# Recycling has changed the whole platinum metals landscape

I have been wondering why – with a clear deficit of supply of new material – the platinum group metals (PGMs) prices don't skyrocket.

As a believer in the law of supply and demand, this fact doesn't seem to make any sense especially since PGM recycling is a well developed industry. But, in fact, the question answers itself: there is really an additional supply of PGMs where they are most needed (by the North American, European, Japanese, and, now, Chinese OEM automotive industries) due to localized and very extensive recycling. This relatively unknown product flow, unquantified purposely for competitive advantage, added to new production is the real "supply" of PGMs.

In fact the cost per kilogram of recycling being far less than the cost of mining PGMs has actually put downward pressure on prices.

The law of supply and demand seems therefore to operate only as a variable rule than a strict law in the platinum group metals sector. That is until you look at the output of recycling of the PGMs, or try to quantify it.

There has been for the last few years and there are expected to be for the next few years deficits in the supply of newly mined platinum, palladium, and rhodium, the three most industrially important of the six PGMs. PGMs are among the most important technology metals for environmental management of the exhaust emissions from internal combustion engines. Their second most important use is in the production of fossil fuels where they serve also as chemical catalysts. Their use in jewelry and as “stores of value” is limited due, mainly I think, to the fact that they are indeed rare, difficult to fabricate, and less “liquid” than gold or silver.

**High barriers to PGM Mining**

Unlike rare earth or lithium juniors who count on the investing public to be unaware of the time required to develop new mines, the more sophisticated investors in PGM mining are only too aware of the onerous burden on capital required to bring a PGM mine into production (and to maintain that production). Added to this burden is the additional operating expense (Opex) burden for what is a dirty and dangerous operation, including the extraction of the PGMs from the companion metals that dominate their ores and the (up until recently) horribly toxic and dangerous chemical systems required to separate and purify the PGMs.

The modern demand for PGMs was created in the 1970s when the automotive exhaust emission catalytic converter was mandated and required to be introduced in the 1976 model year of American cars and trucks. The original versions of these catalysts (called “cats”) were steel cylinders packed with alumina beads coated with either platinum or palladium and with steel screens on either end. These cats were inserted into the exhaust system to catalyze the conversion of carbon monoxide and unburned fuel to carbon dioxide and water, which were then believed to be safer for the atmosphere and for people than carbon monoxide and unburned gasoline.

By 1980 it had been posited that “acid rain” caused by nitrogen oxides and sulfur oxides from automotive gasoline and diesel exhaust was a major problem, so that two advances were made in the construction of “cats.” First the PGM rhodium, Rh, was added to the PGMs in cats in order to catalyze all acid forming nitrogen oxides into “inert” forms of nitrogen and, second, the catalytic converter substrate itself was reformed into a synthetic cordierite ceramic honeycomb with its gas path tubes lined with an alumina wash coat which itself was then coated with the three PGMs deemed necessary for managing the exhaust of an internal combustion engine. This new design rapidly replaced the coated beads in a can model of catalytic converter.

Privately sponsored work on recovering the PGMs from spent “cats” began in 1976 with experiments on chemical processes to selectively extract the PGMs from the coated alumina beads. In 1989 the General Motors sought to establish a PGM recycling operation for its own purposes. I at that time proposed a copper smelter extraction system, modeled on the system that had been then until recently in operation at the AMAX copper refinery in Carteret, New Jersey. The extraction would be followed by the traditional electro-refining of the copper collector, which would concentrate the PGMs in the anode muds or slimes that are the residue of traditional copper electrorefining. The final step for my company was to be the then traditional chemical separation of the PGMs from each other through their preferential solution in a series of strongly oxidixing acid solutions with the attendant safety and health costs. The primary feed stock I proposed was to have been floor scrap from GM’s then catalytic converter manufacturing plants in Milwaukee, Wis, dealer returns, and scrap “cats” bought on the open market.

My company, Group Eight, Inc., was outbid by a then new venture called A-1 Services, which eliminated the need to build a smelter by contracting with existing PGM miner/producers, such as, ultimately, Impala of South Africa.

I believe that what Impala and other legacy PGM miners ultimately did for the world’s car makers was that, upon an agreed analysis of the lots of autocat substrate scrap, a certain percentage of the contained PGMs would be credited to the suppliers’ account and the metal released (from inventory) immediately to the “digesters,” as the coating chemical makers were called in the arcane lingo of the trade, used by the scrap supplier. The balance of the metals due would be settled over a period of six to 18 months as was then common in the "trade." Once the flow was underway it grew until today a substantial portion of global OEM needs are met by this recycling regimen.

European smelting and refining giant Umicore (then known as Union Miniere du Haut Katanga) of Belgium then adopted the same practices and business model and has today become a substantial vertically integrated builder of automotive exhaust emission catalytic converters with its supply chain fed by recycled PGMs from its own legacy smelter system in Hoboken, Belgium. Others in the mining and smelting industries soon followed.

In the last 25 years a new opportunity has arisen for non-legacy PGM cartel members besides Umicore due to innovations in smelting that have lowered overall costs. This was due to the development of the relatively cheap and more efficient electric furnace called a "plasma arc" type. Large automotive scrap dealers in the USA, Europe, Japan, and now China have been able after many early failures to "simply" throw the entire catalytic converter into this type of furnace and extract the contained PGMs into the molten iron as a collector metal.

The PGMs can then be extracted from the solidified collector by dissolving the iron in hydrochloric acid through which chlorine gas is bubbled. This "simplified" process has over the past twenty five years become the dominant form of the recycling of PGMs from auto and some gasoline reforming catalysts by "scrap" dealers and has even been used to augment legacy smelting at both South African and Russian mines.

The principal sources of new PGMs are the platinum, palladium and rhodium recovered in South Africa from nickel bearing ores, and the palladium recovered from Russian and Canadian nickel ores. Significant PGMs are also recovered from the electrorefining of newly mined copper.

**PGM recycling now**

PGMs are among the most recycled materials known and are exceeded in their percentage recovered perhaps only by gold.

PGMs are, like gold, “noble” metals in that they, especially platinum, are highly resistant to attack by the strong acids and bases used in mining hydrometallurgy. Both gold and platinum are often found as native materials which means that, even after being exposed to weathering for hundreds of thousands and millions of years, they still are not corroded or combined with other elements although they are often found as alloys with sister (in the periodic) table elements. The most commonly known of these is electrum, an alloy of gold and silver that was perhaps the first coinage metal being used in Greece in the sixth century BC.

The point I am trying to make is that the purification of the PGMs, preceded by their separation, has been long practiced and has the longest known history of any complex chemical reaction system. Without any real knowledge at all of the chemical structure and reactivity of materials to guide them the alchemists nonetheless devised a witches brew of nitric and hydrochloric acid to dissolve gold. This mix, known as aqua regia, or royal water, has been in use for centuries. Essentially the procedure is to try to dissolve the mixture or alloy suspected of containing gold in ordinary mineral acid such as hydrochloric, then the remaining material not dissolved by HCl can be subjected to treatment with additional acids and bases until finally something is left that does not dissolve.

For PGM recycling, one of the most significant breakthroughs that allows the plasma arc smelting technique to become economic is the application of an extremely metal-selective class of tailored (engineered) ligands to the selective separation and recovery of individual PGMs directly from the $HCl/Cl_2$ solution.

This separation process, known as Molecular Recognition Technology (MRT), was developed by a Utah company called IBC Advanced Technologies, Inc. MRT was based on the pioneering work in molecular recognition and separations chemistry of Prof Reed M. Izatt and his colleagues at Brigham Young University. Prof Izatt and Prof Jerald S. Bradshaw received the 1996 American Chemical Society National Award in Separations Science and Technology for their work in separations science. The importance of molecular recognition in chemistry is shown by the receipt of the 1987 Nobel Prize by three of its practitioners, Charles Pedersen, Donald Cram, and Jean-Marie Lehn.

Highly selective metal separations are achieved in MRT systems by employing pre-designed metal-selective ligands. Incorporation of these ligands by chemical binding to solid supports such as silica gel or polymer substrates makes their use in a column-based solid phase extraction mode possible. The supported ligand product is termed SuperLig®. Organic solvents are not used in these MRT systems. MRT has been used in commercial systems for metal separations and recovery for more than two decades.

MRT green chemistry processes are far faster than less selective traditional ion exchange, solvent extraction, and precipitation separation procedures. MRT has low metal inventories, generates minimal waste, has high metal recovery rates approaching 100%, requires much less space, and employs no solvents or hazardous chemicals. These are desirable properties that make significant positive contributions to the bottom line in determining operating and capital expenses.

The ability of IBC's SuperLig® systems to work and maintain their properties in extremely acid environments plus their long life cycle has made these systems the process of choice for recovering PGMs from numerous sources worldwide. MRT systems have been installed at a number of PGM refineries including, for example, Tanaka Kikinzoku Kogyo (TKK) (Japan), Impala Platinum (South Africa), SepraMet (USA), Sino-Platinum (China) and others, for the separation, recovery and purification of PGMs from secondary sources, including spent autocats, as well as from primary mine feed.

I think I can safely say that the use of SuperLig® systems make plasma arc smelter recovery of PGMs from autocats much more practical and economical and thus successful.

Although the cartel system for PGM metals still exists and PGM metals must be hallmarked by members of the London Platinum and Palladium Market (LPPM), the coating chemicals for the manufacturing of catalytic converters are well into the process of becoming commodities due to the success of the SuperLig® technology.

So if today I were asked what factors determine the supply and therefore the price of the PGMs for automotive exhaust emission catalysis I would say primary production, recycling, and SuperLig® technology.

I note that even if the number and proportion of electric vehicles grows as predicted and as mandated (China) so will the production of internal combustion powered vehicles, so that the demand for PGMs for exhaust emission catalysis will also grow, but if the recycling of PGMs from spent autocats also grows in proportion then the need for newly mined materials will, or may have already, peaked.

SuperLig® technology will allow the plasma arc furnace to become dominant in PGM recycling. The genie is out of the bottle and the primary producers can no longer play with inventories to control prices.

You don’t really think that OEM automotive pays LME, LPPM, NYMEX, or COMEX prices today for PGMs do you? The supply chain managers and economists at the world's OEM automobile manufacturers are far better market "readers" than the hucksters of Bay, Howe, and Wall Streets.

Invest in recycling, not in primary production alone. The PGM markets are a good example of the complexity of supply chain specialization. Any change in a supply chain component can affect the entire chain. IBC's SuperLig® technology is an excellent example of this.

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# Innovative processing for the technology metals market

November 10, 2015 — I would like to take this opportunity to thank everyone who attended the Technology Metals Summit on Wednesday, October 14th. This was the 3rd one we have done and we are actually in the throes of planning another one for May 2016 — a 2-day event, 1 day on technology related to cleantech and the 2nd day dedicated to technology metals.

Yes, Jack Lifton, Sue Glover and I threw this one together in record time, but the audience was full of industry leaders and investors that reinforced that the sector is not only evolving, but is arguably redirected towards competitive environmentally conscious technologies.

The Technology Metals Summit panel where this stood out the most prominently was co-moderated by Alastair Neill of Trinity Management Ltd. and Pol Le Roux, Vice President Sales and Marketing for Lynas Corporation Ltd. and was titled: Innovative processing for the technology metals market. With a record seven panelists, click here to see the following companies represented in this valuable dialogue and debate on technology metals extraction processing techniques: Jaye T. Pickarts, P.E., COO of Rare Element Resources Ltd.; Neil Izatt, IBC Advanced Technologies; Dr. David Dreisinger, Vice President, Metallurgy, Search Minerals Inc.; Patrick Wong, CEO & Director, Innovations Metals Corp.; Kiril Mugerman, President & CEO, GeoMegA Resources Inc.; Wes Berry, Vice President & CTO, K-Technologies, Inc.; and Cameron Davies, COO, Rare Earth Salts.

To access the panel highlights, click below on the InvestorIntel YouTube channel, or click here to access