ORE 330
Mineral and Energy Resources of the Sea
Mining Technology
Deep-Sea Mining Systems

A. Manganese Nodule Systems
   1. Tested systems
      a) Robotic Miners
         Design parameters
         Pick-up systems
         Airlift systems
      b) Continuous Line Bucket
   2. Untested systems
      a) Submersible Shuttle System
B. Manganese Crust Mining System
   Design Parameters
   Crust thickness problem
   Cutter depth optimization
   Ripper design – fragmentation criteria
   Air lift design
C. In-Situ Leach Mining Systems
   Operations for manganese crust and harbor sediment cleanup
   Single point mooring systems for leach mining
   Adaptation for biomining
D. Polymetallic Sulfide Mining Systems Concepts
Figure 2. Complexity of design of hydraulic system.
Figure 2.1.4 Various nodule pick-up principles. (from Thiel et al. 1991 redrawn from Bath 1989)
Figure 2.1.2 Continuous Line Bucket (CLB) mining system and the Preleveur Libre Autonome (PLA) or autonomous robot submersible shuttle system. (not to scale) (from Thiel et al. 1991)
Figure 5. Speculative deep water system.
Figure 3. Cutter head design for manganese crust miner (after Halkyard 1985).
Figure 4-4. Base-case material flows (wet weight)
Depth of Cut = 37 cm

Example of "Level" Cutting Line (Example Profile Across 4.0-meter Swath).
Example of "Level" Cutting Line (Example Profile across 0.5-meter Swath).
Nautilus Minerals’ Tenements

Four deposits discovered by partner Teck in September 2008

SOUTHWEST PACIFIC REGION
LOCATION OF TENEMENTS
May 2008 © Nautilus Minerals

Tenement - Application
Tenement - Granted

Papua New Guinea
Manus Basin
Woodlark Basin
Lau Basin
New Zealand
Havre Trough
N. Fiji Basin
Vanuatu
Solomon Islands
Port Moresby Office
Brisbane Project Office
Mining system to be deployed by Nautilus Minerals

- Technip (Houston) to build RALS using offshore oil technology and Soil Machine Dynamics (UK) to build two 6000 peak tpd SMTs
- Mining to start in 2013 subject to timely permitting by PNG

North Sea Shipping (Bergen, Norway) to provide a new 160m dynamic positioning Mining Support Vessel (MSV) on 5 year lease with an option for 5 more years
Extracting Value - Seafloor Mining Tools (SMTs)

- Soil Machine Dynamics (UK) contract to design and build
  - Experts in deep sea ROV and trenching machine design
  - US$84 million contract for three specialized mining machines
  - Includes control systems and associated umbilicals, handling, and deck equipment
- Engineering has been underway for over two years
- Contract suspension released in March 2009

Auxiliary Miner—cuts ore on uneven surfaces, benching the site

Bulk Miner—cuts ore at high rates on areas benched byAuxiliary Miner

Gathering Machine— slurries cut ore with seawater and transfers to RALS
Existing Seafloor Trenching and Mining Equipment

- 30+ years seafloor trenching for pipelines and communications
- De Beers 20+ years seafloor crawlers for diamond mining
- Utilizing cutting expertise from
Figure 19-5: Seafloor Resource Production System
“... in the ocean depths, there are mines of zinc, iron, silver and gold that would be quite easy to exploit”