Portugal, Science and Resources in the Deep Seafloor

Fernando J.A.S. Barriga

Creminer FCUL, Centro de Recursos Minerais, Mineralogia e Cristalografia, Fac. Ciencias Univ. Lisboa
LARSyS, Laboratory of Systems and Robotics in Engineering and Science (Lab Associado) Lisboa

BGR / Maritime Cluster of North Germany
June 10, 2013

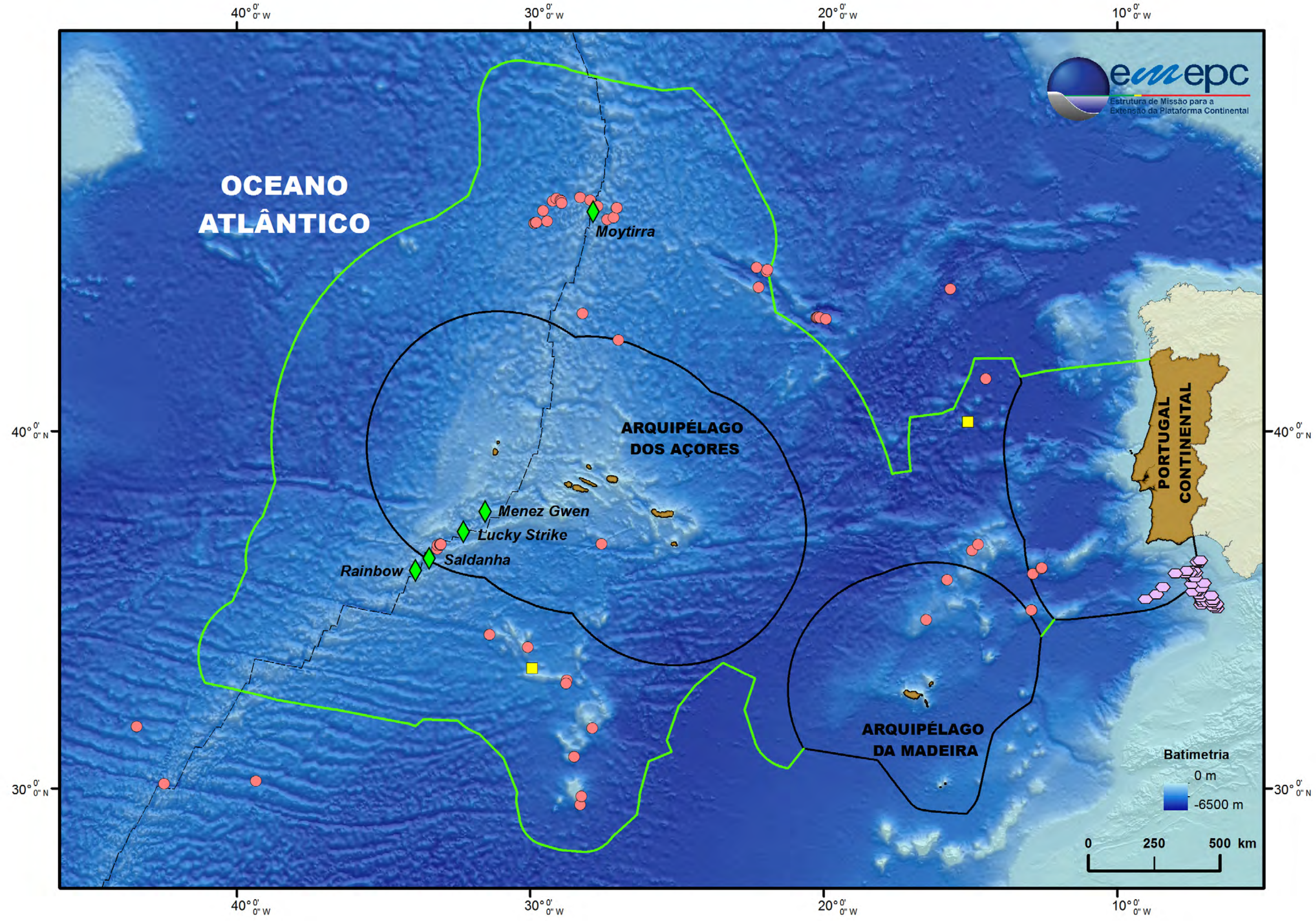
Recursos naturais na crosta oceânica profunda: realidade ou ficção?

Fernando J.A.S. Barriga

Creminer FCUL, Centro de Recursos Minerais, Mineralogia e Cristalografia, Fac. Ciencias Univ. Lisboa
LARSyS, Laboratory of Systems and Robotics in Engineering and Science (Lab Associado) Lisboa

JEAMB 2014 - Jornadas de Engenharia do Ambiente
IST-UL, 18 Fev 2014

RECURSOS MINERAIS DA PLATAFORMA CONTINENTAL PORTUGUESA



Seabed economic rights

Country	EEZ km2	Additional CS	Total seabed jurisdiction	Country area (emmerse)	Ratio seabed/ country area
United States	11,351,000		11,351,000	9,629,091	1.2
France	11,035,000		11,035,000	652,090	16.9
Australia	8,505,348	2,500,000	11,005,348	7,692,024	1.4
Russia	7,566,673		7,566,673	17,098,242	0.4
UK	6,805,586		6,805,586	242,900	28.0
New Zealand	6,682,503		6,682,503	270,467	24.7
Indonesia	6,159,032		6,159,032	1,910,931	3.2
Canada	5,599,077		5,599,077	9,984,670	0.6
Brazil	3,660,955	911,847	4,572,802	8,514,877	0.5
Japan	4,479,388		4,479,388	377,930	11.9
Portugal	1,727,408	2,150,000	3,877,408	92,090	42.1
Chile	3,681,989		3,681,989	756,102	4.9

Seafloor research pays

Seafloor research pays

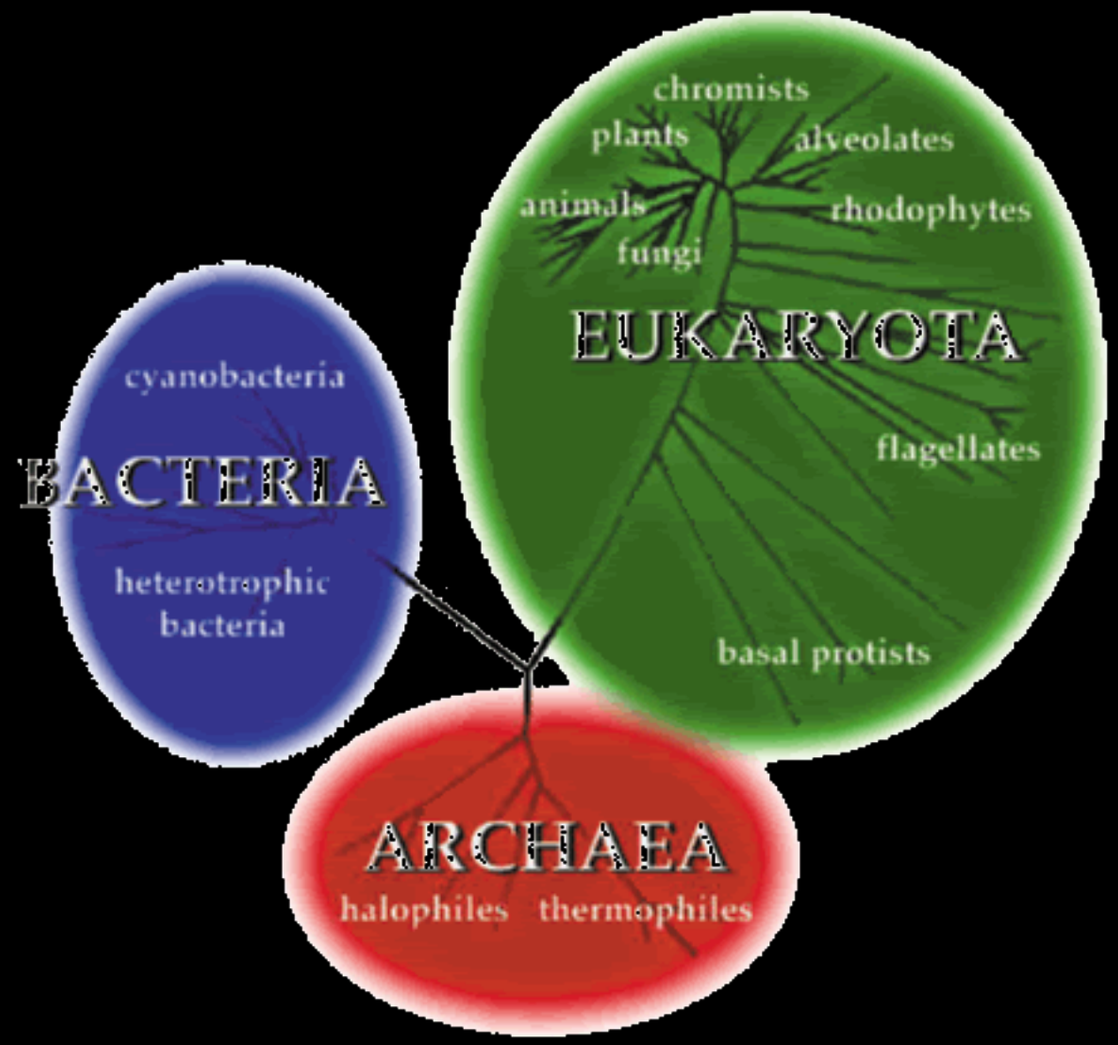
- Submarine hydrothermal activity and minerals

Seafloor research pays

- Submarine hydrothermal activity and minerals
- Gas hydrates

Seafloor research pays

- Submarine hydrothermal activity and minerals
- Gas hydrates
- The deep biosphere



Seafloor research pays

- Submarine hydrothermal activity and minerals
- Gas hydrates
- The deep biosphere
- Older stuff revisited (nodules and crusts)
- Non-resource related (climate, hazards)
- Plate Tectonics

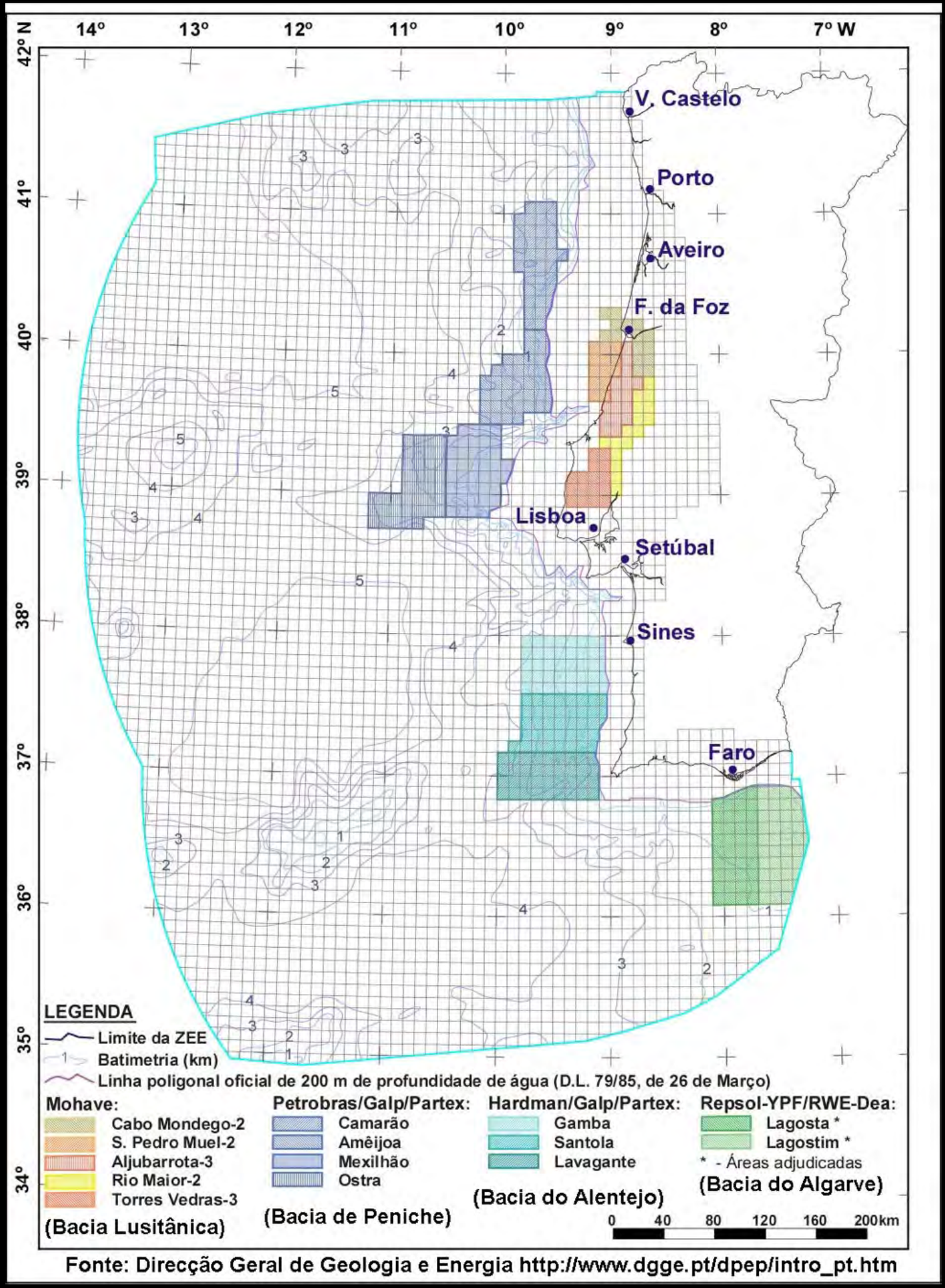
What else is out there?

- New tools and observatories
- Systems research

Known resources

- Sand and gravel
- Co-rich Mn crusts (+ phosphorites)
- sms deposits

Oil and gas



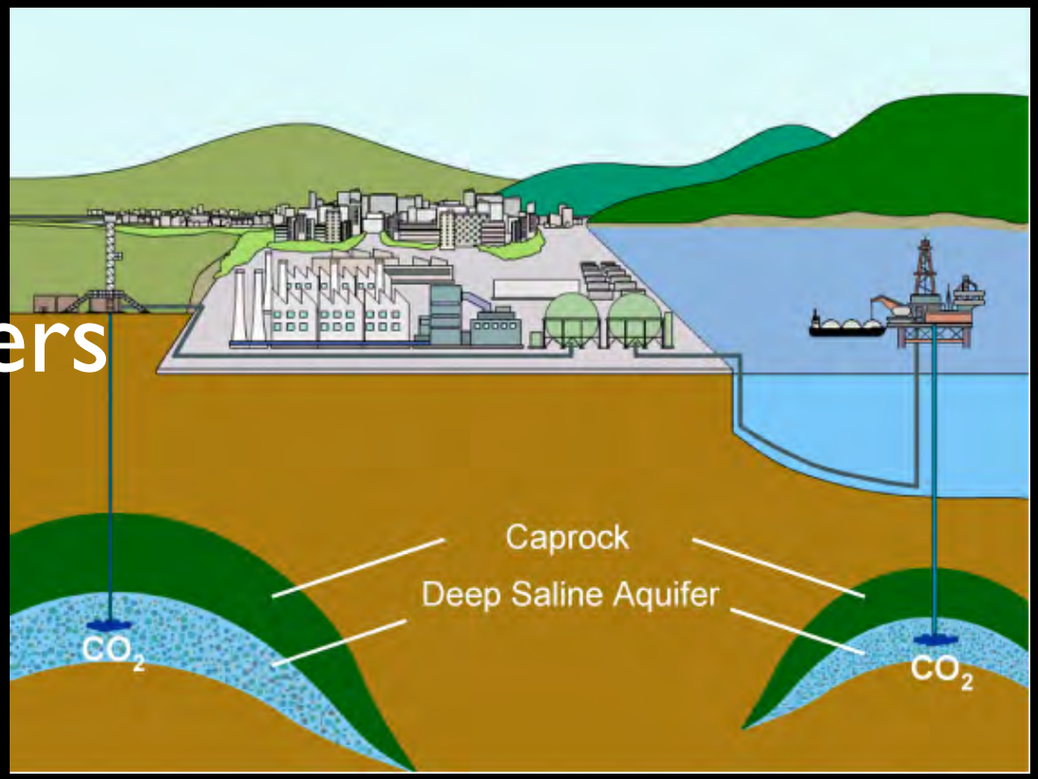
Fonte: Direcção Geral de Geologia e Energia http://www.dgge.pt/dpep/intro_pt.htm

Microbes & biomolecules

- Extremophile microbes / biomolecules
- Biomass=0.1-1 conventional biosphere
- Being produced for economic use (e.g. Seahma)
- Portuguese companies

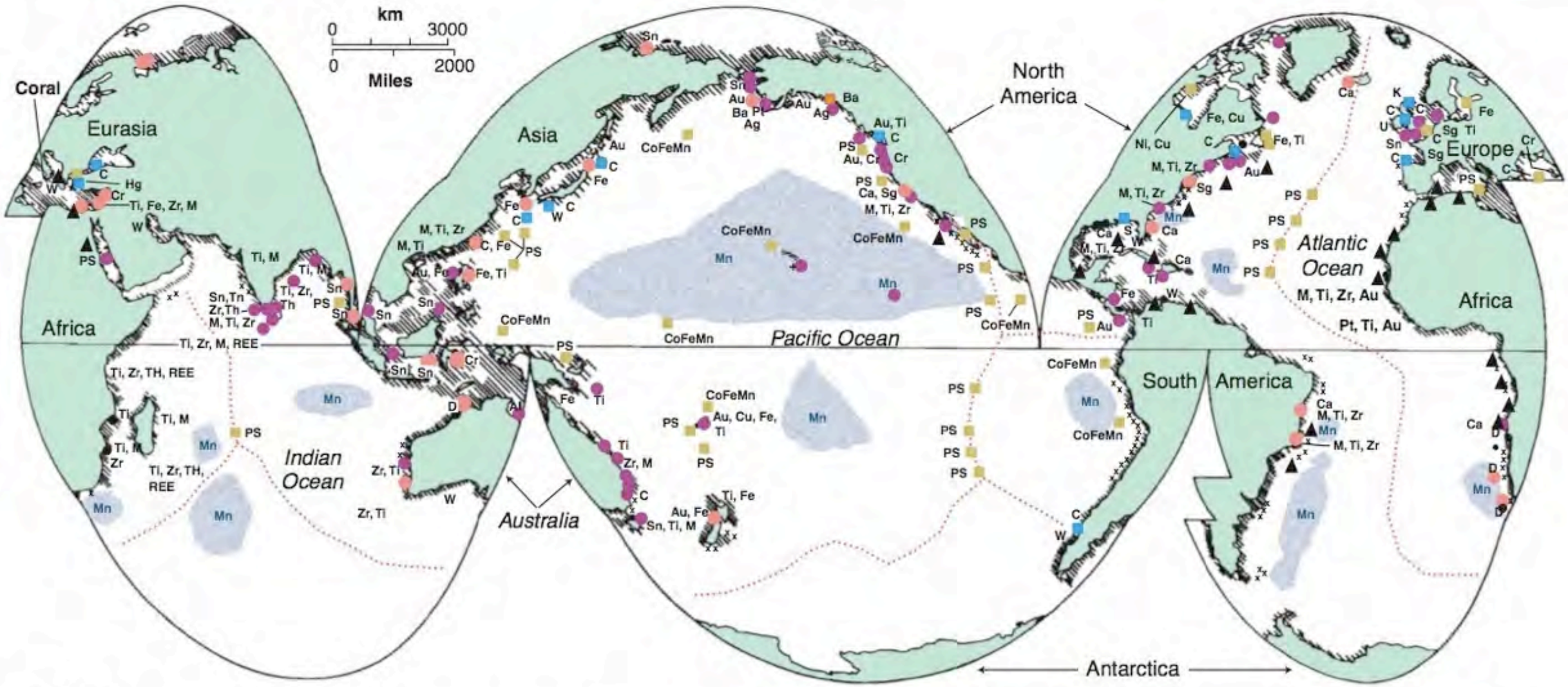
CO_2 sequestration

- Sub-seafloor saline aquifers



CO_2 sequestration

- Sub-seafloor saline aquifers
- Carbonates of Ca, Mg, Fe and Mn
- Already under consideration

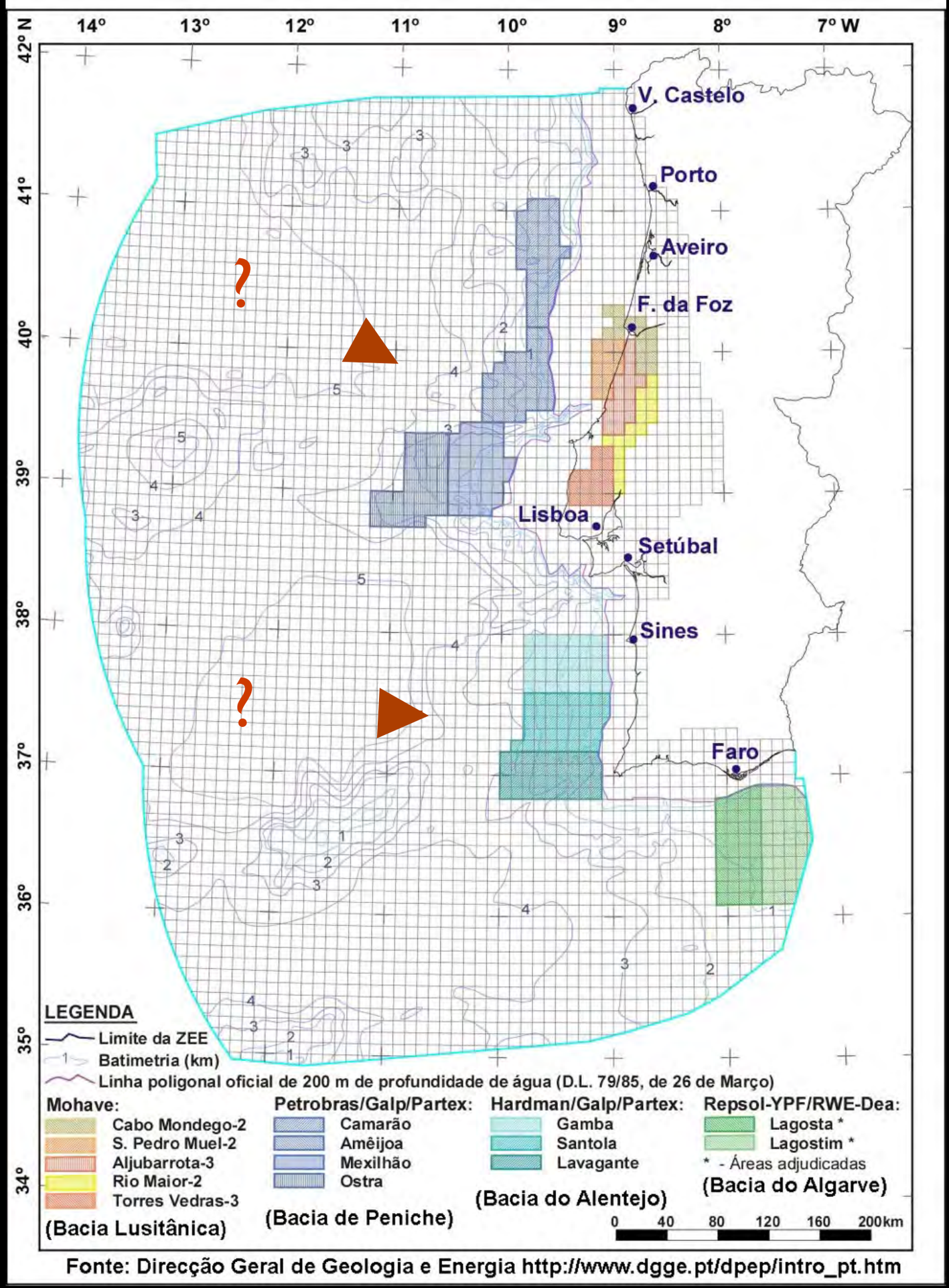


Global distribution of marine mineral resources known at this early stage of ocean exploration.

After Rona, 2003

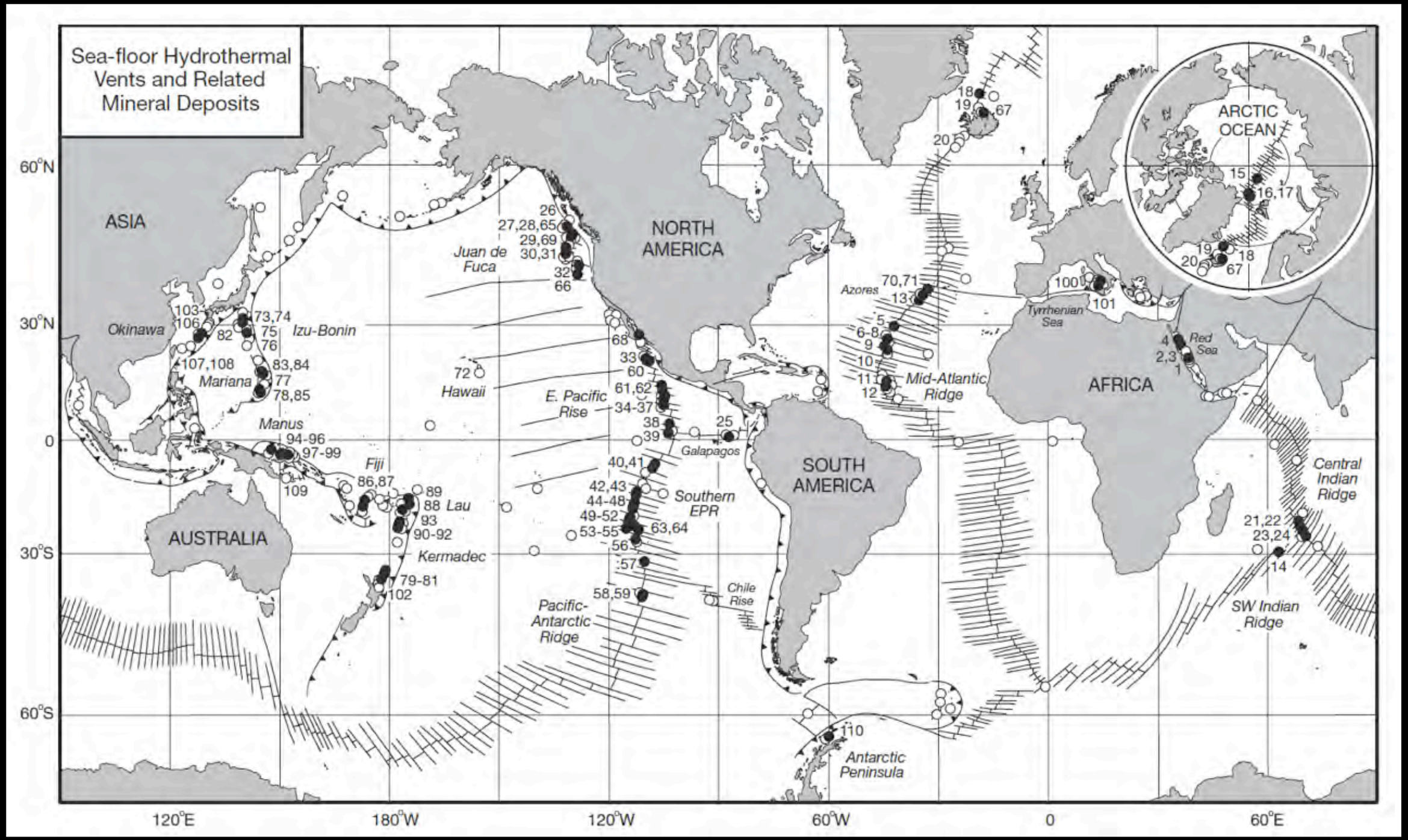
Unconventional HC's

- The deep biosphere & the origin of oil
- Serpentinization HC's
- Both from the crystalline crust
- Sediments needed chiefly as cover rocks



Fonte: Direcção Geral de Geologia e Energia http://www.dgge.pt/dpep/intro_pt.htm

sms deposits

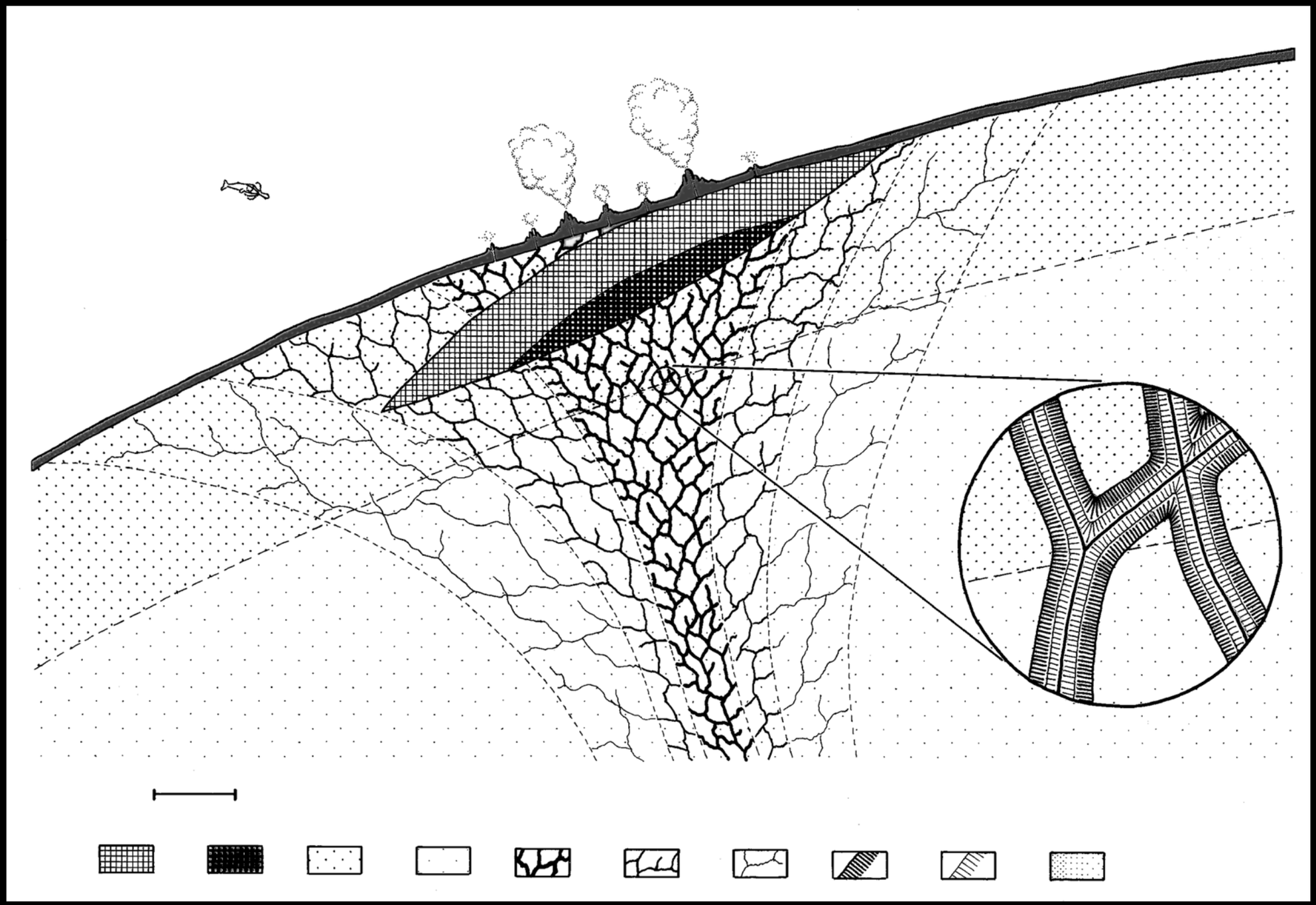


After Hannington et al., 2005

sms deposits

- Exposed on land
  - Few ophiolites
  - Obducted under exceptional conditions
    - Representative?
- Present mid-ocean ridges
- Back-arc basins
- Sub-seafloor massive sulphide deposits
- Very large potential

ssms deposits



After Carvalho, Barriga & Munhá, 1999

34°W
32°W
30°W
28°W
26°W
40°N
38°N
36°N
Corvo
Flores
Graciosa
S. Jorge
Terceira
Faial
Pico
S. Miguel
Menez Gwen
Lucky Strike
Sta Maria
FAMOUS
Segment
Saldanha
Rainbow
200 mile line
0
100
200 km

Exploration

- Provinces with sms activity
- Structure and geomorphology
- "Airborne" geophysics (with AUV's)
- Definition of favorable areas
- Detailed geophys, geochem, mineralogy
- Shallow drilling (sea-floor rigs)
- Via partnerships/joint ventures

Areas requested by Nautilus in the Azores Sea

Nautilus Minerals Inc	MNPPP0309 Verdelho	WGS8405	Nº 196 de 10-10-2012
Nautilus Minerals Inc	MNPPP0313 Moreto	WGS8404	Nº 195 de 09-10-2012
Nautilus Minerals Inc	MNPPP0312 Arinto	WGS8403	Nº 195 de 09-10-2012
Nautilus Minerals Inc	MNPPP0311 Famous	WGS8402	Nº 219 de 13-11-2012 Nº 195 de 09-10-2012
Nautilus Minerals Inc	MNPPP0310 Saldanha	WGS8401	Nº 195 de 09-10-2012

Next

- Interaction between
- Crystalline crust
- Sedimentary cover

Seafloor mining

- Pilot deep sea mining installation
- Area under Portuguese jurisdiction
- Joint ventures (exploration & mining)

Seafloor ecosystems

- Deep seafloor sustainable mining
- There's reasons for hope
- Environmental scientists needed
  - Monitoring
  - Modeling
  - Validation