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Commentary on Geochemistry

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Commentary

Geochemistry is the science that uses the tools and principles of chemistry to explain the mechanisms behind major geological systems such as the Earth's crust and its oceans. The realm of geochemistry extends beyond the Earth, encompassing the entire Solar System and has made important contributions to the understanding of a number of processes including mantle convection, the formation of planets and the origins of granite and basalt. It is an integrated field of chemistry and geology.

The term geochemistry was first used by the Swiss-German chemist Christian Friedrich Schönbein in 1838: "a comparative geochemistry ought to be launched, before geochemistry can become geology, and before the mystery of the genesis of our planets and their inorganic matter may be revealed." However, for the rest of the century the more common term was "chemical geology", and there was little contact between geologists and chemists.

Geochemistry is a broad and fascinating subject both in terms of the topics it addresses and the techniques employed. The Geochemistry section of the Earth Systems and Environmental Sciences module contains many articles discussing state-of-the-art information on the techniques and technical innovations available to the modern geochemist and how the tools and principles of chemistry have been brought to bear on the full range of problems in the Earth and Environmental Sciences. Victor Goldschmidt (1888–1947) is often considered the 'father of geochemistry'. One of Goldschmidt's achievements was to begin to systematize the behaviour of the chemical elements in an Earth Sciences context via his classification of them according to their preferred host phases on silicate Earth. This is still one of the most widespread geochemical classifications of the elements today and was an important step in terms of bringing the principles of chemistry to bear on the study of the Earth.

A field as broad as geochemistry has naturally evolved to be subdivided, at various levels, into sub-disciplines. These sub-disciplines are distinguished from each other in several different types of ways and there is considerable overlap between them in many cases. Division criteria include: analytical geochemistry in contrast to theoretical studies, the technique being employed or the types of measurements an area is concerned with (e.g., isotope geochemistry); the type of sample (e.g., igneous geochemistry and organic and petroleum geochemistry); the class of scientific questions being addressed (e.g., cosmo chemistry); the pressure-temperature regime that a certain subset of geochemists are engaged with (e.g., low-temperature geochemistry).

Geochemistry is the study of the chemistry of natural earth materials and the chemical processes operating within and upon the Earth, both now and in the past. Geochemical analyses are carried out on any natural sample such as air, volcanic gas, water, dust, soil, sediment, rock or biological hard tissues (especially ancient biological tissues) and also on anthropogenic materials such as industrial effluent and sewage sludge. Geochemical analyses therefore involve a wide range of materials and analytes of interest and may be performed for industrial, environmental, or academic reasons. All of the naturally occurring elements in the periodic table are important for one geochemical investigation or another.

Geochemistry plays an essential role in our understanding of processes that produce economic concentrations of minerals whether by hydrothermal, magmatic, metamorphic, hydraulic (both surficial and subterranean) or weathering agents, or a combination of these. Geochemistry also contributes importantly to exploration. All of these aspects are thoroughly discussed in this volume by acknowledged experts. The objective is to produce a treatise on ore deposits focusing on their geochemistry but also including geological models for a complete understanding of their genesis and guides to their exploration. Many chapters constitute a timely update of the popular 'Geochemistry of Hydrothermal Ore Deposits' edited by my PhD supervisor, Hubert L. Barnes, and last published in a third edition in 1997. First, though, a short primer on what constitutes an ore deposit and what makes them of economic value.

A geochemical survey is based on the sampling of available earth materials in a given survey area. Depending on the size of the area and the sampling density, survey types can be roughly divided into continental, regional, targeting, and local scale. Geological materials are commonly refractory substances and may require aggressive chemical preparation prior to analyses. Several articles in this volume deal specifically with the chemical analysis of soils, waters, biological tissues, and organic geochemistry is also covered separately. This article concentrates on analysis of the inorganic constituents of the materials most closely associated with geology—rock forming minerals.

Another useful classification scheme for geochemistry is the Goldschmidt classification, which places the elements into four main groups. Lithophiles combine easily with oxygen. These elements, which include Na, K, Si, Al, Ti, Mg and Ca, dominate in the Earth's crust, forming silicates and other oxides. Siderophile elements (Fe, Co, Ni, Pt, Re, Os) have an affinity for iron and tend to concentrate in the core. Chalcophile elements (Cu, Ag, Zn, Pb, S) form sulfides; and atmophile elements (O, N, H and noble gases) dominate the atmosphere. Within each group, some elements are refractory, remaining stable at high temperatures, while others are volatile, evaporating more easily, so heating can separate them.

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