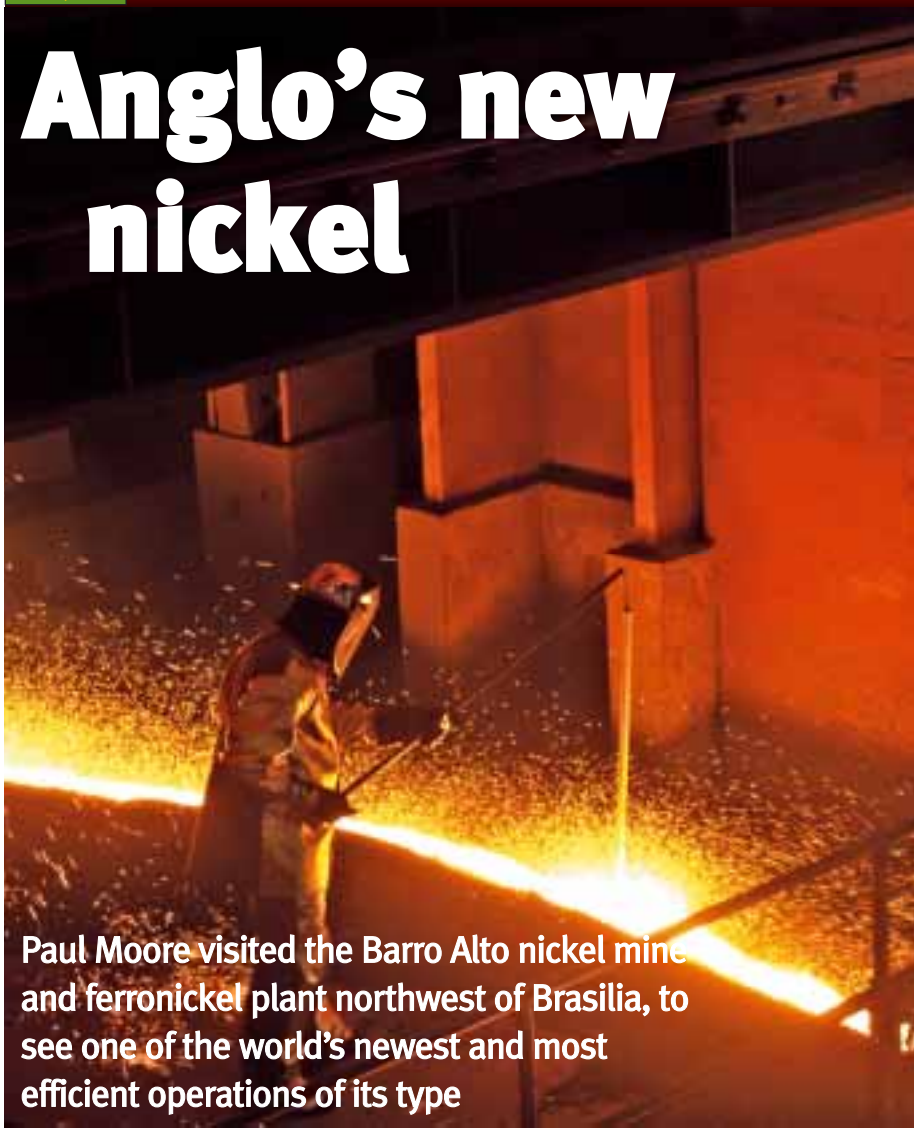
Anglo's new nickel



Paul Moore visited the Barro Alto nickel mine and ferronickel plant northwest of Brasilia, to see one of the world's newest and most efficient operations of its type

The Barro Alto project is located in the state of Goias, Brazil, approximately 170km from Anglo American's existing Codemin nickel operation. The project was approved in December 2006 and first metal was produced on schedule in March 2011, with the overall project having a capital cost of $1.9 billion. The site represents the first of four near-term strategic growth projects in nickel for the company, and is set to produce an average of 36,000 t/y of nickel in ferronickel from the second half of this year and over a remaining mine life of 25 years. Actual production in the initial five years will be about 41,000 t/y from early 2013 onwards as the highest grade nickel ore is processed. Total mineral resources are 1.27 Mt at 1.48 % Ni. The total plant feed is 74.51 Mt at 1.6 % Ni over 31 years. This includes the previous plant supply to Codemin – part of the Barro Alto ore deposit has been processed since 2004 at the ferronickel plant there. In 2007 the construction of the Barro Alto plant began and since 2011 Barro Alto ore has been processed at the Barro Alto plant.

The Barro Alto site is state-of-the-art and brought Anglo American's operating nickel assets up to three along with Loma de Niquel (91% held) in Venezuela, and Codemin 100%), also in Brazil, as well as nickel produced as a by-product of platinum processing at Anglo Platinum in South Africa. The company estimates its current share of the global nickel market at about 11% with the new operation. In 2011, Codemin saw 9,500 t of nickel in ferronickel produced. The same year, Loma produced 13,400 t of nickel in ferronickel and Barro Alto 6,200 t. Overall, nickel production in 2011 increased by 44% from 2012 to 29,100 t.

Another Brazilian project, Jacare in Para state, is also 100% owned. The Jacare project has some 500 Mt of nickel ore with about 3.9 Mt (resources) of contained nickel. The project will enter the pre-feasibility stage this year. The mine would either produce nickel metal or nickel in ferronickel like the other sites, and Phase 1 would see 34-35,000 t/y production with Phase 2 potentially delivering a further 50,000 t/y with cobalt by-products for a total of 85,000 t/y.

Further exploration programs to confirm Jacare's reserves are underway, with feasibility studies set for completion in 2014/2015. A second new project, Morro Sem Boné, is also in Brazil and would produce 30-32,000 t/y of nickel in ferronickel. Morro Sem Bone is a smaller project but the deposit has higher ore grades.

Tapping ferronickel at Barro Alto plant

Nickel's main use is as an alloying metal, along with chromium and other metals, in the production of stainless and heat resistant steel. Approximately 66% of nickel is used to manufacture stainless steel and around 25% in other steel and non-ferrous alloys. Primary nickel is used in the form of pure nickel metal, ferronickel, nickel oxide and other chemicals. The steel industry is also supplied by recycled nickel and, in a more recent development, by nickel pig iron (NPI) in China. However, NPI production, which is a highly energy intensive process, decreased in 2010 due to the initiatives implemented by the Chinese government in order to save energy.

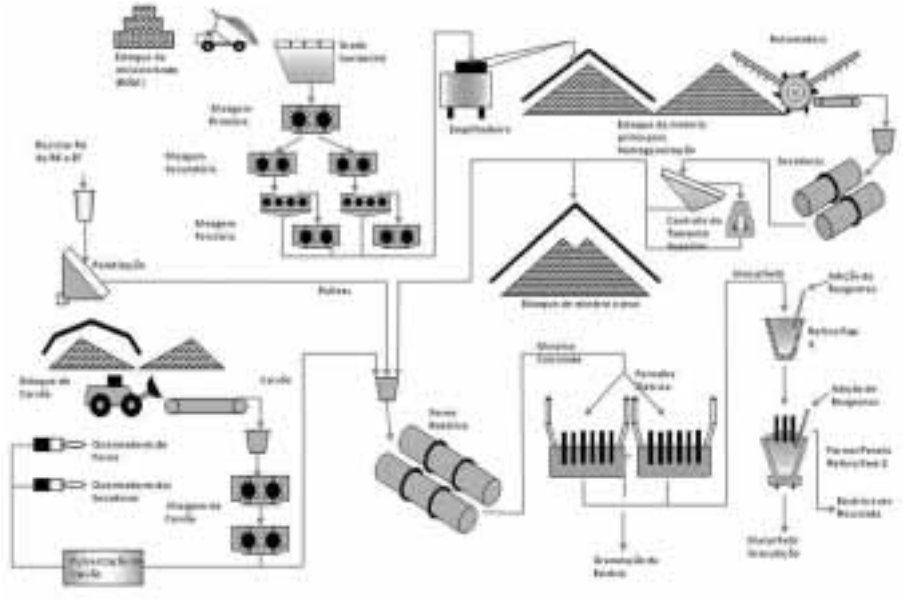
Project	Location	Ni capacity t/y
Codemin	Brazil	10,000
Loma de Niquel	Venezuela	17,000
Barro Alto	Brazil	36,000

Geology and mining

The Barro Alto mineral resource is primarily saprolite overlain by laterites and extends for 35 km in an arc from southwest to northeast. The deposit is in the Barro Alto mafic-ultramafic complex, which is part of the Pre-Cambrian shield in the state of Goiás. The complex is composed of a sequence of serpentinised dunites and pyroxenites, enveloped by gabbros. The mineralisation corresponds to the surficial weathered portions of the serpentinites. There are three types of saprolitic ore. The West type ore tends to have higher nickel grades and silica/magnesia ratios than the East type and Plain type ores.

The project consists of an open pit mine and a ferronickel plant. The shallow pits forming the mine extend over an area 35 km long with a width of no more than 2 km. The plant uses a classical RKEF process to produce ferronickel by processing a nominal 2.4 Mt/y (dry basis) of ore. No blasting is required to access the relatively soft laterite/saprolite ore, which is loaded by a fleet of eight 365CL and four 330CL Caterpillar backhoe hydraulic excavators with a maximum working bench height of 2.5 m. These load a fleet of 44 Scania 35 t trucks with Rossetti bodies, which transport the material to a ROM stockpile. These are operated by contractors Minax and TGL. The mining team uses DataMine and SmartMine programs to conduct short to medium term planning.

This ore is then transported via a fleet of 12 30 t trucks by contractors CTBA and TGL from the mine to the ore preparation yard at the plant site. The ore is dumped into a horizontal grizzly



Process flow diagram for Barro Alto mine and plant

after which it goes through a three stage (primary, secondary, tertiary) process using two roll crushers followed by a Sandvik CH660 cone crusher, before conveying and stacking on a homogenisation stockpile; reclaiming to dryers subsequent and screening. The dryers are 32 m in length and 4.6 m wide. At the pyrometallurgical part of the plant the 2.4 Mt/y of dried ore is fed by a Sandvik MGS conveyor (Sandvik 51% MGS 49%) into the huge rotary kilns along with pellets that have been produced with FEECO pelletising discs from recycled plant dust from the dedusting system and coal. The rotary kilns themselves can use gas or pulverised coal for firing. Ore is heated at very high temperatures in the rotary calcination kilns, which remove moisture and water crystallisation from ore and starts the metallurgical process, pre-reducing the ore before feeding it to two rectangular SMS Siemag electric-arc induction furnaces for smelting at 1,500-1,520ºC, each of which has six 83 MW electrodes. Each FLSmidth rotary kiln is 185 m long and 6.1 x 7 m in diameter, which the company believes are the longest to be installed to date in the industry. Reagents are added to the resulting FeNi metal in a refining ladle furnace (carbon and impurities are removed in slag) that produces the final molten metal product; this 25-30% Ni ferronickel is tapped from a tundish vessel and granulated using water and classified for shipment. The refining slag is stockpiled for future recovery.

ASM Automation worked with SMS Siemag AG on commissioning of the furnaces and dedusting system including PC and PLC software support. For the central control room, FLSmidth developed the state-of-the-art burner management system controls and software for use on the dryers and rotary kilns. All systems and equipment are controlled from the main control room, and managed and operated through the use of software programs incorporated into the overall control system. These include the overarching Siemens PCS7 system.

Additional infrastructure included an electrical main station (maximum demand 210 MW) and a water dam. Energy and water considerations during design included the plant layout which allows solids gravity flow; kiln waste heat recovery; high efficiency electric motors; and water usage in a closed circuit.

Barro Alto timeline

- 1960 Deposit discovered
- 1970 Exploration started
- 1998 Anglo American options the deposit, first feasibility study commenced
- 2002 Anglo American acquires mineral rights
- 2004 Mine operations begin feeding Codemin plant. Barro Alto plant feasibility reviewed
- 2006 Barro Alto project approved
- 2007 Construction starts with SNC-Lavalin/Minerconsult EPCM
- 2011 Q1 first metal production on schedule.

A Caterpillar hydraulic excavator loading a Scania truck with nickel ore at the Barro Alto mine

Third party commissioning

The EPCM work was carried out by SNC-Lavalin along with local partner Minerconsult Engenharia, which signed a $100 million contract with Anglo American Brasil. The EPCM contract also includes project management and related technical services for expansion work on the mine's existing infrastructure and operations. Capital cost of the new metallurgical facility and mine expansion. Detailed engineering and procurement work on the Barro Alto plant began in January 2007 with construction commencing in November 2007. Shortly after this August 2007 announcement, SNC-Lavalin announced the acquisition of Minerconsult.

SGS has also been involved from September 2010 to September 2011, when it was contracted to perform complex commissioning services and management as well as executing various tests in order to ensure a successful start for the facility operation within its planned schedule. The SGS statement said: “In order to proceed with such an extensive project in compliance with all relevant regulations and requirements within schedule, Anglo American, one of the world’s largest mining companies, looked for a reliable inspection, verification, testing and certification company. In September 2010, SGS Industrial division in Brazil was assigned the contract to provide specialist third-party services during the commissioning of the Barro Alto Nickel Project due to its extensive experience and competence in projects of this kind.” SGS executed a wide variety of tests to aid transfer of the plant from construction to operation in the areas of instrumentation and power as well as through effective use of the dedicated Commissioning Management Software developed by SGS. The SGS Commissioning Management Software, known as the CRI system, includes a database capable of generating management reports on mechanical, piping, instrumentation and electrical services. The software presents the actual commissioning situation and generates information about pending work to be executed, including identification of the critical path for start-up, precise and up-to-date information for use in daily meetings, document control as well as information for calibration and testing situations.

Sandvik MGS conveyor and FLSmidth rotary kiln (inset close-ups)

Anglo Research Nickel – ARNi

Nickel is recovered from two major ore types. Sulphides, though only representing 30% of known resources, are the source of 70% of the world's nickel; while laterites, which account for 70% of known resources, are responsible for the remaining 30% of global nickel output. The widely held industry view is that the future of the nickel industry lies in the economic exploitation of laterite deposits. However, owing to the complex nature of laterite deposits, which consist of weathered iron-rich limonite and un-weathered magnesium-rich saprolite, there is currently no commercial process that can treat the entire orebody. Currently, the limonite portion is treated using the High Pressure Acid Leach (HPAL) process – but this has had a very low success rate to date. The saprolite portion has been successfully processed using the Rotary Kiln Electric Furnace (RKEF), but this remains an energy- and capital-intensive process.

Any organisation that can develop a methodology for treating the whole orebody in a single, cost-effective process will have a significant competitive advantage. To this end, the ARNi process has been developed by Anglo American. In this process, the limonite fraction is leached at atmospheric pressure to dissolve nickel, cobalt and iron. The saprolite material is then used as a primary neutralisation agent, with the added benefit that additional nickel and cobalt are leached from the saprolite. Another unique feature of the process is that it is capable of regenerating the major reagents required in the process such as magnesia, sulphur dioxide and hydrochloric acid. The process has been successfully tested at mini-plant scale and a larger, fully integrated pilot plant has now been constructed. This plant was hot commissioned in January 2011 and will process approximately 30 kg/h of laterite feedstock sourced from the Jacare nickel deposit. A pre-feasibility study commenced in late 2011 and a demonstration plant will be constructed at Barro Alto during 2012/13 to thoroughly test and commercialise the process using both Barro Alto and Jacare ores. ***IM***