CNEXO and Ifremer: over fifty years of worldwide marine scientific research and exploration of the French EEZ

Walter Roest
Ifremer, France
When I started my research career in 1959, we did not even know about the mid-ocean ridge, the largest structure on our planet, 60,000 kilometers long. [...] It was the exploration of the oceans that led to the development of plate tectonics in the 1960s, offering for the first time a coherent quantitative model of the evolution of our planet. Paradoxically, this model, still very schematic, relied on entirely oceanic data.

Citation: X. Le Pichon, date?
CNEXO and Ifremer

• Early days
• Plate Tectonics: from the global scale to in situ observations
• Science and technology for exploration of the ocean
• Law of the sea and the continental shelf
• Conclusion
Sea-Floor Spreading and Continental Drift

XAVIER LE PICHON

Lamont Geological Observatory, Columbia University
Palisades, New York 10962

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1 Lamont Geological Observatory Contribution 1197.
2 Now at CNEXO, 39 Avenue d'Iéna, Paris, 16, France.
CNEXO
Centre National pour l’EXploitation des Océans

• CNEXO was one of several research institutions created by law n° 67-7 of January 3, 1967 by General de Gaulle and Georges Pompidou

• CNEXO was a public institution of industrial and commercial character

• The mission of the CNEXO was to develop knowledge of the oceans and research studies aimed at exploiting the resources contained on their surface, in their mass, their soil and their subsoil.
Oceanographic Vessel Jean Charcot

Launched in 1965 for Comexo (Oceans Exploitation Committee), which became CNEXO and then Ifremer
Creation of Ifremer Décret n°84-428, 5 juin 1984

The mission of Ifremer (merger of CNEXO and ISTPM) is to lead and promote fundamental and applied research, expertise and technological and industrial development actions in order to:

1 Understand, evaluate and develop the resources of the oceans and to allow their sustainable exploitation;

2 Improve the methods of monitoring, forecasting evolution, protection and enhancement of the marine and coastal environment;

3 Promote the socio-economic development of the maritime world.

Note: Marine Geosciences represents ~ 6% of human resources
CNEXO/Ifremer geoscience ship tracks
Crustal structure of the mid-ocean ridges

*Journal of Geophysical Research 1965 - 1966*

1. Seismic refraction measurements LE PICHON, HOUTZ, DRAKE and NAFE

2. Computed model from gravity and seismic refraction data TALWANI, LE PICHON and EWING

3. Magnetic anomalies over the mid-Atlantic ridge HEIRTZLER AND LE PICHON

4. Sediment distribution in the South Atlantic Ocean and the Cenozoic history of the Mid-Atlantic Ridge EWING, LE PICHON AND EWING

5. Heat flow through the Atlantic Ocean floor and convection currents LANGSETH, LE PICHON AND EWING
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   absence of a wide heat-flow maximum [...] precludes the possibility of continuous continental drift during the Cenozoic by the spreading-floor mechanism in the Atlantic
Sea-Floor Spreading and Continental Drift

Xavier Le Pichon

~ 30 spreading rate determinations from magnetic anomalies

~ 60 spreading azimuths from fracture zones

Best fit model for 6 rigid plates
Sea-floor spreading and continental drift

Le Pichon, JGR, 1968
Plate Tectonics

• A coherent quantitative model of the evolution of our planet
• Tectonic plates include continents and oceans
• Ability to make predictions and test hypothesis
• Largely beyond geology
  – Hazards
  – Paleo circulation
  – Paleo climate
  – Marine biology
  – Natural resources
Expansion of the French Fleet

• In 1965, *Coriolis* for the Pacific Ocean, then in 1966 *Pélagia* to support coastal research.

• In 1968 *Capricorn* began work in the tropical Atlantic, then the *Cryos* to support the fishing effort in the mouth of the St. Lawrence and off Newfoundland.

• In 1971, the first multipurpose vessel was commissioned, *Le Noroît*, and four years later *Le Suroît* was built to facilitate exploration surveys with light submersibles.

• Finally in 1974, the *Nadir* was launched to support heavier gear, such as the Archimedes bathyscaphe or the Cyana manned submersible.
Exploring the oceans

NESTLANTE II, Jean CHARCOT, 1970

Most of the program has been carried out in the deep sea area and in the Barents Sea despite serious technical difficulties and sometimes difficult conditions.

The buoy test last night was disastrous.

The airgun, which had been made to work for 3 hours, died again. A leak in the chamber. We will take it apart again today.

The magnetometer is still broken.

The results obtained with the buoys in particular are clearly superior to those of Lamont and should allow a fairly clear structural interpretation.

Chief Scientist, Le Pichon
Exploring the oceans

CYANHEAT, Nadir, 1979

© Ifremer - Vic CHAPRON
• In 1971, Xavier Le Pichon, head of the Scientific Department, COB, CNEXO wrote a letter to Woods Hole geologist Ken Emery and proposed a joint U.S.-French expedition to explore the axis of the Mid-Atlantic Ridge using manned submersibles (two years after Apollo 11)

• France had the 200-ton bathyscaphe *Archimède* operated by the Navy and was building a smaller submersible called *Cyana*. The U.S. had the Navy-owned, 15-ton *Alvin*, developed by engineers at Woods Hole

• After significant resistance, operations started in 1973

*Source: WHOI, 2017*
FAMOUS

Xavier Le Pichon with Claude Riffaud, Director of the COB, in front of the world ocean floor map

- French-American Mid-Ocean Undersea Study
- Intense investigation of the Mid-Atlantic Ridge between 36° and 37° N
- Chief Scientists: Jim Heirtzler and Xavier Le Pichon
- Search for evidence of hydrothermal vents

© CNEXO/Ifremer
FAMOUS

Archimède and Cyana completed 27 dives, Alvin 17, collecting 100,000 photos and 1500 kg of rock samples

Le Noroît and Cyana at night in the harbor, Ponta Delgada, Açores, 1974 © Ifremer - Alain MASSOL

© Ifremer
Atlantic Ocean floor

A map of the ocean floor, published in 1968 based on deep ocean soundings compiled and interpreted by Bruce Heezen and Marie Tharp, Lamont

Painted by Berann for National Geographic Magazine
Gravity from Space: Radar Altimetry
William F. Haxby,
Lamont-Doherty Geological Observatory
National Geographic, 1983
FARANAUT, L’Atalante 1992

The cruise allowed to demonstrate the presence of outcropping mantle rocks in the axial zone of the ridge as well as the release of methane, a reflection of active processes.

Complete map of the 15°20’ N fracture zone and the intersections with the mid-Atlantic ridge axis (SIMRAD EM 12 multibeam sounder)

Annual report Ifremer 1992
Plate kinematics of North and Central Atlantic

Olivet, 1984
RUPTURE ET DISPERSION DE LA PANGÉE :
OUVERTURE DES OCÉANS ATLANTIQUE ET INDIEN
ET CHAÎNES DE MONTAGNES ASSOCIÉES
(Ouvrages mécaniques et tectoniques par rapport à l'Arctique)

Olivet and Aslanian, 2000
Age of the Oceanic Lithosphere

Courtesy NOAA, after Müller et al., 2008
Sea-floor spreading and continental drift

Le Pichon, JGR, 1968
Tectonic Plates

Comparing 6 plates in 1968 with 12 plates in 2008
Ifremer - Marine Geoscience Research

- understanding the geological evolution of the planet, of the mechanisms of formation of margins and of sedimentary transfer balances in relation to climat and tectonic variations;
- exploration dedicated to the understanding of geochemical cycles and the search for mineral resources;
- the study of marine geological hazards and the characterization of dynamic structures (active margins, seismicity, ..);
- participation in the technological developments necessary to undertake this research.
Technical Capabilities

- The Ocean Spectrometry Pole, UBO (IUEM), CNRS and Ifremer
- Large pool of OBS
- Sediment core laboratory and storage facility
- Geotechnical probes and geotechnical laboratory, including gas hydrates research

Recent Activities:
- Marine Minerals (ISA and EEZ)
- UNCLOS continental shelf
Pelletier et al., 2016
Hydrothermal Vents

Polar echograms of EM2040 data: inactive chimney (left) and hydrothermal plume above active sulfide mound (right)

© Campagne Serpentine 2007/Ifremer-VICTOR

Fouquet et al, 2015 OTC-25933-MS
UNCLOS Article 76: the continental shelf

Continental Shelf
Slope
Rise
Abyssal Plain

Territorial Sea
Contiguous Zone
Exclusive Economic Zone
Continental Shelf beyond 200 M
the Area

High Seas
Some Numbers

- Global EEZ: ~ 120 million km²
- Global Extended Shelf estimated at ~ 25 million km²
- > 70 States have entitlement over continental shelf beyond 200 nautical miles
- 70 Submissions already lodged with the UN
Conclusions

• After 50 years, plate tectonic theory provides fundamentals tool for our understanding of the earth system

• Only a small percentage of the ocean floor is mapped to modern standards

• Therefore, there is a need to continue exploration, using modern tools

• Significant activities related to UNCLOS and the search for minerals
Thank you!