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ARE WE HEADING INTO THE 4TH GENERATION OF PAL PLANTS FOR LATERITES?

By

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ABSTRACT

Starting with Moa Bay, Cuba, in 1959, we have seen three generations of PAL plants for treating nickel-cobalt laterites. Are we now seeing the beginning of a 4th generation?

Current driving forces include the projected increase in demand for nickel and cobalt for the battery industry, potential growth in demand for scandium, limited future availability of new copper-nickel-cobalt sulphide orebodies, and the desirability of developing alternative sources of cobalt. PAL Project categories under consideration are the expansion of existing PAL operations, new major projects, and new smaller scale projects with scandium as a major product.

Expansion of existing PAL Operations reported to be under consideration include the quadrupling of Gordes in Turkey, and a US$1.5 billion major expansion of Ramu in PNG.

New major PAL projects at various stages of development include the Sunrise Project, Australia, by Clean TeQ, the Morowali Project, Indonesia, by a consortium led by GEM, China, the Pomalaa Project, Indonesia, by Sumitomo and PT Vale Indonesia, and the North Konawe Project, Indonesia, by PT Antam.

New smaller scale PAL projects with scandium as a major product include the Nyngan Project, by Scandium International Mining, the Platina (formerly Owendale) Project, by Platina Resources, the Sconi Project, by Australian Mines/Metallica Minerals, and the Flemington Project, by Australia Mines/Jervois all located Australia.

The main differences from the 3rd phase PAL plants lie in downstream processing due to the emphasis on products for the battery industry or scandium market, or both in some cases.

Keywords: Laterites, PAL, Nickel, Cobalt, Scandium, Battery Industry Projects, Downstream Processing


(Ref: SNCL paper, ALTA 2006)

Starting with Moa Bay, Cuba, in 1959, we have seen three generations of PAL plants for treating nickel-cobalt laterites.

Are we now seeing the beginning of a 4th generation?

Presentation Outline

- 2nd and 3rd Generation PAL Plants
- Driving Forces for 4th Generation
- Project Categories Under Consideration
- Expansion of Existing Operations
- New Major Projects
- New Smaller Scale Projects with Scandium as a Major Product
- 4th Generation Distinctives
- References

2nd Generation Plants

- Bulong
- Cawse
- Murrin Murrin
- All located in Western Australia
- Commissioned in 1999
- Bulong was the trail blazer – project development commenced 1988. Closed 2003 due to a loss of acid supply and the inability to obtain replacement low cost acid.
- Cawse closed 2008 due to low metal prices and loss of acid supply.
- Murrin Murrin still in operation.

Bulong Operation

3rd Generation Plants

- Coral Bay – Sumitomo - Philippines
- Ravensthorpe - Western Australia – suspended 2017 due to low metal prices
- Goro - New Caledonia
- Ambatovy - Madagascar
- Ramu - PNG
- Taganito – Sumitomo - Philippines
- Gordes- Meta Nikel – Turkey

Coral Bay was the first, commissioned in 2005, and expanded in 2009.

Coral Bay Initial PAL Area

Driving Forces for 4th Generation

- Increasing demand for nickel and cobalt for the battery industry,
- Desirability of developing alternative sources of cobalt.
- Limited future availability of new copper-nickel-cobalt sulphide orebodies.
- Projected markets for scandium.

Project Categories Under Consideration

- Expansion of existing operations
- New major projects
- New smaller scale projects with scandium as a major product.

Expansion of Existing Operations

GORDES, Turkey(1)

- Plans to quadruple the current output of 10,000 tpa Ni and 750 tpa Co as MHP were announced Feb. 2018, together with a facility to produce nickel and cobalt sulphates in 50/50 partnership with GSR Capital, China.
- Products will supply a mega battery factory to be established in Turkey in 2023 by a 50/50 partnership between GSR and another Zorlu Group Company, Vestel.
- Meta Nikel are also undertaking R & D work for recovery of by-product scandium from the PAL leach solution.

Gordes Operation

(Ref: Meta Nikel presentation, ALTA 2015)

RAMU, PNG(2)

- A US$1.5 billion expansion is being investigated according to an ASX announcement on 8 October 2018.
- Ramu is currently rated at 34,000 tpa Ni and 3,300 tpa Co as MHP, achieved in 2017.

Ramu Operation

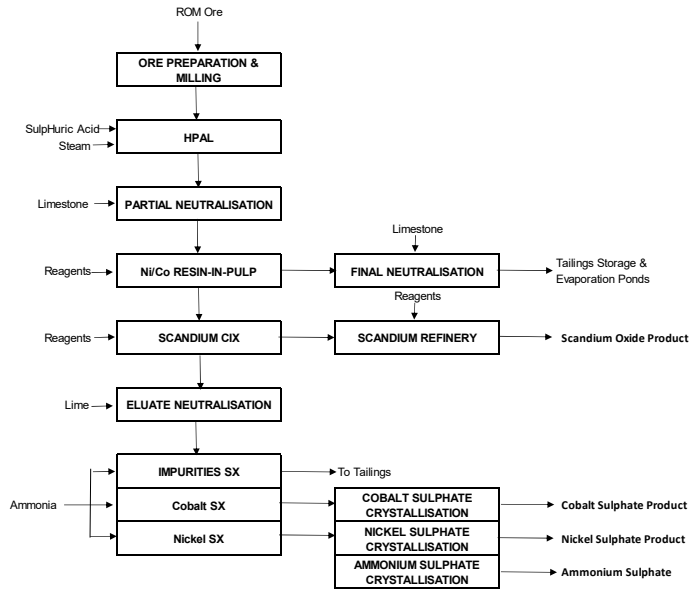
(Ref: Ramu Presentation, ALTA 2011)

New Major Projects

Sunrise, NSW, Australia[3]

- Sunrise Project, Australia: DFS completed June 2018; years 2-11 average production !9,260 tpa Ni, 4,420 tpa Co, in the form sulphates for the battery industry, plus 80 tpa scandium oxide and 82,000 tpa ammonium sulphate.
- Project financing and offtake discussions are well advanced, engineering by MCC, China, is underway and construction is expected to commence in 2019 with first production in 2021.
- An innovative flowsheet uses Resin-in Pulp to concentrate the PAL leach solution followed by refining to nickel and cobalt sulphates using SX and crystallization. Scandium is extracted by IX and produced as oxide.[3][4]

Sunrise Flowsheet[4]



Other Projects

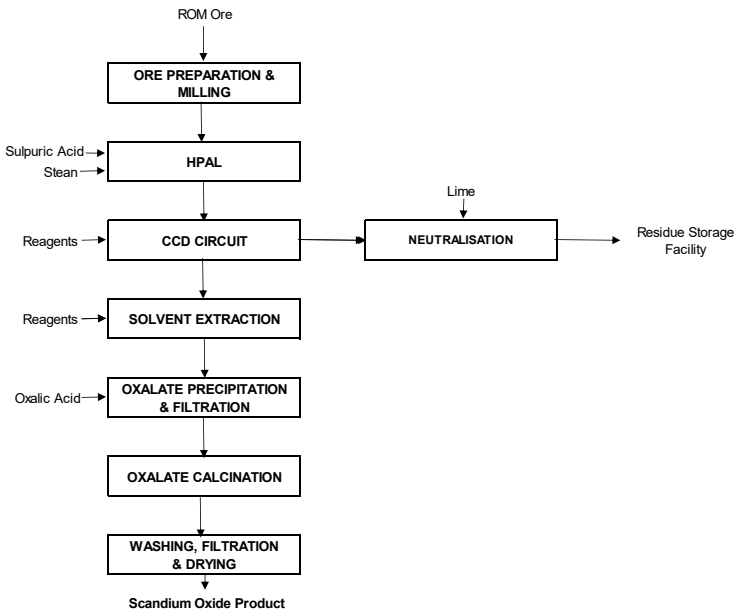
- Morowali Project, Sulawesi, Indonesia, GEM Co Ltd (China) with CATL, Tsingshan and others are planning a 50,000 tpa nickel and 4,000 tpa cobalt operation at Morowali producing nickel intermediates to serve the battery industry.(5) Limonite ore will be supplied by Nickel Mines Limited from their nearby PT Hengjaya Mineralindo Mine.(6)
- Pomalaa Project, Sulawesi, Indonesia, Sumitomo PT Vale Indonesia are conducting a feasibility study for a 40,000 tpa nickel PAL operation to produce nickel and cobalt intermediate product that would then be processed into nickel sulphate for batteries.(7)
- PT Vale Indonesia, and the North Konawe Project, Indonesia, by PT Antam are conducting a feasibility study for 20,000 tpa Ni and 1,900 tpa Co in MHP (stage 1). A future refinery to produce battery metals is planned.

New Smaller Scale Projects with Scandium as a Major Product

Nyngan, NSW, Australia(8)(9)

- Nyngan Project, NSW, Aus., Scandium International Mining Corp.
- Definitive Feasibility Study completed May 2016.
- Pure scandium project - Ni, Co and Pt are too low to be economic.
- Aiming to develop the world's first scandium-only mine, and are focusing on downstream marketing aspects including working to stimulate scandium demand in the aluminium industry.
- In Oct. 2017, initiated critical path engineering on selected critical path components, HPAL autoclave and associated equipment. Production targeted for 2019 at approximately 38 tpa of scandium oxide (Sc_2O_3).
- Throughput 71,820 tpa ore, Sc 40-60 ppm (ave.).
- Recovery of Sc 83.7% at 99.8% scandium oxide.

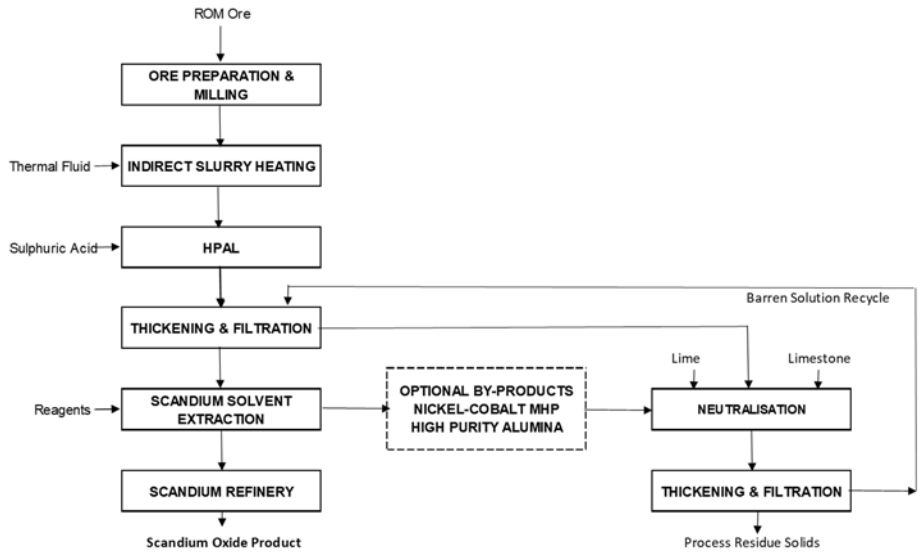
Nyngan Flowsheet(8)



Platina NSW, Australia[10][11]

- Platina (formerly Owendale) Project, NSW, Aus., Platina Resources Limited.
- Definitive Feasibility Study completed Dec. 2018.
- Scandium project with optional Ni-Co MHP and high purity alumina by-products.
- Staged production strategy – 20 tonnes/year of 99.99% purity scandium oxide growing to 40 tonnes/year as market demand increases .
- Ore grade 475-645 ppm Sc.
- Throughput 23,000 tpa increasing to 50,000 tpa.
- Recovery of Sc 83.7% at 99.8% scandium oxide.

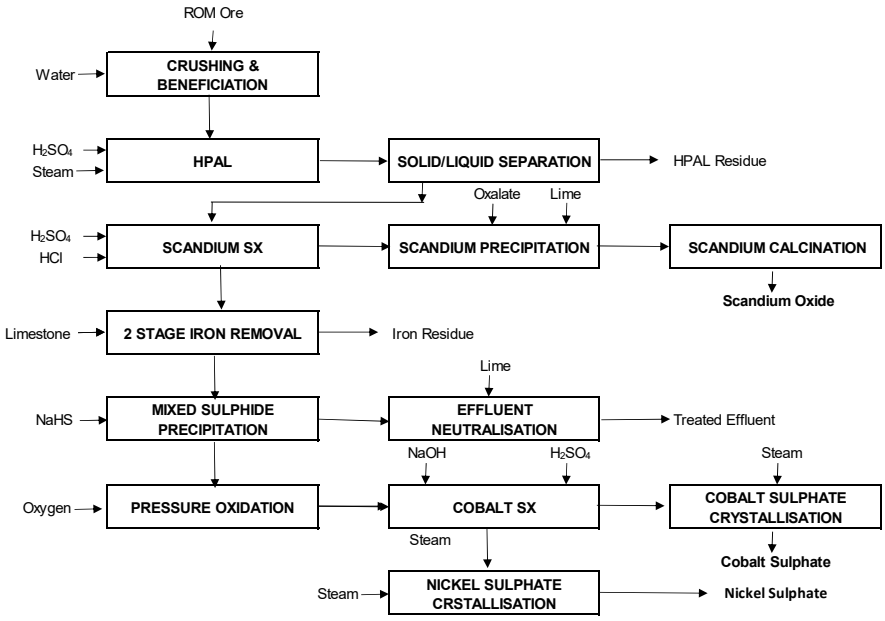
Platina Flowsheet[11]



Sconi, Qld, Australia(12)

- Cobalt-Nickel-Scandium Project, Qld, Aus., Australian Mines Limited.
- Bankable Feasibility Study released Nov. 2018, currently being optimized to reflect results of resource expansion drilling. Targeting construction starting 2019 and production in 2021.
- 18 Year average: 2M tpa feed, 8,500 tpa battery grade cobalt sulphate (1,780 t Co equivalent); 53,300 tpa battery grade nickel sulphate (11,900 t Ni equivalent); and 89 tonnes of scandium oxide.
- Negotiating offtake with battery producer SK Innovation, South Korea,
- Expected average feed grade 0.10% cobalt and 0.67% nickel, with recoveries of 95.7% and 94.8% respectively.
- Continuous demonstration scale plant successfully operated in Perth.

Sconi Flowsheet(13)



Flemington Project[14]

- Cobalt-Nickel-Scandium Project, NSW, Aus., Australian Mines Limited.
- Adjacent to Clean TeQ's Sunrise Nickel-Cobalt-Scandium Project.
- Scoping study in 2017. Progressing to Prefeasibility Study phase.

4th Generation PAL Plant Distinctives

The main differences from the previous generations of PAL plants lie in downstream processing due to the emphasis on products for:

- the booming battery industry
- the potential scandium market
- both in some cases.

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