Advances in Underwater Mining and Associated Technology

EC Workshop – Brussels, June 2014

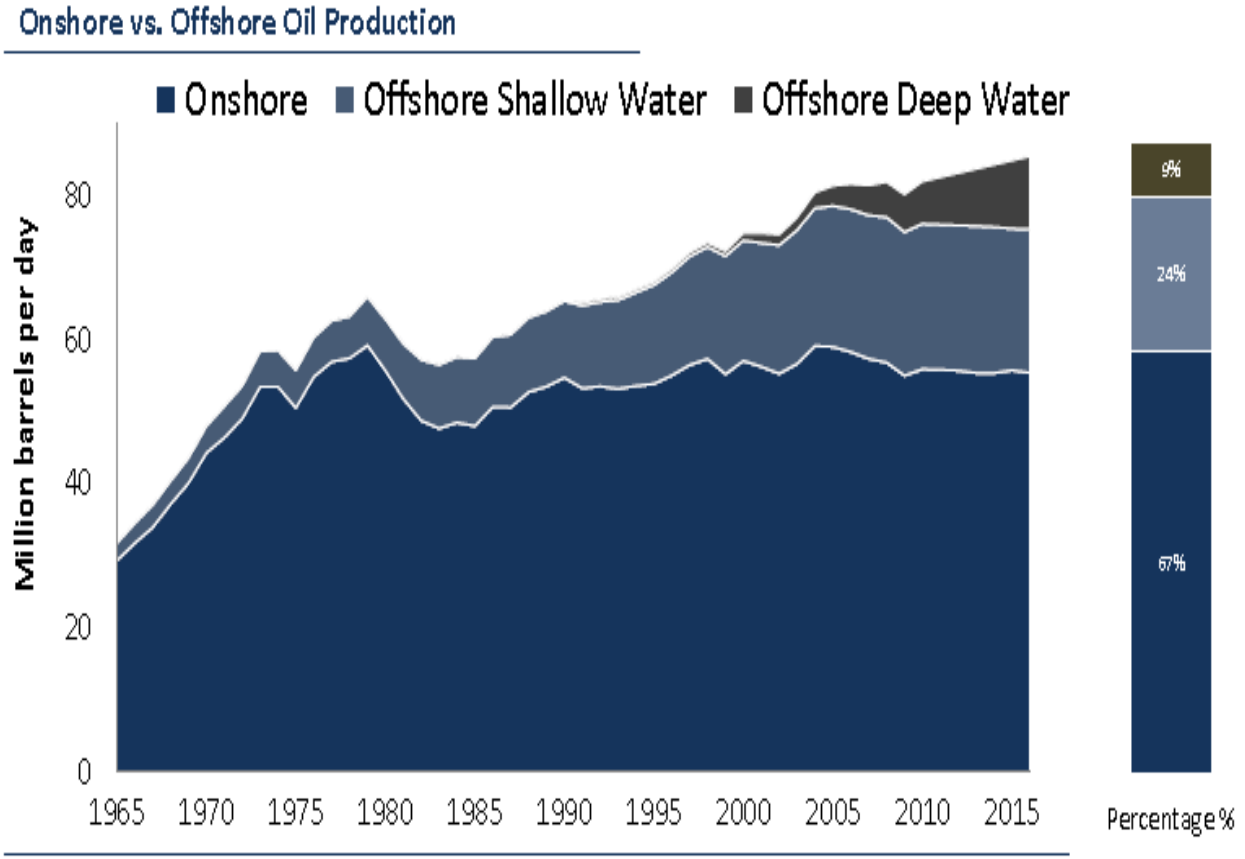
GLOBAL SITUATION

- 70% of the earth is covered in water
- Around half of this is in territorial waters, and half in international waters
- Of the 30% land mass, most has a water table

- Over the past 50 years there has been a gradual increase in exploration and production of various minerals offshore
- In parallel, there has been a gradual reduction in on-land ore quality/grade for key minerals and increased stripping ratios
- Demand for minerals (both for energy and industrial use) has increased
  - Population increases
  - Increased per capita requirements as economies develop

MINERAL EXTRACTION TRENDS

Onshore crude oil production has plateaued and offshore has increased to approximately a third of supply (*source: Infield Systems Limited, 2013*)…



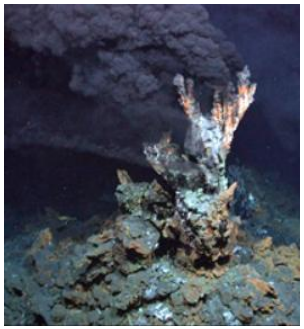
Accompanied by improvements in underwater technology…

MINERAL EXTRACTION TRENDS

…enabling extraction of other minerals underwater

Alluvial Diamonds and Au

Rock Phosphate



SMS

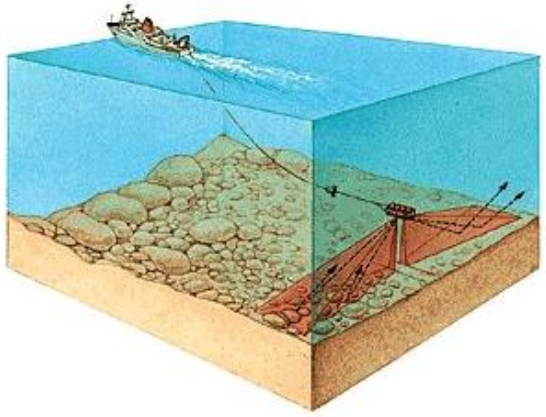
Ferro-manganese crusts

Polymetallic Nodules

- Substantial uncovered resources from zero to 6000m depth
  - From zero to minimal stripping ratio
  - Some of these are very high grade
- And even more unexplored buried resources at sea

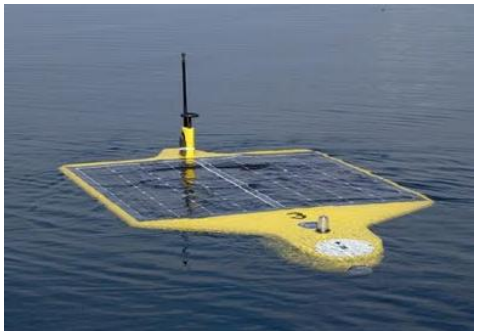
INCREASING DEPTH CAPABILITY

IMPROVED WIDE RANGE EXPLORATION TECHNOLOGY



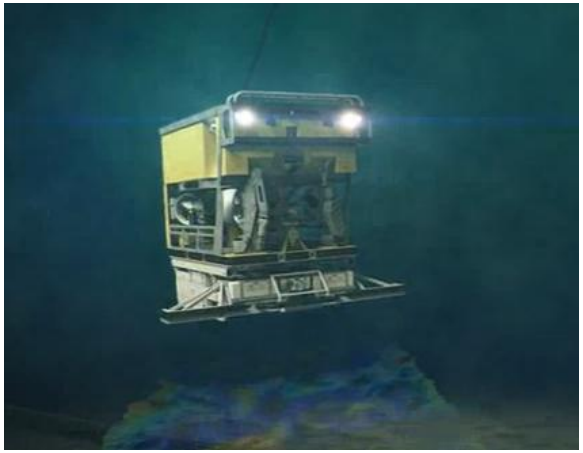
- Side-scan and multi-beam sonar mapping
- Buried object scanning sonar (BOSS)

- Move from towed systems to AUV
- Automated guidance and return of gliders
- Improved mission capability (time and distance)
- Docking systems and induction charging
- Renewable power (sun and ocean thermal gradient)
- Addition of light intervention systems



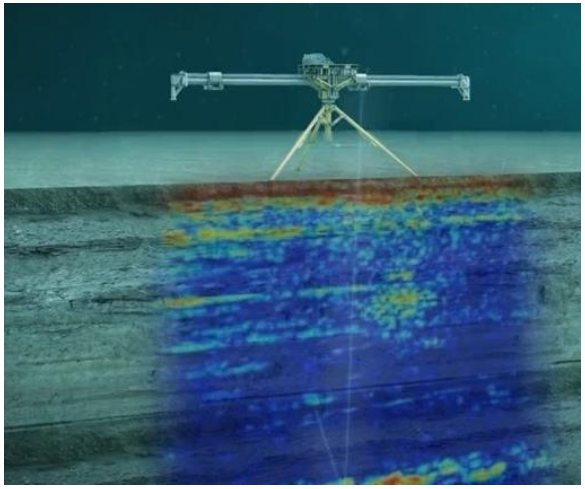
IMPROVED INTERVENTION AND DETAILED EXPLORATION

VARIETY OF SENSING AND CORING TOOLS



PanGeo subsea bottom imager

Seafloor/FUGRO corer



PanGeo 12m sonic corer

Benthic's PROD system

Tracked corer

ADVANCES IN UNDERWATER EXCAVATION CAPABILITY

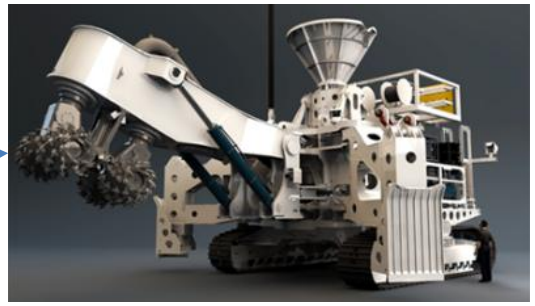
VARIETY OF EXCAVATION EQUIPMENT

Pipeline ploughs

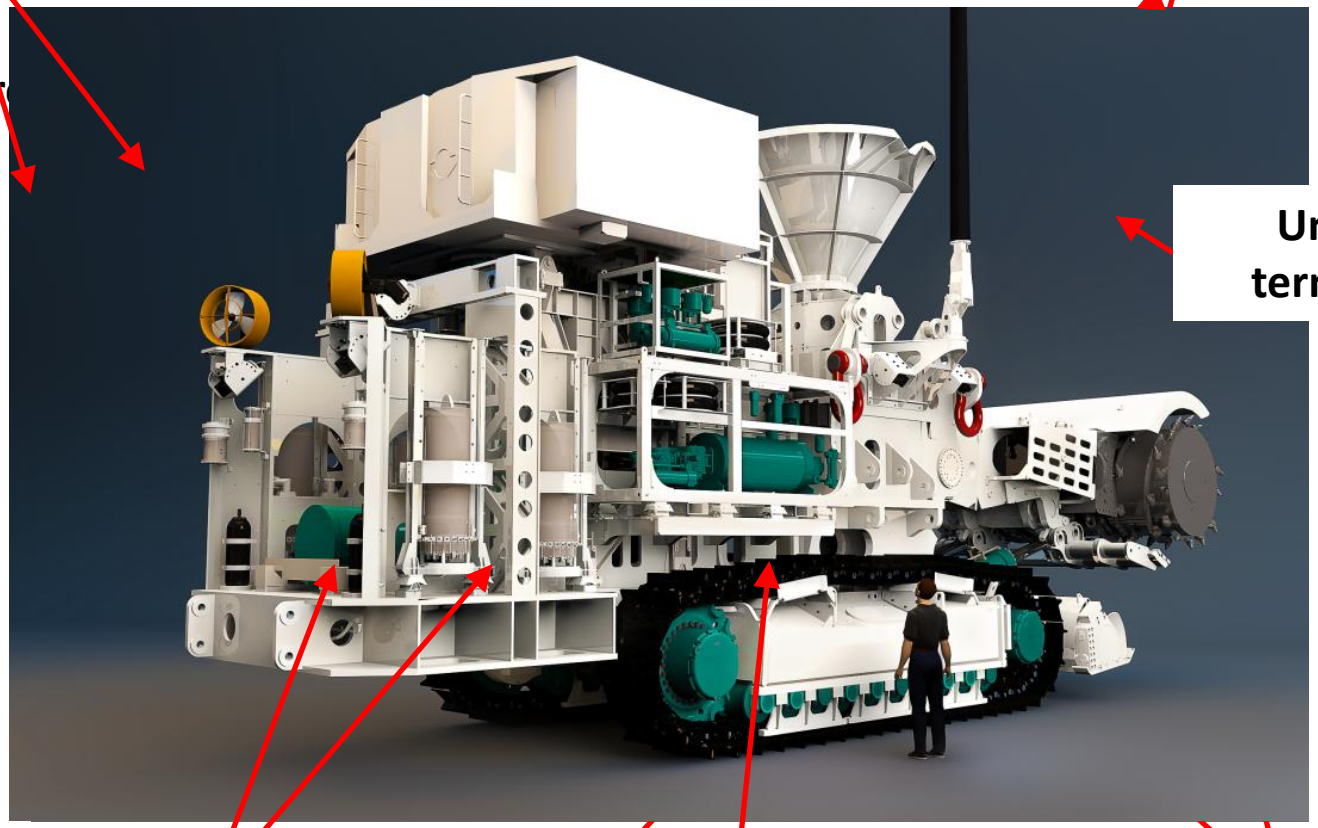
Jetting machines

Multi-purpose excavators/trenchers

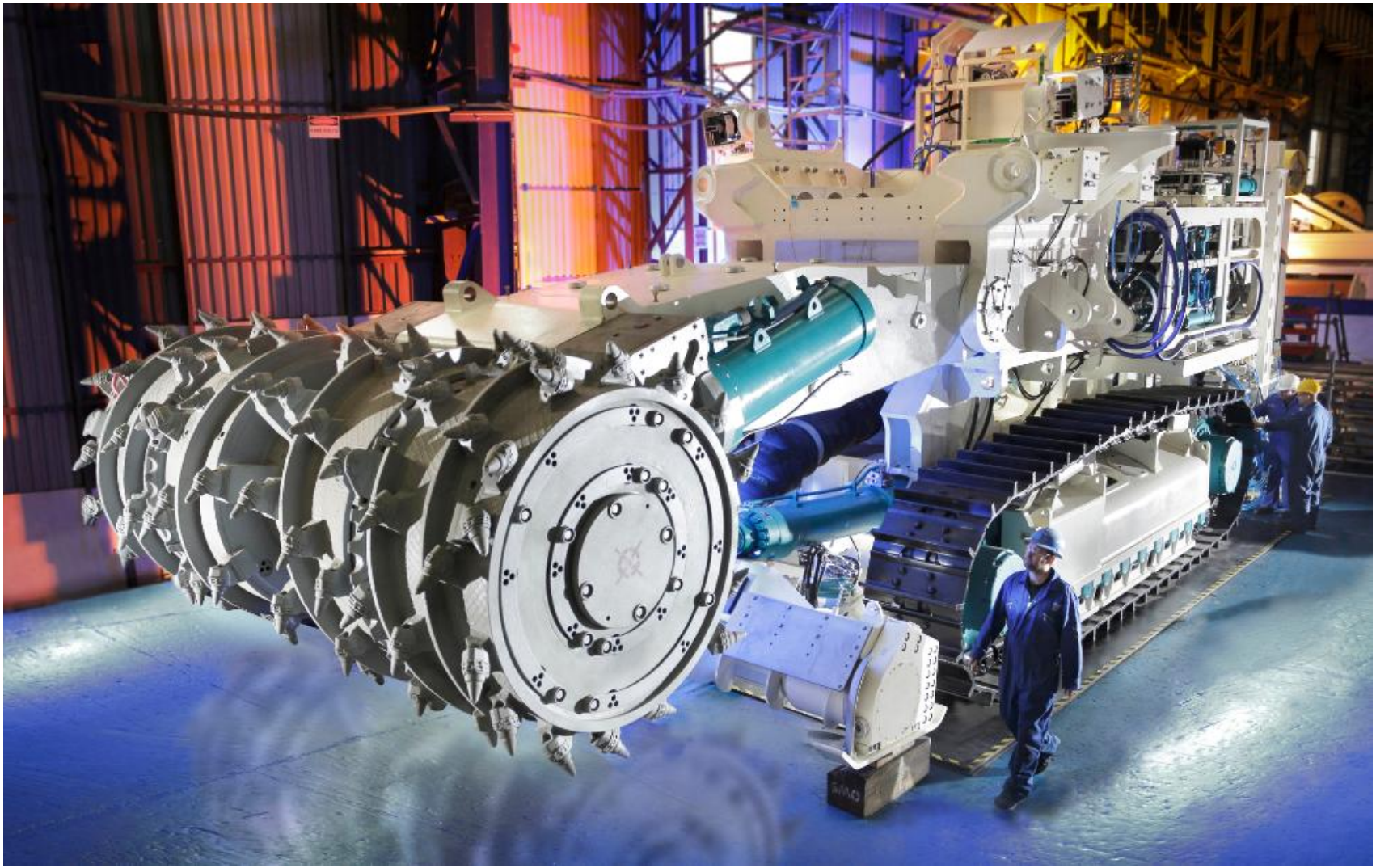
ADVANCES IN POWER AND CONTROL EQUIPMENT



OVERVIEW OF BULK CUTTER

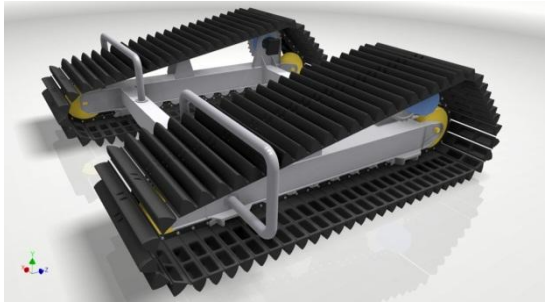


BULK CUTTER

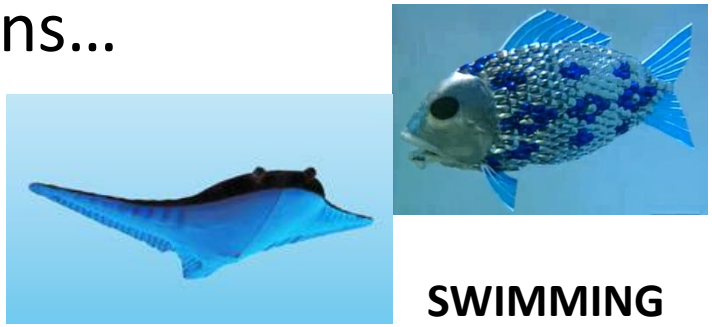


IMPROVED AND VARIED LOCOMOTION SYSTEMS

- Robotic locomotion options…



CRAWLING



SWIMMING

AUGER PROPULSION

WALKING

…dependent upon the task

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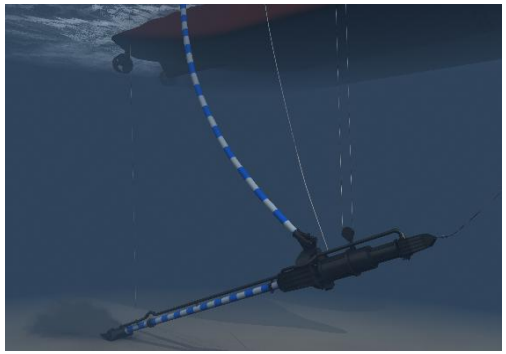
A VARIETY OF RISER / ORE-LIFT SYSTEMS

- Some using centrifugal pumps
- Some using positive displacement pumps
- Some using air-lift techniques
- Some with on-board hose-reels
- Some with a vessel moon-pool and derrick system
- Some attached to floating platforms
- Some with buoyant attachments
- Some with in-built buoyancy



OTHER ADVANCES

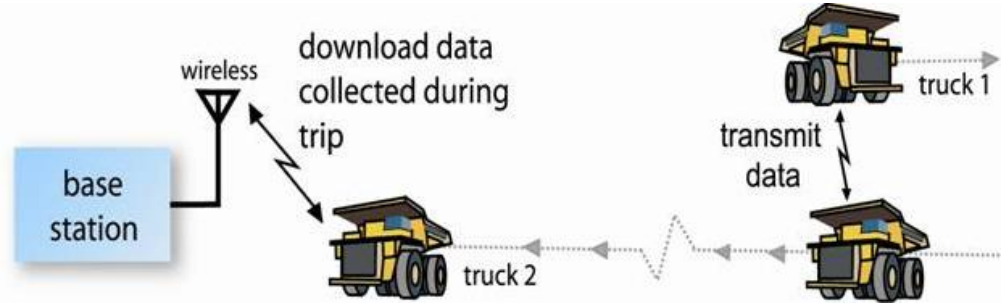
- **Advances in sensing technology**
  3D sonar, interpretation routines, marinisation of LIDAR, virtual digital imaging, fibre sensing, LIBS collision avoidance, bump recognition
- **Advances in subsea survey technology**
  Bathymetric/topographic recognition software and associated camera technology, SLAM systems
- **Developments in launch and recovery systems**
  Development of higher modulus, high strength, lightweight lifting ropes
- **Open-cell Technology**
  Lightweight strong and flexible structures

NOT ALL IMPROVEMENTS ARE FROM OIL & GAS

- **Advances in rock cutting and crushing technology**
  Abrasive resistance materials, diamond composite picks, mobilisation of tensile weakness instead of compression
- **Advances in mineral processing technology in the mining industry**
  Improvements in dewatering plant, separation techniques and environmental discharge control
- **Advances in slurry pumping in the dredging and construction industries**
  Abrasion resistant materials, impeller design and optimisation, density and pressure control systems

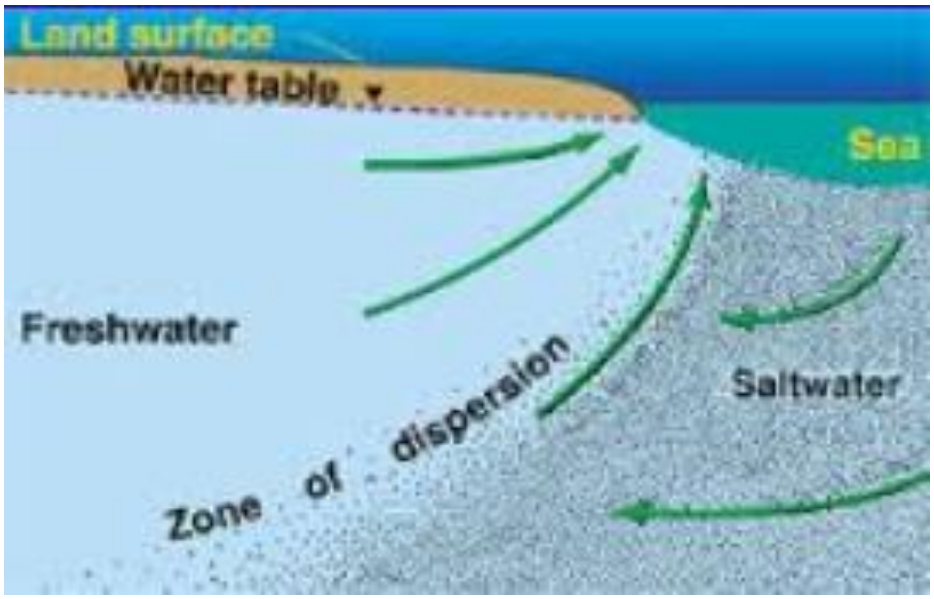
IN-LAND DEVELOPMENTS TOO

- Mine despatching and collision avoidance systems
- Driverless trucks
- Driverless LHD vehicles
- Improved comminution
- Targetted bio-solvent extraction and bio-leaching



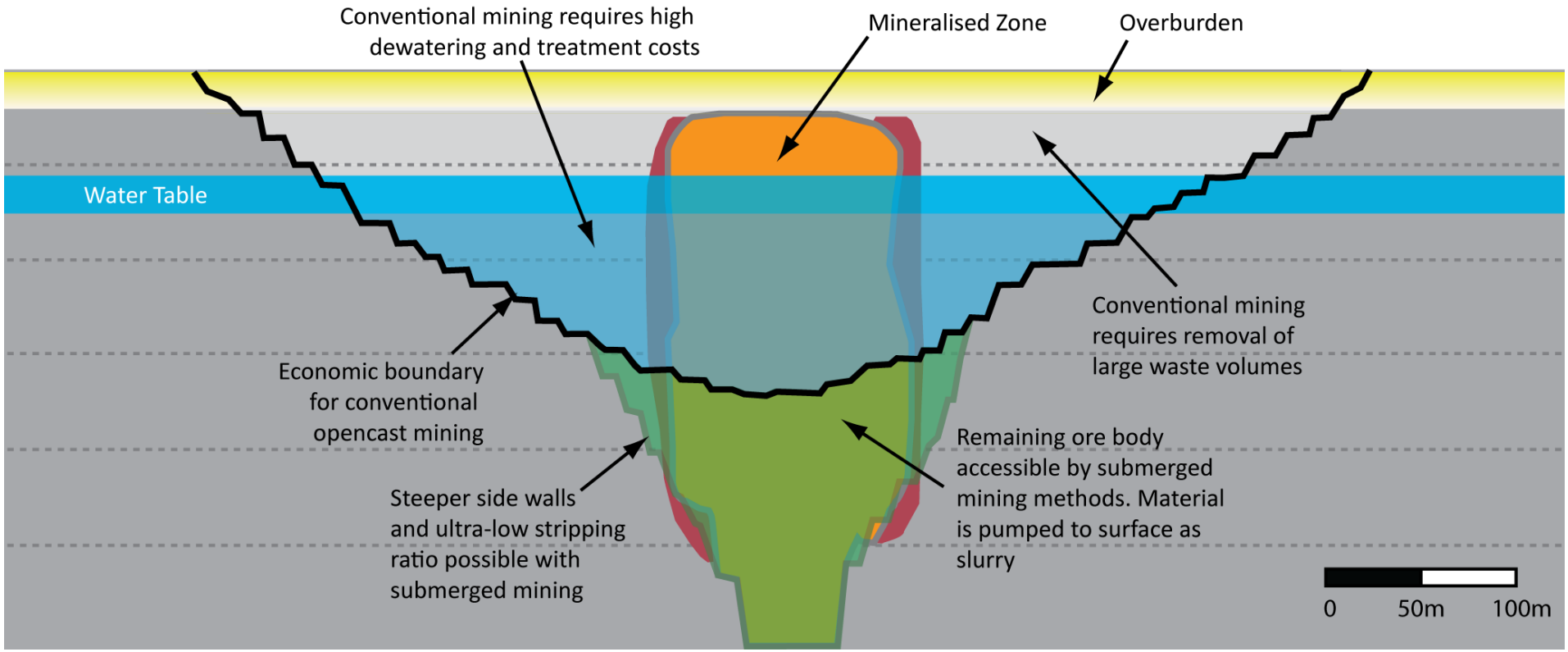
UNDERWATER TECHNOLOGY IS ALSO DEPLOYABLE ON LAND

- >70% of the surface is covered in water.
- Scratch off the dirt from the remaining 30% and we find that most of the land mass is also saturated…



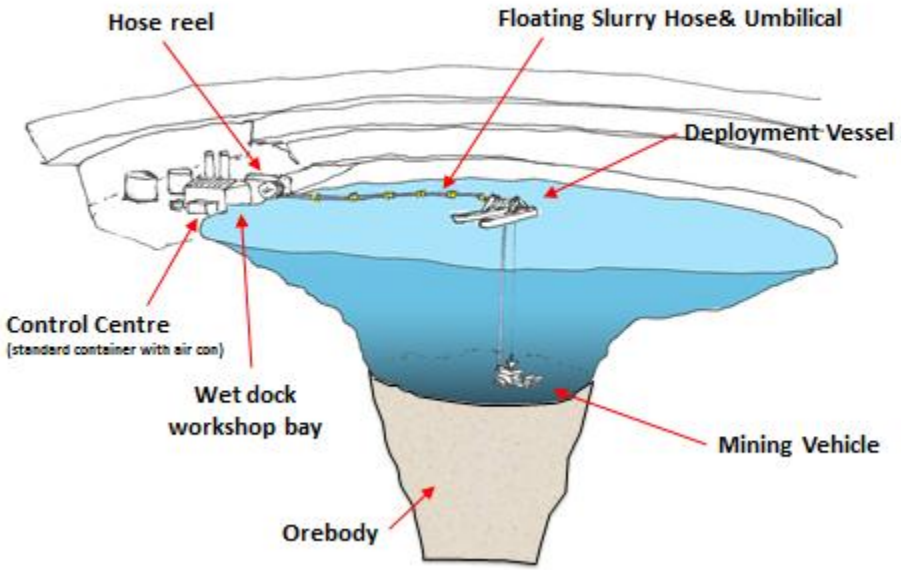
- "Driverless trucks"? How about a "**Truck-less Mine**"?

TYPICAL VOLCANIC OREBODY MINE CROSS-SECTION



SEMI-VERTICAL DYKES AND PIPES

Inland Submerged Mining…



- Consider inland deposits which are saturated…
  - Extension of mines near their economic depth or stripping ratio constraint
  - Re-opening of flooded abandoned mines
  - New mines closer to sensitive areas

ADVANTAGES

- Ultra-low stripping ratio
- No/minimal fauna in the pit
- No/minimal waves to contend with (buoyant raft/winch system versus expensive ocean-going vessel)
- No blast noise or vibration
- No dewatering costs
- No minewater discharge
- No lowering of groundwater table
- No airborne dust nuisance (social and environmental)
- Riser energy costs lower (compared to circuitous truck-hauling)
- No ancillary fleet required to build and maintain haul-roads
- Transportable infrastructure
- Reduced wear on GET's in submerged conditions
- Nobody in the pit – hence no risk from slope stability or inundation etc.

The technology for underwater mining is now available

This applies to both offshore and submerged inland deposits

End