

PRESIDENTIAL ADDRESS

SPECIAL COLLECTION: APATITE: A COMMON MINERAL, UNCOMMONLY VERSATILE

The many facets of apatite†‡

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ABSTRACT

In the past 150 years, with the discovery of petroleum and the invention of the gasoline-powered internal combustion engine, the rate of extraction of minerals from the Earth has made humans a geologic agent for the first time in the history of the planet. Unprecedented changes have resulted in human society as a result of this extraordinary use of minerals, and perhaps no mineral illustrates that linkage more than the mineral apatite; even the exponential growth of the human population to seven billion Earth inhabitants has been allowed by the extraction of sufficient P from apatite ore to provide fertilizer to feed the planet's population. Apatite is used extensively in various geological applications, including dating techniques and studies of rare earth element variation in rocks, and is also widely used in material science and medical applications. Apatite forms virtually all hard parts of the human body, and the bioengineering of anion exchange in the apatite material of human tooth enamel through fluoridation is considered one of the top 10 public health achievements of the twentieth century by the U.S. Centers for Disease Control. In addition, the carbonate content of apatite calcifications is currently being investigated as a non-invasive tool in distinguishing between benign and malignant breast tumors. In material applications, apatite is the principle raw material in the fluorescent lighting industry, and its unique crystal chemical properties make it useful in the production of lasers with controllable properties. Apatite is increasingly being employed in the environmental remediation industry through the process of phosphate-induced metal stabilization (PIMS), and its properties make it a useful material for the storage of radioactive waste as substituents in the Ca sites.

Despite its remarkable utility and its fundamental role in feeding the world's population, the details of the apatite atomic arrangement are not fully understood. The Ca phosphate apatites are an anion solid solution (F = fluorapatite; OH = hydroxylapatite; Cl = chlorapatite), and the anion positions in binary and ternary members of the solid solution are not predictable from the anion positions in the pure end-members because of steric effects of anion-anion interactions. Recent attention has focused on a more complete understanding of the apatite atomic arrangement and its properties, both in inorganic and biominerals apatites, and knowledge of the atomic arrangement is advancing. Apatite illustrates the role of minerals in the evolution of modern society, and also the importance of research in the mineral sciences in the broadest sense.

Keywords: Apatite, phosphate, crystal structure, minerals and society