Platinum in South Africa, a Review

To commemorate the seventy-fifth anniversary of the discovery of the Merensky Reef in South Africa, the major part of a recent issue of the *South African Journal of Science* has been given over to ten articles reviewing various scientific aspects of the platinum group metals (*S. Afr. J. Sci.*, 1999, 95, (11/12)). The papers were commissioned by R. G. Cawthorn, the Platinum Industry's Professor of Igneous Petrology at the University of the Witwatersrand, Johannesburg, who contributed an introductory commentary and two significant papers.

The platiniferous resources of the Bushveld Complex and their processing were considered in papers by R. G. Cawthorn: 'The platinum and palladium resources of the Bushveld Complex' and 'Geological models for platinum-group metal mineralization in the Bushveld Complex'; R. T. Jones: 'Platinum smelting in South Africa'; I. W. S. Smith and M. Laing: 'Solving hydrometallurgical problems in a platinum group metal refinery with X-ray powder diffraction'; and by T. V. Ashworth, V. E. Francois and M. J. Laws: 'The platinum-group metals – an analytical challenge'. These five papers complement two published in this Journal recently (1, 2), and together they present most informative pictures of the three very different ore bodies that are currently the source of about three-quarters of the world's platinum demand, and of some of the efforts being made to improve the recovery of platinum metals from them.

Of particular importance to users and potential users of the platinum metals are the data from mining companies of ore less than 2 kilometres in depth, which indicate proven and probable reserves of platinum and palladium in the Bushveld Complex of about 204 and 116 million ounces, respectively, sufficient to satisfy platinum consumption at the current rate for forty years. Inferred resources amount to another 939 and 711 million ounces of platinum and palladium, respectively. However mining has already taken place at 1987 metres and plans to mine at 2365 metres are being implemented, so inferred resources – and ultimately mineable ore – could be very much greater that the figures given above. Furthermore, assuming a demand increasing at 6 per cent per year, it is suggested that total worldwide reserves and resources could satisfy needs for over fifty years. Beyond that, improvements in mining and metallurgical operations could extend resources significantly, with exploitation governed by price and demand for the metals.

The other five papers are concerned with applications for the platinum metals. V. I. Okafor and N. J. Coville describe some of the chemical and physical properties that enable platinum to be used widely as a catalyst ('Platinum in catalysis'). They then consider: platinum in the refining industry, platinum in the automobile catalyst, platinum clusters and colloids in catalysis, and enantioselective heterogeneous platinum catalysts. In each case further developments are expected from ongoing investigations.

After pointing out that South Africa has one of the highest cancer incidence rates in the world, E. W. Neuse focuses on platinum coordination compounds of interest as antiproliferative agents ('Platinum coordination compounds in cancer research and chemotherapy'). A major part of the discussion is devoted to the strategy of binding platinum complexes to macromolecular polymer carriers with the aim of altering the pharmacokinetic pathway of medicinal agents, in order to enhance overall bioavailability while minimising present obstacles. Tests have confirmed the soundness of the polymer conjugation approach in platinum drug research.

The aluminium-ruthenium, aluminium-iridium, aluminium-nickel-ruthenium, and aluminium-iridium-ruthenium phase diagrams are reviewed by L. A. Cornish, M. J. Witcomb, P. J. Hill and I. J. Horner ('Aluminide compounds of selected ternary ruthenium and iridium systems'). Vicker's pyramidal hardness measurements can show the relationships between structure and properties; therefore hardness testing was undertaken across these systems in order to characterise their mechanical properties and indicate possible applications for some of the compositions. The hardness of AlIr was about 1000 VPN, the presence of the eutectic on the aluminium-poor side had a toughening effect; nickel or iridium can be added to AlRu without compromising the mechanical properties.

With only limited applications, ruthenium is generally in a state of over-supply, a situation which has been exacerbated as the Upper Group 2 chromitite layer has been exploited, as it is richer in ruthenium than the Merensky Reef. However, ruthenium has a number of unique properties and in recent years Mintek, the South African research and development organisation for mining, mineral and metallurgical technology, has undertaken work, in collaboration with local platinum mining companies, to create additional markets for ruthenium. Some of the more interesting developments that have resulted over the last ten years are reviewed by I. M. Wolff ('New applications for ruthenium'). In addition to phase relationship studies, ongoing studies include corrosion-resistant stainless steels and titanium alloys, cemented carbides for drilling applications, and intermetallic compounds for spark plug electrodes.

Over the past ten years Mintek has also undertaken a research programme intended to enable South Africa to play a more comprehensive role in the international platinum jewellery industry, which now accounts for about forty per cent of platinum consumption. Initial work, summarised by S. S. Taylor and T. Biggs ('Innovations in platinum jewellery materials'), sought to introduce a colour variation to platinum but the new materials were too hard and brittle to be formed by traditional jewellery operations. However, they were eminently suitable as gemstones and a white, hallmarkable, platinum alloy suitable for use as a gemstone has also been developed. Additionally, a hardenable platinum-titanium alloy with all the properties required for jewellery applications has been produced, and research on the forming of platinum-gold composites by powder metallurgy is in progress.

Interested individuals may obtain a copy of this issue of the *South African Journal of Science* from: Mr Graham Baker, Editor, P.O. Box 2600, Pretoria, 0001 South Africa; E-mail: sajs@nrf.ac.za; http://www.nrf.ac.za/sajs.

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References

1 R. G. Cawthorn, *Platinum Metals Rev.*, 1999, 43, (4), 146

2 R. P. Schouwstra, E. D. Kinloch and C. A. Lee, *Platinum Metals Rev.*, 2000, 44, (1), 33

Ian E. Cottington retired as editor of *Platinum Metals Review* in 1994. He retains his interest in the history of platinum and its uses, and in new developments in platinum technology, especially for clean energy applications.

Detecting Gas Emissions with an Electronic Nose

Gas emissions inside cars, caused by the release of volatile organic compounds (VOCs) from the interior trim materials, such as leather or plastics, contribute greatly to their internal air pollution. When the VOCs condense on surfaces, they leave an oily film, visible as fogged windscreens. Leather produces gas emissions, which can be high enough to cause nuisance and discomfort. Existing methods of analysing such emissions are a DIN standard fogging test and tests for total VOCs using a gas chromatography-flame ionisation detector (GC-FID) or a GC-mass spectrometer (MS). However, these give inconsistent readings, are time consuming and in the DIN test only one material at a time can be measured.

Now researchers in Sweden have utilised a semiconductor gas sensor array which is combined with a pattern recognition routine, an "electronic nose", to detect gas emissions from the leather used in cars (E.-L. Kalman, A. Löfvendahl, F. Winquist and I. Lundström, *Anal. Chim. Acta*, 2000, **403**, (1–2), 31–38).

Aimed at mimicking the human olfactory system, the electronic nose is an analyser which can recognise, classify and quantify gaseous emissions and odours. The sensor array consists of 10 metal-oxide semiconductor field-effect transistors (MOSFETs) with gates of thin platinum, iridium and palladium of different thicknesses and combinations operated at two different temperatures, and five sensors based on semiconducting metal oxides (MOS).

Sensor array data gave similar and additional information to GC-MS. The electronic nose could also detect deviating leather samples with unusual gaseous emissions. The method is rapid, simple and inexpensive and while having problems with drift, may find use as an on-line monitor of interior trim materials.