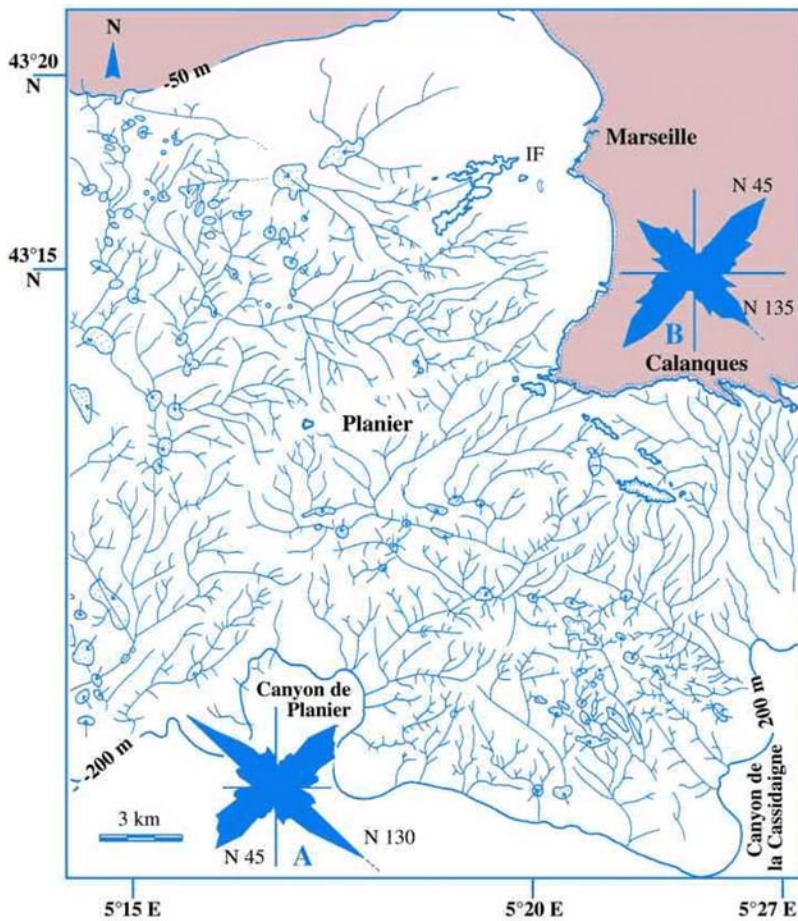


Fig. 5. Network of submarine valleys based on the 1/25.000 map of the Marseille offshore area. Rose diagram of valley alignment directions. Percentages calculated on numbers (A) and lengths (B) (after Collina-Girard, 1996).

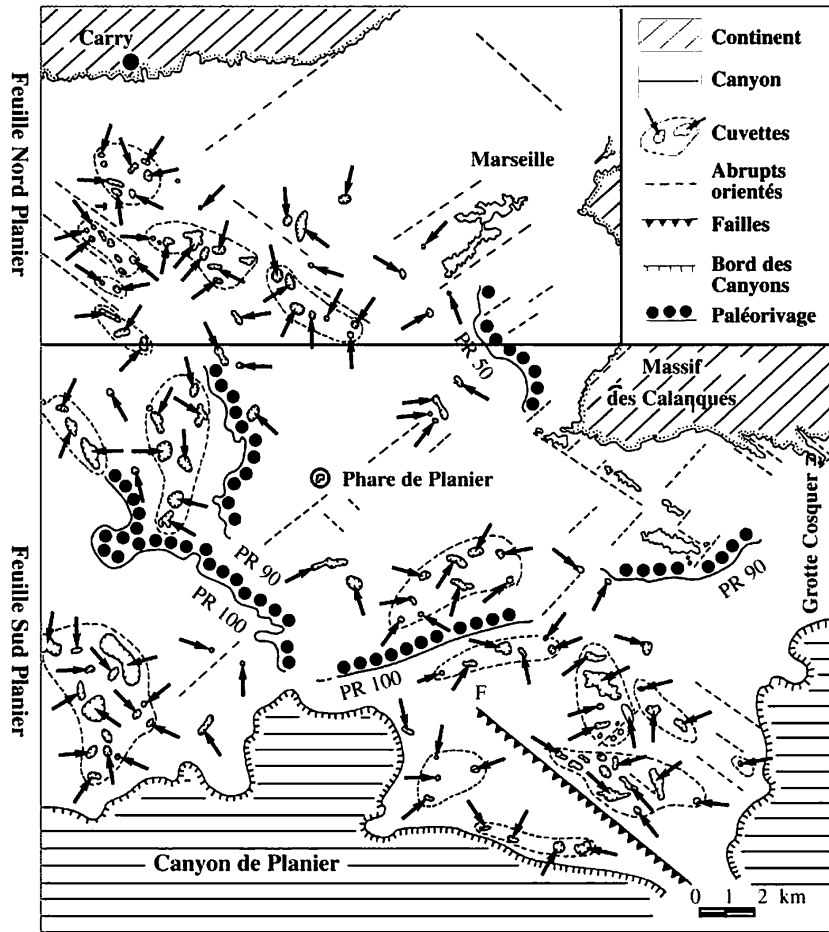


Fig. 6. 1/25.000 bathymetric map and geomorphologic interpretation (after Collina-Girard, 1992). Legend: Continent; Canyon; Sinkhole; Scarps; Canyon scarp; Paleo shore-line.

4.3. A Submerged Karst area

The continental shelf is bounded by the upper limit of the main submarine canyons (Planier and Cassidaigne), about -200m depth. Its extension from the coast covers a width of about 6-20km of prehistoric submerged territories. This submarine area is scattered by a lot of small basins (1-5 m depth), generally oriented according to the main structural directions. We interpreted these small depressions as sinkholes submerged and preserved by the Holocene sea level rise. A remarkable sub-rectangular basin (10km long and 5km wide) lies at the south-west of Marseille with a maximal depth reaching -78m (Fig. 4). This basin corresponds to an off shore extension of the Marseille Oligocene basin (thick clastic deposits, mainly pebbles and clays). In the western part, some small depressions (sinkholes) probably developed in limestone outcrops. This closed depression with a flat bottom could be interpreted as a contact polje, with Oligocene clays bounding the limestone substratum.

4.4. Submerged shorelines

The bathymetric map shows regular escarpments almost parallel to contour lines and independent to the structural directions.

These escarpments could be interpreted as ancient shorelines as observed in other parts of the world. Another example shows that coastal cliffs could be well conserved when the sea level rise is sufficiently rapid to avoid erosion (Quevauviller and Moita, 1986). Three main escarpments are visible. The first one, well developed in the South of Frioul Islands, extends at about -50m depth (noted PR50 on Fig. 6). The second one (noted PR 90 on Fig. 6) could be noticed at about -90m, in the South of Riou Island (Photo 3), and in the south-west of Planier Island. A third escarpment is visible at about -100/-105m in the South of Planier. Finally a slope breaking area, around -130/-140 m, could correspond to the Late Glacial Maximum shoreline (PR130?).

Coastal sediments (pebbles, gravel and sands) were cored in the -100m level. These clastic sediments were associated with *mytilus* shelves.



Photo 3. Submarine cave near Riou Island (photo: Luc Vanrell, Comptoir du Plongeur, Marseille).

Sampling (30g) allows a radiometric dating (Laboratory of Quaternary Geology, Aix-Marseille II). The age obtained is 13850 \pm 200 years BP (Collina-Girard et al., 1996). This age is consistent with several other dating obtained in the region where fossil beaches are systematically encountered at about $-80/-100$ m (Bellaiche, 1972):

- Fréjus Bay: a level at the depth of -80 m/ -90 m was dated at 11800 \pm 200 years BP,
- Gulf of Saint-Tropez: 11700 \pm 200 years BP for a level at -80 m,
- Cape Creus: 13800 BP for a fossil shoreline at $-80/-100$ m,
- Antibes: coastal sands located at -100 m depth dated at 14000 BP (Genesseaux and Thommeret 1968),
- A fossil beach cored about -80 m depth near Lérins islands (Cannes Bay) but not dated (Pautot, 1972).
- In Marseille Bay two other escarpments located at -36 m and -55 m are visible on the map (Fig. 6).

These levels, observed in Marseille and in Provence, seem to be worldly widespread: Mediterranean Sea (Flemming, 1972), Aquitaine continental shelf (Prud'homme, 1972), Portuguese continental shelf (Drago, 1989), Morocco (Griboulard, 1980). These morphological observations suggest a stepped sea level rise at the end of the last deglaciation. The vertical shifts sometimes observed between some areas could be attributed to neotectonic uplifting or subsidence of the continent as verified by precise sketching of submarine cliffs.

4.5. Morphologic study of the submerged coastal areas

A morphological study of the submerged part of coastal cliffs was carried out in Marseille area (1994-1995) with the aim to precise statistically the depth repartition of slope knick points observed on submarine cliffs. Profiles were directly sketched during several hundreds of scuba dives first between Cassis and Carry-le-Rouet, then at the East of Cosquer Cave area, between Cassis and the island of Port-Cros (Collina-Girard, 1995a).

The method is a simple application of the Pythagorean axiom (Fig. 7). A 1.5m long aluminum stick is laid on the slope (Fig. 7A) beginning at its deepest point. The depth is measured at each end of the rod using a diving computer or an accurate electronic depth gauge. The former device is better since it gives an automatic computation of decompression stops. The readings are noted using a plastic writing slate (Fig. 7B). The stick is then swung upward around its upper extremity and in the same direction (controlled by a plastic compass glued to the plastic slate). The new depth of the stick's upper end is then noted and the operation is repeated until the diver reaches the surface. When extra accuracy is needed, it is possible to use a shorter stick with a length 0.5-1m. One of the advantages of this method is that it facilitates sketching of overhanging profiles. An arrow affixed to the corresponding value indicates that the slope overhangs, thus avoiding confusion. The method is well adapted to the diver's safety procedure for decompression, allowing a slow ascent and the shortest possible time in deep water. The many profiles successfully sketched proved that the method was quick, accurate and reproducible by different observers. It can also be easily mastered by the average amateur SCUBA diver: a complete profile from -60 m toward the surface can be completed in about half an hour, in excellent safety conditions and with minimal decompression requirements. The graphical depiction of the profiles may be made later in the laboratory, or even directly on the boat using graph paper and a ruler or dividers (Fig. 7C).

Statistical analysis of the depth of escarpments noted on the sketches pointed out clear modal values at about -25 m, $-35/36$ m and -46 m. Other levels are located at -11 m, $-16/-20$ m and -41 m. In some deep areas (Riou archipelago) we observed at -55 m a well

preserved cliff with overhanging area and caves. In accordance with the radiometric dating of fossil coastal algae rims in contact with the bedrock, the age of this standstill level of the sea, at -55m, is estimated at about 8500-9500 BP (Sartoretto et al., 1996). This stepped morphology (-11m, 16/-20m, -25m, -35/36m, -41m and -46m) was observed at the same depths in the whole area between Carry-le-Rouet and Porquerolles – Port-Cros Islands (Fig. 8).

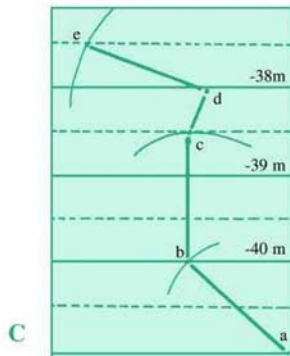
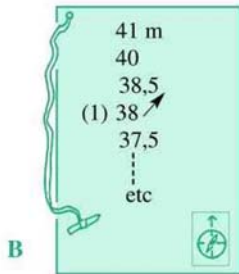
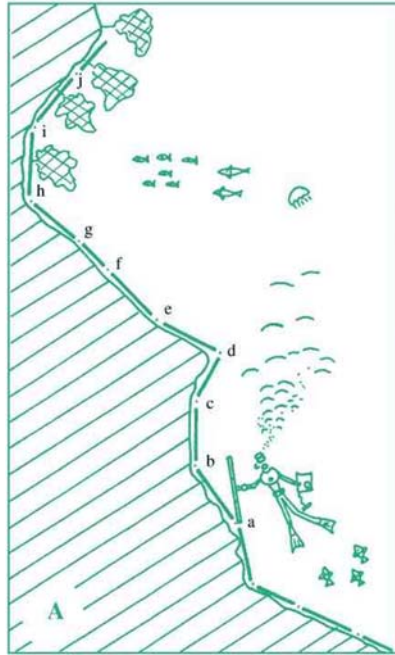


Fig. 7. Submarine sketching of cliff profile. A = on the spot; B = notation; C = graphic restitution (after Collina-Girard, 1995a)

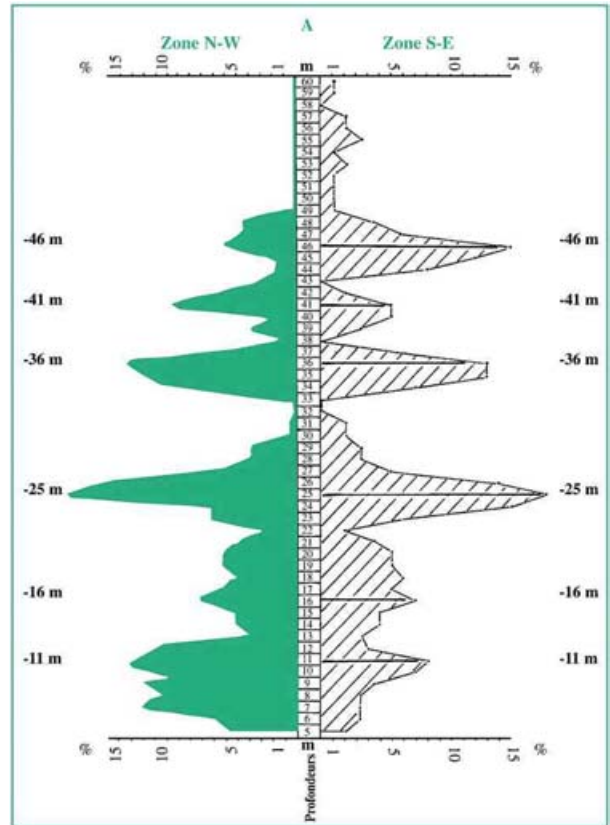


Fig. 8. Slopes breaking depth on 58 submarine profiles located between Marseille and Cassis. NW zone (Frioul and Planier Island), SE zone (Cosquer cave and Riou Arquipelago: 24 profiles, Cassis: 34 profiles; after Collina-Girard, 1995a).

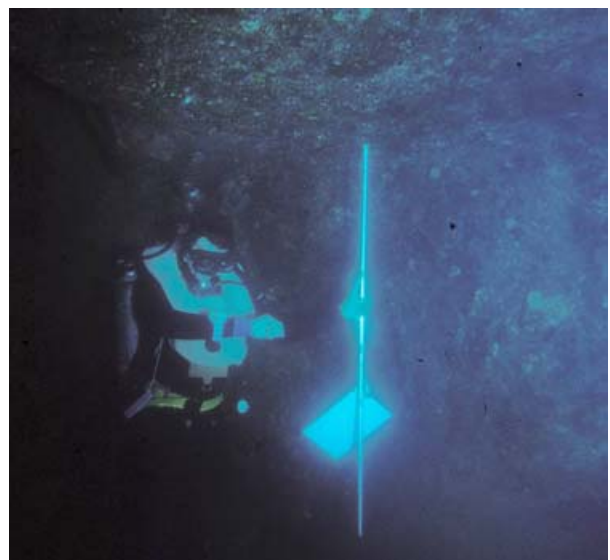


Photo 4. Sketching submarine topography along a submarine cliff around 45m depth.

5. Conclusions

The unexpected discovery of Cosquer Cave in Summer 1991 was totally surprising in this part of France where prehistoric rock art was totally unknown excepting for an isolated engraved bison in Verdon Valley (De Lumley, 1968) and in the caves of Ardèche Valley, located several hundred of kilometres to the North (Collectif, 1984; Chauvet et al., 1995). Marseille Bay appears as a perfect example to link, in a reduced area, the specific aims of Archaeology, Quaternary Geology, Karstology and Palaeosismology. It constitutes a perfect didactic example for illustrating recent geological events linked to the story of humankind. We can notice here that not specially informed peoples are fascinated by this discovery which evokes mythical lost worlds and others sunken cities. The mediatic success of this discovery is probably caused by the impressive action of these largely shared myths, most particularly among the divers and others peoples fascinated by the sea as it was analysed by psychologists (Thomere, 1995).

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