Study to investigate the state of knowledge of deep-sea mining

Land-based mining vs. Seabed mining: an environmental perspective

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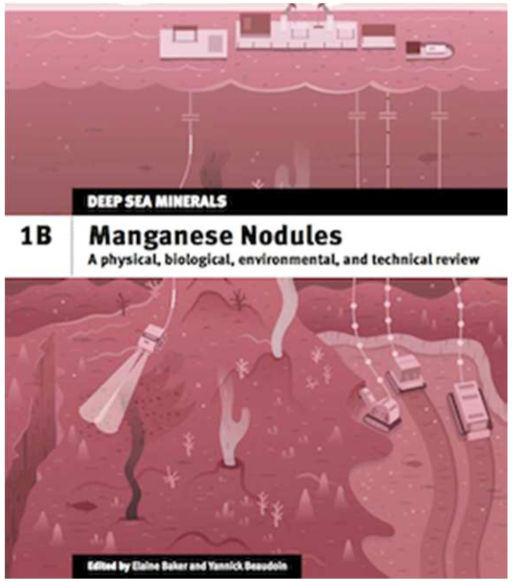
Brussels, Belgium

The event is organised as part of the study to investigate the state of knowledge of deep-sea mining commissioned by DG Maritime Affairs and Fisheries

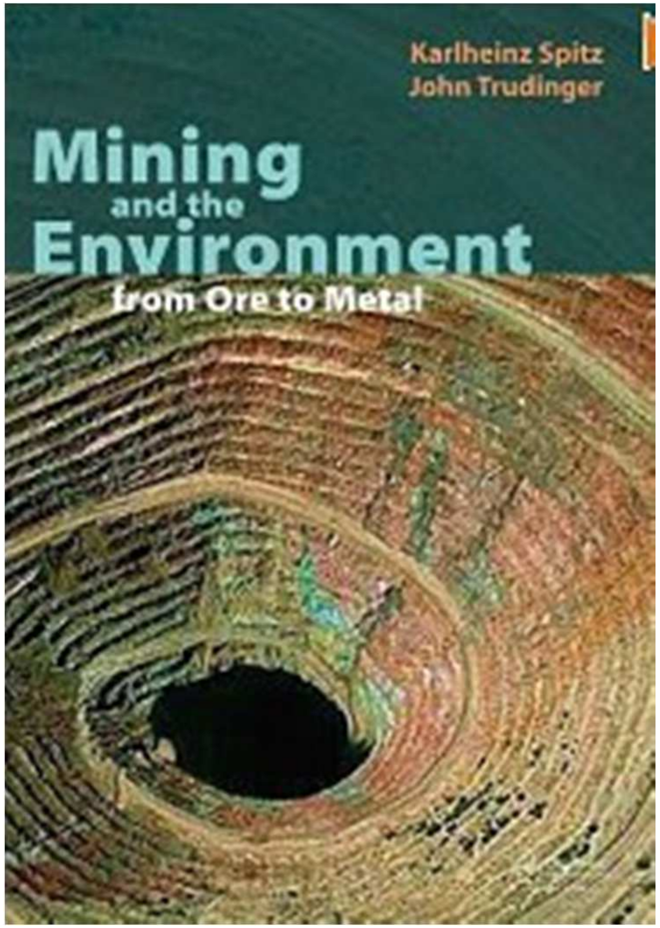
Environmental Impacts of DSM

Ecorys - Interim Report

SPC-SOPAC/Grid Arendal Reports



Environmental Impacts of Terrestrial Mining



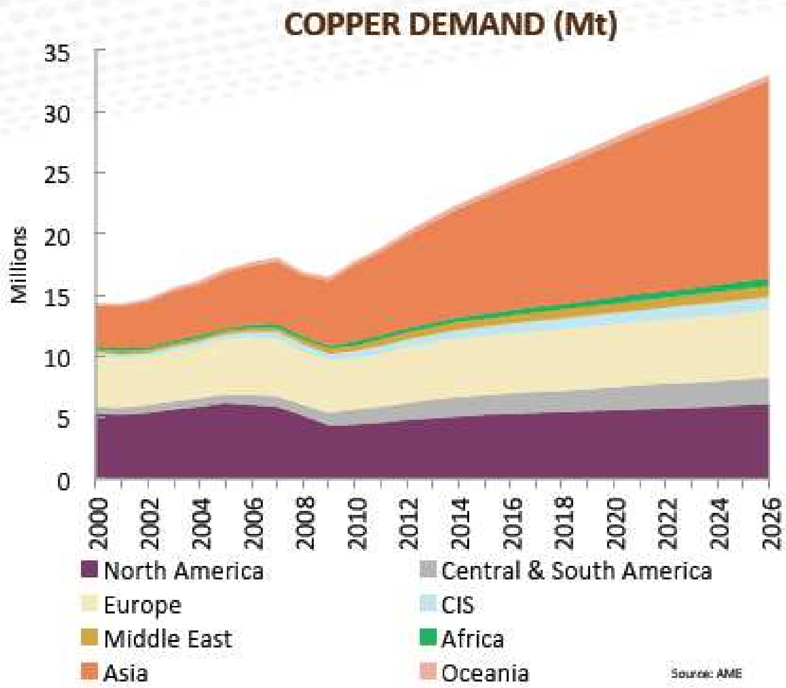
Spitz & Trudinger (2008)
Mining and the Environment, from ore to metal

Barrie Bolton ed. (2008) The Fly River, Papua New Guinea: Environmental Studies in an Impacted Tropical River System

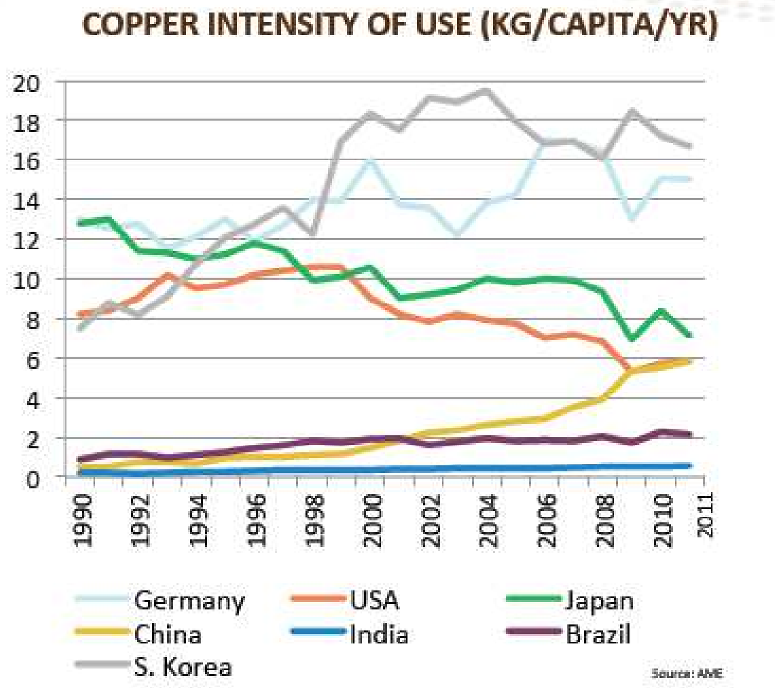
Drivers of deep sea mining

	Global	Industry	Pacific Island countries
Primary drivers	Global economic growth: supply and demand, population and consumption, increased industrialization and urbanization	Innovative, frontier field in an industry used to high-risk investment	Alternate development option: alleviate poverty, meet rising aspirations, lack of comparative advantage in other areas
	State actors: securing access to essential resources, capable of vertical integration of resource extraction and processing with product manufacture	Increasing difficulty and complexity of terrestrial mining: increasing costs, decreasing grade, slowing discovery, environmental issues, social and cultural issues	Marine minerals are a new natural resource capable of commercial exploitation in a region with few economic industries/choices
Secondary drivers	Growing societal aspirations for environmental and social sustainability	Technological improvements and scalable applicability	National independence and autonomy
	New uses/markets, the green economy		
Restricting forces	Price volatility	Availability of finance, financial uncertainty	Increasing community concerns about governance of, impact and returns from extractive industries
	Concerns over threats to marine environment, lack of marine science to inform conservation planning	Regulatory uncertanty in EEZ and the Area Significant obligations to share knowledge proceeds	Lack of governance, capacity, and regulation

Economic & Societal Driver: Copper



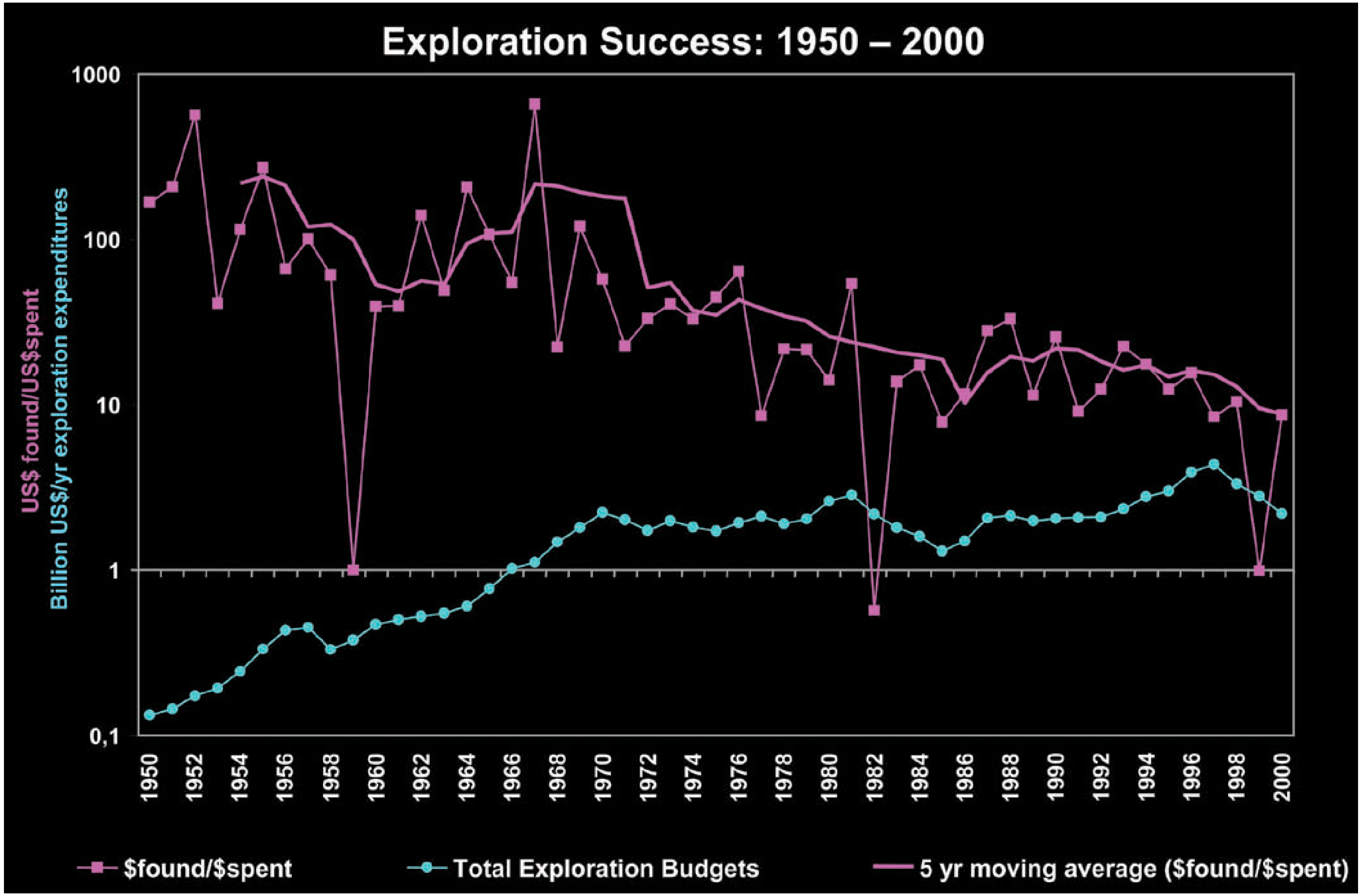
Copper demand is steadily growing and is forecast to increase to over 32Mt by 2026, a 4% CAGR



Intensity of consumption increasing in emerging markets driven by urbanization / infrastructure development

Image from RCF, 2013

Economic Driver: Exploration Costs Increase while Discoveries Go Down



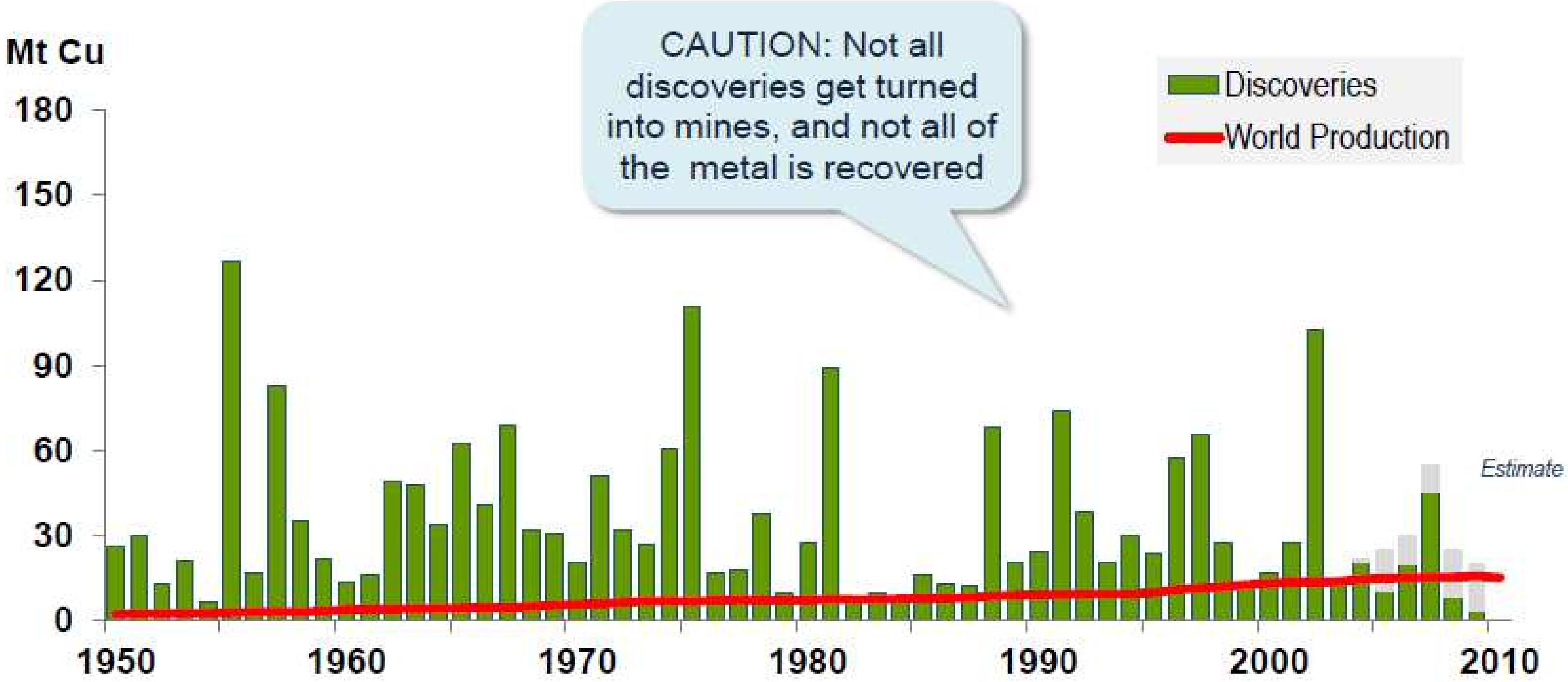
Global Copper Reserves

Copper in Reserves, Resources, and Past Production in Major Copper Discoveries by Country, 1999-2010

(Total Reserves, Resources, and Past Production of 229.1 million mt)

Mining & Discovery rates for Copper

Amount of copper mined and copper found in the World: 1950-2009

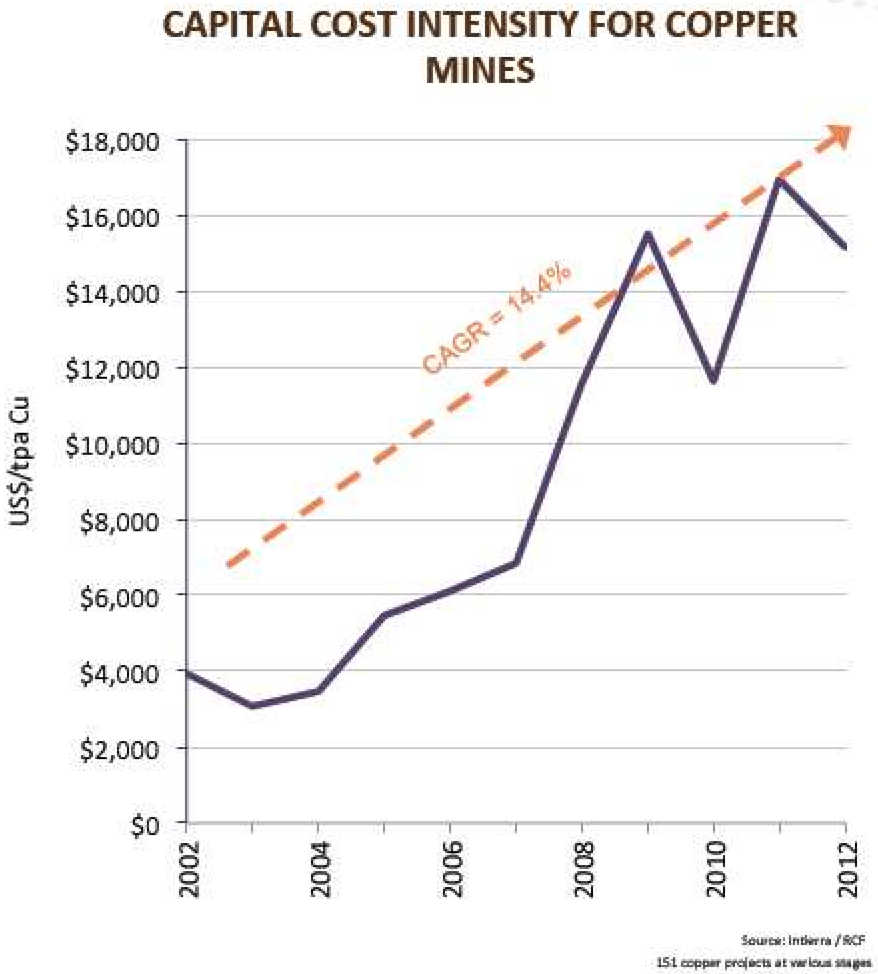


Note: Chart include minor adjustment for deposits missing from the database
Is based on discoveries > 0.1 Mt Cu

Sources: MinEx Consulting Feb 2010.
Production data from USGS

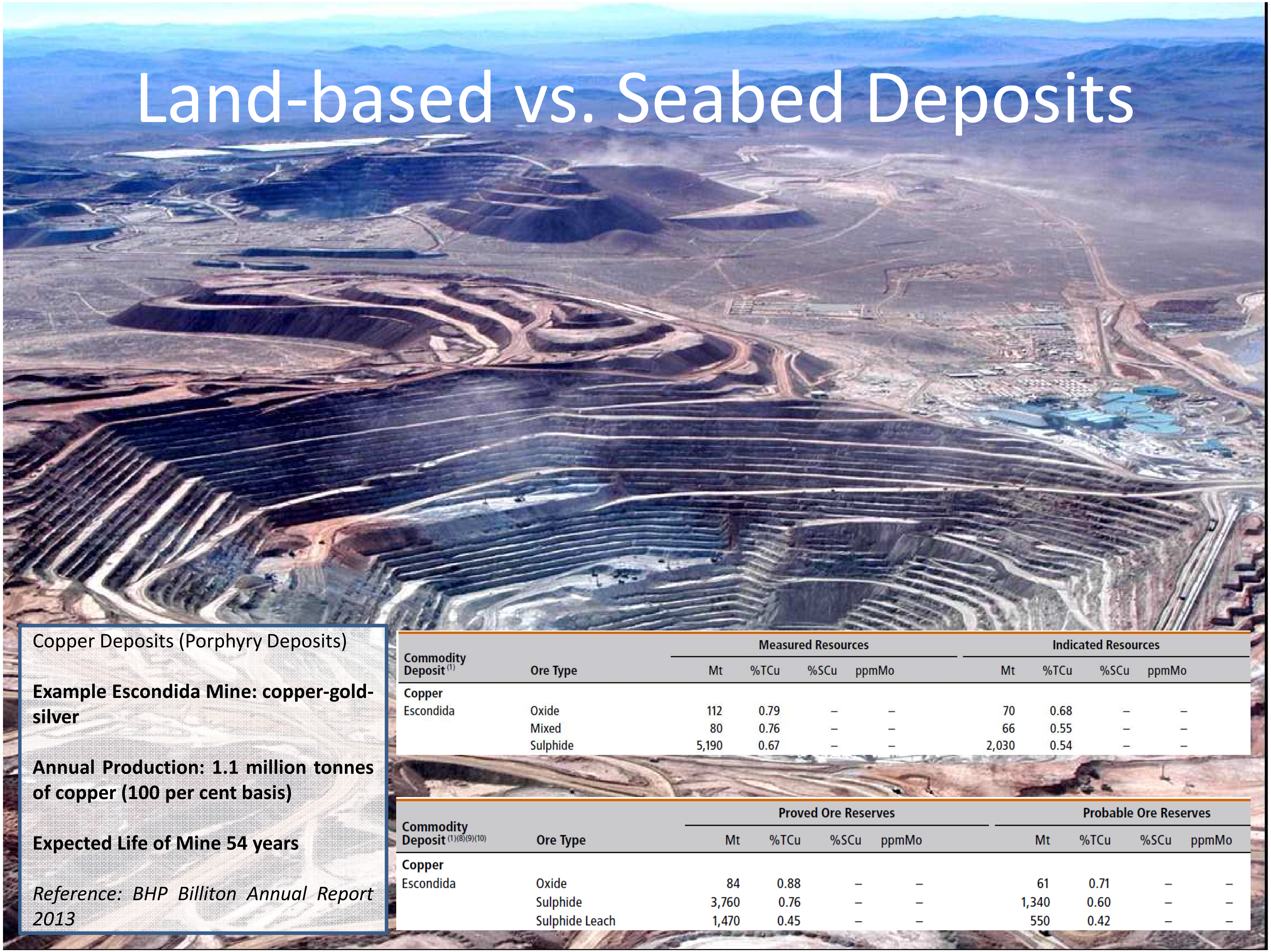
Copper: More Expensive Over Time ?

- **Absolute capital cost increases and intensity**
- **Operating costs increasing**
- **Regulatory constraints**
  - Permitting timetables
  - Green / NGO issues
  - Political risk (tax, royalties, contracts)
  - Land access
- **Infrastructure requirements**
- **Financing**
- **Human resources**
  - Skills shortages
- **Engagement with local populations**



RCF 2013

Land-based vs. Seabed Deposits



Copper Deposits (Porphyry Deposits)

Example Escondida Mine: copper-gold-silver

Annual Production: 1.1 million tonnes of copper (100 per cent basis)

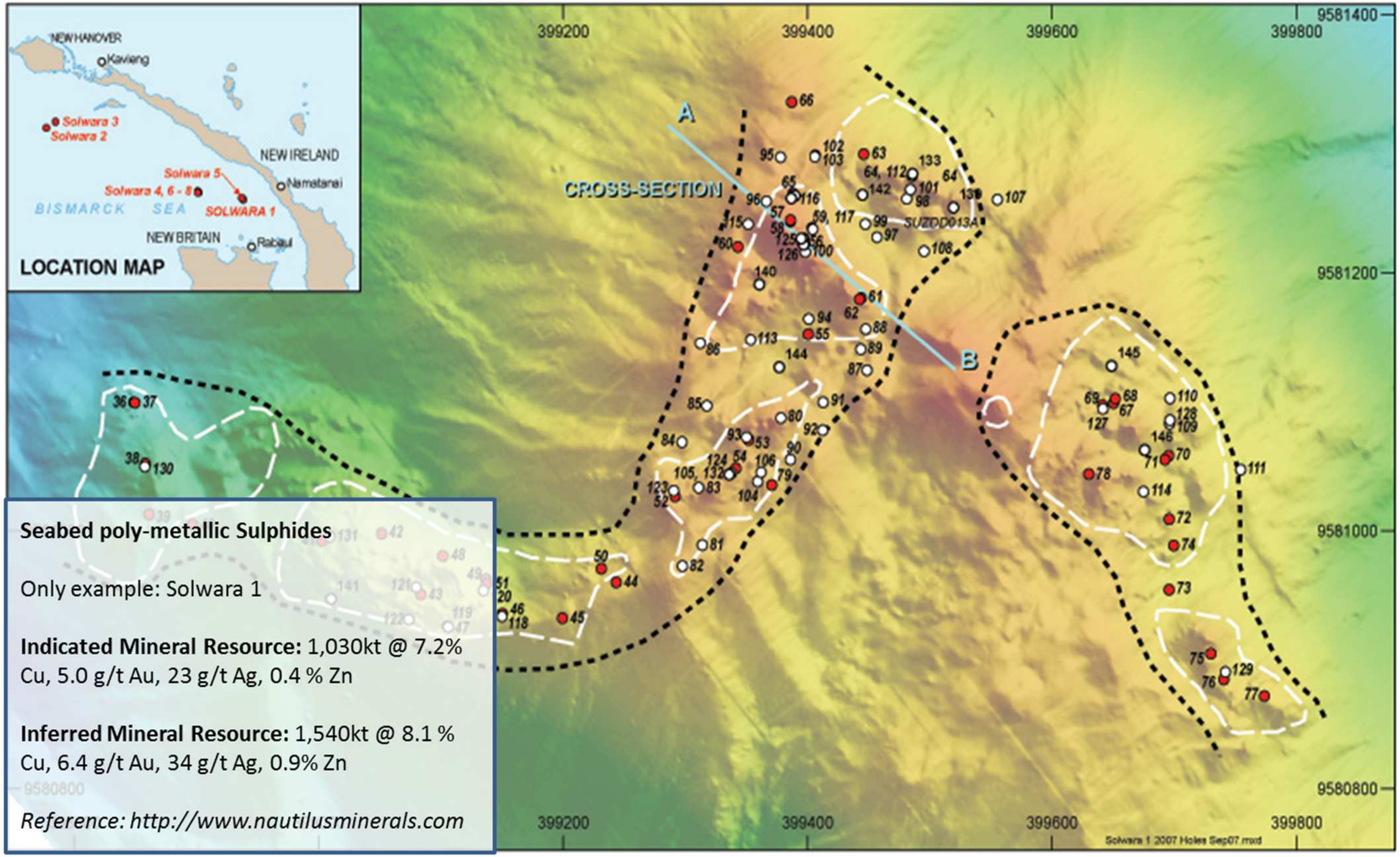
Expected Life of Mine 54 years

Reference: BHP Billiton Annual Report 2013

Commodity Deposit [1]	Ore Type	Measured Resources				Indicated Resources			
		Mt	%TCu	%SCu	ppmMo	Mt	%TCu	%SCu	ppmMo
Copper									
Escondida	Oxide	112	0.79	–	–	70	0.68	–	–
	Mixed	80	0.76	–	–	66	0.55	–	–
	Sulphide	5,190	0.67	–	–	2,030	0.54	–	–

Commodity Deposit [1][8][9][10]	Ore Type	Proved Ore Reserves				Probable Ore Reserves			
		Mt	%TCu	%SCu	ppmMo	Mt	%TCu	%SCu	ppmMo
Copper									
Escondida	Oxide	84	0.88	–	–	61	0.71	–	–
	Sulphide	3,760	0.76	–	–	1,340	0.60	–	–
	Sulphide Leach	1,470	0.45	–	–	550	0.42	–	–

Land-based vs. Seabed Deposits



Seabed poly-metallic Sulphides

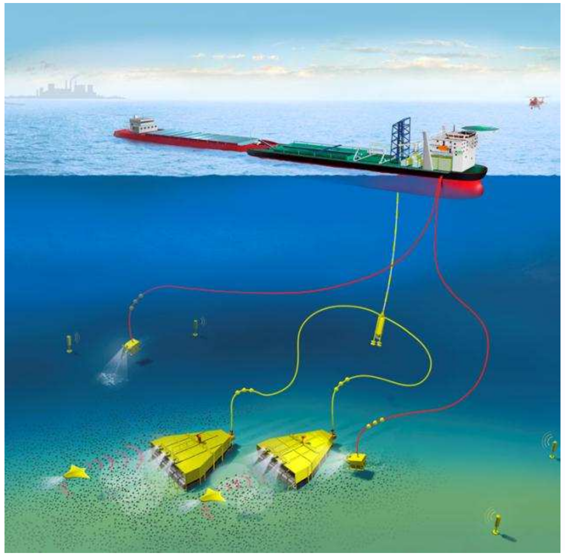
Only example: Solwara 1

Indicated Mineral Resource: 1,030kt @ 7.2% Cu, 5.0 g/t Au, 23 g/t Ag, 0.4 % Zn

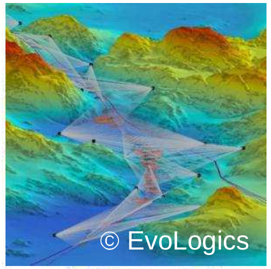
Inferred Mineral Resource: 1,540kt @ 8.1 % Cu, 6.4 g/t Au, 34 g/t Ag, 0.9% Zn

Reference: http://www.nautilusminerals.com

Preferred partner



Ecological and
sustainable
deep-sea mining



Technological and economical challenges of manganese nodule mining in the Clarion-Clipperton-Zone

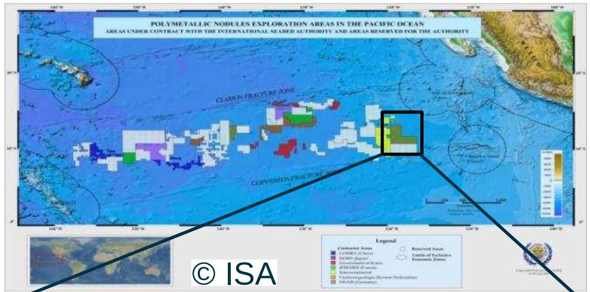
Future Ocean – Seafloor Mineral Resources
March, 19th 2013, Kiel

Technology & Innovation | Aker Wirth GmbH, Erkelenz

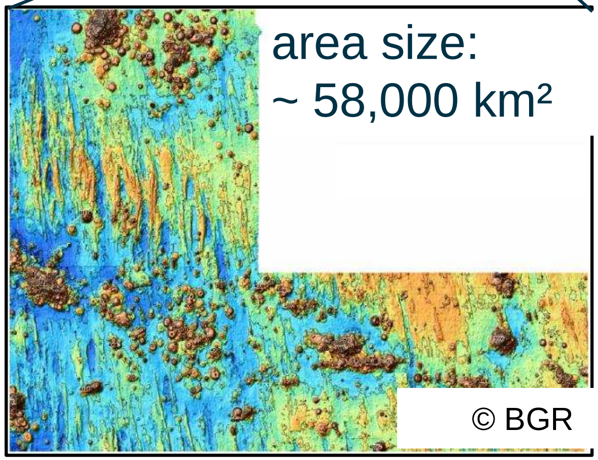
Dr. Steffen Knodt: steffen.knodt@akersolutions.com

Christian Dornieden: christian.dornieden@akersolutions.com

Basic conditions for sustainable manganese nodule mining



German license territory



Sustainable, ecological choice of mining areas:

- occupancy rate > 10 kg / m²
- gradient < 3°

→ 18 % of the eastern German license territory: 10,500 km²

→ compliance of guidelines for protection of environment

Conveying 2.2 Mio. t manganese nodules per year allows mining for approx. 42 years

93 Mio. t of manganese nodules
➔ value of metals > 71 Mia. €

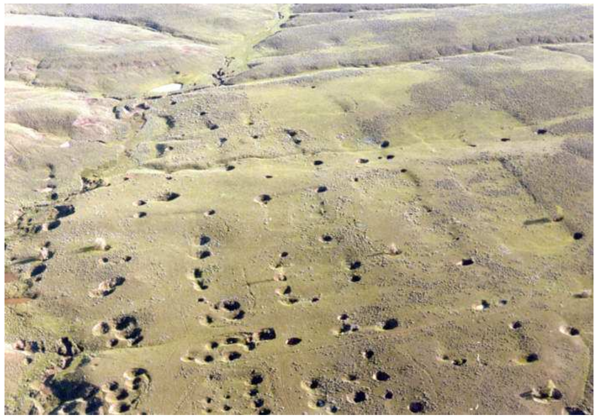
Terrestrial Mining: Environmental Impacts

The “image” of mining……..

- “Footprint” - legacy
- Carbon output
- Erosion and endangered species habitat
- Water use and wastewater

Terrestrial Mining: Environmental Impacts

- **Open pit mining**
  - Exposes previously concealed rock
    - metallic dust
    - Interaction with ground water
  - Processing/separation
    - Tailings - leakage
  - Deforestation



- **Underground Mining**
  - Surface subsidence
  - Water
    - Interaction of exposed rock with ground water
    - Dewatering
  - Waste disposal
    - Dumps
  - Deforestation

Terrestrial Mining: Environmental Impacts

- Carbon output
- Erosion and endangered species habitat
- Water use and wastewater

Dust

Risk	Affected compartments	Relevant toxic compounds
Overtopping of tailings dam	groundwater, surface water, soil	**Water emissions:** • in most cases radionuclides, mainly thorium and uranium; • heavy metals; • acids; • fluorides; **Air emissions:** • in most cases radionuclides, mainly thorium and uranium; • heavy metals; • HF, HCl, SO_2 etc.
Collapse of tailings dam by poor construction	groundwater, surface water, soil	
Collapse of tailing dam by seismic event	groundwater, surface water, soil	
Pipe leakage	groundwater, surface water, soil	
Ground of tailing pond not leak-proof	groundwater	
Waste rock stockpiles exposed to rainwater	groundwater, surface water, soil	
Dusts from waste rock and tailings	air, soil	
No site-rehabilitation after cease of mining operation	land-use, long-term contaminated land	
Processing without flue gas filters	air, soil	
Processing without waste water treatment	surface water	

MIT website

Planning for Mine Closure

Best Practices On-shore:

- Mine closure plan is essential for mining permit
- Balance out all stakeholders interests (social impacts and environmental impacts)
- Typically "increased bio-diversity" than before
- Imposes Operational Constraints

(Reference: www.rwe.com 2013)

(Reference: www.LMBV. de 2013)

Deep Sea Mining Environment

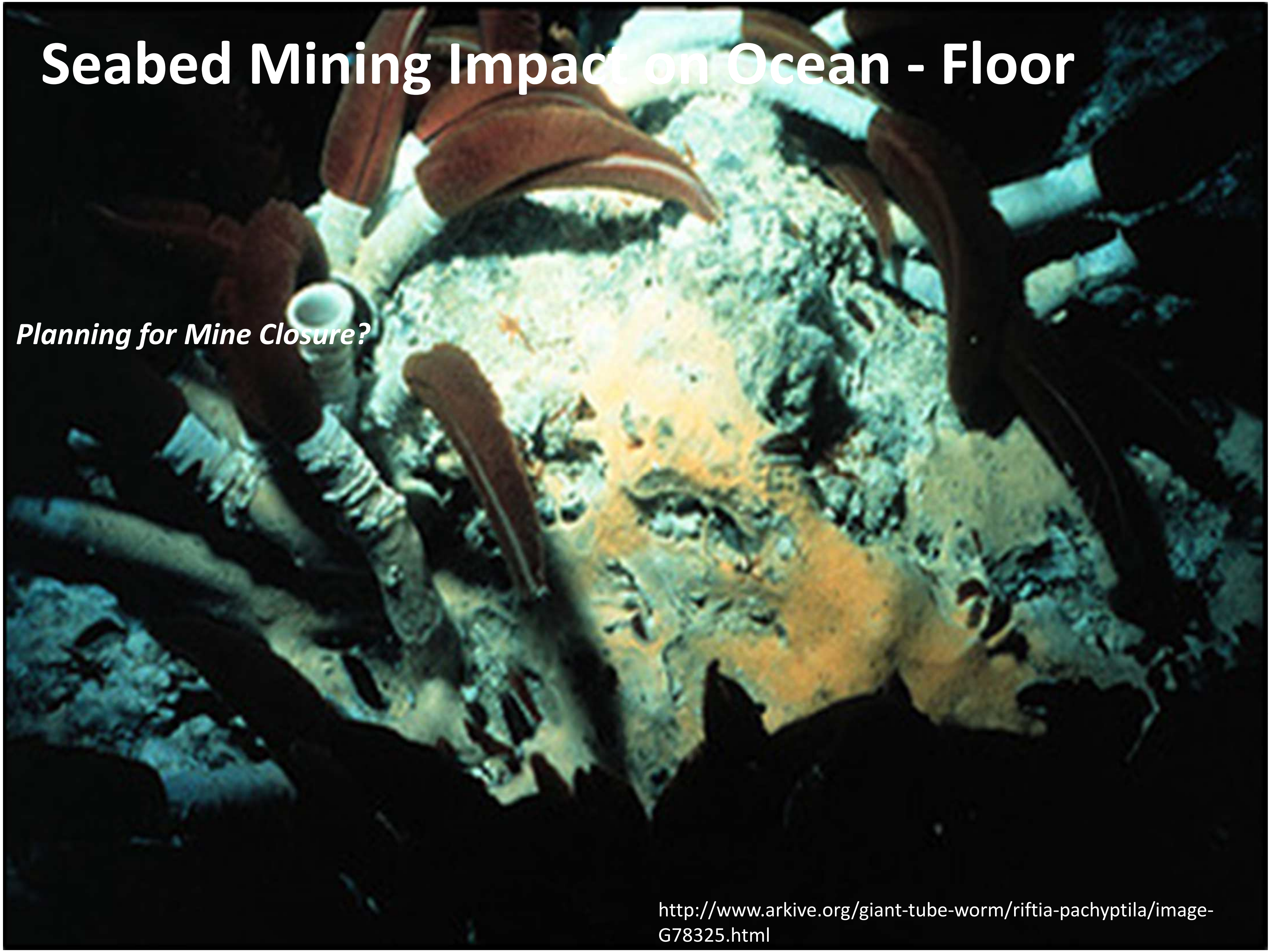
- Covers 70% of the Earth, average depth 3200m
- 50% ocean floor is abyssal plain (mud flats)
- Variety of features: canyons, trenches, mountains, vents
- Deep sea mining has been proposed for variety of habitats
  - Hydrothermal Vents
  - Seamounts
  - Metalliferous crusts
  - Mn nodules on the abyssal plain

No direct human observation to check and monitor!


Seabed Mining Impact on Ocean - Ecosystem

Seabed Mining Impact on Ocean - Floor

Planning for Mine Closure?



http://www.arkive.org/giant-tube-worm/riftia-pachyptila/image-G78325.html

Deep Sea Mining Environmental Aspects

- The impact that the actual mining (disturbance of the ocean floor) has on life on the sea floor (light, digging action, displacement of equipment, dust, noise).
- Waste discharge on the sea floor will have an impact on life on the sea floor.
- Waste discharge from a ship or platform will also influence sea life which lives not on the sea bed, but in the water layers in between.
- Mining will cause dust clouds in the water. How far reaching (distance) will be their influence?
- You do not immediately see the impact: leaving out weather conditions, the sea surface looks the same before and after.
- We have no detailed knowledge on life on the ocean floor.
- We also do not know much about life in great water depths (but not on the ocean floor).

REE – DSM Opportunity?

This report indicates that the production of **a single tonne of refined REE oxide from Bayan Obo**, the world's most important REE deposit, also produced **63 000 m3 of harmful S- and F-bearing gases**, 200 m3 of acidic water, and 1.4 t of radioactive waste (especially Th-related wastes). **The safe disposal of these wastes**, especially the radioactive wastes that are often produced during REE production, **is a significant problem that needs to be overcome during REE mine planning and remediation**. Rare earth element mining and processing also involves a wide range of **occupational hazards** such as pneumo-coniosis as well as potential occupational poisoning from Pb, Hg, benzene, and phosphorous.

Weng et al. 2013 Assessing rare earth element mineral deposit types and links to environmental impacts. Applied Earth Science (Trans. Inst. Min. Metall. B)

Some constants in mining

- Governance and Corruption
- Poor distribution benefits
- Unintended consequences
- Industry/regional level assessment
- Assessment, monitoring, regulation
- Cumulative Impacts

Elements for DSM

- Transparency
- Effective monitoring (science and community)
- Minimum standards
- International impacts/politics/agreement
- EU - good environmental status
- Precautionary Principle

DSM Poem from Papua New Guinea

Vented topsoil nation 1500m below the sea A Bismarkian mystery Raped by the International Seabed Authority.

Yeah, I know We weren't even there To say aye or nay But we're gonna fuck it anyway.

"Inevitable environmental damage" Plays backseat to the real "need" And the UN Convention on the Law of the Sea Gives the poor folks some of the proceeds… Yippee.

"We are at the threshold of a new era of deep seabed mining." Knowledge well worth having But not executing Not on this planet.

The Clarion-Clipperton Zone An entire alien race's home They think they have it all mapped But it doesn't depict their head up their ass.

"Proper controls equals proper sustainabilty." Are bold words for someone with no accountability It's just a paycheck For someone who doesn't give a shit.

Soil Machine Dynamics Accomplishes the fantastic With seafloor mining tools Never before used.

We rise up As we fall down Choking on our own failures With eyes to the sun.

Thank you very much for your attention

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