Living in the Material (Mineral?) World

From the time we first tamed fire and then materials such as iron, steel, plastics, and silicon to when we landed on the moon, the human race has gone to far-flung lands in search of natural resources. Christopher Columbus set sail in 1492 for India to afford Spain entry into the lucrative spice trade. The British East India Company set up shop in India during the period 1757-1858 to trade in cotton, silk, indigo dye, saltpetre, tea, and opium. Perhaps a lesser known aspect of Charles Darwin's expedition on the HMS *Beagle* was his discovery of natural deposits of sodium nitrate or *salitre* near the Andes Mountains in Chile. However, off the coast of Peru was an even more vast and precious deposit, which fueled a steady stream of ships from Europe in search of the world's best natural fertilizer (at least at that time)—namely *guano*—over a period of twenty years from the 1840s to the 1860s. With the subsequent discovery that nitrates could be used not only to grow food but also to make gunpowder and high explosives, this precious resource took on strategic implications for a country like Chile. (Chile features again in the discussion below.) A turning point came at the dawn of the 20th century when two German scientists, Fritz Haber and Carl Bosch, developed a synthetic process for making ammonia from hydrogen and nitrogen. How this revolutionary "bread from air" process saved millions of lives but also killed millions during the two world wars has been eloquently described in Thomas Hager's book, *The Alchemy of Air*.

Much has been written and discussed (including in this column and these magazine pages) about declining fossil fuel resources ever since a Texan geophysicist, M. King Hubbert, predicted in the 1950s and 1960s that the world's oil production would peak and then decline. However it is not just energy resources that we should be concerned about. Copper, for example, underpins many critical industrial sectors because of its high electronic and thermal conductivity and we are faced with an increasing demand for it. Noble metals (*e.g.*, Rh, Pt, Ga) are essential to automobile catalytic converters, and in energy conversion devices and chemical processes. Rare earth elements play a key role in media and communication devices. Recycling of these materials (a lesson we can learn from the lead acid battery industry that has done it so well) will increasingly play a critical role to their sustainable use. Equally significant, the search for more "earth-abundant" material substitutes is a very important area of R&D and one where the Society membership can make crucial technical contributions. On a broader scale, countries such as China and Russia are paying increasing attention to natural resources. For example, China was a significant global leader in 2009 in the production of key resources such as zinc, tungsten, iron ore, gold, phosphate, tin, and rare earths. Its recent forays into the mining and metal sectors in Australia and the African continent obviously have strategic implications. The discovery of vast deposits of copper, cobalt, gold, iron, and lithium in Afghanistan has also stirred up considerable media interest.

On my recent scan of a Web listing of natural resources listed on a country-wide basis (http://nationmaster.com/graph/geo_nat_res-geography-natural resources), the very rich natural resource base of several nations in the African continent (*e.g.*, South Africa, Sierra Leone, Congo, Burundi, Cote d'Ivoire, Gabon, Ghana, Mali, Namibia, Somalia, Tanzania) was particularly striking. Morocco has 75 percent of the world's phosphate reserves. Other parts of the world boast significant natural resources as well. The largest reserve base of lithium lies in Bolivia while the U.S. Geologic Survey estimates that Chile has the largest annual production of this metal. The human race's endless search for natural resources frequently clashes with environmental concerns. The proposal to build a huge copper mine in Alaska's Bristol Bay region (*National Geographic*, December 2010) is one such example of this dichotomy. Human beings have always had the "treasure-seeking impulse" as noted by the author, Saleem Ali, in his recent book: *Treasures of the Earth: Need, Greed, and a Sustainable Future*. He also writes about the "resource curse" exemplified by the civil wars in African countries spurred by natural resources such as diamonds.

This special issue of the magazine also has a material-oriented theme and features yet another form of carbon, namely graphene. This two-dimensional material has come to the fore from both fundamental and practical application perspectives as discussed in the pages that follow. Stay tuned.

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