Discussion of the Environmental Impacts of the Solwara 1 Copper Concentration and Smelting Processes

◀ Tongling Non-Ferrous Metals Group copper smelter
Image credit: nerin.com

Once the mineralized material is transferred to the shipping vessels, the Tongling Non-Ferrous Metals Group has custody of the material, its copper products, and process by-products. Tongling operates one of the larges, and cleanest, smelters in the world.

This section presents a discussion of the environmental impacts of the proposed concentration and smelting processes for the Solwara 1 project.

It does not compare the chosen smelter for Solwara 1 with any other smelter operations as there is limited confirmed data available in relation to the chosen smelter for Solwara 1.

The Solwara 1 mineralized material will be sold to the Tongling Non-Ferrous Metals Group (TNFM) located in the city of Tongling in the Anhui Province of the People's Republic of China. The Earth Economics team did not visit the TNFM site and relied on interviews with Nautilus management. No direct comparison between the TNFM facility and other potential smelters was conducted.

Nautilus is legally responsible for the mineralized material during mining and up to the transfer of the material from the production vessel to the Handy Max-sized shipping vessels, at which point the mineralized material is 'purchased' by TNFM and is no longer within the control of Nautilus. The previous analyses of the mine site in this report included the mining process for which Nautilus has custody. Once the mineralized material is transferred to the shipping vessels, the client has custody of the material, its copper products, and process by-products.

Copper concentration and smelting is both capital- and time-intensive. A comprehensive description of the concentration, smelting and refining process can be found in the World Copper Factbook 2013.[120] As of 2002, there were 124 copper smelters in the world.[121] Appendix D provides a few of the many cases of local contamination from older copper smelters.

Mineralized Material Shipping Transfers

Once Nautilus brings the mineralized material up the riser system to the production support vessel and accomplishes dewatering, the copper will then be transferred to 25-30,000 Metric ton Handy Max sized vessels for shipping to China about every 7-10 days.[122]

From there, the material will be transferred from the Handy Max vessels to barges in Nantong or Nanjing. Subsequently, the material will be offloaded from barges in Tongling at the TNFM port facilities. The material will be transferred directly from the port facilities to the concentrator by truck. There will be no temporary stockpiling at the port. Dust control during discharge and handling of the material will be accomplished using water sprays. Stockpiles and barge cargos will also be covered when necessary.[123]

There are significant environmental risks associated with transferring ore at export terminals. For example, Colombia recently closed a BHP Billiton Ltd. Coal export terminal, which used to be the second largest supplier

of coal to Europe, because the barge and crane system was spilling coal and materials into marine water and harming coastal ecosystems.[124]

The choice for transferring ore from the Handy Max vessels to barges in either Nantong or Nanjing will be made by TNFM on a shipment by shipment basis, taking into account operational constraints at each of the port facilities. Both Nantong and Nanjing are major Chinese ports subject to environmental performance standards of the People's Republic of China and local port authorities. TNFM is still in discussion with port authorities over the ore transfer procedures to be applied.

Tongling Non-Ferrous Metals Group Concentrating and Smelting Facilities

The primary objective of Tongling Non-Ferrous Metals Group is to process the Solwara 1 mineralized material to produce only saleable products with no waste that has to be stored or disposed of. This is feasible in Tongling as there are other industries such as cement works, steelworks and underground mines in close proximity to their smelter that can make use of tailings and leach residues generated during processing.

Copper ore is often concentrated close to its mine source. However, in this case, TNFM will handle both the concentration and smelting processes. The facilities are all located along the Yangtze River in Tongling, China. TNFM doubled its capacity in 2014 with one of the most modern, and one of the largest, copper smelters in the world. This new smelter has a production capacity of 400,000 metric tons of copper per year.

The primary objective of TNFM is to process the Solwara 1 mineralized material to produce only saleable products with no waste that has to be stored or disposed of. This is feasible in Tongling as there are other industries such as cement works, steelworks and underground mines in close proximity to their smelter that can make use of tailings and leach residues generated during processing. TNFM has recently been recognized by the Anhui provincial government for their achievements in terms of this recycling philosophy. The process is described in further detail in the following paragraph.

On arrival at the TNFM facility, the mineralized material will be concentrated by flotation into two products, a copper concentrate containing 20% copper content and a pyrite concentrate containing high levels of iron and sulphur. The tailing from the flotation plant represents 15-20% by mass of the mineralized material. This tailing is mostly comprised of "Gangue minerals", which are undesirable minerals that often occur with copper material. The venting environment at Solwara 1 is such that the concentration of copper is very high and the concentration of gangue minerals is very low. This means that the relative tonnage of tailings produced when processing the mineralized material is also relatively low. This material will either be used as backfill in TNFM's underground mines or as landfill on construction sites. There is no tailings storage requirement and no tailings storage facility will be built for the Solwara 1 concentrator. Pyrite produced in the concentrator is processed through a roast / leach plant. This plant produces acid and precious metals. If the leach residues have an iron content in excess of 50% iron, then they are sold as feed for steel-making plants. Residues with

a lower iron content are sold to cement works as cement additives. The pyrite produced from the Solwara 1 mineralized material is likely to have a high iron content and will therefore be used in the steel-making industry.

The traditional smelting process for copper sulphides such as those contained in Solwara 1 mineralized material involves first roasting and then smelting in reverberatory furnaces (or electric furnaces for more complex materials). This process produces copper matte (copper-iron sulphide), and converting for the production of blister copper (98% copper content). Blister copper is further refined through electrolysis to cathode copper (greater than 99% pure copper). These traditional processes produce air pollutants such as SO2 and particulate matter (potentially including arsenic) as well as liquid effluent and solid by-products. Fortunately, this traditional process route with its inherent environmental issues will not be used for Solwara 1 mineralized material.

At TNFM, the copper concentrate will instead be processed through TNFM's new smelter with a Flash Smelting and Flash Converting process that was first commissioned in 2013.[125] This process is also used at the Bingham Canyon mine in Utah, USA by Rio Tinto Kennecott. Using this new technology, TNFM has the opportunity to provide copper to the market with fewer environmental externalities in the smelting process.

The Flash Smelting Furnace and Flash Converting Furnace (FSF/FCF) process is based on sealed furnaces, which enable better control of gas flows together with higher production efficiency, more flexible processes and more efficient capture of solid, liquid and gaseous contaminants. The flash process is more energy efficient because during sulphur oxidation, the ore releases energy that can be utilized by the furnace, thereby reducing energy inputs. According to TNFM, SO2 emissions are effectively controlled through acid production. The double flash technology produces a higher concentration of SO2 in off-gasses when compared to conventional smelters, and this allows higher efficiency for the acid plant and a commensurately lower level of final SO2 emissions. The acid plant currently achieves emission levels of 99.8 ppm SO2 compared to Chinese and International standards of 200 ppm and 140 ppm respectively. The acid produced is used in a range of chemical industries, such as fertilizer production.[126]

Deleterious Elements in the Solwara 1 Mineralized Material

Copper naturally occurs with both inert and dangerous elements and minerals.

In general, there is no greater concern associated with the copper material from the Solwara 1 site than would surround copper ores from other mines. Copper naturally occurs with both inert and dangerous elements and minerals. At the Solwara 1 site, hot geothermal waters dissolve copper, gold, arsenic, sulphur, iron and other elements. These hot, element-rich waters move through vents at around 1,000 degrees Celsius and are

expelled into cold seawater at the deep seabed. At lower temperatures, the water can no longer hold the metals and they are instantly precipitated out as sulphide minerals such as chalcopyrite. Copper ores differ in concentrations of arsenic, sulphur, iron, gold, silver, and selenium between and within deposits. Arsenic and salt are two aspects of the Nautilus mineralized material that deserve consideration in smelting and disposal.

Arsenic has been a present, persistent problem around copper smelting areas since the Bronze Age.

Arsenic

Arsenic occurs in copper sulphide minerals including chalcopyrite ores. Indeed, arsenic has been a present, persistent problem around copper smelting areas since the Bronze Age.[127] Arsenic concentrations in ore are not reported under the GRI. A terrestrial copper sulphide mine would likely emit more arsenic per metric ton of pure copper produced, but have a lower concentration of arsenic per metric ton of copper than Solwara 1. China limits the allowable concentration of arsenic in imported ore and concentrates, and requires testing and tracking for the levels of arsenic in ore and concentrates shipped to the country. Every shipment from Solwara 1 will be tested for arsenic concentrations. Copper material from Solwara 1 must be below the required limit of 0.5% arsenic in order to be shipped to China.

TNFM reports that arsenic fed to the smelter leaves the process by two different routes. Approximately 70% of the arsenic reports to the final slag (the slag produced after taking into account slag retreatment). The arsenic in the slag is in an inert form that poses no danger of remobilization. This slag is sold as feed to local cement works. The remaining 30% of the arsenic reports to a concentrate with a grade of approximately 20% arsenic. This concentrate is produced from acid purification circuits in the acid plant. The concentrate is sold to specialist arsenic refining companies which produce arsenic compounds for use in various chemical and processing industries. The shipments of Arsenic concentrates are monitored and tracked by Chinese environmental agencies. Both the buyer and the seller have to be registered to produce and ship arsenic. These registrations are required at both state and provincial government levels, and there appears to be a high level of scrutiny to ensure all arsenic is adequately accounted for throughout the process.

Salt

Copper material from Solwara 1 requires the removal of salt water. Most of the salt is removed when the water is drained off from the mineralized material (dewatered). However, some salt is present in the residual water that remains with the mineralized material after dewatering. Test work has indicated that this salt will not have any significant negative impact on the flotation or smelting process.[128]

The TNFM site operates with a net negative water balance as a result of high rates of evaporation during the cooling of slag. This means that fresh water is always being added to the process with no need for discharge of treated water

The Tongling refinery site operates with a net negative water balance, which means that fresh water is always being added to the process with no need for discharge of treated water to local water courses.

to local water courses. The site can accommodate treatment of the Solwara 1 mineralized material and still maintain a net negative water balance. The only impact on the site will be an increase in the levels of chlorides in the slag and in some of the other product streams produced by the smelter complex.

Solwara 1 has a social and environmental benefit advantage over terrestrial mining because there is no damage in the upper catchment to surface and groundwater resources. In addition, arsenic is far better contained because it is not distributed throughout millions of tons of waste rock and tailings piles, where it may interact with or impact on communities. Gangue minerals and damaging associated elements such as selenium are very low in Solwara 1 mineralized material.

Arsenic and salt are contained within the material handling concentrating and smelting process. This does provide the opportunity to isolate hazardous materials like arsenic more effectively.

Nautilus and TNFM are continuing to plan details for the processing of copper mineralized material from Solwara 1. Nautilus aims, where possible, to work with TNFM to ensure the mineralized material and byproducts are handled in a best practices, responsible manner.[129] Nautilus is setting a higher-than-industry standard by following the product stewardship line and including environmental and social impact criteria for smelter selection.

An analysis of the efficiency (pollutants/ton of copper ore produced) could not be conducted at this time for either TNFM or other smelters. The TNFM smelter complex is likely in the top 10%, if not the top 1%, of least air-polluting smelters per metric ton of copper produced, due to new technology, production efficiencies, and closed systems.

The TNFM smelter is new, and is likely to operate at full capacity. At the smelter scale, copper mineralized material from Solwara 1 will displace copper ore from terrestrial mines rather than be additive.

Even with modern facilities, copper smelting is not a pristine process. Currently, there is no advertised “clean copper” standard and no assurance that it would fetch a higher price if such a standard were in place. However, if a future analysis shows that the TNFM is comparatively better than other concentration and smelter sites, reducing impacts and effluents, this may contribute to upgrading the overall sustainability of copper production.