



Workshop on Processing Technologies, Metal Recoveries and
Economic Feasibility of Deep Sea Mining,
Warsaw, Poland, 3-6 September 2018

JOGMEC activities on the R/D of processing and metallurgical technologies for cobalt- rich ferromanganese crusts

September 2018

Nobuyuki Okamoto^{*1}, Hiroshi Shibasaki^{*1}, Mikio Kobayashi^{*1}, Mayumi Ito^{*2},
Yasuhiro Konishi^{*3} and Tasuya Ooki^{*4}

^{*1}:JOGMEC, ^{*2}: Hokkaido University, ^{*3}: Osaka Prefectural University, ^{*4}: National Institute of Advanced
Industrial Science and Technology (AIST)

Japan Oil, Gas and Metals National Corporation

- **JOGMEC Mission**
- **Processing & Metallurgical Technologies for Crusts**
 - **Processing**
 - **Metallurgy**
 - **Bio-leaching**
- **Other Topics (Polymetallic sulphides)**
- **Conclusion and Future Plan**

JOGMEC's Mission

JOGMEC is an organization under the jurisdiction of the Ministry of Economy, Trade and Industry (METI)



JOGMEC contributes to the stable supply of various mineral resources and energy to Japan

JOGMEC survey history on marine manganese deposits

More than 30 yrs. history in the high seas & EEZ

1987 NW pacific for crusts



Stage 1 (Dredge sampling) Stage-2 (Coring sampling)

1985 South Pacific region (SOPAC)



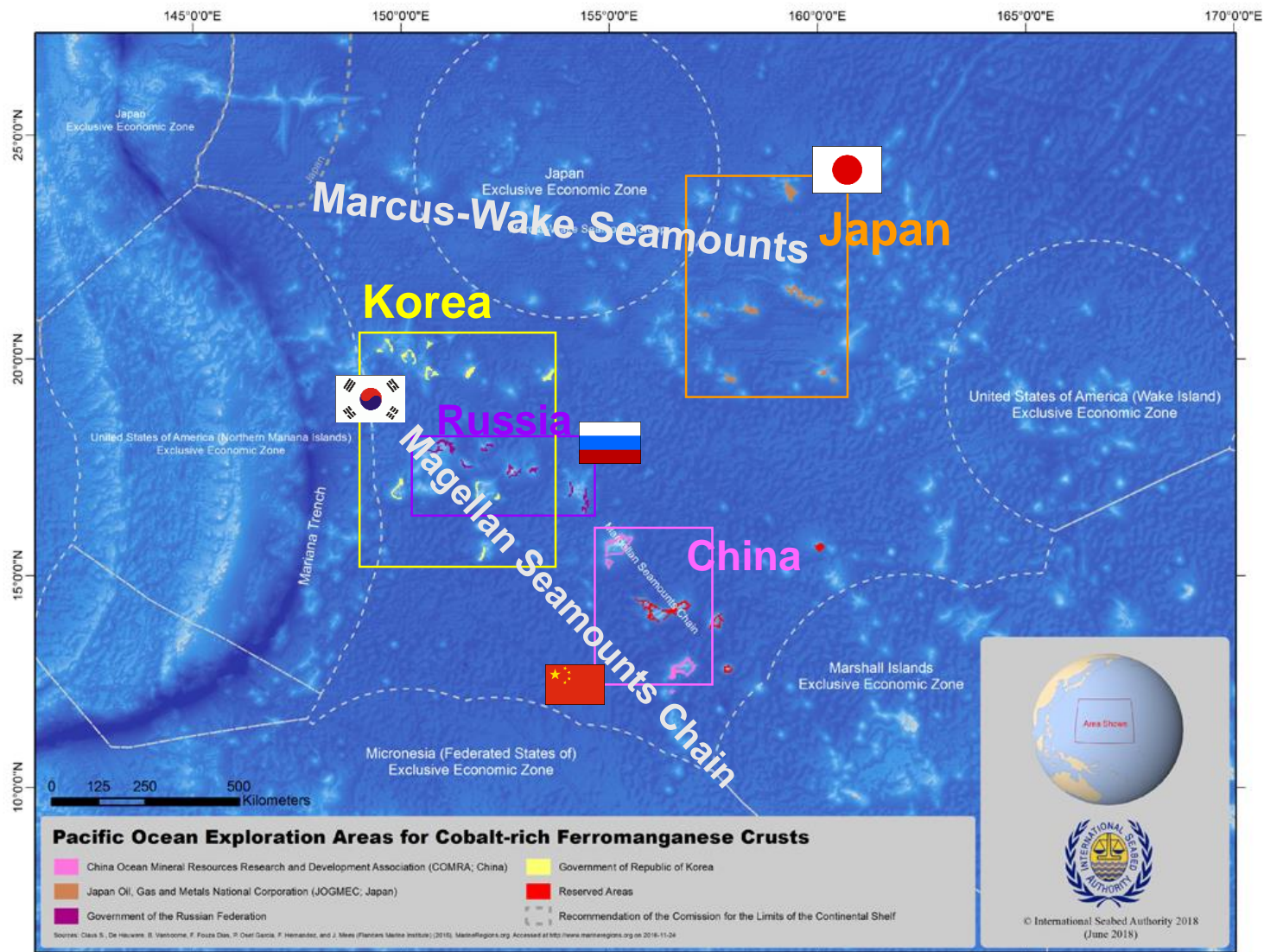
- Manganese nodules: Cook, Kiribati, Tuvalu, Samoa, Niue
- Crusts: Marshall, FSM, Kiribati, Tuvalu

ISA license area for crusts

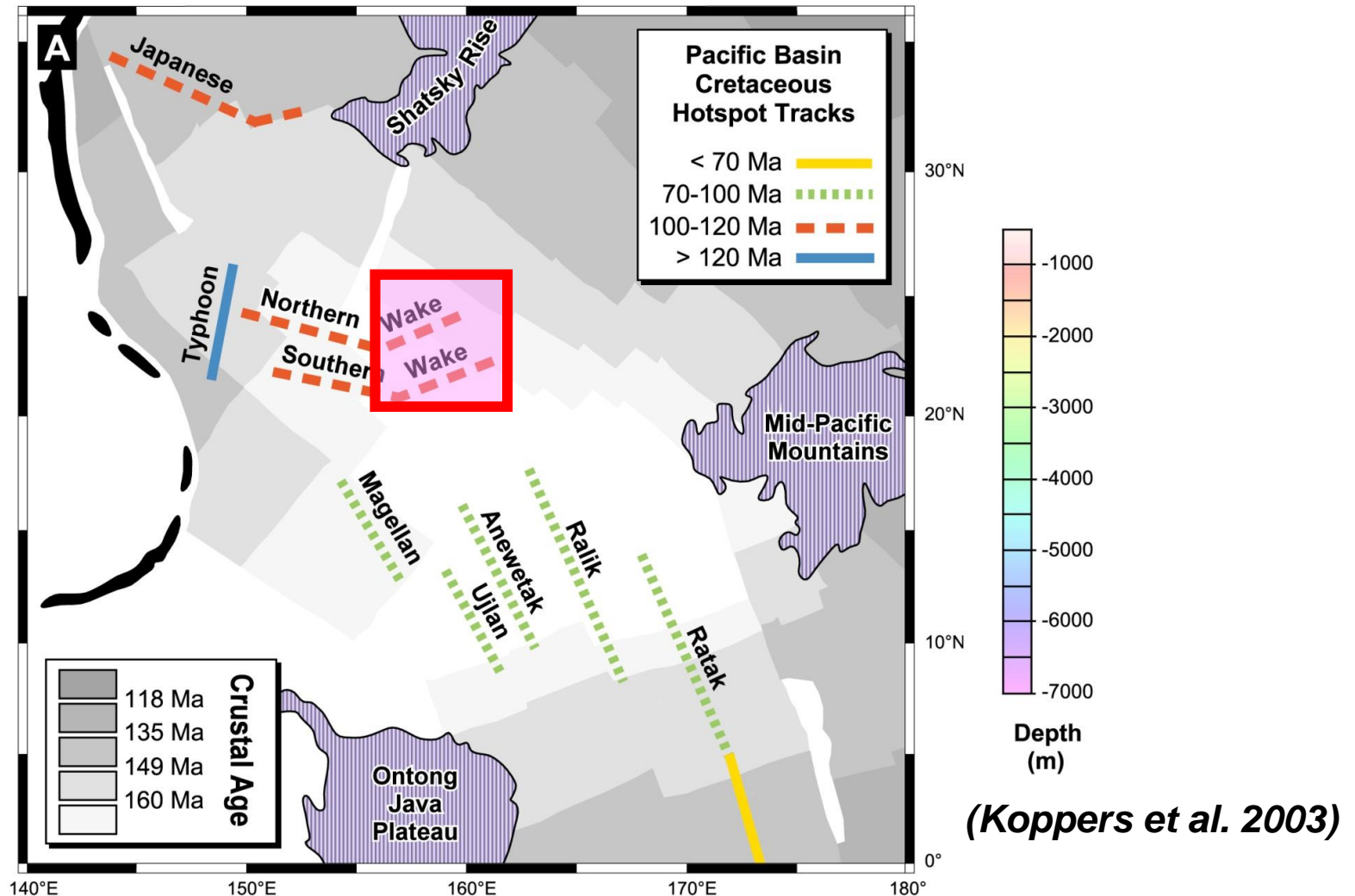
2014



Exploration areas for cobalt-rich ferromanganese crusts



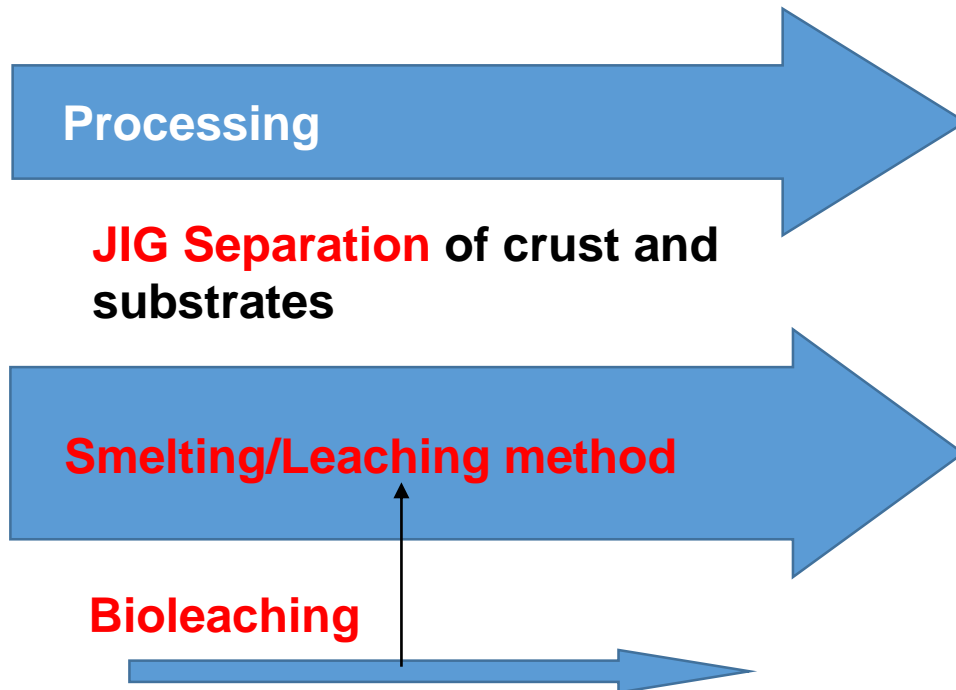
Geological setting @ Japan's license area for crusts



R/D history of processing and metallurgy for CFC

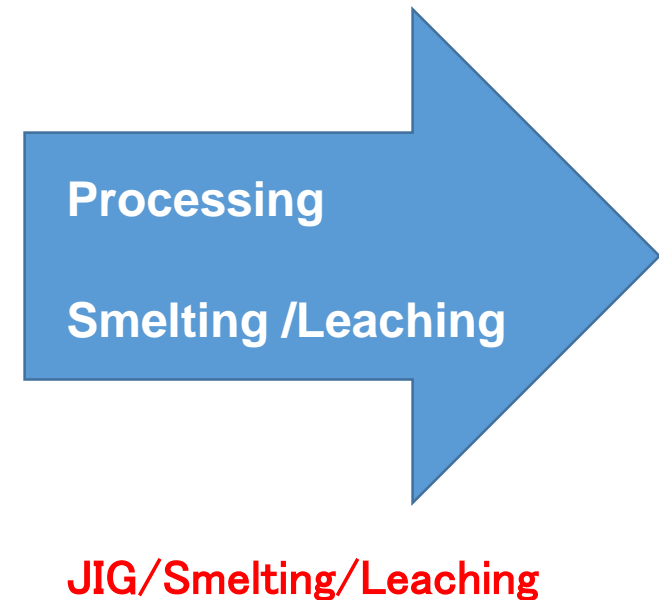
Preliminary study prior ISA contract

2003-

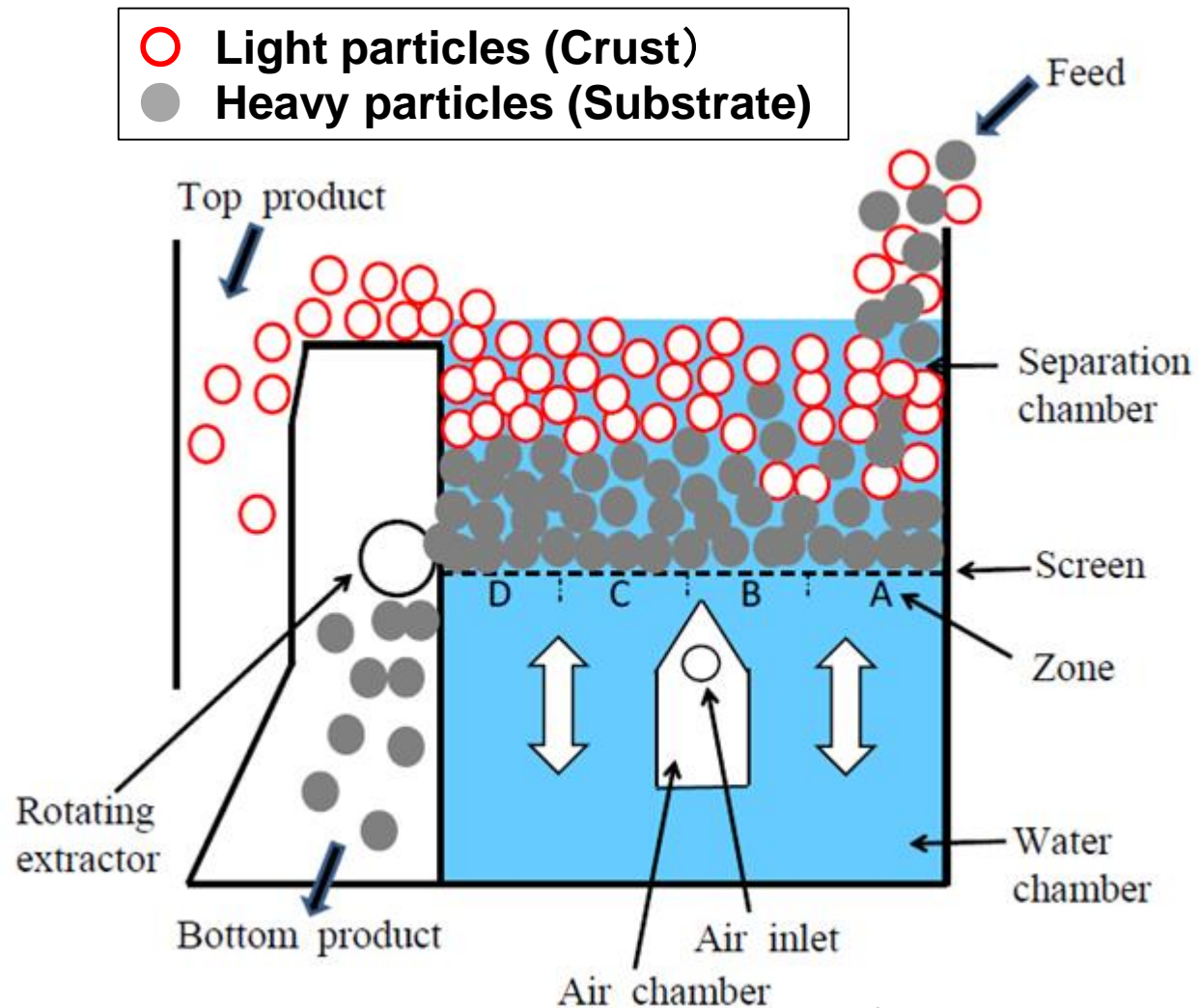


ISA contract

2014-

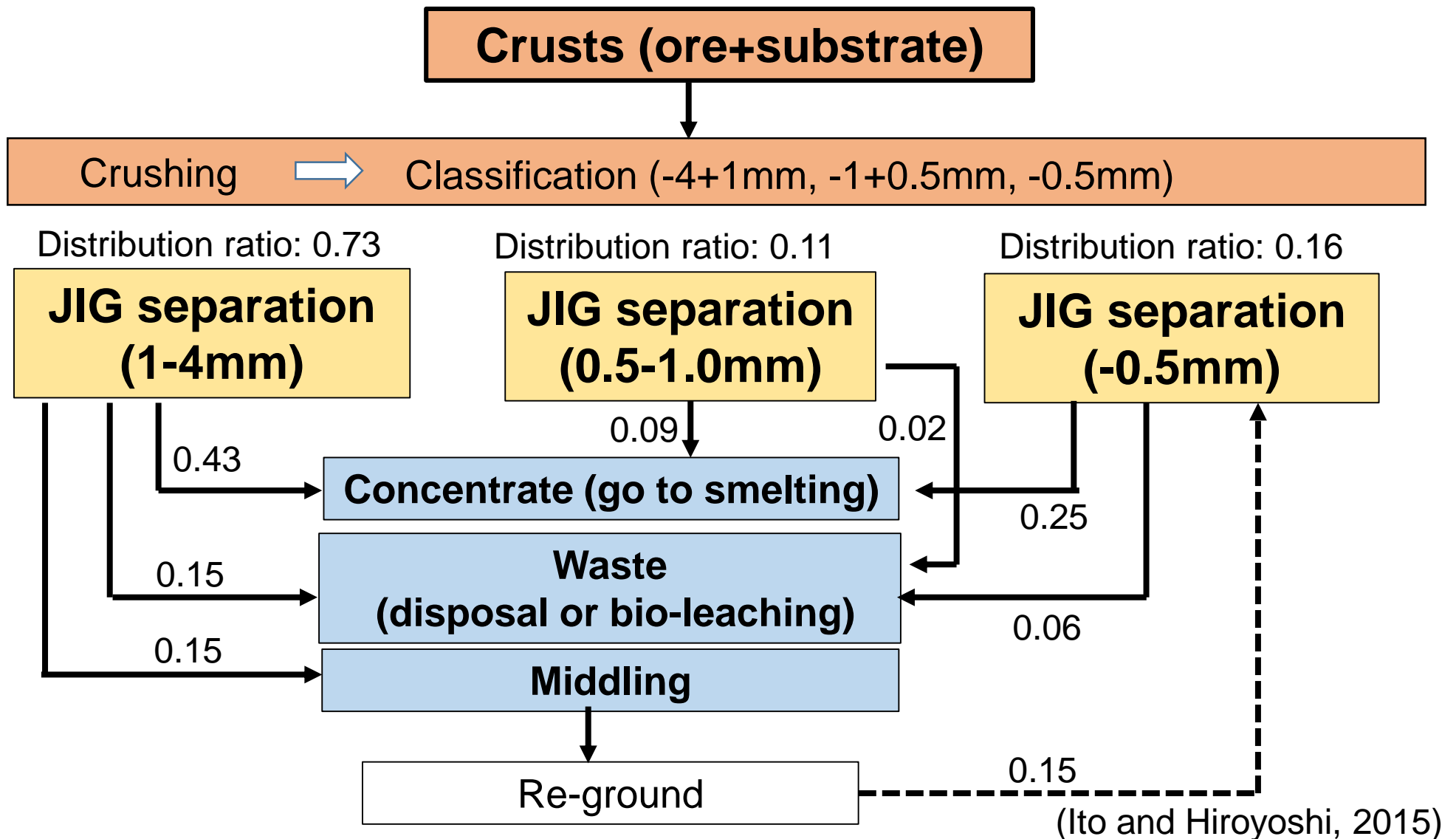


RETAC JIG separation diagram



(based on Tsunekawa et al., 2012)

Proposed total process flow-sheet for CFC



RETAK JIG



Results of JIG separation test



Crust samples with substrates



Cursing

RETAK JIG



Before

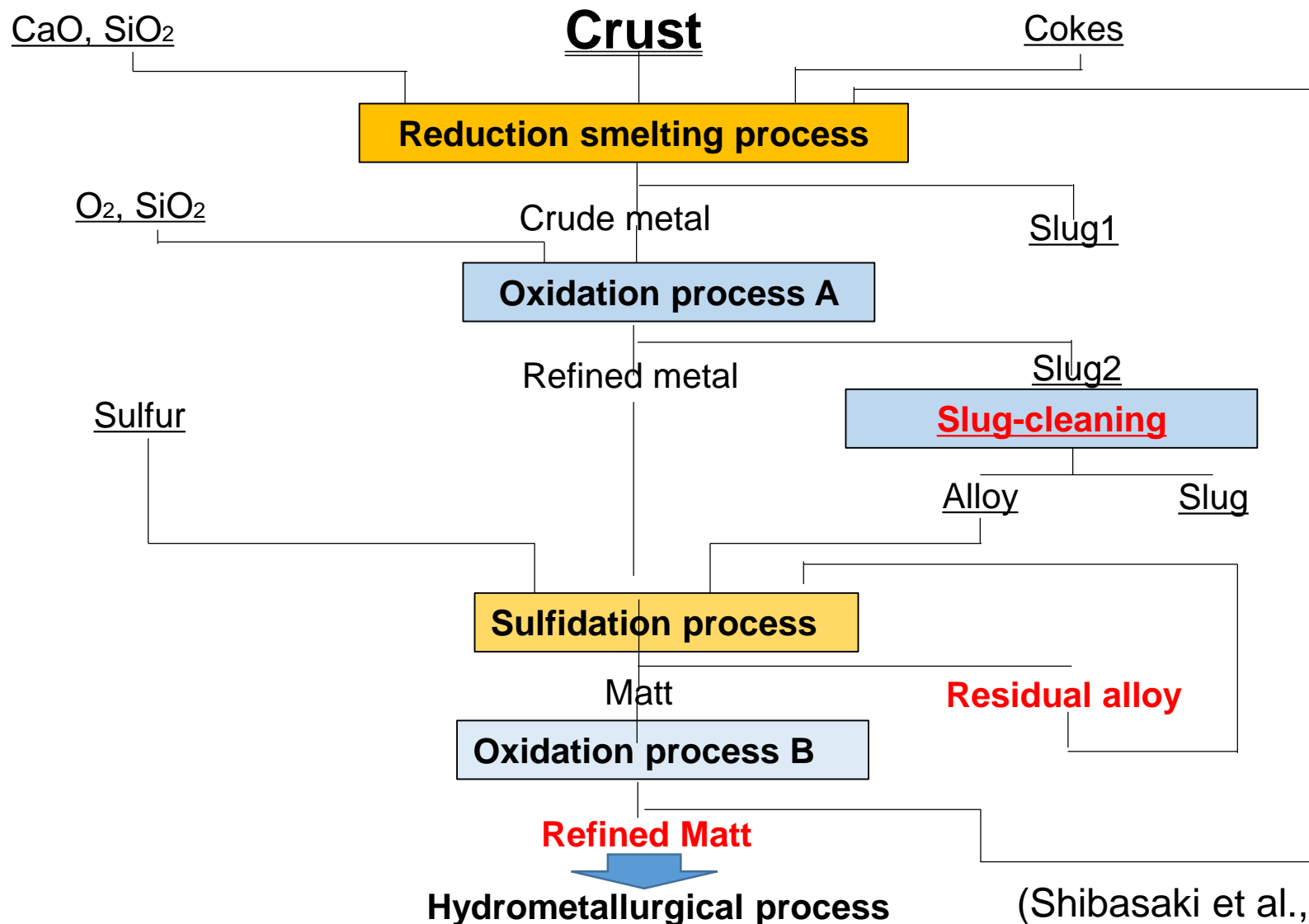


After

Crust concentrate

Substrate rocks

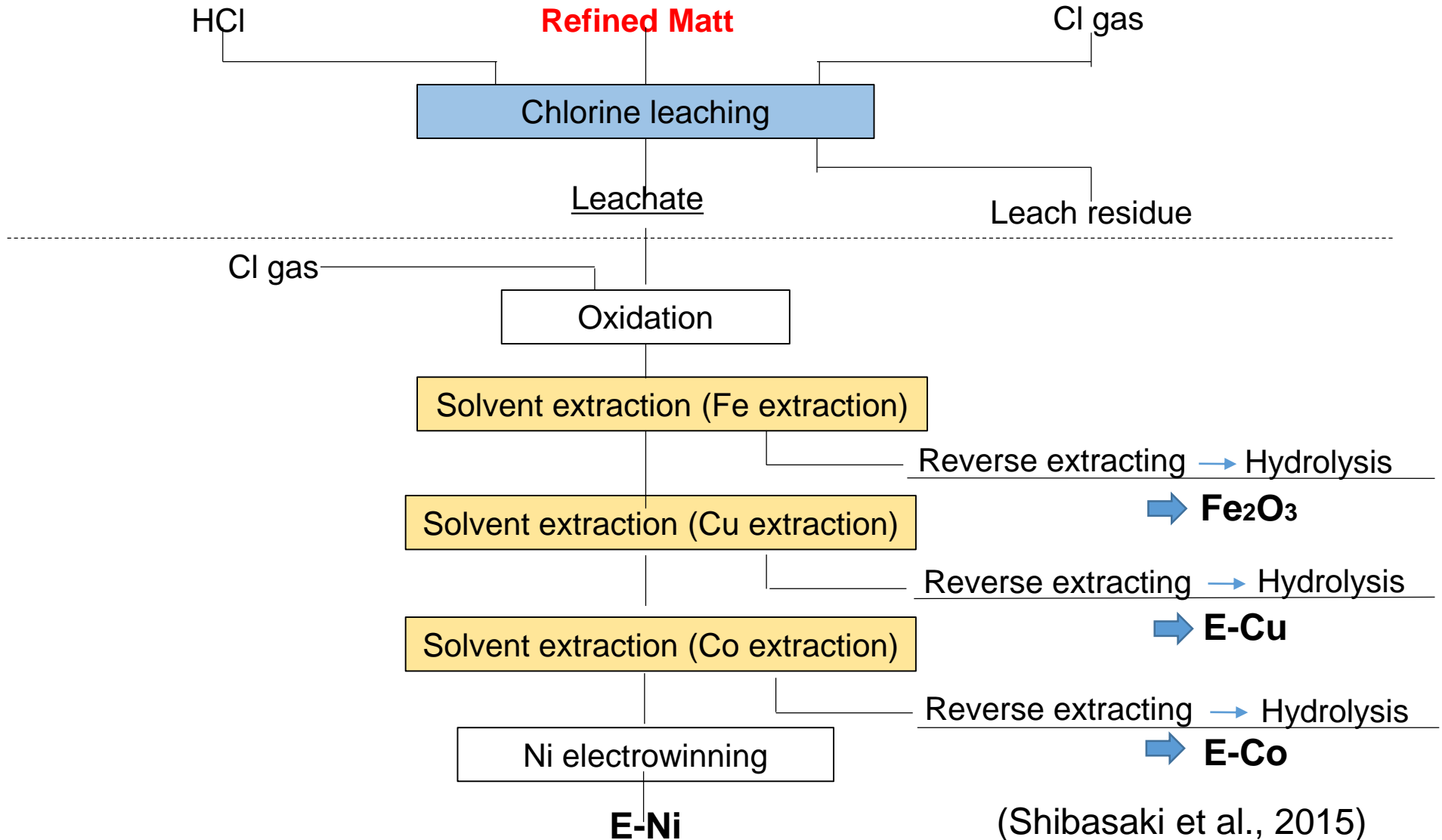
Improved smelting and chlorine leaching process for CFC



(Shibasaki et al., 2015)

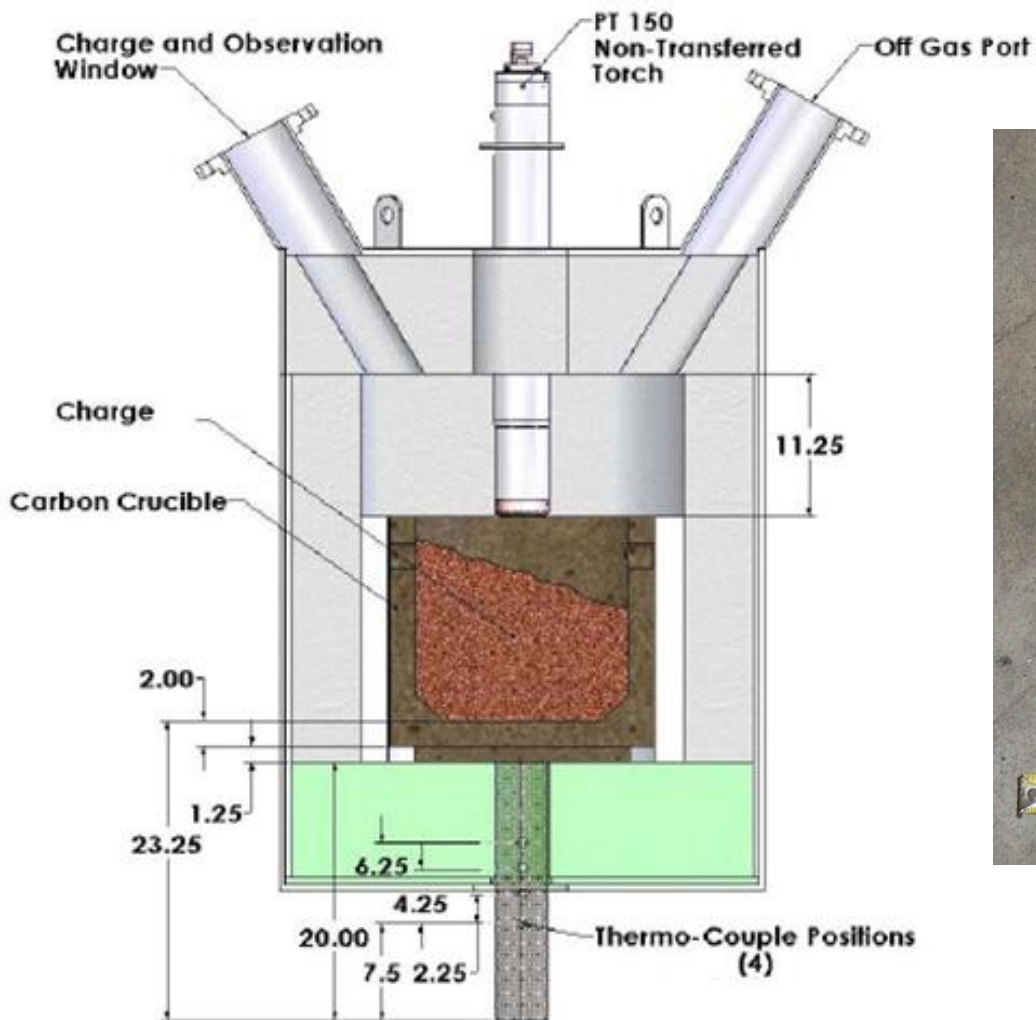
Improved smelting and chlorine leaching process for CFC

(cont.)



(Shibasaki et al., 2015)

Reduction smelting test (Plasma torch furnace)



(Shibasaki et al., 2015)

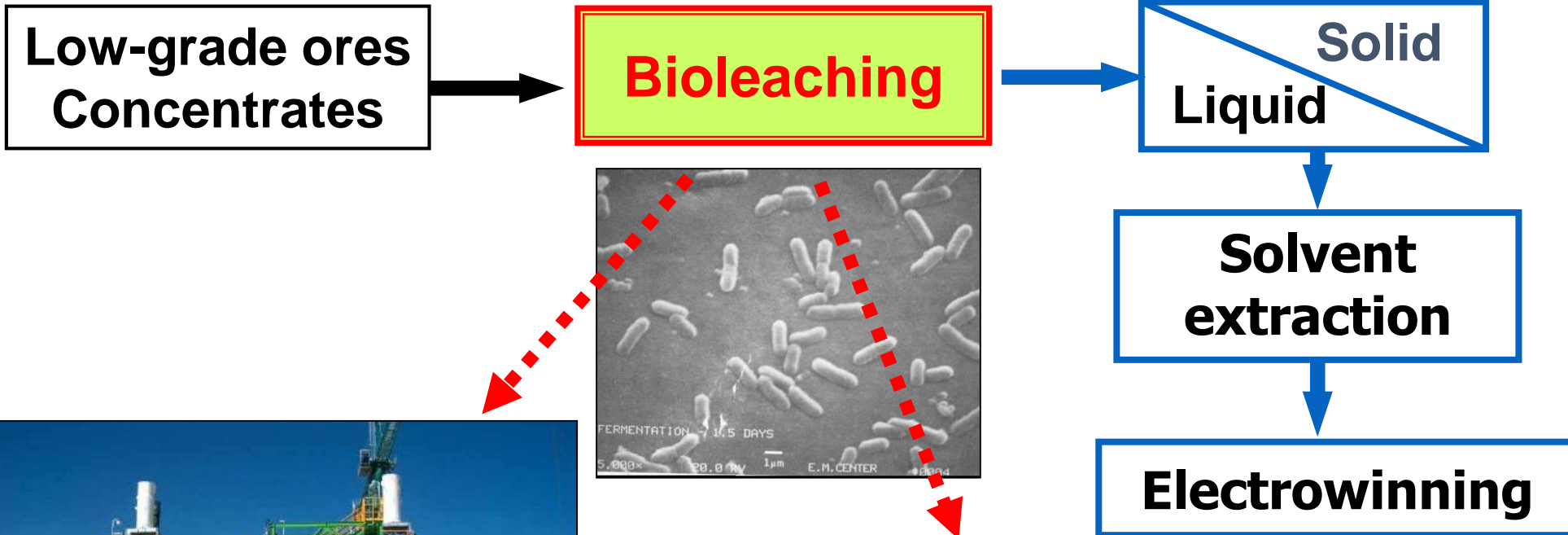
➤ Conventional processing to recover value metals

- Pyrometallurgical process :
 - smelting
- Hydrometallurgical process :
 - high-temperature and high-pressure acid leaching
 - gas-reduction and ammoniacal leaching

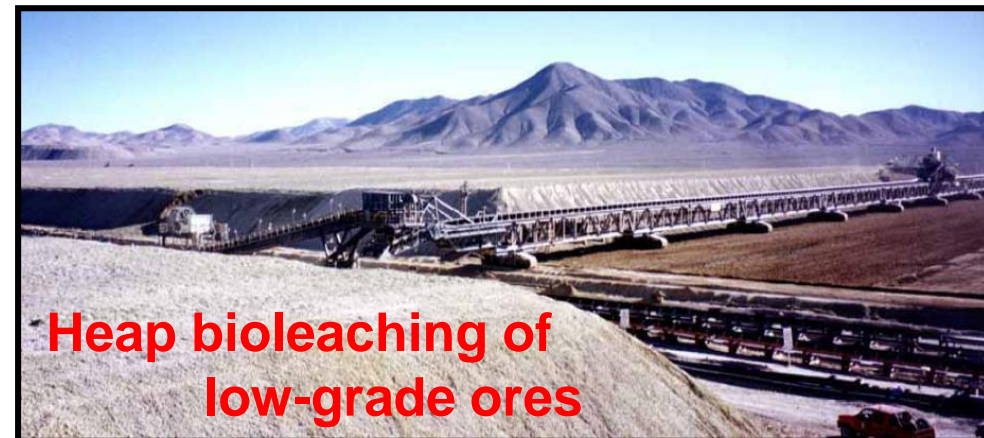
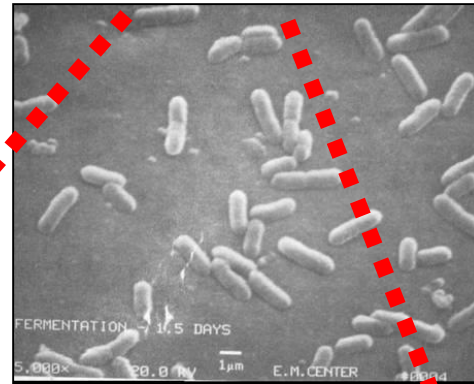
➤ Lab scale study: Bio-hydrometallurgical process

“Bioleaching” : the use of microbes to recover value metals at room temperature and atmospheric pressure

Commercial-scale copper bioleaching plants



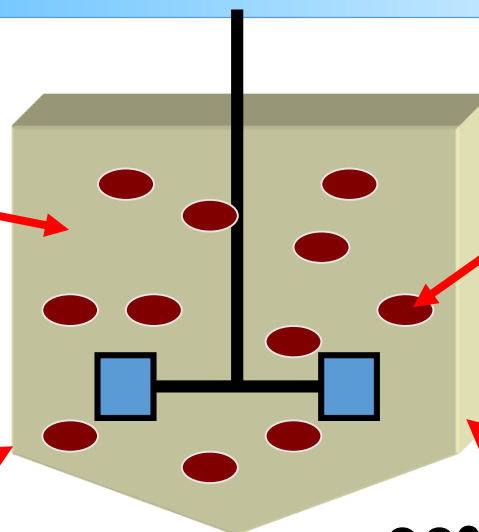
Tank bioleaching of concentrates



Heap bioleaching of low-grade ores

Bioleaching tests in a tank reactor

- Fe(III) –reducing bacterium
Shewanella algae
(ATCC 51181)



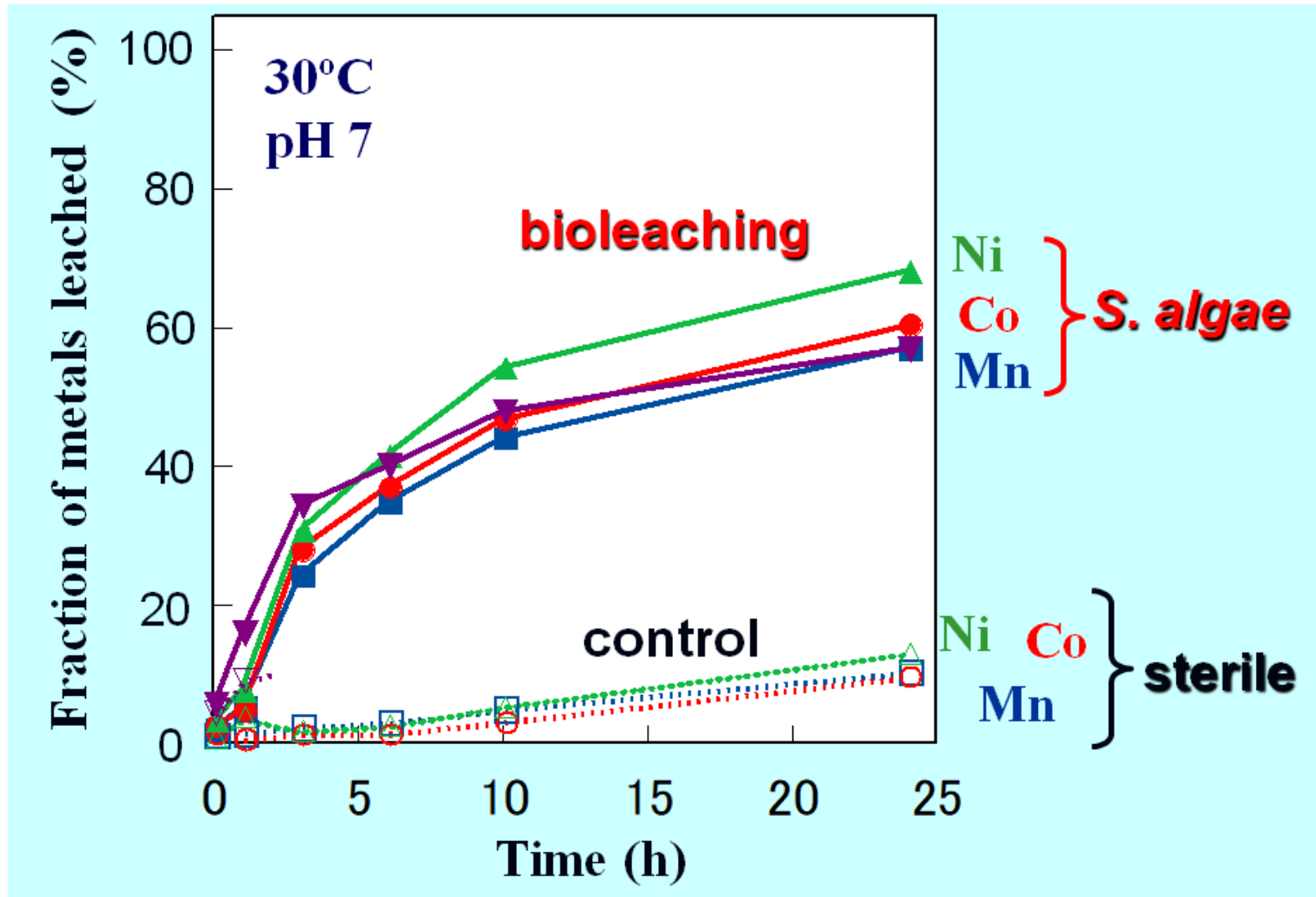
crusts particles
($< 75 \mu\text{m}$)

stirred tank reactor
(volume : 1000 cm^3)

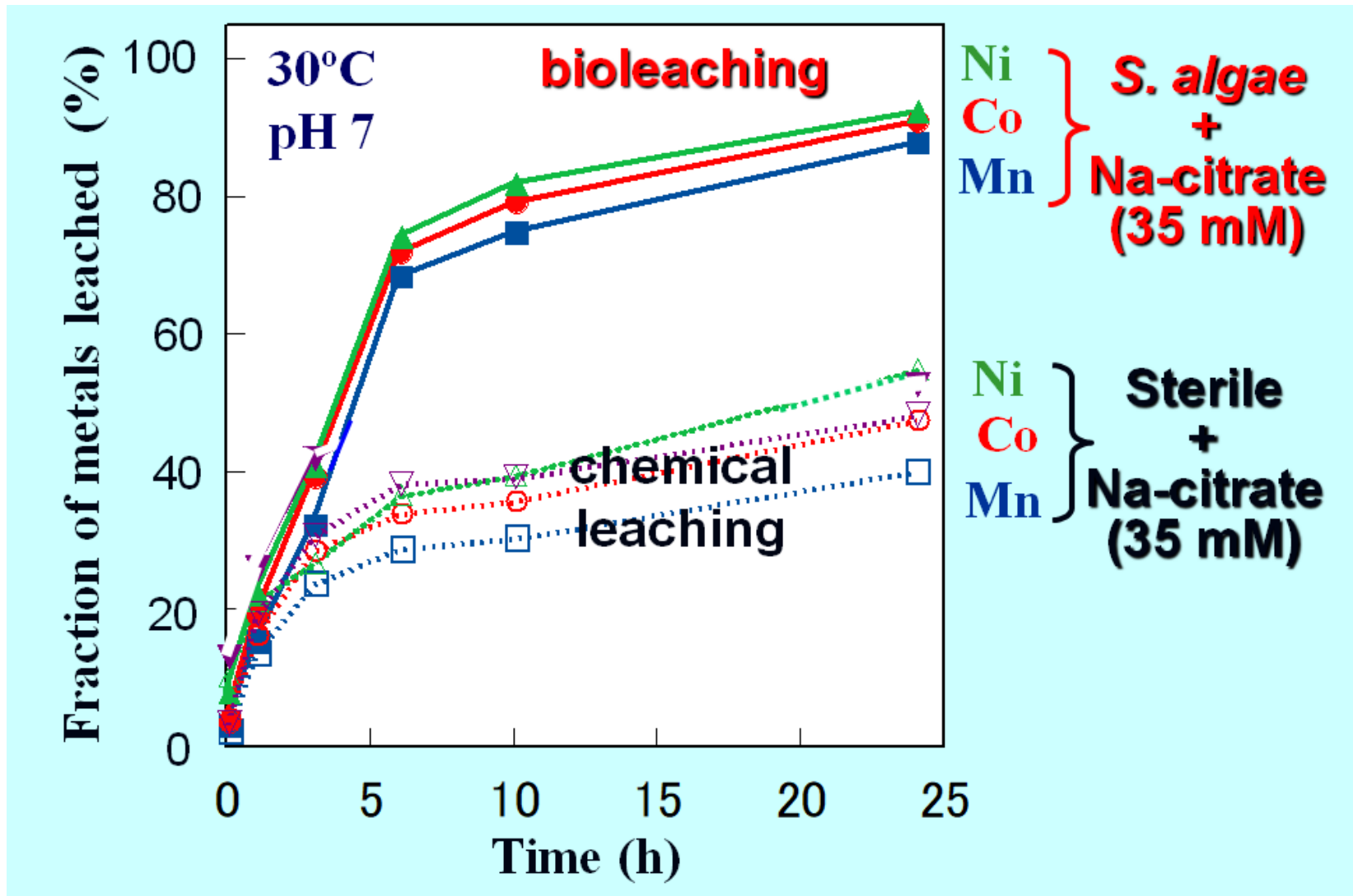
30°C , pH 7
anaerobic conditions

	Initial operating conditions
Cell concentration	5×10^7 cells / cm^3
Crust - liquid ratio	5 g /L
Leach solution	5mM Fe (III)-citrate [electron acceptor] 100 mM formate [electron donor] 35 mM Na-citrate [complexing agent]

Bioleaching of Co, Ni and Mn from ferromanganese crusts in a batch reactor

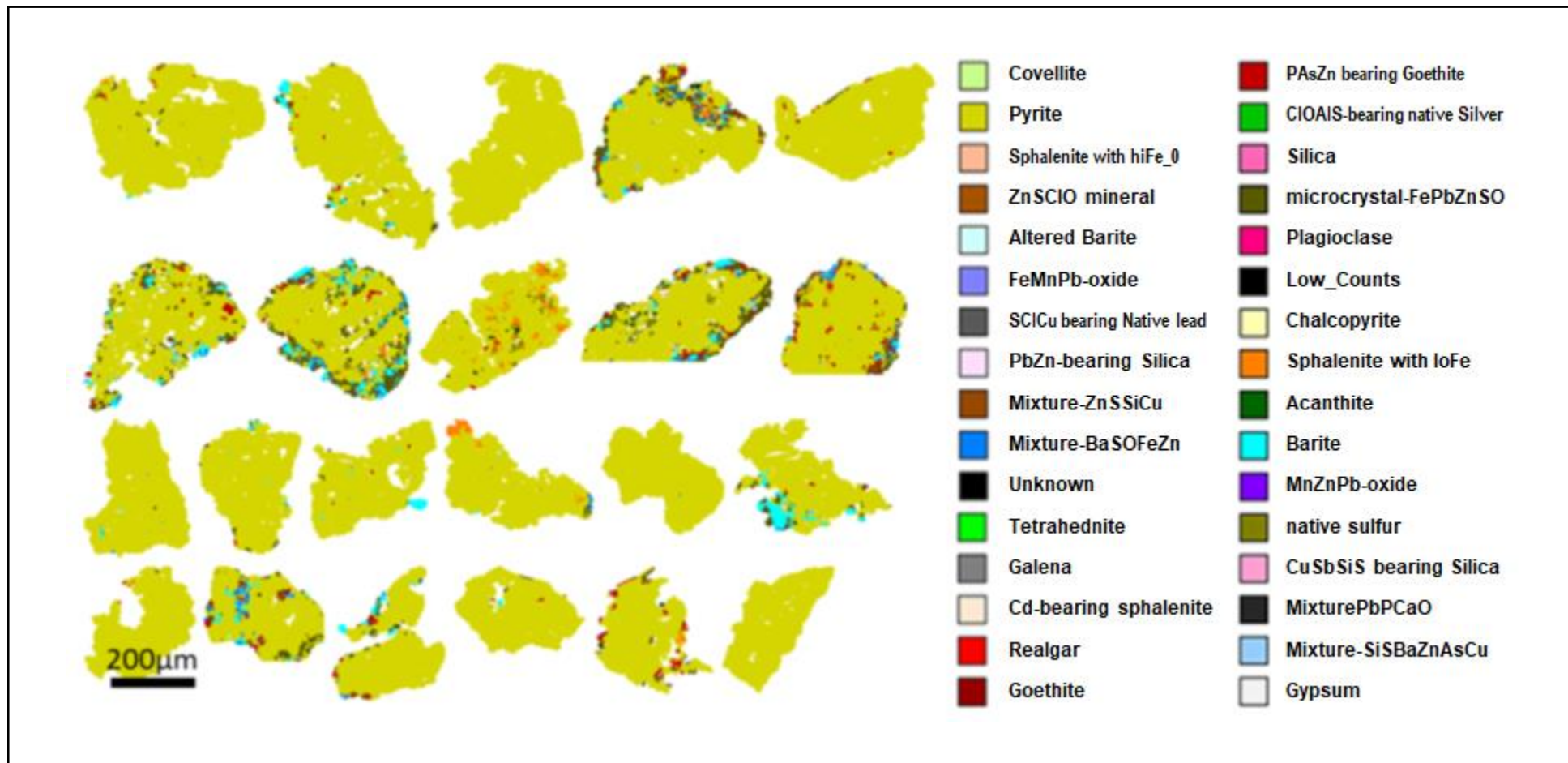


Bioleaching of Co, Ni and Mn from ferromanganese crusts in a batch reactor



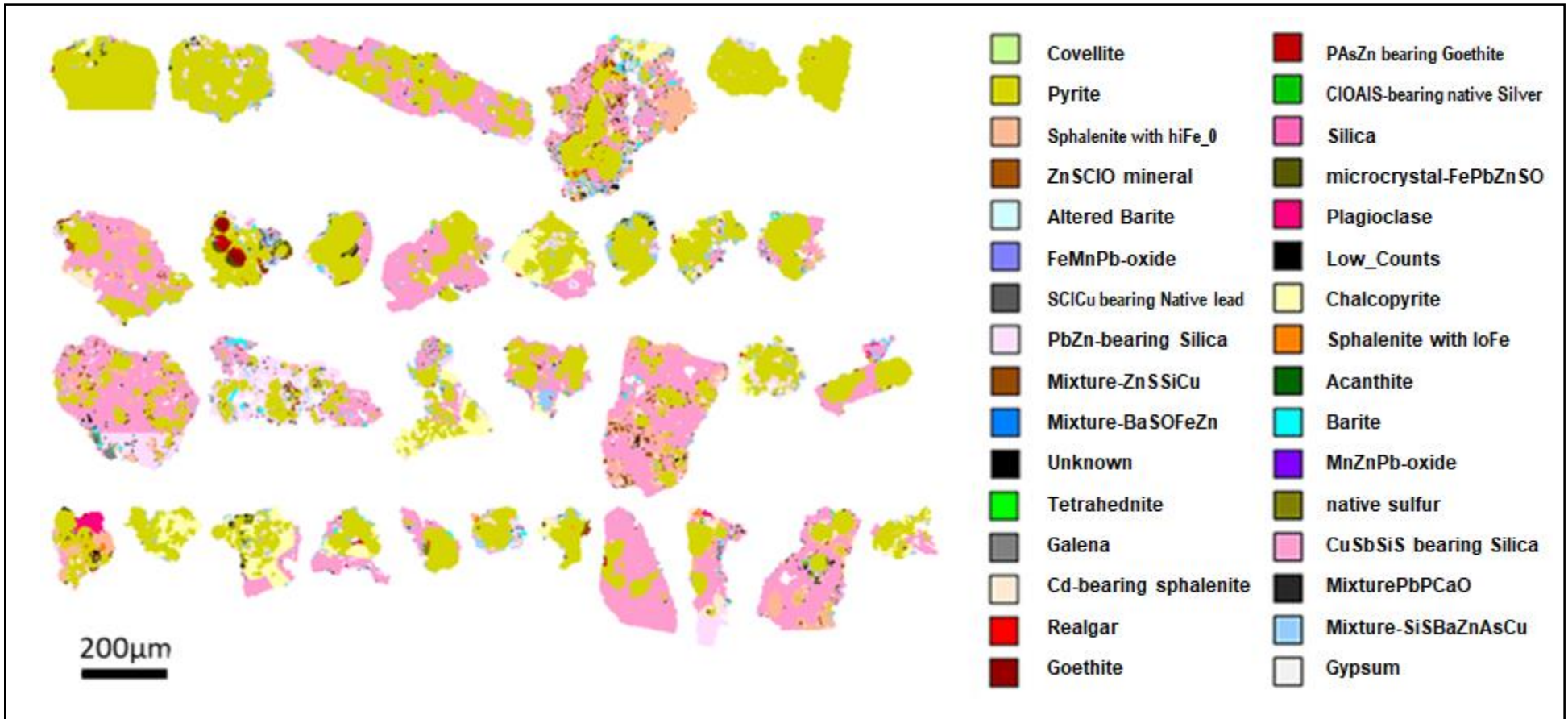
Other minerals

SEM-MLA images of Okinawa-C sample



(Ooki, et al., 2015)

SEM-MLA images of Izu-Ogasawara-C sample



Grain size of each minerals is under 10µm

(Ooki, et al., 2015)

➡ **Not easy to product Zn, Pb, or Cu concentrates respectively.**

Conclusion and future plan

- **Basic studies of processing and metallurgical technologies was started in 2003.**
- **High crust recovery rate of 96% from -4+1mm grain size of crust and substrate mix samples obtained with RETAC JIG.**
- **Improved smelting and chlorine leaching method with Pt recovery process were developed.**
- **Lab-scale new test with bio-leaching technologies were also conducted. In the test by bioleaching process, a much higher leaching rate was obtained as compared with chemical leaching. But application point of this method is limited.**
- **Scale-up tests and more efficient process are conducting during exploration contract.**