Exploración de Capitales Naturales de los Fondos Marinos: Avances Tecnológicos de una Industria Emergente

Sandor Mulsow, PhD
Director LEET-IG-UACH
GESAMP Member
ISA-LTC Member
the oceans and seafloor we know it is not that old....
Funciones ecológicas de los Océanos

Chandler, Kaufman and Mulsow, 1996
Previlegio: conectividad directa a bases oceanicas

seamounts

Inactive vents

thank you Plate Tectonics Theory
...and on this ocean, a huge revolution took place......
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...at that time evolution exploded with new clades of animals...never seen before and after
...new ecological niches were available and rapidly occupied. Mollusk predators appears and induced a dramatic change on the seafloor, that changes everything and it is what we have till now.
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Ocurrió entonces, hace 600 ma, una revolución trófica y como consecuencia un radiación evolutiva sin precedentes, el big bang de la diversidad (Liñan y Gomez, 1999)
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Ojos que no ven....bentos que no sienten?

bentos que si sienten
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bentos que si sienten
Importancia de los océanos (water column only) en nuestro planeta (Costanza, 2000)

...desde entonces nuestros oceanos columna de agua, han proporcionado beneficios a *Homo sapiens*.... Pero, hay otros beneficios (servicios) tangibles que proporciona el fondo marino.

<table>
<thead>
<tr>
<th></th>
<th>Oceans</th>
<th>Coastal Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worldwide GNP</td>
<td>10*</td>
<td>15</td>
</tr>
<tr>
<td>Human welfare</td>
<td>8.4</td>
<td>12.6</td>
</tr>
</tbody>
</table>

*Unidades en trillion USD*
Importancia de los océanos (water column only) en nuestro planeta (Costanza, 2000)

1. Funciones Ecologicas: biogeochemical cycles
2. Capitales Naturales (Goods): minerals
3. Cultural: paleoceanography, paleohistory

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Diagrama de Capitales Naturales con potencial de minería

Distribución de nódulos
Geographical Differences

concentration ppm

Fe-Mn nodules database from IFREMER-France
Geographical Differences

concentration ppm

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concentration ppm

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n = 317 cases
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Servicios ecosistémicos intangibles. Fe-Mn nodules had recorded the Pacific Ocean history...
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Wednesday, July 7, 2010
Northwest Pacific Ocean

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Wednesday, July 7, 2010
No es tan simple...

depositos masivos de polisulfuros ricos en Au y Ag
HV: French data, importance of host rock type
Detection of hydrothermal particulate plume by CTD-X

South flank of South Su Knoll, Eastern Manus Basin
depositos masivos de polisulfuros ricos en Au y Ag

importancia biogeoquimica y balance de masas de los oceanos
depositos masivos de polisulfuros ricos en Au y Ag

importancia biogequímica y balance de masas de los océanos
depositos (acumulaciones) masivos de polisulfuros ricos en Au y Ag

13°N East Pacific Rise (R. Hekinian)

Wednesday, July 7, 2010
Concentrations in ppm (Au in ppb)

selected elements and relative concentrations from MSD (ISA 2010)
Exclusive Economic Zones (EEZ) Map.
Back arcs are most prospective but are in territorial waters.
Neptune Resources

Are we there yet?
Nautilus is the first company to commercially explore the seafloor for copper, gold, zinc & silver deposits.

Nautilus Inc. Emerging producer – start up planned 2010 (subject to timely permitting)
Vision can change and rapidly.

Exploration/exploitation of offshore oil (USA)
Technology is here, just need to be transferred to deep sea mining uses.

Wednesday, July 7, 2010
Riser handling equipment is off the shelf
Ocean Mining

Can we? (Technology)
Exploration
Evaluation
Recovery

Should we? (Environment)

Photo courtesy Yves Fouquet
Ocean Mining

Can we? (Technology)
Exploration
Evaluation
Recovery

Should we? (Environment)

...es solo cosa de tiempo humano....
Homo sapiens demands....
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Grades of ancient (Cyprus, Kuroko) massive sulfides and averaged analyses of modern seafloor sample

<table>
<thead>
<tr>
<th></th>
<th>Basalt-hosted</th>
<th>“Dacite”-hosted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cyprus</td>
<td>N. Fiji</td>
</tr>
<tr>
<td>No. analyses</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Wt %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>~4</td>
<td>7.5</td>
</tr>
<tr>
<td>Zn</td>
<td>0.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Pb</td>
<td>~0</td>
<td>0.06</td>
</tr>
<tr>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ag</td>
<td>39</td>
<td>151</td>
</tr>
<tr>
<td>Au</td>
<td>0.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Size of seafloor and on-land sulfide deposits (Dekker & McConachy 2000)
Cuántos años más?

algunos límites de condición...
Driving forces to deep sea mining

MA Scenarios, 2000
In MA Scenarios:

- Population projected to grow to 8–10 billion in 2050
- Per capita income projected to increase two- to fourfold
Since 1960:
- Flows of biologically available nitrogen in terrestrial ecosystems doubled
- Flows of phosphorus tripled

> 50% of all the synthetic nitrogen fertilizer ever used has been used since 1985

60% of the increase in the atmospheric concentration of CO$_2$ since 1750 has taken place since 1959

**Human-produced Reactive Nitrogen**

Humans produce as much biologically available N as all natural pathways and this may grow a further 65% by 2050
Ocean Mining

Can we? (Technology)
   Exploration
   Evaluation
   Recovery

Should we? (Environment)
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La pregunta debería ser estamos preparados para jugar un rol o no en esta actividad económica emergente?
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“... in the ocean depths, there exist mines of zinc, iron, silver and gold which would be quite easy to exploit”
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Captain Nemo in Jules Verne (1870) Twenty Thousand Leagues Under the Sea
Advantages of Ocean Mining

- No shaft*, extensive excavations**, roads, town, power plant:
  - * mine shafts $US4500 - 7500 per meter
  - ** mine tunnels $US1200 – 2300 per meter

- Shipping costs lower
- Less polluting?
Cost of developing seafloor sulphide mining?
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~ $US300 million
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Cost of developing seafloor sulphide mining?

~ $US300 million

Compare $650 million spent on manganese nodules
Cost of developing a mine on land?
Cost of developing a mine on land?

Approximately $US300 million to find and develop a typical copper, zinc, silver, gold deposit 300 km north of Montreal

Kidd Creek Mine, Canada
Mining technologies
Make use of experience
with manganese nodules
and diamonds

Namssol diamond miner

Lockheed nodule miner
Nautilus has proposed using a tv-guided grab in Manus Basin.....

- Grab capacity 2 tons
- Deployment 60 m/min
- Water depth ~1800m
- Minimum time for one grab ~90 min
- Maximum daily recovery 36 tons
- In situ value at $1000/t = $36,000
  - $500/t = $18,000
  - $200/t = $7,200

(In situ value at 5% Cu + 10% Zn + 90 g/t Ag + 5 g/t Au = $321 on September 3, 2004)
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- A 10 million ton deposit (e.g., TAG) would take 700-1000 days to recover (3.5-5 years with 200 days/year operating time).
- About 8 million metric tons of waste would remain on the seafloor (20% recovered).