From Russia with love

Dave trudged several kilometres through a driving snowstorm to get a photo in front of the Russian Academy of Science. Totally worth it, right?

One of the many joys of my job is that the mining industry calls me to various far-flung parts of the world. I am afforded the great pleasure of visiting interesting places, and working alongside people whose lives and experiences can be remarkably different from my own, or surprisingly similar. And while no mining site is ever pretty, at least when I'm travelling, the sites are 'not pretty' in another language.

I am generally called in to solve problems with the mineralogy of the ore or concentrate that is ill-suited to conventional technology – due to environmental concerns, logistics, metal recoveries, or cost, or indeed most often some combination of all of these factors (see box).

Recently, a new challenge was brought to me from somewhere in the vast territories of the Russian Federation. Australia has world-leading facilities for the development and testing of new minerals processing technology. But each project is individual, and sometimes local factors are such that it is easier to cooperate with a laboratory closer to the site.

So it is that I find myself sitting at a bench in a Soviet-era former 'institut' building in St Petersburg, working with a local team of scientists to find a technological solution to this new mineral challenge. Outside, the day is grey, a bit bleak, and plenty cold in Australian terms (about −5°C) – albeit that my new Russian friends are complaining that it isn't 'a real Russian winter'.

St Petersburg is one of the world's great houses of chemistry. It was from here in the northern summer of 1869 that Dmitri Mendeleev first published his periodic table of the elements (in the German periodical *Zeitschrift für Chemie*). And to paraphrase the Royal Society's web page on the topic: Why is Mendeleev considered to be the 'father' of the periodic table while others are

Neat solution for a concentrate

In Asia, a bench-scale experimental program to investigate a pre-treatment for an arsenical gold concentrate has been successfully completed recently. If this material were to be roasted according to conventional methods (for non-arsenical gold concentrates), the resulting airborne arsenic trioxide would create an expensive exercise in environmental and safety hazard management.

Instead, we trialled a wet chemical leaching technique at atmospheric pressure and low temperature, to convert the arsenic to stable scorodite ($FeAsO_4$). The process liberates the gold for subsequent gold extraction using conventional technology and existing on-site equipment. Overall, the result was a neat, relatively inexpensive potential solution to the problem, with no airborne emissions or liquid effluents.

considered to be also-rans? Because he was right! Mendeleev's work created a predictive tool that both corrected errors in the measurements of the day and anticipated the properties of elements yet to be discovered.

In keeping with this grand tradition, the square and forbidding concrete building in which I sit houses a laboratory staffed with excellent chemists, men and women who really know their science, and who have been remarkably quick to get up to speed with the methods and theories of my specific area of mineral chemistry.

During my visit, I watch my Russian colleagues take to the endeavour with enthusiasm and expertise. While the snow falls outside, the atmosphere in this lab is warm with pleasurable collaboration on a shared problem. The facility is relatively modern and clean (for a minerals lab), with articles of bespoke equipment that leave me just a little envious – no ageing infrastructure here.

As a visitor to the lab, I am impressed by the cohesiveness of the team, all of the members working together with evident goodwill, and everyone very capable of multitasking across many skill sets to balance a demanding workload.

Contrary to the grim stereotype of Russian austerity and humourlessness, to my delight the team laugh readily with each other and at themselves … as well as at my pathetic attempts to pronounce even the basic greeting *zdrastvuite*.

Outside the laboratory, some of the stereotypes actually do have a basis. The old centre of St Petersburg is truly beautiful. And the Russian roads are chaotic – because even when the soviet-era traffic lights are green, they're still red.

I'll head home confident that our work can continue apace. The experience has been entertaining, even enlightening, and overall a true pleasure. So, until next time, *do svidanija*.

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The Balmain colliery

A little over 30 years ago, New South Wales Premier Neville Wran famously said: 'Balmain boys don't cry.' He was referring to his own upbringing in Balmain and its reputation as a tough place. During his childhood years, there was an active colliery at Balmain. Coal production ceased there in 1931 after more than 40 years. However, methane was produced there until some years later. This is in anticipation of current trends, where coal seam gas is an increasingly important fuel.

According to a 2007 NSW government document (bit.ly/PqBis0), the same coal deposit could have been accessed from places such as Neutral Bay, and there was bore logging in Cremorne in 1890. Pressure from north shore residents and businessmen led to the eventual location of the mine south of the harbour, evidence that nimbyism was present in pre-Federation Sydney.

Similar events were also taking place in one region of the Old Country, where coal was discovered in Kent. The Kent Coal Company operated from 1896 to 1920, always on a precarious basis. The enterprise at Balmain was also precarious from the start.

Conditions at the Balmain colliery were dismal. They included hazards from methane as well as poor ventilation. The temperature was such that had water been used to control suspended dust, the level of water vapour in the mine atmosphere would have been restrictive. On a combined day-, afternoon- and night-shift basis, each of the 245 miners was expected to produce 5.5 tonnes of coal per day (bit.ly/1cvyEv4). After coal production ceased, there was very limited, and unreliable, methane production at the mine. The peak year was 1944 when over 3 million cubic metres of gas were produced.

Natural gas, unlike any solid or liquid fuel, is sold on a heat, not quantity, basis, and benchmarks such as the US Henry Hub price use $US per million British thermal units (BTU). Conveniently, one million BTU is equivalent (to within 1%) to a gigajoule (10^9 J). If we assign a value of 37 MJ m^{-3} to the calorific value of natural gas, then the gas produced at Balmain in 1944 would have released when burnt:

$$3 \times 10^6\ m^3 \times 37 \times 10^6\ J\ m^{-3} \times 10^{-9}\ J\ GJ^{-1} = 111\,000\ GJ\ (\equiv \text{million BTU})$$

The Henry Hub price in early 2014 fluctuates around $US5.50 per million BTU, so the entire gas yield from the Balmain colliery even in its most productive year would have been worth a mere $US0.6 million at today's prices.

The mine was only viable because the wartime closure of shipping routes that brought refined oil products to Australia meant that methane from the mine was put to vehicular and industrial use. By 1950, the annual gas yield at the Balmain site was worth £50, reflecting the availability of petroleum fuels and raising questions about the mine's viability. It terminated operations that year.

Methane in mines has been responsible for huge numbers of deaths among miners. In addressing this point, the NSW Department of Primary Industries stated: 'The source of methane which had been a problem in coal mining operations [at Balmain] has mainly been the face of freshly broken coal' (bit.ly/PqBis0). This is possibly an interpretive error. Once coal is broken, the new surface formed is more reactive towards oxygen than is coal in situ in the mine. In reacting with oxygen, coal so broken self-heats, thereby providing an ignition source for methane. This, not any additional 'source' of methane, is the most probable reason for the hazard with newly mined coal with its unweathered surfaces.

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