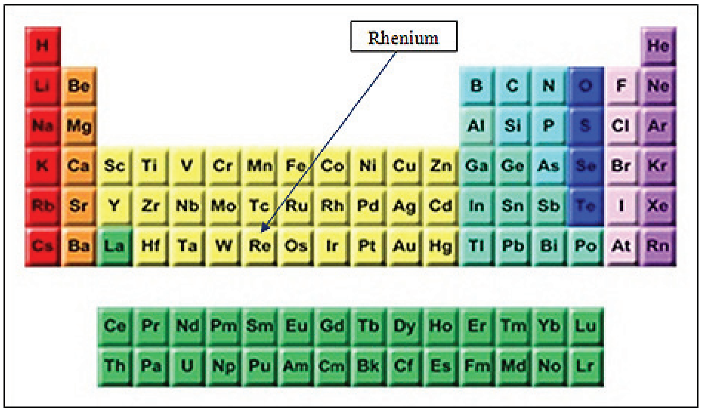
Features and Interviews

Rhenium: Son Of Moly

Written by Tom Vulcan
Tuesday, 05 August 2008 00:00

Back in 1870, had you scanned the periodic table below to find rhenium, you wouldn't have found it - it wasn't there. There were still gaps for predicted, but-as-yet-undiscovered, elements, and one of them was waiting for rhenium.

The Periodic Table



In fact the element (atomic number 75), was only discovered some 55 years later, in 1925, by a team of German scientists: Otto Berg, Walter Noddack and Ida Tacke. They subsequently named rhenium after the river Rhine. Indeed, rhenium was one of the two last naturally occurring chemical elements to be discovered. One of the reasons is that it occurs neither freely in nature nor as a compound in a distinct mineral species. Once it has been extracted, however, rhenium is a heavy, silvery white metal.

Son Of Moly

Rhenium is the "Son of Moly" for a couple of reasons. Not only is most rhenium today produced as a by-product of the copper and molybdenum mining industries, but like molybdenum, rhenium has some very special, if not unique, properties.

Like moly, also, there's not much of it around. In fact, there's considerably less rhenium than there is moly. In the Earth's crust, it is only to be found in single-digit parts in a billion. Only about 50 metric tonnes of it are produced each year, and total world reserves of the metal are probably not much more than 10,000 metric tonnes.

Characteristics

Why is rhenium so special? Here are just some of the reasons:

* Extraordinarily high melting point: Around 3,180 ºC, a melting point exceeded only by tungsten and carbon. It is, therefore, a refractory metal (extremely resistant to heat and wear), but the only such metal not to form carbides.

* Extremely dense: A density exceeded only by iridium, osmium and platinum.

* No ductile-to-brittle transition temperature: It remains ductile (i.e., malleable or being able to be deformed plastically without fracturing) from Absolute Zero (-273.15 ºC) to its melting point. A unique property.

* High modulus of elasticity: Extremely stable and rigid under stress (great tensile strength), rhenium has the third-highest modulus of elasticity of any metal.
* High electrical resistivity: This is true; however, rhenium-molybdenum alloys actually become super-conducting at 10 ºK (-263.15 ºC).

* Low friction

* High resistance to creep: i.e., the tendency to move slowly or deform permanently when under stress.

* Exceptionally resistant to chemical poisoning: Rhenium is particularly resistant to poisoning from nitrogen, sulfur and phosphorus and can be used very effectively for the hydrogenation (the addition of hydrogen - H_2) of fine chemicals.

Rhenium Demand

With all these very special characteristics and its industrial importance, rhenium truly can be defined as a "strategic" metal: one of the 40 mentioned at the beginning of the article on moly. (While its "strategic" nature really cannot be argued, it remains to be seen when, or even if, the U.S. government will include it in the nation's strategic stockpile of minor metals. At present the stockpile contains precisely none!)

Some everyday (albeit more often than not, industrial) demands for it, most usually in combination with another material as an alloy, include:

- Filaments in ion gauges, mass spectrographs and photoflashes
- Electron tubes & targets, and vacuum tubes for X-rays
- Temperature controls, high-temperature thermocouples, thermistors and heating elements
- Gyroscopes
- Electrical contacts, semiconductors and electromagnets
- Treatment of liver cancer and restenosis following balloon angioplasty

Of the rhenium used in the U.S. in 2007, the USGS (United States Geological Survey) estimates that 20% (15% worldwide) was used in petroleum-reforming catalysts. Bimetallic platinum-rhenium catalysts are used in the production of high-octane hydrocarbons, which are, themselves, used in the production of lead-free gas.

Lastly and most importantly, however, the USGS estimates that of the rhenium consumed in the U.S. in 2007, 60% (77% worldwide) was used in the production of super-alloys. Essentially, when combined with other metals, it imparts to the resultant compounds, or super-alloys, those exceptional qualities it has itself. Indeed, it can augment these qualities.

Super-alloys containing rhenium are used not only in the nuclear power industry and ground-based gas turbines, but also to make vital components in both civil and military jet engines and rockets. In jet engines, one of their most significant uses is to make turbine blades.

While the metal has been used in military aircraft for decades, in, for example, both the old F-16s and the new F-22s and F-35s (Joint Strike Fighters), it has only been used relatively recently in civil jet engines. Indeed, Boeing 777s, with just two engines, rely upon super-alloys using rhenium. By being able to run at higher temperatures, jet engines using rhenium are much more fuel-efficient. Anything other than rhenium super-alloy turbine blades would melt at the temperatures at which some modern jet engines built by the likes of the Rolls-Royce, General Electric and Pratt & Whitney run.

In addition, rhenium is used by the military, particularly in its stealth aircraft, to help control the heat from jet engine exhausts, and in the production of rocket thrusters, chambers and nozzles where both its extreme resistance to heat and stability are of particular importance. (Rocket thrusters made using rhenium have been tested through 100,000 thermal fatigue cycles without failing.)

Two further uses of rhenium as an alloying metal are worth noting. First, when combined with boron, the resulting compound - rhenium diboride - is harder than diamond. And, second, when combined with silicon to form silicon cage clusters, the resulting clusters are particularly stable. This property could, in future, prove important both in the building of nanostructures and, in particular, so-called quantum computers.

Rhenium Supply

Rhenium is essentially a by-product of a by-product, extracted from molybdenum, which is itself a by-product of mining porphyry copper deposits. Nobody actually mines rhenium.

Rhenium is usually extracted from the flue gases and dust produced in roasting molybdenum concentrates. (In Kazakhstan, however, it also exists in sedimentary copper deposits.)

Roskill Information Services Ltd, the London-based metals and mineral research house, estimated world production of rhenium in 2007 to have been just 50.45 metric tonnes. And while it estimated production at some 48.69 metric tonnes in 2006, with the release of some 15 metric tonnes from stocks, around 72 metric tonnes actually entered the world market that year.

Whatever the figures for the last two years, rhenium is, in absolute terms, a very rare metal.

The world's largest producer of rhenium is Chile, followed by the U.S. and then Kazakhstan. (USGS figures, however, show Kazakhstan producing some 8 metric tonnes of rhenium in 2007 - just a tad more than the 7.3 metric tonnes produced by the U.S. last year.)

World Rhenium Production - Primary[1] (Metric Tonnes)

	2006	2007
Chile2	27.5	28
SA	7.9	7.2
Kazakhstan	4.4	4.5
Poland	0.25	2
China	1.75	1.25
Russia	1.4	1.4
Uzbekistan	0.85	0.9
Armenia	0.6	0.5
Total	**44.65**	**45.75**

Source: Roskill (USGS; Roskill; Powmet)

Notes:
[1] Produced as a by-product of molybdenum processing
[2] Based on reported exports of rhenium metal and APR (ammonium perrhenate)

World Rhenium Production - Secondary[1] (Metric Tonnes)

	2006	2007
Germany	2.64	3
France/USA2	0.55	0.6
Estonia	0.5	0.5
Czech Republic	0.25	0.25
Other Countries	0.1	0.35
Total	**4.04**	**4.7**

Source: Roskill (USGS; Roskill; Powmet)

Notes:
[1] Produced from recycling catalysts, super-alloys and other rhenium-containing scrap
[2] BASF secondary production takes place in both the USA and France

World Total Reserves (Metric Tonnes)

USA	4,500
Chile	2,500
Canada	1,500
Peru	550
Russia	400
Other Countries	360
Kazakhstan	250
Armenia	120
Total	**10,180**

Source: USGS

The Current Market Situation

Currently, supply and demand for rhenium is very finely balanced. According to Roskill, over the last decade demand has grown from “perhaps 35,000kg to an estimated 65,000kg” with supply barely keeping pace. And, indeed, over the past couple of years the market has tightened considerably.

With USGS figures for the “apparent consumption” of rhenium in the U.S. alone at 51.8 metric tonnes in 2007 (2006: 46.8 metric tonnes), current demand certainly appears

to be outstripping mined supplies, with the remaining demand being met by the release of stocks (mainly from Kazakhstan) onto the market. If, as would seem likely, demand continues to increase, this raises the important question of just what stocks actually remain to be released to fill the gap. According to some industry sources, current supply just about equals demand from the top three users alone.

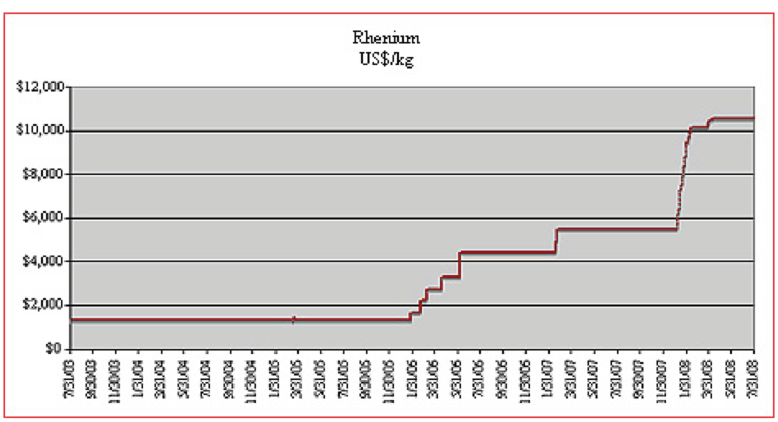
And demand does look as if it is set to increase. Not only are high aviation fuel prices and increasing environmental concerns forcing airlines to be more fuel efficient, but, in addition, the new rhenium super-alloy turbine blades that can help them achieve this efficiency now require a rhenium content of up to 6%, when, previously, it was only 3-5%.

Of the civil aircraft manufacturers, Boeing alone “expects to supply 475-480 commercial planes this year and 500-505 in 2009, up from 441 planes in 2007.” Its European rival, Airbus, is set to deliver some 470 this year and up to 453 in 2007.

The U.S. military has targeted a production of some 3,000 F-35 aircraft and 6,000 engines, all of which would use third-generation nickel-based super-alloys containing 6% rhenium, as will the 700 or so F-22 Raptors scheduled for production.

Both an increased use of rhenium in catalytic converters in petroleum refining, and the use of the metal in technology currently being developed to convert gas to liquid could bring further, severe, pressure to bear on the market.

The price of rhenium has, subsequently, soared around tenfold in the last five years. As an indicator, BASF is currently (end-July) quoting the metal at $10,582 per kg ($4,800 per lb). In mid-July, this elicited such article titles as “Super hot metal rhenium may reach “platinum prices”” (Reuters).



Source: BASF

Opportunities In Rhenium

Rhenium, like moly, is available neither on the LME nor on any other exchange. And, most probably, never will be. If, however, an investor wants to invest in the physical metal, it is available either from the likes of BASF, Rhenium Alloys, Inc., H. Cross Company, etc., or, possibly, from a minor metals trading house that deals in rhenium.

In investments, exposure to rhenium is predicated on an exposure to moly. But exposure to moly does not, however, necessarily bring exposure to rhenium. Roskill estimates that, while a large proportion of primary rhenium comes from moly roasters, some 15 metric tonnes of the metal could be "lost to the market" each year in roasters without recovery circuits. So, when looking at moly producers, it's important to ascertain if they do have the facility either to extract rhenium themselves or sell the rhenium-bearing residues they produce.

If moly producers are small in number, the number of primary rhenium producers is even smaller.

Molibdenos y Metales S.A. of Chile, know by all as Molymet (**Bloomberg Ticker - MOLYMET: CI**), is the world's largest producer of primary rhenium and is public traded. It produces around two-thirds of such output, most of it as metallic rhenium. In 2007, 100% of Chile's rhenium metal exports (23.3 metric tonnes) went to the U.S., which as a country, according to the USGS, had, in 2007, to rely on imports for some 86% of its apparent consumption.

As a state enterprise, the world's second-largest supplier, Zhezkazganredmet (Red Met) in Kazakhstan is not open for public investment.

The world's third-largest primary rhenium producer is Phelps Dodge of the U.S., part of Freeport McMoRan (**Bloomberg Ticker - FCX: US**). And while both Molymet and Red Met rely on rhenium-bearing residues bought from others, Phelps Dodge actually has its own copper/moly mine in Arizona.

At one remove, other U.S. producers of moly concentrates containing rhenium include: Asarco Inc., Montana Resources and Rio Tinto (**Bloomberg - RTPPF: US**). And while for these companies moly is just one of the metals (or concentrates) they produce, one must not forget the pure moly play - Thomson Creek Metals (**Bloomberg - TCM: CN**).

How much, if at all, the balance sheets of these companies derive value from any rhenium to be found in the moly concentrates they produce would need further investigation. As, indeed, it would for other, smaller, pure-play moly mines such as Roca Mines Inc (**Bloomberg Ticker - ROK: CN**), General Moly (**Bloomberg Ticker - GMO: US**) and Moly Mines (**Bloomberg Ticker - MOL: CN**). Since China, too, is a rhenium producer, the same would also be true for such publicly quoted Chinese moly producers as Jinduicheng Molybdenum (**Bloomberg Ticker - 601958: CH**) and China Moly (**Bloomberg Ticker - 3993: HK**).

Finally, never forgetting to extol the virtues of scrap, I would have suggested looking at producers of secondary rhenium, particularly in Germany, a major producing country. However, unfortunately, Advent International and The Carlyle Group have already snapped up H.C. Starck GmbH and K.G. Company, and W.C. Heraeus GmbH remains, as it has been for the last 155 years, a private company.

Conclusion

Demand for rhenium looks unlikely to weaken for some time, especially in these times both of high fuel prices and environmental concern. And any new uses for the metal will only strengthen this demand further.

The rhenium market is currently tight, and appears set to remain so for some time. The price of the metal remains high, but without any new primary capacity coming to market soon, it does look under-pinned. The question remains, however, just how much in stocks remains lying around to fill any supply/demand gap: It may not be that much.

While rhenium is, essentially, a moly play (and always will be), this should not prevent an investor particularly interested in the metal from keeping an eye open for, I am sure, what will be only ever-increasing mentions of it in mining discoveries - for example, that of the Canadian mining concern MetalCORP (**Bloomberg Ticker - MTLCF: US**) back at the end of June this year.

Keep your eyes open!

Resources

Minor Metals Trade Association (MMTA)
Roskill Information Services Ltd
U.S. Geological Survey