QUICK FACTS: PRECIOUS METALS AND PLATINUM GROUP METALS (PGMs)

PGM's (Platinum Group Metals) are essential for cleaning automobile exhaust fumes, for manufacturing glass, fertiliser, high octane fuel and a variety of chemicals including cancer fighting drugs. They are widely used in jewellery and electronics such as hard drives, circuitry and cell phones. PGM's could also play a crucial role in fuel cell technology to produce clean energy for cars, homes and businesses.

The first ever inventory and geological assessment of known and undiscovered platinum group metals (PGM's) resources estimates that more than 150,000 metric tonnes of PGM's may exist in the two southern African countries that produce most of the global supply of these critical elements. This is more than 20 times the total tonnage produced since the 1920's when PGM mining began in these countries.

The identified resources will meet global demand for many decades, given current growth rates and with supplies also coming from recycling, according to the study. About 90% of PGM's in the Earth occur in limited areas of only three countries: South Africa's Bushveld Complex, Zimbabwe's Great Dyke, and Russia's Norilsk region.

PLATINUM

Platinum is a beautiful silvery white metal when pure and is malleable and ductile. It has a coefficient of expansion almost equal to that of soda lime silica glass and has been used to make sealed-in electrodes in glass apparatus. The metal does not oxidise appreciably in air at any temperature, but is corroded by halogens, cyanides, sulphur and caustic alkalis. It is insoluble in hydrochloric and nitric acids, but dissolves when they are mixed to form aquaregia, forming chloroplatinic acid, an important compound.

Platinum can be found occurring naturally, accompanied by small quantities of iridium, osmium, palladium, ruthenium and rhodium, all of which belong to the same group of metals (PGM's).

The metal is extensively used in jewellery, wire, vessels for laboratory use and in many valuable industrial products including thermocouples. It is also used for electrical contacts, corrosion resistant apparatus and in dentistry. Platinum cobalt alloys have powerful magnetic properties. One such alloy made of 76.7% Pt and 23.3% Co, by weight, offers a B-H (max) almost twice that of Alnico V. Platinum resistance wires are used for constructing high temperature electric furnaces. The metal is used for coating missile nose cones, jet engine fuel nozzles, gas-turbine blades, etc. which must perform reliably for long periods of time at high temperatures under oxidising conditions. The metal, somewhat like palladium, absorbs hydrogen, retaining it at ordinary temperatures but giving it up at red heat.

In the finely divided state platinum is an excellent catalyst, having long been used in the contact process for producing sulphuric acid. It is also used as a catalyst in cracking petroleum products. There is much current interest in the use of platinum as a catalyst in fuel cells and in antipollution devices for automobiles.

Platinum clad anodes are extensively used in cathodic anti-corrosion protection systems for large ships and ocean going vessels, pipelines and steel piers.

More about platinum

Platinum was discovered in 1735 in South America by Ulloa and again by Wood in 1741. The metal was used by Pre-Columbian Indians. The main sources of alluvial deposits are in the Ural Mountains of Siberia, and in certain Western American States. A large suite of platinum containing chalcogenide minerals are found associated with sulphide mineralisation in ultramafic ores in South Africa and elsewhere. Sperrylite (platinum arsenide) is found with nickel-bearing sulphide ore deposits at Sudbury, Ontario. These produce a large amount of platinum metal (and palladium) as a by-product, although the nickel production helps to offset the costs of recovering the very low levels of platinum present (0.5 ppm) in the ore.

The price of platinum has varied widely; more than a century ago it was cheap enough to be used to adulterate gold. It was nearly eight times as valuable as gold in 1920.

Health and safety

Platinum metal is inert under body conditions and it and its alloys have been used in a variety of prosthetic applications. Its wider use is limited by its expense.

Platinum salts vary in toxicity according to the anions present.

Inhalation of the dust of, or skin contact with certain soluble platinum salts may cause sensitization resulting in "platinum asthma" (a proscribed disease).

The Occupational Exposure Standard is:-
Platinum metal - 5 mg/cubic metre (8 hour time weighted average).
Soluble platinum salts (as Pt) - 0.002 mg/cubic metre (8 hour time weighted average).

PALLADIUM

Finely divided palladium is a good catalyst and is used for industrial hydrogenation and de-hydrogenation reactions. Its alloys are used in the jewellery trade.

White gold is often produced by addition of palladium. Like gold, palladium can be beaten into leaf as thin as 1/250,000 in. The metal and its alloys are used in dentistry, watchmaking, in making surgical instruments and in electrical contacts.

More about palladium

The metal was named after the asteroid Pallas which was discovered at about the same time. It was recognised as an element by Wollaston in 1803. It is found in placer deposits in the USSR, South and North America, Ethiopia and Australia. It is also found in sulphide inclusions in ultramafic rocks in South Africa and elsewhere.

It is a steel white metal, does not tarnish in air and has the lowest density and melting point of the platinum group metals. When annealed it is soft and ductile. Cold working greatly increases its strength and hardness.

Palladium is attacked by nitric and sulphuric acids. At room temperature the metal has the unique property of absorbing up to 900 times its own volume of hydrogen. Hydrogen readily diffuses through heated palladium and development of this property provides a means of puifying the gas.

Physical properties

Palladium is a monomorphic metal, with a face-centered cubic structure and extremely close atomic packing. The melting point of palladium is 1552°C and its boiling point is 3980°C. Like all platinum group metals, palladium has comparatively low electrical resistivity and a high temperature coefficient of resistance. It is paramagnetic and has the highest magnetic susceptibility of all the platinum group metals.

Mechanical properties

The Brinell hardness of commercial grade palladium is 31.5 Kgf/mm². Cold working palladium metal causes a sharp increase in its hardness and tensile strength. With a 10% deformation, the hardness of unalloyed palladium reaches 61 Kgf/mm². The increase in hardness becomes proportionally less as the deformation is further increased and only reaches 79 Kgf/mm² at 90% deformation.

Palladium has the lowest elastic characteristics of the platinum metals, having comparatively low strength, and high reduction in area at high percentage of elongation.

Health and safety

Palladium metal and its salts are of low toxicity.

RHODIUM

As the bulk metal it is mostly used as an alloying agent to harden platinum and palladium. Such alloys are used as furnace windings, thermocouple elements and to make bushings for glassfibre production. It is a useful electrical contact material due to its low electrical resistance, low and stable contact resistance, and it is highly resistant to corrosion.

Electroplating or vacuum evaporation produces a highly reflective and exceptionally hard and durable surface suitable for use in optical instruments. Rhodium is also used for a range of catalyst applications and as alloys and coatings for jewellery.

Rhodium has a higher melting point than platinum, and lower density. It is highly reflective, hard and durable.

More about Rhodium

Wollaston discovered Rhodium in 1803-4 in a crude platinum ore which he presumably obtained from South America. Rhodium occurs native with other platinum metals in river sands of the Urals and in North and South America. It also occurs in sulphide ores associated with ultramafic rocks in South Africa and elsewhere.

The metal is silvery white and at red heat is slowly oxidised to the sesquioxide in air. At higher temperatures the oxide decomposes to the metal again.

Health and safety

Rhodium metal is extremely inert under body conditions and toxic reactions are unlikely.

The Occupational Exposure Standard for Rhodium as metal fume or dust is 0.1mg/cubic meter (8 hour time weighted average).

The Occupational Exposure Standard for dust of soluble rhodium salts is 0.001 mg/cubic meter (as Rh) (8 hour time weighted average).

RUTHENIUM

Ruthenium is found naturally along with other members of the platinum group metals in the Ural mountains, in North and South America and in South Africa.

The metal is produced as powder by the hydrogen reduction of ammonium ruthenium chloride. Powder metallurgical techniques or argon arc melting are used to consolidate this powder.

Ruthenium is a hard white metal with four crystal modifications. It does not tarnish at room temperature, but will oxidise in air at about 800°C. The metal is not attacked by hot or cold acids or by aquaregia. However it oxidises explosively when potassium chlorate is added to the solution. It is also attacked by halogens and alkali hydroxides.

The addition of 0.1% ruthenium to titanium immensely improves the corrosion resistance. It is a versatile catalyst and can be used to promote the splitting of hydrogen sulphide by light using an aqueous suspension of cadmium sulphide loaded with ruthenium oxide. This is thought to have application to removal of hydrogen sulphide during oil refining and other industrial applications.

More about Ruthenium

It was discovered by Berzelius and Osann in 1827 when examining the residues left after dissolving crude platinum from the Ural mountains in aquaregia. While Berzelius found no unusual metals, Osann thought he found three new metals, one of which was ruthenium. It was not until 1844 that Klaus showed that Osann's ruthenium oxide was very impure, but that it did in fact contain a new metal, hence he is generally regarded as the discoverer.

Health and safety

Ruthenium metal is extremely inert and is unlikely to produce toxic reactions in the body.

A range of compounds has been synthesised, but relatively little is known about the toxicity of these.

IRIDIUM

Iridium possesses quite remarkable properties. It is the most resistant of all metals to corrosion, it is insoluble in mineral acids including aqua regia and is unattacked by many molten metals or silicates at high temperatures, but it is attacked by molten salts such as NaCl and NaCN, and to a lesser extent by alkali metal hydroxides under oxidising conditions.

Iridium occurs uncombined in nature, and in combination with platinum and other metals of this family in alluvial deposits. It also occurs in sulphide mineralisation associated with ultramafic ore bodies.

The earliest uses were for making durable tips for fountain pen nibs and compass bearings. In 1908 Sir William Crookes first used iridium for crucibles and high temperature apparatus, and more recently for electrical contacts.

Present day uses include parts for radioisotope thermoelectric motors for space missions. The fuel consists of plutonium-238 dioxide in the form of spheres which are encapsulated in iridium to provide a secure shielding of exceptionally high melting point and strength. A large proportion of iridium production is consumed in alloys with the other platinum group metals, which then take on something of the strength and good corrosion resistance of iridium itself.

Iridium only occurs as a very small percentage of the platinum metals content of an ore so that production tends to fall short of industrial requirements.

More about Iridium

Iridium was discovered in 1803 by Tennant in the insoluble residue from dissolving platinum in aqua regia.The salts are highly coloured thus giving the metal its name. Iridium metal is silvery white similar to platinum, but has a slight yellow tinge. Iridium is harder and more difficult to work than any other face centered cubic metal and this has been attributed to trace impurities. Due to its high tensile strength and high melting point it has been increasingly used for crucibles for crystal growing. These can only be satisfactorily deep drawn to form seamless crucibles if the work is carried out above the recrystallisation temperature (1000°C)

Health and safety

The toxicity of the metal and its compounds is generally low. There is no numerical data and no Occupational Exposure Standard at the present time.

OSMIUM

The metal is lustrous, bluish white, extremely hard and brittle even at high temperatures. It has the highest melting point and lowest vapour pressure of the platinum group metals. The metal is very difficult to fabricate but can be sintered in a hydrogen atmosphere at a temperature around 2000°C.

The solid metal is not affected by air at room temperature but the powdered or spongy metal slowly gives off osmium tetroxide, which is a powerful oxidising agent, and has a strong smell. The tetroxide boils at 130°C.

The metal has been used to produce very hard alloys with other platinum group metals, for fountain pen tips, for instrument pivots, for gramophone needles and electrical contacts.

It is used in some catalytic applications and has an interesting chemistry based on cluster compounds.

Osmium Tetroxide OSO4

In addition to the osmium we also synthesise and supply osmium tetroxide (OsO4) which is predominantly used in electron microscopy as a stain to add contrast to digitally scanned images. There is currently significant research on new applications such as cancer treatments.

OsO4 can be supplied in concentrated powder or concentrated solutions.

Did you know that that the "Osram" name is derived from Osmium and Wolfram (German for Tungsten, also used in English), as both these elements were commonly used for lighting filaments at the time the company was founded.

More about Osmium

Osmium was discovered in 1803 by Tennant in the residue left when crude platinum is dissolved in aqua regia. Osmium occurs in iridosmine, and in platinum-bearing river sands of the Urals and North and South America. It also occurs in sulphide mineralisation in ultramafic ore bodies in South Africa and elsewhere.

Health and safety

Osmium metal forms the tetroxide on exposure to air.
The Occupational Exposure Standard for the tetroxide is:- 0.002 mg/meter (8 hour time weighted average).

SILVER

Silver has attracted humankind's fascination for many thousands of years. Ancient civilisations found silver deposits on or near the earth's surface. Relics of these civilisations include jewellery, religious artefacts and food vessels formed from the durable malleable metal. This metal took on near mystical qualities in marking important historical milestones throughout the ages, and served as a coinage metal for centuries.

Silver more than other precious metals has significant demand rooted in sectors as diverse as imaging, electronics, coinage, superconductivity and water purification. For this reason silver is no longer known as just a precious metal, a store of value, a work of art or an industrial metal. It is all of these. Today silver is indispensable, working all around us to improve the quality of our lives.

The 20th century marked an important economic function for silver.

GOLD

Industrial demand for gold continues to be dominated by the electronics sector. Gold's conductive properties and resistance to corrosion means that it remains central to innovations in wiring and coatings in this field.

However, the metal's unique properties and the advent of 'nanotechnology' are driving new uses on the cutting edge of medicine, environmental management and advanced electronics, which could grow into significant new markets for gold.

Nanotechnology is a branch of science that exploits both the properties exhibited by materials at the scale of a few nanometres (the size of a few atoms) and our rapidly evolving understanding of biology and chemistry to build materials with specific roles. Through these techniques, gold can be used to build highly-targeted methods for delivering drugs into the human body; to create conducting plastics and specialised pigments; or advanced catalysts which can purify water or air.