

Report from Working Group #1 - Processing

The state of development of processing of polymetallic nodules was reviewed. The discussion focussed on three questions.

1. State of Processing and Metal Recovery
 - a. Discuss the state of development for the various hydrometallurgical and pyrometallurgical flow sheets
 - b. Scale of development?
 - i. Benchscale, pilot scale, demonstration plant scale
 - c. Novelty of chemistry or unit operations
 - d. Key challenges presented
2. Comprehensive Utilization of Polymetallic Nodules
 - a. Discuss status of comprehensive utilization in relation to processing routes
 - b. What are the limits of comprehensive utilization?
 - c. Technology limitations
 - d. Market limitations
 - e. Value limitations?
3. Waste Disposal
 - a. Discuss the issues of waste disposal/emissions from a PN processing facility
 - i. Air (gases/dust)
 - ii. Water
 - iii. Solids
 - b. What opportunities exist to minimize waste disposal/emissions

For the processing of polymetallic nodules, the scale of development varies from benchscale (few grams or 10's of grams) up to a few tonnes of nodules treated in pilot or large scale testing. There is a major challenge in obtaining sufficient nodules to run a demonstration or pilot plant. The cost of a pilot plant or demonstration plant is significant and would benefit from a cooperative approach to minimize cost and increase collaboration. For example a number of contractors are working on similar approaches using smelting and hydrometallurgy. There is a desire to minimize the capital and operating costs of a PM nodule plant by making use of an existing processing facility (eg. Moa Bay Nickel in Cuba).

The scale up of pyrometallurgical processing requires larger scale furnaces and testing to develop data for scale up and engineering. The hydrometallurgical processes (eg. Solvent extraction and electrowinning) are well known technologies that are relatively easy to scale up from small scale experiments.

The comprehensive utilization of the full mass of the nodules is a common goal amongst a number of contractors. The contractors are attempting to achieve 100% utilization of the polymetallic nodules to achieve a zero solid waste operation. It is technically feasible to recover an alloy or a matte containing Cu-Ni-Co-Fe and a slag that contains Mn-Fe-Si and other elements. The alloy or matte can be processed to

produce metal products and essentially zero solid residue. The slag can be processed to recover Fe-Mn and Si-Mn products and a final slag that can be used as an aggregate material for the construction industry.

The comprehensive utilization of the polymetallic nodules has not been studied from an economic point of view. The capital and operating costs for these process options are not yet available from formal engineering studies. As a result there is a broad uncertainty about the costs (+/- 100%).

The issue of wastes from hydrometallurgy and pyrometallurgy plants was discussed. The pyrometallurgy plants have emissions of dust and gases and finally solid products (alloy or matte, Fe-Mn, Si-Mn and slag). The hydrometallurgy plants have waste water streams and solids waste streams. The removal of all chemical contaminants from waste water is feasible. The solid wastes may need to be stabilized or treated to prevent release of trace metals. The Indian R+D group is working to minimize release of contaminants from waste solids and effluents.

Some work has been completed on molybdenum, lithium and rare earth recovery beyond the four metals.

Some work is being conducted on other uses of polymetallic nodules and residues.

The use of bioprocessing of ferromanganese crusts and nodules was also reported.

Table of development (Partial – to be completed)

Contractor	Process Option	Testing Scale			Economic Evaluation/Engineering Study		
		Bench	Pilot	Demonstration	Scoping Study	Pre-feasibility study	Feasibility Study
UKSR	Cuprion	X			X		
BGR	Pyro/hydro	X	X	In planning	Pending		
ROK	Pyro/hydro	X	X		X		
IOM	Coprocessing with Ni laterite	X			X	Pending	
JOGMEC	Pyro/hydro	X			Pending		
YMG	Pyro/hydro	X	X		X		
India	Hydro/pyro	X	X	X	X		

Bench plant – single experiments for each step in the process

Pilot plant – miniature continuous testing of the process with locked cycle

Demonstration plant – scaled down commercial process facility