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Groundbreaking work

Smart ways to seek metals PART I

We need to look at metals in new ways and in new places, to see what commodities are there for the taking, says DAVE SAMMUT.

Almost 50 years ago, the Club of Rome published a notorious text, *The predicament of mankind*, which made dire predictions about the limited availability of non-renewable resources, most particularly oil. Subsequent versions – peak oil, peak copper, peak helium – have been desperately overblown.

Although those predictions have been repeatedly wrong – failing to properly consider advances in technology, replacement, and supply and demand – basic mathematics says that sooner or later their underlying principle has to be correct. Perhaps more critical than the absolute quanta of resources available versus those required to serve the growing population and per-capita consumption, the *rate* at which resources can be gathered and distributed is likely to become a key factor in global geopolitics. With scarcity comes competition. When nations compete for resources, war is too frequently the result.

Crude oil resources are becoming deeper and more sour (higher sulfur content). Miners are increasingly required to turn to deeper, lower grade, more complex (often polymetallic) resources, often in less politically stable regions. Barring incremental improvements in efficiency and scale, production costs across many metals industries are rising.

I have spent much of my career working on ways to improve the efficiency of metals extraction and processing, most particularly in step-change new technology for base metals (copper, lead, zinc and nickel). Throughout this time, the opportunity for any new technology has been closely linked to the global prices of these commodities, but not always in straightforward ways. It has often been that the greatest pressure to bring forward advances has been when the prices were trending downwards, and therefore when margins were under threat. Of course, there comes a time in such a cycle when the innovative money simply dries up and all progress slows or stops, but the underlying message has always been 'if your new technology can get into the bottom quartile of the industry cost curve, then it might have legs.'

Clearly, if new technology can extend the life of existing mines, if it can rework old ground to more thoroughly exploit what has already been disturbed, then the need to open new mines to satisfy demand is deferred.

This is the first of a two-part discussion of some clever ideas in the technology pipeline that might one day play their part in the global metals cycle. None is yet truly competitive, but the whole point of the supply–demand equation is that the situation will always be fluid. As the pressures shift, one company's problem will become another's opportunity.

Above-ground resources

The best form of metal resource is metal that is already above ground. For this purpose, scrap recycling is a thoroughly established ideal. Metallic lead, for example, is one of the most recycled metals on Earth, far more than even copper or aluminium. According to the International Lead Association, more lead is recycled each year than is mined, and used lead–acid batteries are 'the world's most recycled consumer product', at nearly 100% in North America and Europe.

Reworking old mine tailings is another established practice. With advancements in technologies, old tailings dumps can be an incremental source of metal sitting at-surface (without the costs and impacts of going deep). In simple terms, the older the former mine, the more likely it is that the tailings can be usefully re-worked, both because of the improvements in extraction and because older mines were generally higher grade. Some new mines being opened have lower grades than some early tailings dumps. For example, at the Migori Project in Kenya, the Macalder tailings has a grade of 1.7 g/t, while the Mikei shear zone (ore) has a grade of 1.3 g/t.

In a similar fashion, multiple proposals have looked at mining old municipal waste dumps, particularly those dating from the mid-20th century and particularly in North America. Such 'urban mines' have often decomposed much of the putrescible material (making the residue easier to reprocess), but were formed during an era when the intensity of metals consumption had risen sharply and therefore have high metal grades.

Metals in sewage and wastewater sludge

For the past several years, a sewage treatment facility in the Nagano prefecture north-west of Tokyo has been recovering gold from incinerated sewage sludge. The gold levels in this ash have been world-class, with 1890 g/t of gold in the ash, as compared to <20 g/t for a typical gold mine. The prefecture reportedly expected to receive about 15 million yen from the recovered gold in its first fiscal year (2009), subject to gold prices … and these went up considerably after the GFC.

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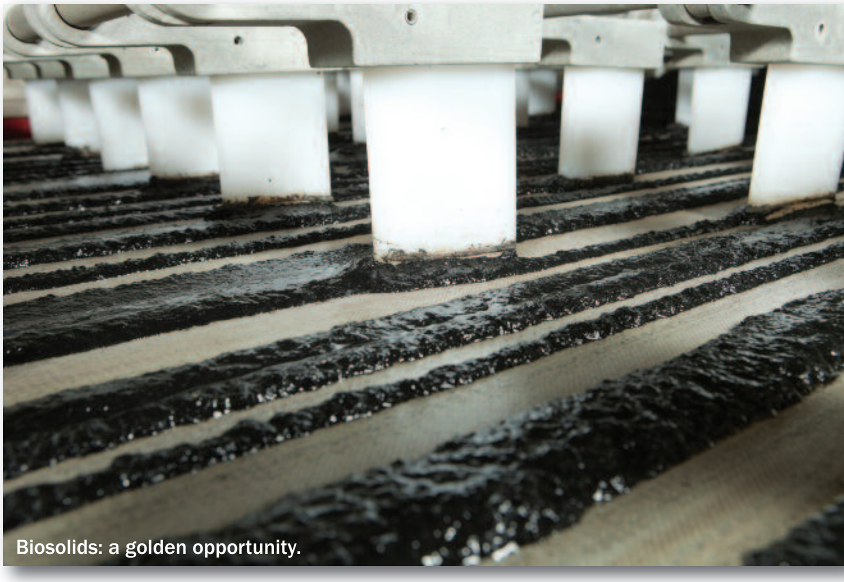
Lead–acid batteries continue to play a significant role in the automotive industry, and are a major source of metals.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Biosolids: a golden opportunity.

The gold content in the Nagano ash is somewhat higher than might generally be expected, reportedly because of a substantial local presence of high-tech industry, which is presumably somehow permitted to dispose of metalliferous waste to the sewers (this would attract heavy penalties in most regions of Australia).

More widely, metals are generally known to concentrate in sewage. This is due to their ubiquitous presence in household products, plus the effluents of local industry, storm run-off particularly from roads – which have levels of platinum group residues from automotive catalysts – and anything else that gets flushed down the drain.

A recent study (doi: 10.1021/es505329q) estimated that the sewage sludge from a typical US city with a population of one million could contain metals worth up to US$13 million annually, including US$2.6 million in gold and silver.

That metal value is an enticing economic 'pull' factor for recovery, but society should also be applying a 'push' factor to waste sludge. In many urban wastewater and sewage plants, including in Australia, the metals that are contained in the sludge are not stabilised in any way prior to the current disposal routes, often landfill, agriculture or oceanic outfall. Typical facilities rely on the greater bulk of the organic residues to reduce metal content to levels deemed acceptable by regulatory regimes – a classic example of 'dilution as the solution to pollution'. In terms of the otherwise-reusable metals being thrown away, it makes the waste wasteful. Between the lost opportunity for reuse and the environmental effect of disposal, it's a double negative.

The key to the metal sludge studies has been the initial incineration of the sludge, which first removes the organics that would hinder most conventional metals extraction techniques, and second concentrates the (non-volatile) metals into the ash for easier recovery.

However, incineration creates its own potential problems, both technical and societal. Incineration of sewage sludge may generate limited calorific value, but the bulk of the energy is lost due to the heat of evaporation of water, so that fuels are actually added in some cases to incinerate the sludge. Some attention is being paid to alleviating this problem, mostly for developing nations. The Bill & Melinda Gates Foundation has, as an example, put its weight behind the Omni Processor, designed by a US firm to treat sewage on a thermally self-sustaining basis to yield clean drinking water.

Another obvious problem is that halogens are ubiquitous in waste and sewage, through the extensive use of chlorinated and brominated plastics, and the natural processes that leach and distribute low levels of chlorine quite widely. When incinerating anything with significant organic levels and even low levels of halogens, persistent organic pollutants (POPs, particularly dioxins and furans) form readily between 250°C and 400°C. Incinerators may operate at higher temperatures, but the off-gases need to be rapidly quenched to prevent POP formation.

Incineration also has a reputational problem. Commonly practised in the mid-20th century, incineration of municipal waste was a convenient way of reducing mass and putrescible organic content. This was sometimes coupled to heat utilisation, but with limited or no emission controls, those practices were clearly problematic and were mostly phased out.

So the legislation and regulations governing the recovery of metals and energy from waste, in the case of materials with high calorific value, still carry the legacies of the old problems. Similarly, the social and environmental groups that are necessarily involved in the permitting of proposed waste to energy and waste recycling facilities tend to hang on to the negative connotations of the old paradigms. This is understandable, but it is an impediment to newer, clean facilities that can recover the useful components of sewage and/or other organic sludge.

New frontiers

In the second part of this series, I will explore seabed mining and asteroid mining as novel ways to address the world's future problems with metals supply. Each is technically fascinating, and both are massively challenging with potentially global environmental, societal and legislative consequences.

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