The Role of Geochemistry and Mineral Chemistry in Sustainable Development

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The chemical sciences have a broad reach into the fields of technology, economy, and human health, and there are already diverse ways chemists are contributing to support global sustainable development. American Chemical Society (ACS) has identified United Nations' seven priority Sustainable Development Goals (SDG) that are foundational to the work of the chemistry community. These are: (1) Zero Hunger, (2) Good Health & well Being, (3) Clean Water & Sanitation, (4) Affordable & Clean Energy, (5) Industries, Innovations & Infrastructure, (6) Responsible consumption & Production and (7) Climate Action. Geochemistry or Mineral chemistry has an important role to play in achieving each of the above goals.

The prosperity of our societies and standards of living are directly related to the ability to find, exploit, and manage metal and mineral resources. Metal and mineral deposits are, in fact, geochemical anomalies and, as such, applied geochemistry plays a critical role throughout the mineral resources value chain, from early-stage exploration to mine closure including rehabilitation. The fundamentals of element mobility (i.e., transport and fixation) in the near-surface environment are used by geochemists to detect mineral deposits at depth, reveal element distributions in and around deposits, assess the total geochemical environment, and decide on effective and environment-friendly extraction and waste disposal techniques. Both pure and applied research ventures play fundamental roles in providing the techniques to manage metal resources and thereby benefit society. During mine operations and mine-closure activities, the oxidative dissolution of sulfidic minerals releases extremely acidic leachate, sulphate and potentially toxic elements such as As, Ag, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Th, U, Zn from different mine tailings and waste dumps. For the sustainable rehabilitation and disposal of mining waste, the sources and mechanisms of contaminant generation, fate and transport of contaminants have to be clearly understood.

With projections of population growth to nearly 9 billion people by 2050, the world needs adequate supplies of mineral raw materials for industry and fertilizer to fulfill the aspirations of the growing population. Recycling and substitution will play an important role in supply but cannot eliminate the demand for primary resources in the coming decades. This is largely because mineral stocks are locked in durable infrastructure that cannot be recycled immediately. Recycling of discarded material originally extracted from minerals will be a challenge for the scientists. Researchers including metallurgists and geochemists are currently collaborating under the theme of "Wealth from Waste" to invent new recycling technologies in this field. This group focuses on 'Mining above Ground Resources', which are the metals contained in collections of discarded manufactured products and consumer goods.

Geochemistry has contributed significantly to the understanding of ground-water systems over the last 50 years. Historic advances include development of the hydrochemical facies concept, application of equilibrium theory, investigation of redox processes, and radiocarbon dating. Hydrochemical and isotopic information can be used to interpret the origin and mode of ground-water recharge. Geochemical techniques are the key tools to assess ground water quality, identify toxicity and recommend permissible (safe) levels as well as remediation processes. Hydrogeochemical and soil geochemical mapping are extremely useful tools in mineral exploration, land-use planning, environmental monitoring, understanding geo-medical issues and soil nutritional/toxicity properties (i.e. Se deficiency, As-Cd toxicity, Skeletal-Dental Fluorosis, Chronic Kidney Decease). Sri Lanka has made some progress in producing these geochemical data sets but limited spatial coverage and poor sample density impair their applications.

Climatologists have found that global greenhouse gas emissions need to reach zero by around 2050 to avert the worst effects of climate change. Many of the world's leading economies have set goals to eliminate pollution from fossil fuels in the next few decades. Both generation and storage of clean energy require increased quantities of minerals like silica, graphite and cobalt-nickel ore. For example, an electric vehicle requires six times more mineral material than a car that runs on fossil fuels. According to International Energy Agency the world isn't mining enough minerals to reach a future that runs on clean energy (IEA). In fact, mineral ores containing chemical elements such as Li, Co and Ni are the building blocks for clean energy economies. Countries can't meet their new climate goals without sufficient quantities of these minerals. Thus, exploration geochemists will have a heightened responsibility to explore suitable deposits containing these materials. Another growing area that contributes to the sustainability of mineral raw material is nanotechnology. Development of nanomaterial-based batteries with higher storage capacities will boost the industry that produce clean energy. Research is also advancing towards replacing rather inefficient silica cells with nano particles. Applications of graphene technology in sustainable development efforts are highly promising, yet to be fully evaluated. Sri Lanka has the advantage of having world's purest graphite deposits with C>99.5% in developing and promoting natural graphite-based graphene products. Geological carbon-sequestration is promising greenhouse gas mitigation technology. It is estimated that at least 2000 Gt of CO2 can be accommodated underground globally. Geochemistry plays a significant role in many aspects of geologic carbon sequestration, from dissolution and precipitation of minerals in the reservoir and seal rocks, to modification of the properties of mineral surfaces and their effects on fluid flow and capillary trapping. This abstract has attempted to summarize and highlight some of the key areas where our geochemical and mineral chemical understating is essential in the global sustainable development efforts. In this context the important role played by geochemists and mineral chemists can't be overemphasized.

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