Minerals Engineering 88 (2016) 53–60

Contents lists available at ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

# Why heap leach nickel laterites?

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ARTICLE INFO

*Article history:*
Received 30 June 2015
Revised 22 September 2015
Accepted 23 September 2015
Available online 1 October 2015

*Keywords:*
Nickel laterites
Hydrometallurgy
Heap leaching
Nickel and cobalt

ABSTRACT

With the majority of nickel naturally occurring in laterite ores but the majority of production still in sulphides, it is high time there was a standalone commercial nickel laterite heap leach operation. The broad success of heap leaching of other metals has allowed hitherto uneconomic deposits to undergo successful economic exploitation, and heap leaching now accounts for at least one third of global copper and gold production. Nickel laterites are no different, every major and several junior nickel miners have evaluated nickel laterite heap leaching over the past decade and shown projects to have robust economics, with much lower capital costs than alternative hydrometallurgical options which have in general been dismal failures, both technically and commercially.

Nickel Laterite Heap leaching is simple and flexible, and can be applied to the many laterite deposits that currently have no realistic path to production.

This paper aims to review the current state of nickel laterite processing and aims to show that heap leaching of nickel laterites is a viable and economically attractive alternative.



## 1. Introduction – Global nickel laterite production

The world's resources of nickel are either sulphides or laterites and while almost ¾ of the world's resources of nickel are found as laterites, until 2009 less than half of the primary nickel production came from laterite sources as illustrated in Fig. 1.1 (Dalvi et al., 2004). This figure has been updated to 2009 production using data from Wood Mackenzie reviews.

Total production of nickel has increased more than 10-fold since 1950, when sulphides accounted for as much as 90% of the world's nickel, in 2009 laterites exceeded the 50% mark for the first time and in 2015 they are expected to account for two thirds of word production. According to Wood Mackenzie (2013) predictions 72% of world nickel will be from laterites by 2022 (see Fig. 1.2).

Laterite ores are divided into three main ore types which until now have largely been treated separately to recover the nickel within. It is however the conclusion of Alyssum Ventures Limited (AVL) and Brazilian Nickel Limited (BRN) after significant amounts of test work at different scales that all ore types could be treated without the need for any selective mining, by heap leaching. Fig. 1.3 was published by Brand et al. (1998) without the heap leach addition.

## 2. Recent nickel laterite projects

### 2.1. Existing state-of-the-art

Nickel laterites are currently processed with the exception of the hybrid Caron process by either a Pyrometallurgical or a Hydrometallurgical route.

Most pyrometallurgical routes (ferronickel and matte smelting) use a conventional flow sheet which includes steps for upgrading in the mine, drying, further upgrading, calcining/reduction and electric furnace smelting followed by either refining to produce a ferronickel product or converting to a low iron-containing matte.

Outside of China where there are 2 atmospheric leach project and a small heap leach the only operational hydrometallurgical processes are High Pressure Acid Leaching (HPAL).

### 2.2. Pyrometallurgical

For all pyrometallurgical nickel laterite operations the ore must meet quite specific criteria to result in a commercially attractive project.

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http://dx.doi.org/10.1016/j.mineng.2015.09.018
0892-6875/

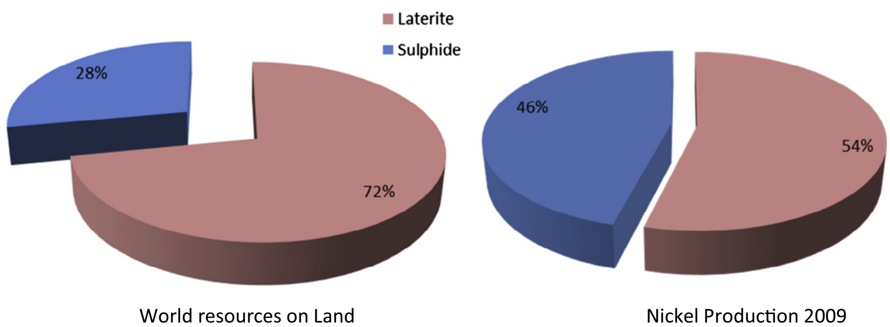


**Fig. 1.1.** Nickel resources and production; sulphide and laterite.

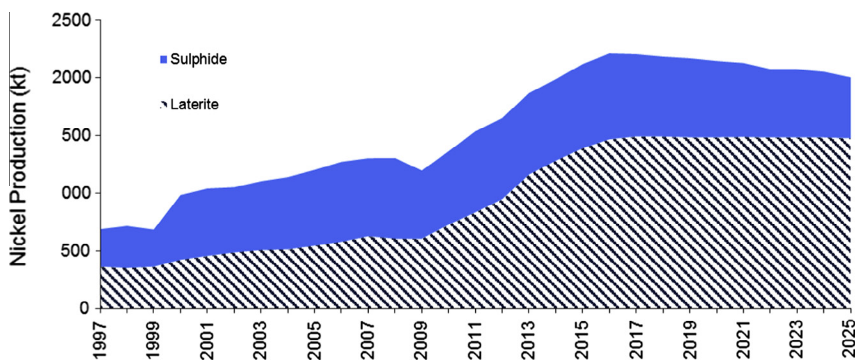


**Fig. 1.2.** Nickel production past and future predictions (Wood Mackenzie, 2013).

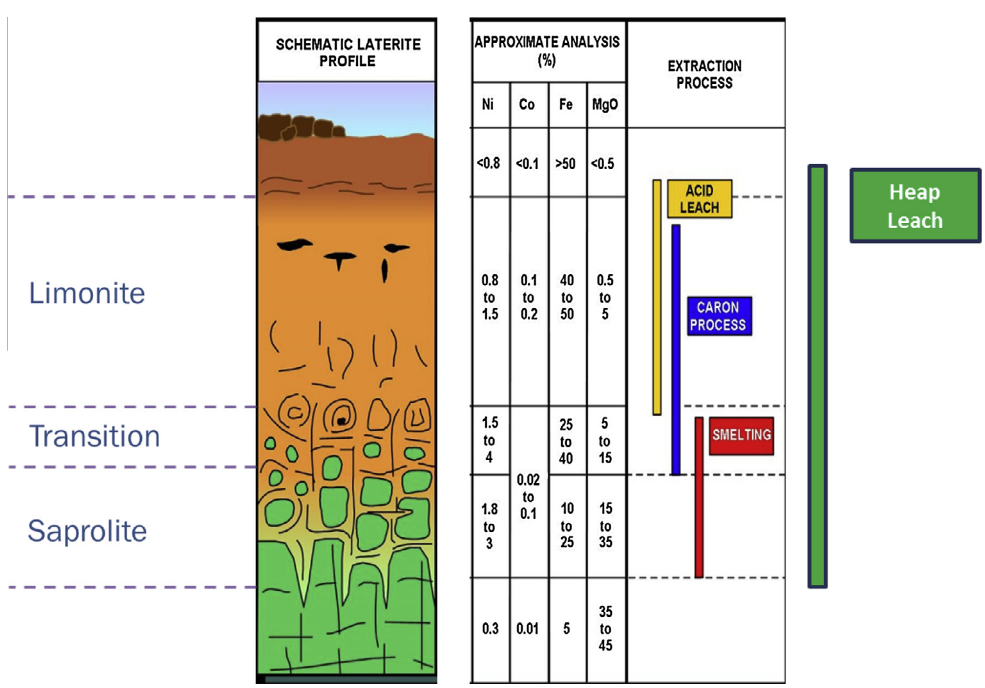


**Fig. 1.3.** Processing options for nickel laterites (Brand et al., 1998).

For both FeNi Pig Iron (NPI) and Ni matte smelters the ore must meet fixed requirements in terms of their Ni grade, Fe/Ni, Ni/Co and $SiO_2$/MgO ratios. These are typically a Fe/Ni ratio of 12, a Ni/Co ratio of 40 and a $SiO_2$/MgO ratio of 1.9 if these criteria are met then good recovery and good product grade can be obtained. These ratios can be extended but then the recovery and the product grade are much lower at similar operating costs resulting in non-profitable operations.

Ferro nickel smelters require Ni grades of typically over 1.8%, with initial grades >2% required for up to 5 years to enable capital payback. They also require Fe/Ni, Ni/Co and $SiO_2$/MgO ratios of <12, >30 and <1.9 respectively in order to be a commercially successful operation.

### *2.2.1. New ferro nickel smelters*

In recent years there have been 3 major new Ferro-Nickel smelters. These projects have all experienced long delays in start-up and major cost overruns, these are illustrated in Figs. 2.1 and 2.2.