JOM, Vol. 67, No. 2, 2015
DOI: 10.1007/s11837-014-1289-0

Critical Metals Hydrometallurgy

HARALD OOSTERHOF[1,2]

1.—Umicore, Watertorenstraat 33, 2250 Olen, Belgium. 2.—e-mail: harald.oosterhof@eu.umicore.com

In 2013, the E.U. Ad hoc Working Group on Raw Materials published its second criticality analysis report.[1] The motivation to write this report came from the observation that in today's world, our economies become more and more dependent on a number of metals and raw materials. Achzet et al.[2] visualized the growing importance of metals in our daily life by mapping the elements that are used in so-called energy pathways. Whereas in medieval times only base metals like copper and iron were used for the construction of steam engines, the number of metals required for modern (automotive) combustion engines increased significantly in the last century. Nowadays, with the growth of renewable energy, the number of metal accrued even further and examples such as wind energy (application of neodymium and dysprosium in magnets) and solar energy (indium, germanium, gallium, selenium and tellurium in various types of thin-film cells) are self-explanatory. It is therefore not a surprise that most of these metals are also mentioned in the *Critical Materials Strategy* that was published by the U.S. Department of Energy in 2011.[3]

In their analyses, the European Union and the Department of Energy applied more or less similar assessment methods to analyze the criticality of a number of metals and raw materials. Both publications examined two assessment components: the importance of the metal for their economy on the one hand and the risk of supply on the other hand (see Fig. 1). Each report subsequently proposed substitutability and recycling as solutions to reduce the supply risk. Especially, recycling is viewed as an alternative to primary production in countries with poor governance.

The result of the European exercise is visualized in Fig. 1 and the highlighted area (top right) is used to draw attention to the metals that are considered critical: Here, supply risk and economic importance are both high.

As can be seen, both heavy and light rare-earth metals are considered critical, which is an obvious result of the growth of a number of "clean-tech" applications (such as wind energy, rechargeable batteries, and low-energy lighting) and the tightened Chinese export quotas. The graph, however, also visualizes the criticality of several less obvious metals.

The Rare Metal Extraction & Processing 2015 symposium at the 2015 TMS Annual Meeting in Orlando, FL, will focus on the processing of a number of the metals that are also considered critical in Fig. 1. Work on rare-earth metals, precious metals, beryllium, tungsten, and indium is presented in the various sessions of this symposium.

The present *JOM* topic features three articles that deal with recycling of some of these critical metals. Recycling is considered one of the remedies against risk of supply, and it can provide an alternative to primary production, which is not only strategic but also sustainable. As will become clear from the three articles, development of hydrometallurgical recycling processes is challenging at a number of different levels. The articles by Inoue and Alam on liquid crystal displays and Steinlechner and Antrekowitsch on automotive catalyst recycling describe *novel processes* that are devised to treat new streams of end-of-life waste, whereas the article by Robertz et al. on germanium focuses on sustainability assessment of already *existing* processes, both hydrometallurgical and pyrometallurgical. Each article is written in such a way that it offers easy access to the broader *JOM* public. It is the aim of the Hydrometallurgy and Electrometallurgy Committee to keep paying attention to this kind of publications to further stimulate and visualize the work that is currently being done in the field of recycling of various critical metals.

The following articles being published under the topic of Critical Materials Hydrometallurgy provide excellent details and research on the subject. To

Harald Oosterhof is the guest editor for the Hydrometallurgy and Electrometallurgy Committee of the TMS Extraction & Processing Division, and coordinator of the topic Critical Metals Hydrometallurgy in this issue.

(Published online January 13, 2015)

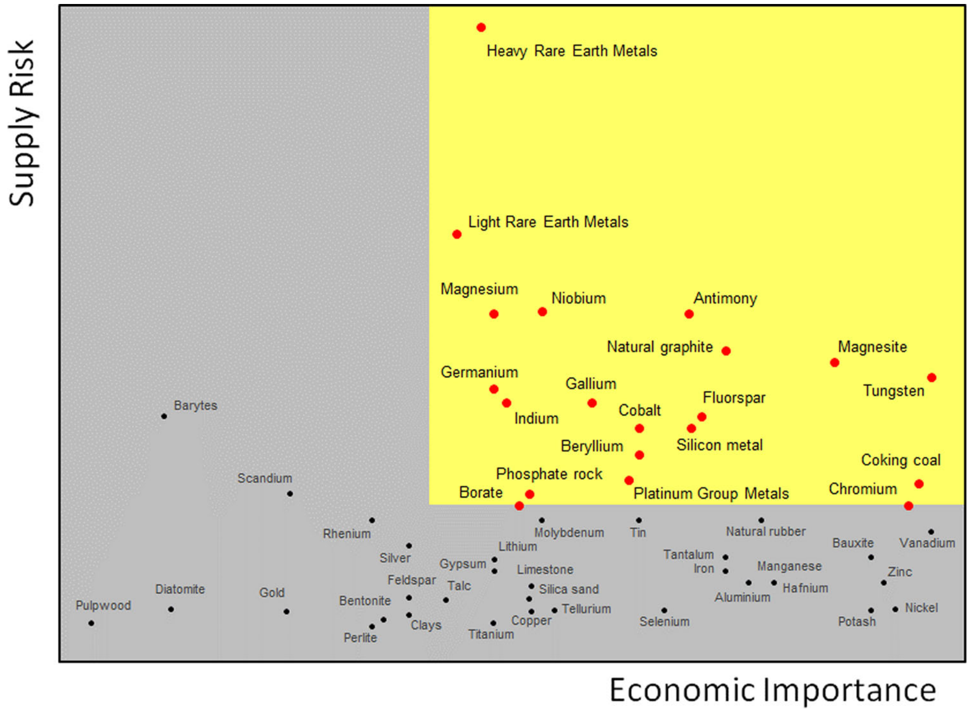

Fig. 1. Assessment of the criticality of a number of metals based on economic importance and the supply risk.

download any of the papers, follow the URL: http://link.springer.com/journal/11837/67/2/page/1 to the table of contents page for the February 2015 issue (vol. 67, no. 2).

- “Hydrometallurgical Recovery of Indium from Flat-Panel Displays of Spent Liquid Crystal Televisions,” by Katsutoshi Inoue and Shafiq Alam
- “Potential of a Hydrometallurgical Recycling Process for Catalysts to Cover the Demand for Critical Metals, Like PGMs and Cerium,” by Stefan Steinlechner and Jürgen Antrekowitsch
- “The Primary and Secondary Production of Germanium: A Life-Cycle Assessment of Different Process Alternatives,” by Benedicte Robertz, Jensen Verhelle, and Maarten Schurmans

The list of references is given for further reading on the topic of critical metals.

REFERENCES

1. European Commission, *Report on Critical Raw Materials for the EU*, Report of the Ad hoc working group on defining critical raw materials (Brussels: European Commission, 2014), http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/crm-report-on-critical-raw-materials_en.pdf.
2. B. Achzet, A. Reller, V. Zepf, C. Rennie, and M. Simmons, *Materials Critical to the Energy Industry: An Introduction* (Augsburg: University of Augsburg, 2011).
3. U.S. Department of Energy, *Critical Materials Strategy* (Washington, DC: U.S. Department of Energy, 2012), http://energy.gov/sites/prod/files/DOE_CMS2011_FINAL_Full.pdf.