



# New Spanish conquests

High metal prices, better exploration techniques and better technologies are seeing a rebirth of Spanish mining and, in particular, the fabulous Iberian Pyrite Belt. **John Chadwick** picks some highlights

**W**e are seeing fresh opportunities for many old mining countries where our industry has, perhaps, been sidelined over past decades. Spain, with a long history of mining, occupies about 85% of the Iberian Peninsula and has some of the most mineralized territory in Western Europe, particularly the Iberian Pyrite Belt (IPB). The main polymetallic deposits, from west to east, include Aljustrel and Neves Corvo in Portugal, and Tharsis, Sotiel, Rio Tinto, and Aznalcollar in Spain.

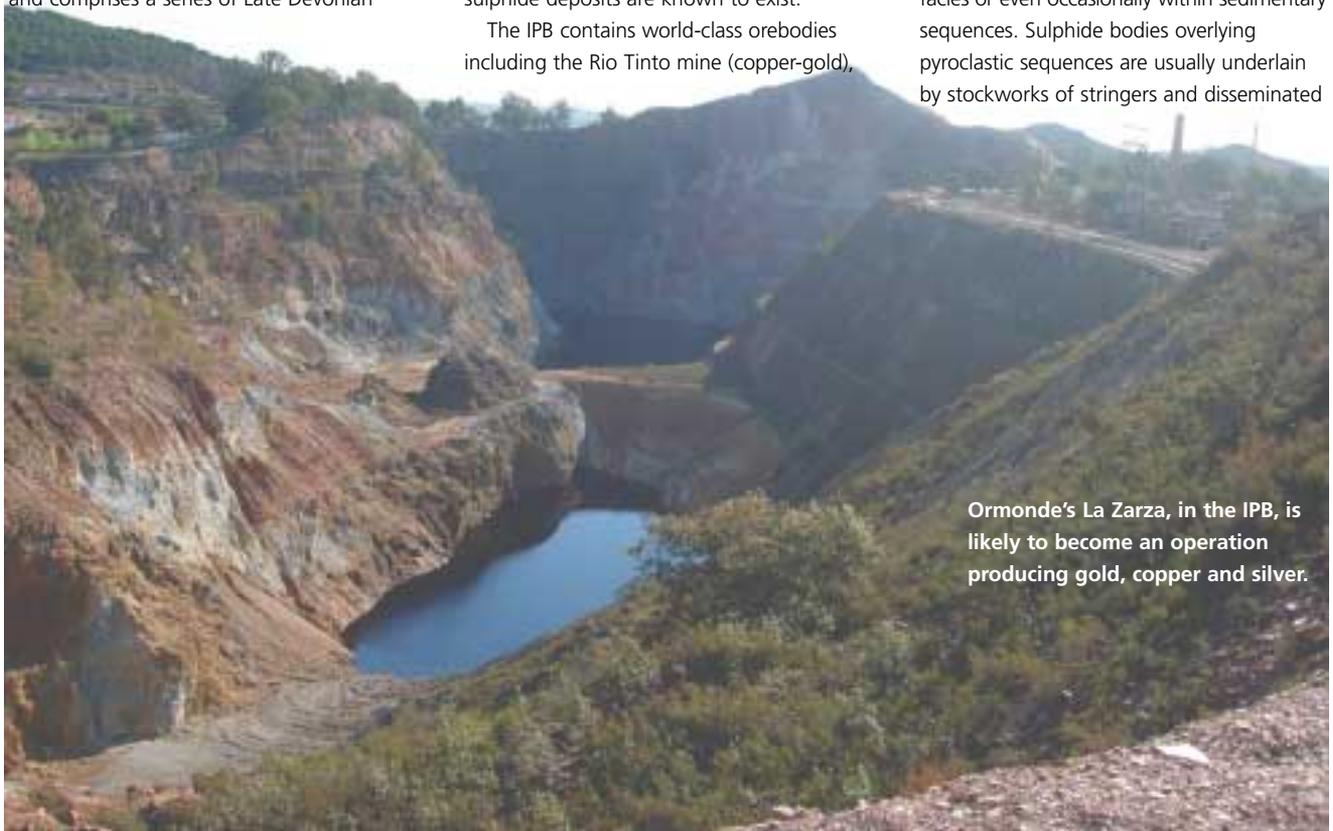
The IPB stretches from Seville in southern Spain west to south of Lisbon in Portugal and comprises a series of Late Devonian

through to Mid Carboniferous age rocks. It is dominated by a thick Lower Carboniferous volcanic package referred to as the Volcanic Sedimentary Sequence (VS). Underlying the volcanics is a late Devonian phyllite and quartzite formation known as the Phyllitic Quartzite (PQ) that is predominantly shale and quartz sandstone, but also includes thin bioclastic units locally. The VS is overlain by a southwest prograding turbiditic sequence of Culm age which, towards the south, is in turn overlain by a cover of Tertiary and Quaternary alluvial sediments. Within the VS, at least 80 volcanic hosted massive sulphide deposits are known to exist.

The IPB contains world-class orebodies including the Rio Tinto mine (copper-gold),

and numerous deposits in the 10 to 100 Mt range. A total of 1,700 Mt of massive sulphide ore, both mined and *in situ*, has been defined within the IPB, making it the largest massive sulphide province in the world. In such well-mineralized terrains it is not uncommon to find further mineralization in close proximity to known deposits.

The massive sulphide deposits of the IPB invariably occur within stratigraphic horizons representing the waning stages of felsic volcanism. The mineralization may occur close to a volcanic centre or in a laterally equivalent position within distal volcanic facies or even occasionally within sedimentary sequences. Sulphide bodies overlying pyroclastic sequences are usually underlain by stockworks of stringers and disseminated



Ormonde's La Zarza, in the IPB, is likely to become an operation producing gold, copper and silver.

mineralization not found in deposits with more distal volcanic or sedimentary footwalls.

Whilst much attention has been paid to the genetic origin of the massive sulphide mineralization, Cambridge Mineral Resources (CMR) considers that it is the complex structural history of the IPB that dictates the potential for locating new deposits. The company notes there has been "much debate over the tectonic history of the zone but it is reasonable to state that the zone represents a south verging, thin-skinned, fold and thrust belt propagating southwards as a result of the oblique collision of the South Portuguese plate and the Ossa-Morena Zone of the Iberian Autochthon. This event may have inverted earlier extensional structures intimately associated with the initial mineralization. Re-interpretation and remodelling of these complex structures may reveal possible stacking of sulphide zones and lead to the discovery of further blind mineralization."

Spain is one of the leading European Union (EU) countries in the value of its mine output of metallic and non-metallic minerals and quarry products. It has one of the highest

levels of self-sufficiency with respect to mineral raw materials among the EU members. Spain has had a long history of base-metal mining and in recent years has attracted renewed interest from many of the world's major mining companies for gold and base metal exploration and extraction. International mineral investment has been encouraged, CMR says, by several important factors including the:

- ◆ The highly prospective geology of the Iberian Pyrite Belt in the south and the recent gold discoveries in the north
- ◆ Transparent legislative framework and positive fiscal environment covering the extraction of natural resources
- ◆ Well-developed infrastructure and available skilled work force
- ◆ Extended mining tradition and the track record of exploration success and mine development
- ◆ Availability of non-refundable Government grants for both exploration drilling and mine development

## Rio Narcea

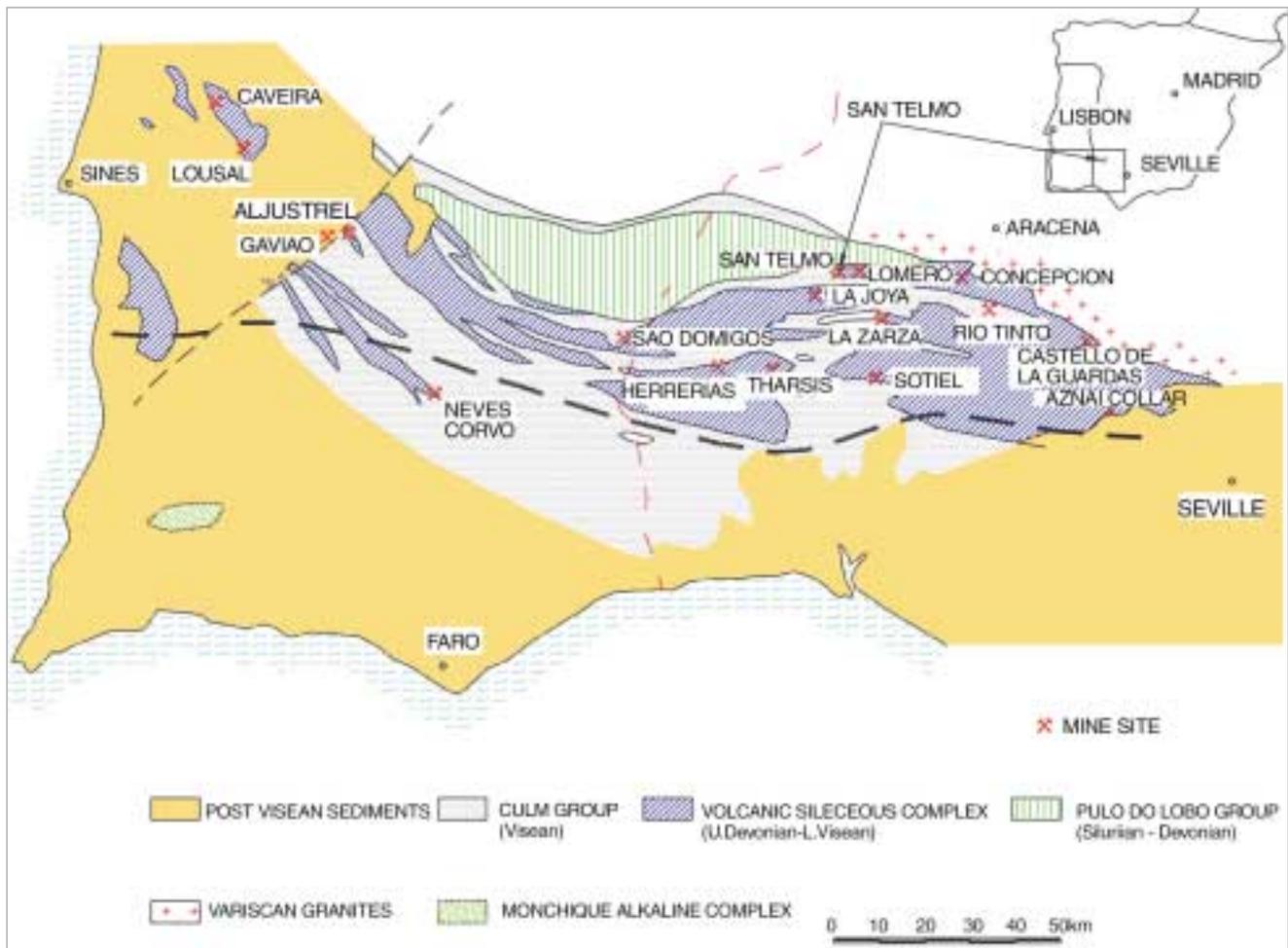
Rio Narcea Gold Mines is perhaps the best known of the 'new' Spanish players. The company name is actually now not a true

reflection of activities, as nickel has become its most important metal. In the first quarter of 2006, revenues were \$47.4 million, of which \$27.2 million were from nickel operations.

Production from the new Aguablanca mine was 1,590 t of nickel and 1,542 t of copper. However, while the current gold operations (El Valle and Carlés) in northern Spain are slated for closure by the end of 2006, Rio Narcea is still anticipating production of some 50,000 oz of gold from these mines in 2006. Furthermore, Rio Narcea has commenced legal proceedings against the Regional Government of Asturias seeking reversal of its decision to prevent development of the Salave gold deposit, or significant monetary compensation. The company is also actively pursuing new gold and other metal opportunities and is continuing exploration on large mineral holdings on the Iberian Peninsula.

During the first quarter Aguablanca processed 314,730 t of ore, a 15% improve-

*Simplified geology of the Iberian Pyrite Belt showing location of mines and some mineral deposits.*





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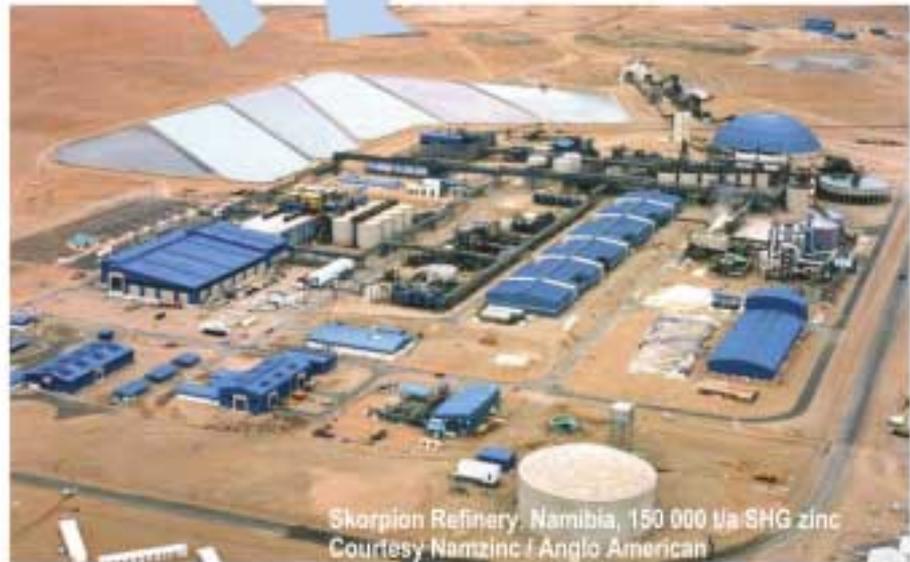


Pilot Plant  
TR R&D Centre



SX mixer-settler prototype  
TR R&D Centre

Our effort on research, development and innovation has placed us in the forefront of hydrometallurgy, specifically, on Solvent Extraction processes applied to the recovery of non ferrous metals such as zinc, copper, lead, nickel and others.



Skorpion Refinery, Namibia, 150 000 t/a SHG zinc  
Courtesy Namzinc / Anglo American

TR is an international general contractor dedicated to the engineering and construction of industrial facilities. It develops and licenses proprietary processes designed for ores such as polymetallic sulphides and low grade oxides, and for secondaries such as mine tailings, furnace dusts, spent batteries and chemicals.

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ment in throughput. Head grades were 0.68% Ni and 0.54% Cu, with recoveries of 75.4% and 90.9%, respectively. Mine head grades continued to reconcile to the ore block model for the open pit, which has an average grade of 0.66% Ni and 0.46% Cu for the life of mine.

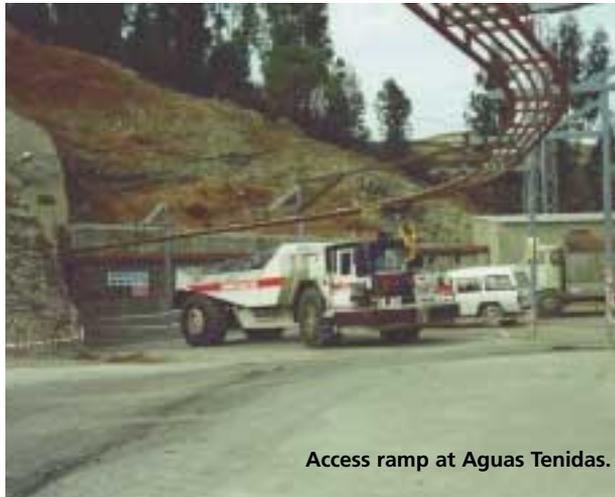
Since January 1, 2006, the plant has been treating an average of 180 t/h, which corresponds to annual throughput of some 1.5 Mt. Rio Narcea says further increases up to 235 t/h should be achievable during the year. Grades of nickel and copper in the bulk concentrate during the first quarter of 2006 were 7.2% nickel and 6.8% copper, compared to 6.6% nickel and 5.2% copper during the fourth quarter of 2005.

During the first quarter, the Rio Narcea's gold operations produced 13,467 oz of gold at a cash cost of \$539/oz as compared with 23,435 oz at a cash cost of \$443/oz in the same period of 2005. The El Valle plant processed 87,354 t of Rio Narcea's ore at an average grade of 5.2 g/t Au, compared with 145,117 t with an average grade of 5.5 g/t Au in the prior year period. Recoveries averaged 92.3% in the first quarter of 2006 compared to 91.9% a year earlier.

In February, after a thorough performance review of El Valle and Carlés, the company decided to close these operations. This is to be an orderly mine closure procedure, with the ultimate cessation of production and the closure of both the El Valle and Carlés mines being completed no later than the end of 2006.

In reaching this decision, Rio Narcea says it was "significantly influenced by the decision of the Regional Authorities of Asturias, not to approve the 'change of land use' required to develop the Salave gold project located some 70 km west of El Valle. The concentrates planned for production from Salave would have been processed at El Valle's plant, with improved economics.

The decision by the regional Government of Asturias, says Rio Narcea, was "not based on environmental factors [and] was not anticipated because it contradicted several other authorizations received by the company from various departments of the Asturian Government, among others, the approval for construction of a bio-heap leach pilot plant, a mining and archaeological permit for the extraction of the open-pit ore to feed



Access ramp at Aguas Tenidas.

the pilot plant and the expropriation of farm land and its dedication to mining use." As a result, Rio Narcea has commenced legal applications to the local courts.

Ongoing exploration includes Ossa Morena (Spain and Portugal), where recent work in the regional area focused on the evaluation of nickel and gold stream sediment anomalies that were obtained from a new geochemical survey. In addition, continued evaluation of the Guijarro-Chocolatero gold project has outlined new targets. Guijarro-Chocolatero is one of several gold targets along the Bodonal-Cala gold belt where Rio Narcea has been evaluating potential for large iron-copper-gold systems.

In March 2005, the company entered into a Joint Venture agreement with Kinbauri Gold under which Kinbauri can earn up to a 65% interest in the Corcoesto project by expending \$ 4.8 million over five years. In 2005 Kinbauri conducted 2,245 m of core drilling in 12 holes. The second phase of exploration began in late January, comprising additional soil geochemistry, trenching and core drilling.

The only gold exploration carried out at or near El Valle mine is in Area 107, located close to the existing underground operations. Drilling here encountered a number of high-grade gold intersections and also indicated structural continuity of the mineralized zone. The mineralization remains open at depth and along strike. The company is evaluating options to advance exploration in this area.

### Las Cruces

In early May, Inmet Mining announced an increase in the design capacity as well as updated capital and operating costs for the Las Cruces copper project located near Seville, following the completion of basic

engineering. The annual design production capacity has increased to 72,000 t/y of copper, up from 66,000 t/y. The updated capital costs are €380 million, including €26 million already spent since April 2005 on the project. The project also has the benefit of €54 million in non-refundable subsidies from the government, which reduces the above noted capital expenditures. The deposit will be mined primarily as an open pit and copper cathode will be produced on site applying atmospheric leaching and conventional SX/EW technology

Inmet owns 70% of the project and its Chairman, Richard Ross, said: "The completion of the basic engineering and the enhanced economics of the project are an important milestone for Inmet's growth in copper production. I am also very pleased to report that we are still on schedule to produce the first copper from Las Cruces in early 2008." Las Cruces is expected to produce 996,000 t of copper over a 15 year mine life at a cash cost of €0.39/lb of copper produced. The internal rate of return for the project is expected to be 24% using a long-term copper price of \$1.10/lb and a € to \$ exchange rate of \$1.20.

Jochen Tilk, Inmet's President and COO said: "We are very pleased with the engineering work and the consideration given to the environmental sensitivity of the region. We are looking forward to working with the local communities on making this project a great success."

SNC Lavalin has been confirmed as the engineering, procurement and construction manager (EPCM) for Las Cruces and Outokumpu Technology as lead technology supplier for the grinding, leach and SX-EW facility. The mine plan has been adjusted to include some underground mining, which reduces stripping requirements by 21 Mt of waste.

Work on site has started and the aquifer water management system was to begin operating in June. Plant construction is scheduled to begin in the third quarter of this year. Las Cruces contains proven reserves of 9.79 Mt at 6.4% Cu and 7.84 Mt at 6% Cu (including 0.74 Mt at 7% Cu to be mined from underground) for a total of proven plus probable mineral reserves of 17.63 Mt at 6.2% Cu.

Las Cruces boasts a very experienced management team, located in Spain.

François Fleury, who was responsible for the construction and operation of Inmet's Troilus operation, is Managing Director. He is supported by Phil Dunston, Manager, Construction, whose most recent experience included the development of Oxiana's Sepon copper project in Laos; Wayne Hopkins, Manager, Metallurgy, has extensive experience in SX-EW technology and was with Aker Kvaerner for more than 13 years; Americo Villafuerto, Manager, Mining, was involved in the development of Barrick's Pierina mine in Peru; and Fernando Fernandez, Director, Business and Administration, previously led the Spanish team through permitting efforts.

## Ormonde's La Zarza

The objective of Ormonde Mining is to develop gold-focussed projects in Spain and take them into production. Its portfolio includes substantial gold and copper resources at the advanced La Zarza project, and several exploration properties. Its strong local Spanish management is supported by a Board with extensive mine development and exploration experience.

La Zarza, in the IPB, is likely to become an operation producing gold, copper and silver. A Preliminary Assessment Study is underway using results from ongoing drilling, metallurgical testwork and resource estimation, leading to

a Feasibility Study later in the year. The new JORC-compliant resource estimate (total Indicated + Inferred) amounts to 6.8 Mt containing 85,000 t of copper, 486,000 oz of gold and 6.9 Moz of silver.

The latest metallurgical testwork shows 60% gold recovery to copper and lead concentrates as the simplest and lowest-cost processing route. Flotation would achieve 80-90% copper recovery. It is an old pyrite mine with underground workings to extract pyrite that extend into the gold-copper orebody. It has Mining Concession status and local and central government support, including grants for investigation work (€145,000 awarded in December 2005).

The Salamanca gold Project is located 250 km west of Madrid and Ormonde has earn-in agreements with two private Spanish companies over a 720 km<sup>2</sup> permitted area. The permits, which are located in a historic tungsten producing area, cover mineral occurrences with potential for high-grade zones and several prospects where there has been no or only limited follow-up exploration.

Ormonde's results to-date have confirmed Salamanca to be a highly prospective, multi-target gold play. Soil geochemistry has identified a major new zone with potential for a near-surface, bulk-tonnage gold target and drilling during 2006 will test this.



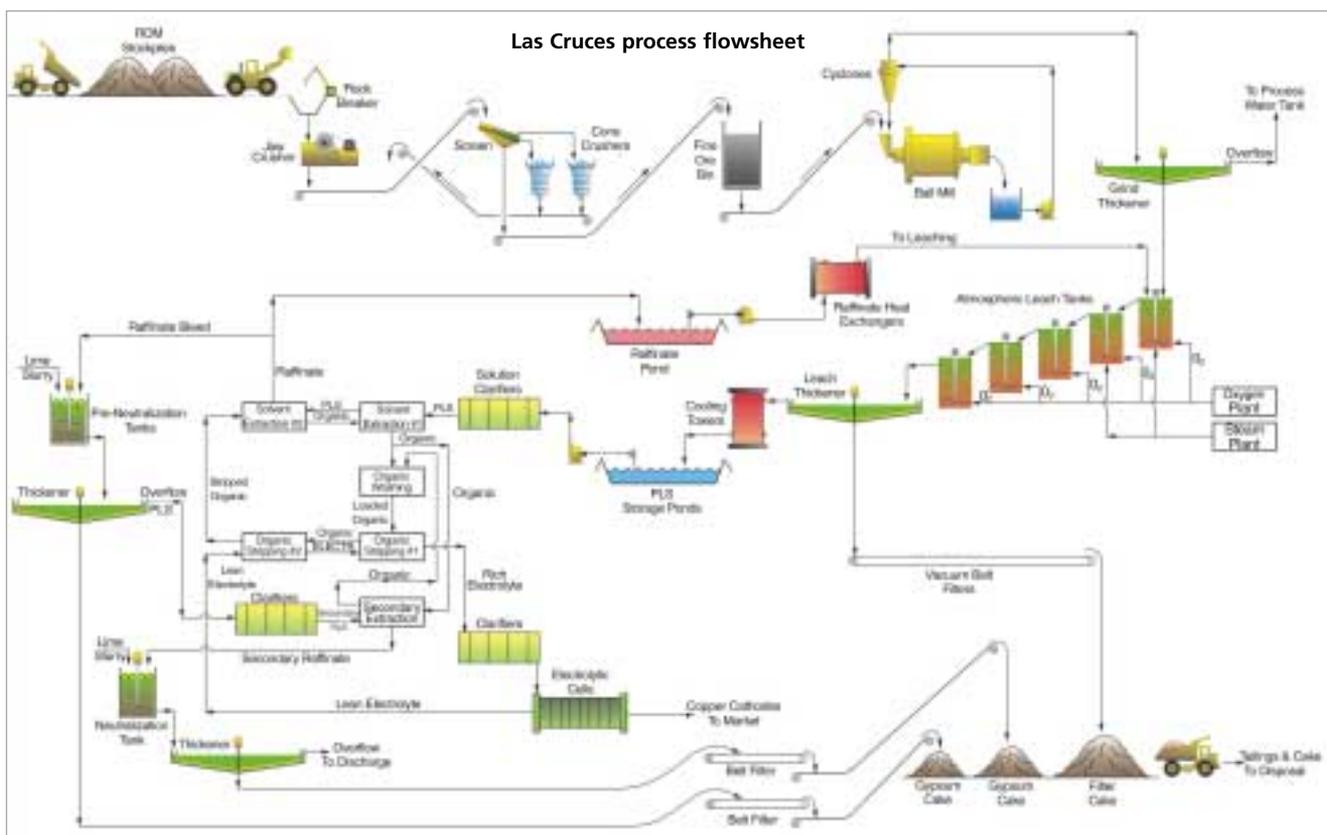
Core from La Zarza.

Several other promising prospects are being assessed, including some with joint tungsten-gold potential, with a view to establishing mineral resources for more advanced evaluation.

## Masa Valverde

In January, CMR acquired two permits covering 38.7 km<sup>2</sup> over the Masa Valverde deposit in southwest Spain. This is a polymetallic deposit with zinc-rich Volcanogenic Massive Sulphide (VMS) and copper-rich stockwork orebodies. CMR has estimated the orebodies to have geologic resources of around 11.95 Mt at 0.57% Cu, 1.28% Pb, 4.3% Zn, 42 g/t Ag and 0.86 g/t Au of polymetallic mineralization and 79.95 Mt at 0.76% Cu, 0.38% Pb, 1.28% Zn, 22 g/t Ag and 0.43 g/t of cupriferous mineralization.

CMR's Lomero-Poyatos project is a gold-



rich, polymetallic VMS deposit, within the IPB, some 70 km north of the port of Huelva and 8 km west of PGM Ventures' Aguas Tenidas. Historically, Lomero-Poyatos was mined to produce sulphuric acid, from 1905 to 1984 producing some 2.6 Mt of massive sulphide ore at an estimated grade of 5g/t Au, 80g/t Ag, 1.2% Cu, 1.1% Pb and 2.91% Zn. In 2003, CMR calculated an Indicated resource on the underground and open pit of 3.71 Mt grading 3.26g/t Au, 28g/t Ag, 1.57% Zn, 0.87% Cu and 1.16% Pb.

In 2005, an independent pre-feasibility study assessed the economic viability of the project as an underground mining operation in conjunction with the acquisition of the nearby Almagrera processing plant, including the potential for processing ore from other European deposits. The study concluded that, taking into account capital and operating costs, the project would not generate a sufficiently attractive rate of return to justify its development at this stage. CMR subsequently decided to cease development at Lomero-Poyatos and is seeking a JV partner to advance the asset further.

PGM Ventures' Aguas Tenidas copper/zinc deposit could produce 1.6 Mt/y over a mine life of at least ten years. Annual metal output has been projected at 25,000 t copper, 50,000 t zinc and 12,000 t lead. The deposit is more than 1,600 m long, 20 to 70 m thick and 100 to 300 m wide with high-grade copper and zinc ore zones with substantial credits from by-product metals (Pb, Ag & Au). PGM ventures has stated that production costs will be low. The project includes significant (538 km<sup>2</sup>) of existing exploration permits encompassing several attractive exploration targets.

AGD holds a 42.5% interest in Daytal Resources, which has

entered into a conditional agreement to acquire Los Santos wolfram deposits in Salamanca Province from Siemcalsa. At Los Santos, Siemcalsa and Billiton conducted a comprehensive drilling program and extracted bulk underground samples in the course of proving up a reserve 2.6 Mt of ore grading 0.58% WO<sub>3</sub>. Their plans to mine Los Santos were halted by the collapse of tungsten prices in the 1980s.

The Joint Venture of Cambrian Mining, Tungsten SA and Prehenita (Daytal Resources) has finalized the assessment of Los Santos tungsten project's feasibility, and is currently planning for project start-up through its fully-owned subsidiary, Daytal Resources. Project optimization, basic engineering and the independent feasibility review report have been completed by Golder Associates.

*Drilling at Lomero Poyatas, this CMR project is a gold-rich, polymetallic VMS deposit, within the IPB.*

The project comprise some 4.98 Mt, at a grade of 0.26% WO<sub>3</sub> (cut-off of 0.05% WO<sub>3</sub>) or 3.56 Mt at a grade of 0.34% WO<sub>3</sub> (cut-off of 0.10% WO<sub>3</sub>). From a comprehensive project geology and deposit characteristics to the combination of traditional mining methods, the Project, is a good example of modern mining, combining low cost production with high grade, good quality concentrates in Europe. Daytal Resources PLC recognises sustainable management as a high priority so that the project adopts environmentally sound technologies.

## Coal

Coal is Spain's most plentiful indigenous energy source, with reserves of some 700 Mt. The country produced 12.3 Mt of hard coal in 2002, along with 8.2 Mt of lignite. The country consumes about 50 Mt of coal, relying on imports for the balance – 24.5 Mt in 2004. Overall coal consumption has remained relatively flat over the past decade,

with Spain's electricity sector constituting the largest share. Coal mining is spread over a number of small, isolated fields, including Asturias (Central and Western field), Leon (Bierzo-Villablino, Sabero and Nord), Palencia (Guardo and Barruelo), Cataluna (Pirenaica, Teruel (Teruel-Mequinenza), and Sud (Purtollano and Penaroya). Private companies produce most of the coal in Spain, though the single-largest company is Hunosa, producing about 1.5 Mt/y, owned by the government through the Soc Estatal de Participaciones Industriales (SEPI) holding company.

## Working in Spain

The Instituto Geológico y Minero de España- IGME- (Geological Survey of Spain) is a senior



(founded 1849) research institution attached to the Ministry of Education and Science. IGME is the main national Earth Sciences Research Centre in Spain, with a total of more than 400 employees, 200 of whom are graduates. IGME is particularly specialized in several fields of activity such as geology, environment, hydrogeology, mineral resources, natural hazards and land use planning. IGME's facilities including its headquarters, project offices in several locations around the country, laboratories, warehouses, drill core repository, library and museum, are all equipped with advanced technology and technical resources.

After 150 years of research and project development, IGME holds the most important and valuable mining and minerals databases available in the country (many directly accessible through its web page [www.igme.es](http://www.igme.es)), and has a wealth of technical expertise and know-how, in order to help any interested party in developing a mining project in Spain.

The Spanish Association of Professional Geologist (ICOG) is the only public professional body representing all geologists in Spain. The ICOG advocates for the profession of geology and promotes consultation with government officials, policy makers, authorities and other professional associations in a variety of fields, including exploration and mining, and environmental management. It also sponsors and supports the European Federation of Geologists as well as the non-profit organisation, World Geologist.

ICOG's delegation to the UK works with public and state institutions and private companies as well. Contact: Roberto Carsi Sister, [carsisister@yahoo.es](mailto:carsisister@yahoo.es)

### ... and Spanish technology

Tecnicas Reunidas (TR) is a world leading developer and supplier of hydrometallurgical technologies for base metals and precious metals extraction from primary and secondary sources. TR designs and delivers hydromet plants, processes, and proprietary equipment adapted to each customer's requirements.

One of the main abilities of TR is to move from an initial lab proposal to the development and supply of specific and tailored processes at commercial scale aiming to fit the customer's needs. Hydrometallurgical applications developed by TR are the result of 35 years' history of extensive research and development at TR's R&D centre, supported by experience of many commercial contracts.

That enormous effort has made TR a leading developer of hydrometallurgical technologies applied, for example, to complex sulphides processing which are typical of the IPB.

TR says its SX technology is a market leader, especially in zinc extraction from a diversity of primary ores, concentrates, and secondary materials, e.g. by applying the modified ZINCEX™ process, which is the benchmark of the players in zinc hydrometallurgy.

Four industrial plants with capacities ranging from 500 to 150,000 t/y SHG electrolytic zinc have been built based on the ZINCEX technology and a fifth plant is currently under construction. The most important reference of this technology is Anglo American's Skorpion integrated mining and zinc refinery complex in Namibia, which has been successfully operating since May 2003.

Complex ores are abundant as massive sulphide deposits in the IPB and many mines have been developed in that region over a long time using differential flotation. However, the results from selective flotation applications are very frequently inefficient and costly due to the finely disseminated form of the minerals, which cannot be separated into clean and saleable concentrates, suffering high penalties when put in the market.

Historical operational data from several mines in the IPB, like Aznalcollar and Sotiel (Spain) and Aljustrel (Portugal) show that the major difficulty associated with selective flotation of their polymetallic ores is to get commercial grade lead concentrates. Most of the time, lead content ranges 40% to 45% Pb, while metal recovery remains low (around 50-60%). On the other hand, galena is usually finely disseminated and associated

to sphalerite, which makes it very difficult to obtain high-grade zinc concentrates (normally, zinc tenor ranges 50-52% Zn, while metals recovery is around 75-80%) and obliges operations to perform very fine grinding and to use some unfriendly flotation reagents like cyanide.

TR says the hydrometallurgical technologies it has developed aim to overcome these difficulties and provide an ideal partnership to mining companies wishing to exploit and process complex sulphides or difficult minerals deposits.

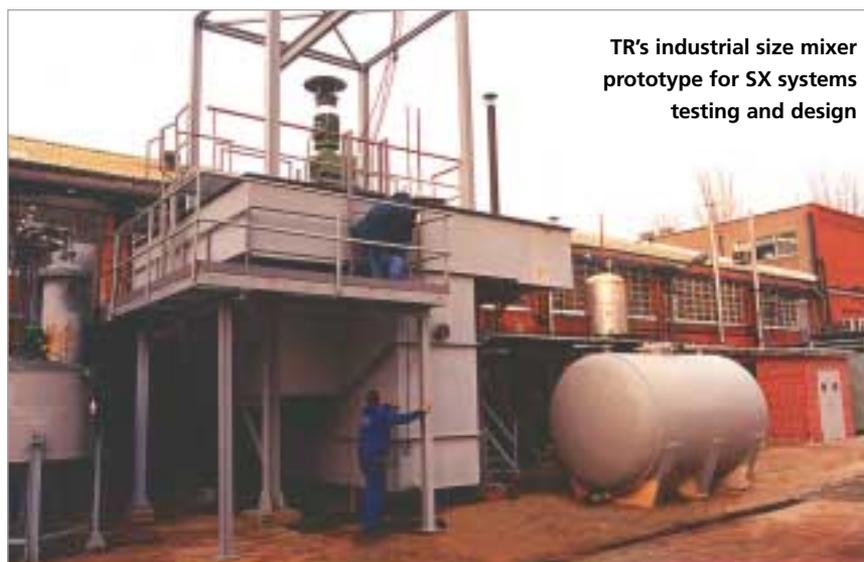
TR's hydrometallurgical process solutions are flexible and adaptable to every specific ore or concentrate, and it can be easily annexed to any existing or new flotation plant, increasing notoriously difficult metals recovery efficiency and facilitating a more simple flotation process. Those technologies can accommodate many different types of concentrate such as:

- ◆ Cu, Zn, Pb commercial concentrates
- ◆ Cu+Zn+Pb bulk concentrate
- ◆ Cu+Pb bulk concentrate
- ◆ Zn+Pb bulk concentrate
- ◆ Low-grade or dirty galena concentrate

Any precious metals and minor metals content in the concentrates, like indium, gallium, etc, are amenable to recovery as well, and sometimes those metals make the difference in project economy that allows suitable profitability.

In recent years, TR has undertaken many projects in co-operation with mining companies from the IPB and worldwide. Some relevant examples of the applied technology approaches are summarised below.

The ZINCEX process has been chosen as the preferred technology in several mining

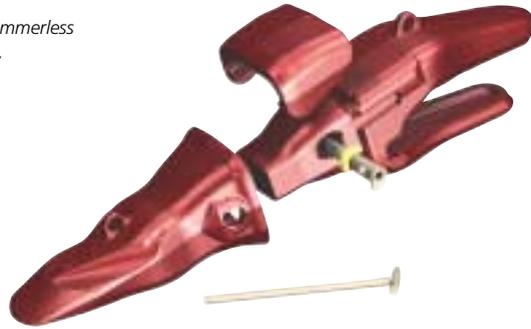


**TR's industrial size mixer prototype for SX systems testing and design**

projects like Medhdiabad in Iran, Sierra Mojada in Mexico, and many others that are under secrecy agreements. This revolutionary technology is creating new profitable business opportunities dealing with non-sulphide zinc deposits such as oxidised, carbonated and silicated zinc minerals resources, as well as zinc secondaries (EAFD, Waelz oxide, etc.), offering additional zinc assets to the market, TR says.

The PRIMALEAD process allows selective extraction of lead in complex concentrates such as Cu+Pb concentrates and Zn+Pb concentrates, producing a clean lead-oxide

MTG Systems StarMet, a hammerless tooth system for heavy duty applications.



concentrate (>70% Pb) able to be treated in either primary or secondary (battery

recycling) lead smelter, and obtaining at the same time commercial high-grade copper or zinc concentrates (free of lead).

Application of direct and indirect bioleaching processes is being developed to deal with complex or low-grade zinc ores or concentrates which are amenable to heap bioleaching, recovering the zinc metal by the ZINCX process and further EW. In addition, other metals like copper, nickel, etc. are recoverable if dissolved along the leaching process.

A project based on the COMPREX process applied to Cu+Zn+Pb bulk concentrates from southern Spain was developed using TR's autoclave pressure leaching technology and subsequent Cu SX-EW recovery and Zn SX-EW recovery, while Pb and precious metals were extracted from the leaching residue by hot brine leaching (PLINT technology). The COMPREX process maximises metals recovery in the integrated bulk flotation plant and metals refinery.

[www.tecnicasreunidas.es](http://www.tecnicasreunidas.es)

### MTGtwist wins favour

At the Intermat exhibition in Paris in April, the innovative MTGtwist hammerless fixing solution for bucket teeth was awarded the bronze medal for Technological Innovation 2006. This solution is applied to:

1. MTGPlus tooth adaptable to Caterpillar\* side pin system.
2. MTG Systems StarMet, hammerless system for heavy duty applications.

MTGtwist works by turning the attaching pin with a removal tool (standard square head) to fit or remove the pin. In operation impacts on the bucket tooth will not cause the pin to turn. MTG says "it cannot detach because it has excellent retention."

When changing the teeth safety is enhanced as no hammer is used. The effort required to change the teeth is much less than with the hammer. Costs are reduced because one person can change the tooth. [IM www.mtg.es](http://www.mtg.es)

## Any rock... Anywhere!



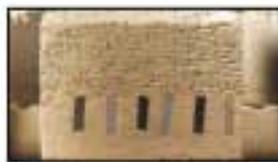
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