

York Potash

The UK has not seen the like of it for many decades. John Chadwick reports on a massive mining project that plans to use some of the best in advanced mining technology, including TBMs, mechanised shaft sinking and pipeline transport of ore to the plant site

Potash projects abound but this is necessary to satisfy demand. The International Fertilizer Association estimates that demand for potash will continue to grow at 3.5% per annum based upon current consumption patterns. This equates to some 2 Mt of new capacity KCl product every year – the equivalent of one new mine being commissioned every year. According to Sirius Minerals, “potash is one of the few global commodities for which there is virtually no elasticity of demand. This is evidenced by the extent to which recently increased demand has quickly translated into extreme price fluctuations. The primary reason that potash demand is price inelastic is the status of potash as a vital component in chemical fertilisers without any substitute. This fact, in conjunction with a number of global macro trends, indicates strong long-term fundamentals for the potash market.”

Saskatchewan in Canada accounts for about a third of the world's annual production of about 55 Mt. Russia and Belarus are the only other major producers, currently.

The York Potash project is Sirius Minerals' flagship development asset. Based in North Yorkshire, UK, the project targets both polyhalite as a source of sulphate of potash (SOP), and potassium chloride (KCl) as a source of muriate of potash (MOP). The project footprint includes over 661 km² of mineral rights agreements and growing. Sirius believes it could be developed as one of the world's largest low-cost SOP producers. An Inferred Resource of 1,350 Mt of 88.7% polyhalite has been announced, based on just 2% of the project area.

Saskatchewan is the world potash hotspot. BHP Billiton has received ministerial approval for the development of the Jansen project, and this is the big one there. The company announced in June 2011 that it had approved 488 million of further investment to support the development of Jansen in its feasibility study stage. Mine design and engineering are now being completed along with initial surface construction and the first 350 m of shaft sinking.

Based on the current schedule, Jansen is expected to start producing saleable potash in calendar year 2015. The project is designed to ultimately produce about 8 Mt/y of agricultural grade potash from its 3,370 Mt *in-situ* Mineral Resource with an estimated 70-year mine life. See also *IM*, July 2012, pp58-62.

Western Potash's proposed solution mine in Milestone has the potential to produce at least 2.8 Mt/y of potash for at least 40 years. Solution mining involves pumping water into the mineral deposits and dissolving them for extraction. It is less costly, perhaps more environmentally-friendly and faster to commercialise than conventional mining.

Vale and Rio Tinto have entered the hunt for potash in Saskatchewan. The latter did so by partnering-up with one of Western Potash's peers in the junior potash sector, North Atlantic Potash, in 2011. The German fertiliser heavyweight K+S AG also took the fast-track to becoming a potash producer in Canada by acquiring another small player, Potash One, last year.

Sirius is also present in Western Australia's Canning Basin and currently holds exploration permits covering over 600 km² of land overlying the prospective Boree Salt Member, a formation with significant salt and potash potential in central Queensland and also holds interests in the Prairie Evaporites in North Dakota, USA.

Elsewhere, there are a number of projects in

Brazil. In Eritrea, South Boulder Mines has been actively exploring for potash at the Colluli project since 2009. Engineering scoping study results were favourable, proving that an economic 1Mt/y. potash mine can be built at half the cost of a typical potash development. Definitive feasibility studies will be complete in early 2013 with production scheduled for 2016 or sooner.

Mengo is a greenfield potash project under development in the Republic of Congo (ROC), by MAG Industries, with an initial annual design capacity of 600,000 t/y of potash. In Ethiopia, Allana Potash is currently developing the Danakhil deposit, located in the Afar State. Total Measured and Indicated Mineral Resources are estimated at of 1,297 Mt from all four potash horizons with an average grade of 19.3% KCl.

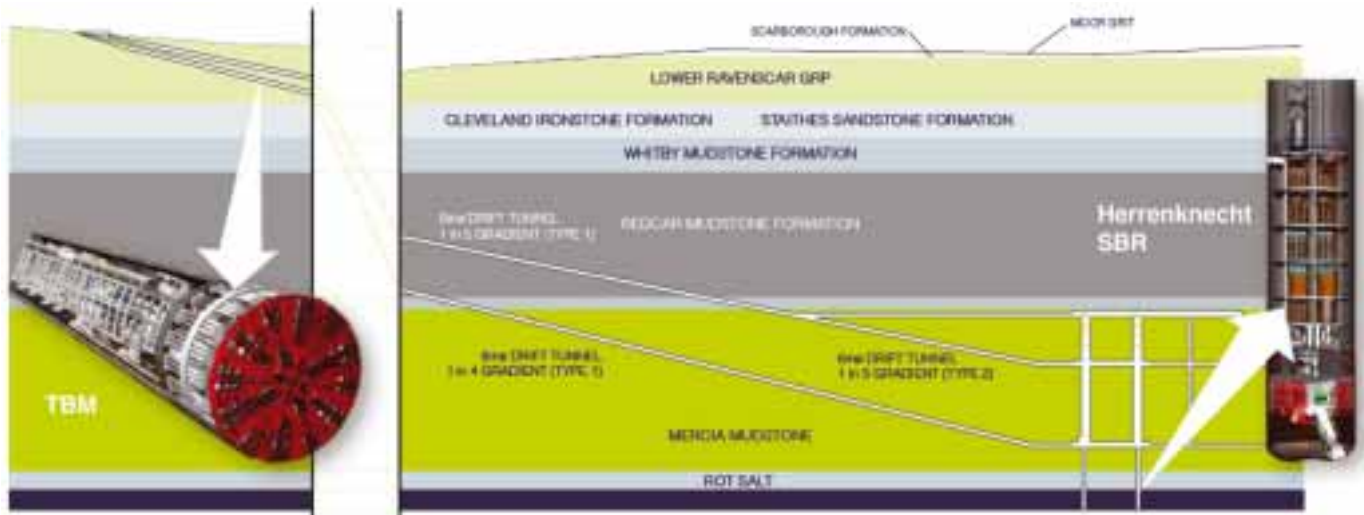
IC Potash intends to become a primary producer of SOP and Sulphate of Potash Magnesia (SOPM) by mining its 100%-owned Polyhalite Ochoa property in New Mexico, USA, a highly advanced mineral deposit containing proven and probable reserves of more than 340 Mt of ore within the proposed mine plan.

English potash

The evaporite sequences in Yorkshire constitute the western extensions of deposits from the 'Zechstein Sea', laid in multiple cycles of evaporation during the Permian age about 200 million years ago. The eastern margins extend to Germany, where considerable potash mining occurs today. The present North Sea covers most of the former Zechstein Sea. The UK is currently only a relatively small producer of potash. Cleveland Potash, a business unit of ICL Fertilizers, currently operates the UK's only potash mine, Boulby, from which it produces over 1 Mt/y of potash and more than 500,000 t of salt.

Boulby employs conventional underground mining and froth flotation processing. It is estimated that it supplies over half of the UK's domestically consumed potash, and exports the

Study Responsibility		
Overall Report Compilation	SIRIUS YORK POTASH	<ul style="list-style-type: none"> Project Management and Leadership Integration of the various expert reports and general assumptions Compilation of financial models
Mining	ERCOPLAN	<ul style="list-style-type: none"> Mine design and mining methods Mining operating and capital cost assumptions
Shaft System	Alan Auld	<ul style="list-style-type: none"> Alan Auld principle shaft load design and development concepts Herentwecht providing technical input into development
Pipeline Transport	MURPHY	<ul style="list-style-type: none"> Pipeline route and installation assumptions provided by Murphy CSI, providing key technical review and input to shaft system
Processing	K-UTEC HATCH	<ul style="list-style-type: none"> Process design and cost analyses provided by K-Utec Mine site crushing and grinding costs and analysis by Hatch
Infrastructure and Utilities	px group	<ul style="list-style-type: none"> Energy and water access and cost analysis and Confined Heat and Power (CHP) cost assumptions for processing cost analysis
Commodity Pricing and Shipping	Roskill	<ul style="list-style-type: none"> Market, price, and cost analysis for various assumptions



balance of production primarily to Western Europe. The British Geological Survey has been quoted as saying that Boulby is the most important non-petroleum mining operation in the UK.

Potash was first discovered under North Yorkshire in 1939 during petroleum exploration but the technology for extraction was not sufficient at the time thus not pursued. Boulby mine went into production of MOP in 1973.

The Detailed Scoping Study (DSS) announced in April 2012 confirmed York Potash's worldclass status with potential to create a large-scale, low-cost, long-life mine with a sustainable footprint. The project "provides a viable world-class multi-product project producing SOP, epsomite (magnesium sulphate) and gypsum with scale, expandability and an innovative approach to creating a sustainable, low impact project. The unique value of polyhalite's byproducts could see York Potash towards the bottom of the global potash industry cost curve with competitive capital cost and bottom of the cost curve opex potential."

Mine construction

Sirius' preferred mine construction plans (as shown in the diagram) are based on an underground development concept, where Tunnel Boring Machines (TBMs) will drive to 500-750 m below surface for freeze holes and freezing plant, hoisting and headframe installation. The proposed development plan will see shafts sunk using the Herrenknecht Shaft Boring Roadheader (SBR) to the 1,400 m level with waste and

ore hoisted to underground headframes - conveyor to surface. Over time, additional vertical ventilation shafts could be bored to surface.

The DSS included a second concept; the sunken headframe concept involves the TBM declines developed in parallel to surface pre-sink of the 6.5 m internal diameter vertical shafts. The shaft headframes will be sunk below surface level, to reduce their visual impact. Raises will be bored to surface using the SBR to sink from surface but with the 750 m deep decline used for waste removal. Ore will be hoisted to the surface headframes.

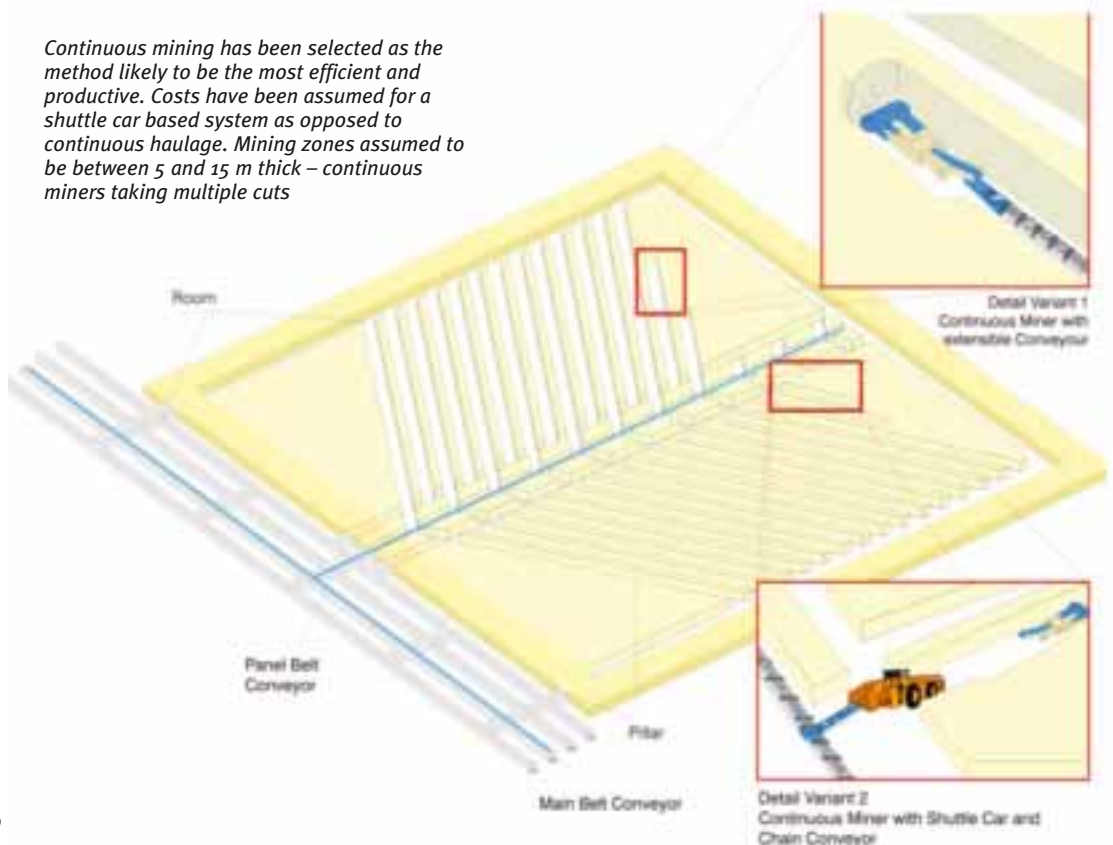
Alan Auld Engineering is developing lining design and sinking concepts for the project. The

shafts will be sunk to well over 1,000 m through highly varied strata and will require a lining that can withstand high hydrostatic loadings, as well as being able to accommodate strata subject to deformations and time dependant creep.

The choice to develop an underground mine was taken due to reduced impact, cost, and development time. The declines, in the preferred concept, provide high speed access to depth to develop the underground sinking and freezing station. This station will reduce costs, time and impact.

Having the hoisting system underground reduces surface impact, shortens hoisting height and increases shaft capacity. The initial installed hoisting capacity of 15 Mt/y of rock

Continuous mining has been selected as the method likely to be the most efficient and productive. Costs have been assumed for a shuttle car based system as opposed to continuous haulage. Mining zones assumed to be between 5 and 15 m thick - continuous miners taking multiple cuts



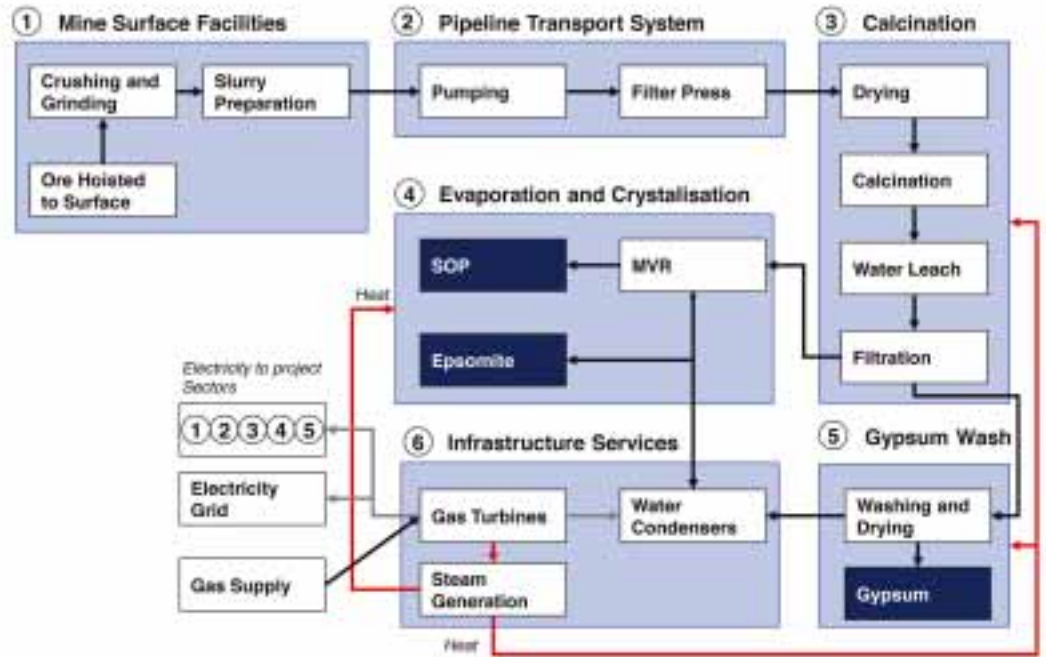
offers a low-cost expansion potential to 20 Mt/y.

Sirius believes this preferred underground development concept will result in:

- Lowest possible impact on the surface
- Shortest possible construction period
- A small number of surface buildings
- Future expansions would be achieved with ventilation shafts above the sub-surface infrastructure
- Sunken headframe concept is also low impact but more concentration of facilities at the mine head location.

Twin 600-mm diameter lined pipelines; buried 1.2 m below surface will carry the polyhalite ore as suspended particles in water.

This pipeline system is expected to run some 50 km to Teesside - the preferred processing and port site – carrying up to 20 Mt/y of polyhalite. Dry transport alternatives to avoid the requirement for drying the ore are to be investigated.



reduce energy costs if done in lower energy cost environment.

Sirius believes that York Potash “could be one of the world’s largest, high-quality potash mines [with] potential leadership in magnesium products and gypsum.” It has scale and expandability, and an “innovative approach to creating sustainable, low impact project.

The capital cost of Phase 1 is estimated at \$2.7 billion:

- Phase 1: Start-up 1.4 Mt/y of SOP (5 Mt/y of ore)
- Phase 2: Build-out 4.1 Mt/y of SOP (15 Mt/y of ore)
- Total capex to build both phases of \$6 billion – internally funded beyond Phase 1
- Expansions possible with modest shaft investments and modular mine and process works
- Bottom of cost curve opex potential – \$65/t SOP (after byproducts) FOB.

The operating cash cost after byproducts

reflects operating cash cost of SOP of \$225/t and assumes sale of all epsomite (\$85/t) and gypsum (\$25/t) for a total byproduct credit for SOP of \$160/t. It excludes royalties and maintenance capex.

The polyhalite has three key components of value, with Sirius highlighting these points:

- SOP can be used for a wider range of crops if available than KCl/MOP
- SOP performs as well as MOP in all cases and better than MOP in certain cases
- Magnesium sulphate can be used directly as a fertiliser and can be a feedstock for downstream magnesium products such as magnesium oxide, magnesium hydroxide, and potentially magnesium metal
- Calcium sulphate (gypsum $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is widely used as an ingredient in plaster and in the production of plasterboard for construction
- Based on 15 Mt/y of polyhalite ore, an output of 7 Mt/y of saleable gypsum can be produced
- Gypsum is the main residue of the leaching process. It only needs to be washed/dried to increase the gypsum purity to make it a readily applicable input for the plasterboard industry
- In its anhydrous form (CaSO_4), called anhydrite, is used for the production of sulphuric acid and as a filler in paper.

There is greater value and depth of market in the downstream magnesium products - upgrading derisks the byproduct credit and creates value. A prefeasibility study has been commissioned into the direct thermal decomposition of epsomite to form MgO. Early work has demonstrated the importance of the value of the sulphuric acid produced to offset costs of conversion. **IM**

Processing

- SOP/epsomite route selected as base case for DSS due to the increased volume of SOP and also enhanced byproduct value potential
- Detailed pilot plant test work to be undertaken during feasibility studies to validate costs
- Energy optimisation study demonstrated a significant reduction in energy costs through integrated CHP (Combined Heat and Power) sized for heat and steam requirements
- Capex optimisation potential through modularisation - estimates based on 1 Mt/y polyhalite processing modules
- Dual processing and distribution hubs could

Key Risk	Sirius Delivery Strategy
Detailed mine design	Detailed rock mechanics testing commencing. Initial mine design to be completed as part of the feasibility studies
Mine Rights, Land Access and Approvals	Existing contracted mineral rights position over 60km ² and increasing. Negotiations have commenced for multiple mine surface and processing sites. Preparation for approvals on going with major applications in Q4 2012
Process Testwork	H-Utec has an existing pilot facility in place which can be adapted for testing York Potash Polyhalite as part of the feasibility studies
Time to Production	Sirius will selected all key development options and commence detailed engineering as soon as possible. Management continues to pursue all acceleration options available to the project
Finance	Sirius has a strong board and management team with extensive experience in financing large projects. There are multiple options available to finance the component parts of the project
Capital Cost Inflation	Sirius to adopt best practice cost control systems and push suppliers for optimised quotes. Project selections to balance between construction and operations optimisation
Operating Costs	Sirius to secure long-term utility supply agreements in optimal logistical locations and optimise the process designs to maximize internal energy efficiency and re-use
Potash Market	Sirius continues to analyse the market, current studies support the view of continued growth in world demand for potash. Where appropriate, Sirius will seek off-take agreements with major customers to reduce market risk exposure
By-Products	Sirius will seek potential strategic partnerships and/or off-take agreements with existing industry incumbents to de-risk the by-product revenue streams and capture value