

# **GEOLOGICAL CARTOGRAPHY IN THE ATLANTIC AND THE MEDITERRANEAN**

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The first marine geological charts to be drawn up were those of the English Channel and in the Atlantic. The cartographic method used for these charts is not, however, considered suitable for the Mediterranean in view of the geological differences between these seas. It is first proposed to describe surveys carried out in both the Channel and the Atlantic and then to outline the principles underlying our work that gradually became more clearly defined as the Mediterranean operations progressed.

## **1. FRENCH SURVEYS IN THE CHANNEL AND IN THE MEDITERRANEAN**

When the first marine geological charts were published at the beginning of 1969 very few comparable charts existed elsewhere. A New Zealand chart was in fact the only one mentioned in the literature. At about the same time, however, the "Centre national pour l'exploitation des océans" (CNEOX) which had been founded in 1967 was to define one of its objects as "exploration, and development of the continental shelf". A reorganized "Bureau de recherches géologiques et minières" (BRGM); which now included a Geological Chart Section, also started to take an interest in the marine environment. There thus existed a powerful combination of forces able to work out and to implement a programme of complete cartographic coverage of the continental shelf.

In the April 1970 number of *Annales des mines* Monsieur J.-P. ROBERT (CNEOX) and Monsieur G. SCOLARI (BRGM), charged with the project's cartographic organization, described the scheme in the following term :

"Depicting all the available data on charts involves a large number of organizations and researchers. Consequently a plan of action is a necessity, although this organization is only at the preliminary stage and cannot

therefore be considered as final. However, it is already possible to give the broad outlines. Briefly described these are that CNEOXO takes every care to see that the main objectives it has fixed for the French oceanological effort are respected so far as fixing the cartographic coverage is concerned; and it collaborates closely at all meetings and with all working groups.

“ For its part the BRGM takes on the task of coordinating and editing these geological charts in the same way as it already does for land maps. This role means that the BRGM is called upon to act as a sort of General Secretariat for the geological chart of the French continental margin. It directs and calls together the various working groups in which any interested organization or research worker may take part, and it maintains overall responsibility for implementing its programmes. According to the area concerned, a particular organization or researcher will take the technical responsibility for the team drawing up the models ”.

A more detailed description of this scheme is given in the *Bulletin CNEOXO*, No. 34, October 1971.

Several round table conferences have been convened to decide upon a homogenous method for working out and representing the geologic characteristics of the ocean's substratum. The result has been to give the French a kind of charter for their cartographic effort in the domain of marine geology. This can be roughly outlined as follows :

Three distinct documents have to be drawn up. One is a chart showing information on the nature of the bottom (“ drift geology ”), then a geological chart in the strict sense of the word (“ solid geology ”), and finally a structural chart using the geophysical data.

The charts have to be objective, but interpretations can be carried as insets, a particularly important role being given to the legends and to these insets.

The charts are to be on the Lambert projection, as a direct continuation of the land area maps.

Both the “ drift ” and the “ solid ” charts will be on the 1/100 000 scale, whereas a 1/250 000 scale is proposed for the structural charts. The editing of these charts will be provisional, not very costly, and will be carried out even if complete coverage is not achieved. The first preoccupation is the need to make these three kinds of document available rapidly.

At present it is only the “ drift ” charts that are being prepared for publication. Instructions regarding the establishment of such charts (\*) were published by the BRGM in 1970. Professor GUILCHER described to the French Geographical Association how the first five charts of the Atlantic continental shelf sediments are being established :

“ For the land masses we have retained the lines of equal altitude and the place names. For the sea the contour lines established from the various available documents are shown in black at 10 m intervals, and thus the principal relief is built up. The geomorphology proper will be shown on separate charts illustrating the thesis of their authors.

(\*) “ Notice pour servir à l'établissement de la carte des dépôts meubles ”.

“ The object of the present chart is to portray sediments : these are shown in various colours, on the following basis :

“ Red hachuring indicates rocky bottom, but does not show its nature. Another series of documents — the geological charts — will show the nature of these rocks. Preliminary tests for the area off the coasts of southern Brittany have already been carried out by the BRGM.

“ Red dots indicate gravel (more than 20 mm in size).

“ Pale yellow dots indicate grit and sand (between 20 mm and 50 microns).

“ Green dots depict pelites of less than 50 microns).

“ There are also sub-divisions of these principal categories which are depicted by “ screens ”. For example there are three ranges for the pelites (50 % - 80 %, 20 % - 50 % and 5 % - 20 %). As the various categories are often intermingled, these screens can be shown superimposed on one another. Thus we may find a pelite screen over a sand screen or a grit screen over a gravel screen.

“ Besides granulometry, another fundamental characteristic of sediments is their percentage of calcium carbonate. This characteristic is depicted in golden yellow with four screens, indicating the ranges : over 70 %, 50 % - 70 %, 30 % - 50 % and 10 % - 30 %.

“ Finally, the sedimentary facies such as maerl (lithotamnion), the percentage of shells, or other faunal facies are depicted. Here the authors were given fairly large latitude, but it does not appear that this has led to any lessening of the charts' homogeneity..

“ To make sedimentary drifts easier to understand hourly current roses are given for their direction and speed, since these currents play an essential part in the accumulating of existing deposits as well as accounting for their absence.

“ A brief explanatory note is given at the foot of each chart. This note follows the same principles as those featured on the detailed geological maps of France. The region's characteristics are described, including its hydrodynamic character, and particulars given about the rocky bottom and its covering of sediments ”.

## 2. BRITISH PROJECTS AT THE PRESENT DAY

Great Britain, which was somewhat inexplicably behind in this field, is rapidly making up for lost time. To Mediterranean eyes, it seems that the National Institute of Oceanography although it was the first to perfect such completely original methods as side scanning sonars has not yet had the opportunity to turn its attention to a geologic chart of Britain's continental shelf. Furthermore, BOWERS' work on continuous seismic sounding carried out in the sixties has unaccountably been lost.

Three scales are being used in Britain, according to McQUILLIN (personal letter). The projection system chosen is the UTM for sea areas.

(a) 1/2 500 000 : a geological chart in colour assembling all the relevant data will be published in 1972. This will cover the continental shelf and the British Isles. It is likely to be re-edited every two to five years as new data become available.

(b) 1/250 000 : these sheets will cover 1° of latitude and 2° of longitude. The dry land as well as the ocean bottom will be depicted.

Six different types of transparent overlay are envisaged, among them those showing the solid geology, the drift geology, and the bathymetry and various geophysical data. To these could be added others portraying geochemistry, geotechnics and structural geology.

(c) 1/100 000 : these will be the working documents, and instead of being printed they will merely be available to the public on request as duplicated copies.

Thus it is clear that there are several differences between the French and English concepts.

Marine data, for instance, could be added to the 1/1 000 000 geological map of France. The different scale adopted by the U.K. seems essentially due to the shape of their country.

The 1/250 000 charts which in England will be an essential part of the publication did not to begin with find favour in France. Personally (Leenhardt), I have insisted on a 1/100 000 scale, in view of the complexity of known detail in the Mediterranean, particularly in the Provence area (southeastern France).

I wonder whether I was right. Experience has not yet shown. The British decision not to print any 1/100 000 charts is certainly more economical.

Superimposable transparent overlays might turn out to be awkward to use. The French system utilizing very full legends and inset explanations should be more practical.

### 3. THE PARTICULAR PROBLEMS OF THE MEDITERRANEAN

Marine geologists working in the Mediterranean do not quite agree with the recommendations of their Atlantic colleagues, for the following reasons.

(a) *Morphology.*

In the Mediterranean the continental shelf does not extend so far out as it does in the Atlantic or in the Channel. In general, it is narrow, above all where it meets areas of crystalline and metamorphic formation.

It is always channelled by submarine canyons, often deeply so, and in time these canyons often get buried and so become superimposed on one another.

(b) *Sedimentology.*

Outwards from the coast the landscape is divided into three distinct bands :

- (1) A Flandrian covering in depths of under 80 m;
- (2) Regressive Preflandrian sands which do not necessarily appear as outcrops;
- (3) Sandy Würmian muds.

This distribution occurs with regularity. In the absence of the sands the two kinds of mud are found above one another. Other forms of outcrop are the exception.

(c) *Geology.*

In the main, the geologic formations around the Mediterranean are as heterogeneous as could possibly be found in so restricted an area. All varieties of stratigraphical series and all structural types are encountered, as has been shown by Professor GLANGEAUD (1966).

This stratigraphic variety is found again in the seismic profiles, although certain elements may be absent on account of tectonic unconformities.

In its detail, the zone which we are more particularly illustrating (figure 1) has many such atypical unconformities.

In the Gulf of Lions the hard substratum is deep. When we talk of unconsolidated sediments what do we mean here? In the Atlantic where the mud covering is not very thick, and in the Channel where it is often non-existent, we have no difficulty.

The continental flexure has deformed the shelf. The continental slope is a complex talus whose geological form is a combination of the series that dip towards the continent, of normal fault lines subsiding in the seaward direction, and of slumpings of the covering, all of which pile up on one another.

Steep slopes — and these are poorly represented on the seismic profiles — complicate the interpretation still further.

Unless the representation is somewhat interpretative the complexities would be very hard to understand, whereas objective data immediately suggest that off the coast of Brittany there exists a pericline of an older mountain terminating beneath a geological series which is of progressively younger age as we move outward from the coast. The only unconformities in this simplified outline are the beds of several rivers and some instances of Würmian and Flandrian deposits which sometimes cover over the bedrock.

The Mediterranean abyssal plain is on the contrary flat, and its geology easy to depict. The age of some of the structures found there gives us the clue. Geologists whose speciality is the Mediterranean outline thus their methods of work.

Three types of documents are available :

1. *Bathymetric charts.*

2. Seismic profiles at different scales :

- (a) Sediment probes to deal with the unconsolidated mud or sandy mud covering the bottom.
- (b) Continuous seismic sounding at different strengths to study the various levels of Plioquaternary strata. This sounding can sometimes reach as deep as the top of the Secondary (if encountered) or to the basement itself.
- (c) Seismic sounding with explosives (for the oil industry) which can go as far as the crystalline basement.

3. Sediment samples. To be able to interpret these samples we have to transcend sedimentology proper.

(a) At the first stage of interpretation, sedimentological studies will indicate the nature of the sea-bottom as well as the immediately underlying layers. This is lithological information.

(b) At the second stage we have to try to distinguish deposits of various ages from the correlation between samples, for example by an analysis of the mineral content of their clay and their percentage of oligo-elements as well as of the paleontologie aspect of their macro- and micro-fauna. This is stratigraphic information.

(c) At the third stage the seismic data for the thin upper layer are integrated with the outcropping layers (table-like stratifications, flexures and various tectonic unconformities). Insofar as possible the subjacent series that never outcrop will also be taken into account, for the deep structure sometimes governs the arrangement of the upper layers, and thus it will only be possible to interpret them if we have taken account of the deep structure. Here the information provided is clearly of a structural nature, and thus we have followed the same procedure as the one used for geological maps of land areas.

Finally, although these Mediterranean charts are of an interpretative nature they are nevertheless more complete than those of the Atlantic where for instance neither the thickness nor the arrangement and age of a layer of mud is portrayed.

Thus it is clear that the Atlantic and Mediterranean geologists are at variance. As the sediment conditions in the two basins differ so also do the concepts for the role that the chart should play. Descriptive science is the aim of Atlantic geologists, but we on the other hand are forced for the sake of clarity to propose interpretations and hypotheses.

## CONCLUSION

Whatever progress has been achieved in the charting of submarine geology and whatever methods for drawing up such charts have been specially conceived there remains the question of the interest their actual publication will have. No-one will gainsay that small scale coverage is invaluable for building up a picture of the whole, but the interest of a chart must, in the event, be measured by the number of buyers, and unfortunately geological data have still very few applications. Charts for use by fisheries or for geotechnics or for underwater navigation are likely to be at least as profitable. Finally, the speed with which new data are acquired means that published data tend to become rapidly outdated. What is required, therefore, is a balance between production costs and the number of possible purchasers. The British solution of making the large scale plotting sheets available to interested parties certainly seems sensible from an economic point of view.

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