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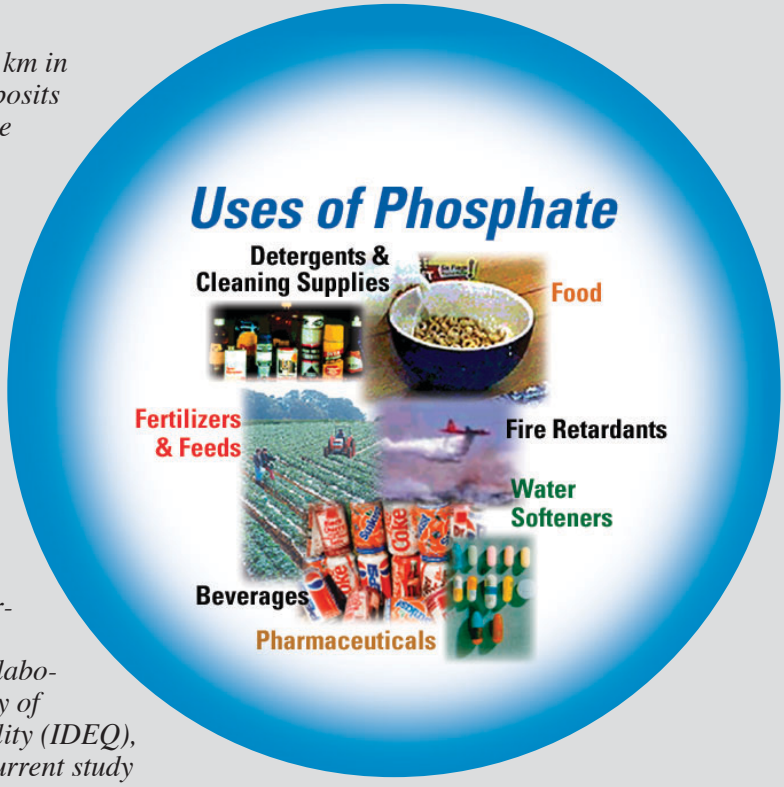
Mineral Resources Program

Western Phosphate Field, U.S.A.: Science in Support of Land Management

Introduction

The Western Phosphate Field, an area of 350,000 sq km in the northern Rocky Mountains, contains extensive deposits of commercial-grade phosphate. The thick, high-grade phosphate deposits constitute an important economic resource that has been mined for almost 100 years. The principal use for phosphate is as fertilizer. However, products derived from phosphate are also used in other industrial applications, such as the production of fire retardants, detergents and cleaning supplies, pharmaceuticals, food and beverages, feed, herbicides, and water softeners. Currently five open-pit mines are operating in the Western Phosphate Field (four in Idaho and one in Utah) that produce about 12 to 14 percent of total U.S. phosphate production.

USGS scientists are in the final stages of a multidisciplinary study focused on the Western Phosphate Field in southeastern Idaho (fig. 1). This study, undertaken in response to a request by the U.S. Bureau of Land Management (BLM), has been conducted in collaboration with the U.S. Forest Service (USFS), University of Idaho (UI), Idaho Department of Environmental Quality (IDEQ), and regional phosphate producers. The goal of the current study was the characterization of the primary phosphate ore bodies and adjacent rock units. In addition, it is important when studying phosphate to examine the geoenvironmental issues, consequently, the studies were expanded to include an examination of the residence, mobility, and pathways of elements of environmental concern, such as selenium, that are associated with phosphate.



Phosphate and phosphoric acid, refined from the phosphate, have many uses in common products used in everyday life.

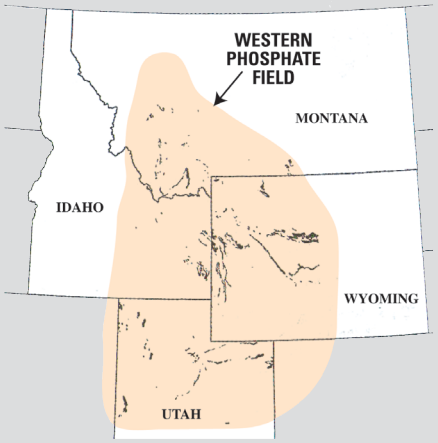


Figure 1. *The Western Phosphate Field is a 350,000-square-kilometer area of the northern Rocky Mountains. Darkened areas represent exposures of the Phosphoria Formation.*

Geologic and Resource Background

The phosphate deposits are contained in marine sedimentary rocks that were deposited about 265 million years ago on the western margin of North America. The phosphate-bearing layers of rock are called the Phosphoria Formation. These rocks consist primarily of organic carbon- and phosphate-rich mudstone, siltstone, phosphorite, carbonate, shale, and chert deposited over a period of about 10 million years (m.y.). The deposits were later severely deformed by folding and faulting, with the youngest faulting occurring during formation of the Basin and Range Province, about 10 to 20 m.y. ago. As a result of variations in the original depositional environment, such as water depth and distance from the ancient shoreline, the formation is generally thickest in southeastern Idaho and thins to the north, east, and southeast. Phosphorite is a sedimentary rock with a high enough content of phosphate minerals to be of economic interest. Total production from marketable phosphate in the Western Phosphate Field since 1911 is 230 million metric tons, 12 percent of the cumulative production for the United States. The Western Phosphate Field reserves, containing 24 percent phosphate, are 1.6 billion metric tons. These reserves constitute 3 percent of world reserves and 30 percent of U.S. reserves. Phosphate mining constitutes the largest mineral industry of Idaho, producing more than $600 million in processed mineral value in 1997.

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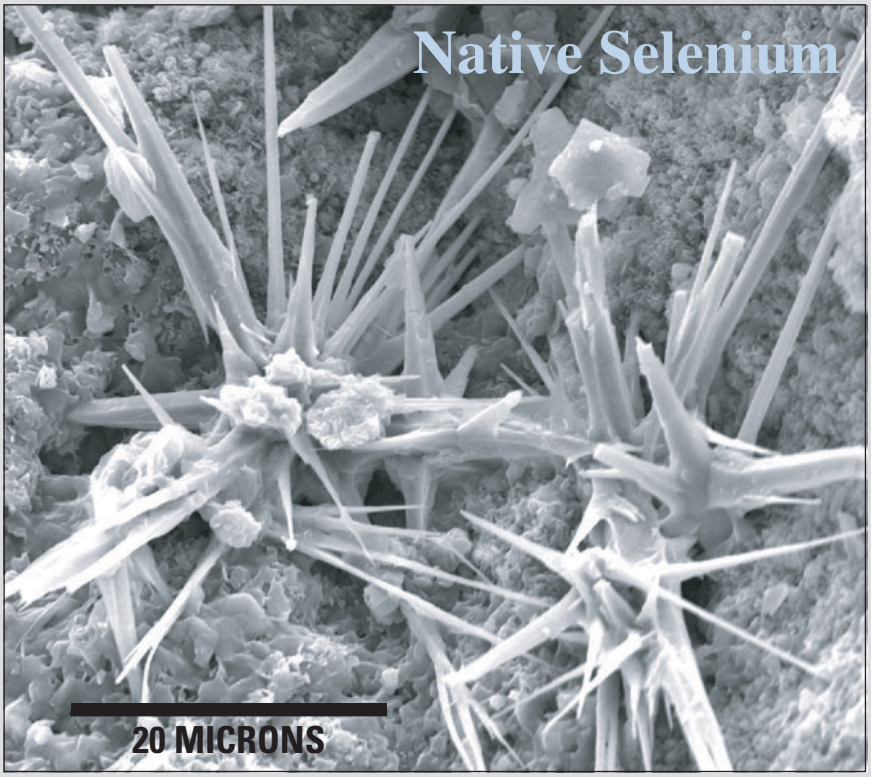
In southeastern Idaho, phosphate is mined from two high-grade zones in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation. The ore zones enclose a middle waste zone about 25 to 30 m thick composed of low-grade phosphatic shale. The low-grade rocks are placed in waste piles along with unmineralized rock that is removed to expose phosphate-bearing rock rich enough to be mined. The waste pile rocks contain elements of environmental concern including selenium, cadmium, chromium, copper, molybdenum, vanadium, uranium, and zinc.

USGS Studies

Responding to a request from the BLM, the USGS coordinated studies with USFS, UI, and IDEQ designed to update resource estimates for the Western Phosphate Field and collect information on the sources and concentrations of potentially toxic elements associated with the extraction of phosphate. As a result of these studies, the main ore bodies and waste zones were characterized, estimates of the grade and tonnage of phosphate resources on public lands were revised, and geoenvironmental investigations were conducted.

The work in the Western Phosphate Field was expanded to include geoenvironmental studies because the process of leaching that occurs on the phosphate mine waste dumps by ground water and surface water releases potentially toxic elements into the environment. Some of these toxic elements are concentrated in the biota and water. One of these elements is selenium which occurs naturally, is essential for life, but an element that can be harmful where it is found in elevated concentrations.



Native selenium rosettes in the Meade Peak Phosphatic Shale Member.

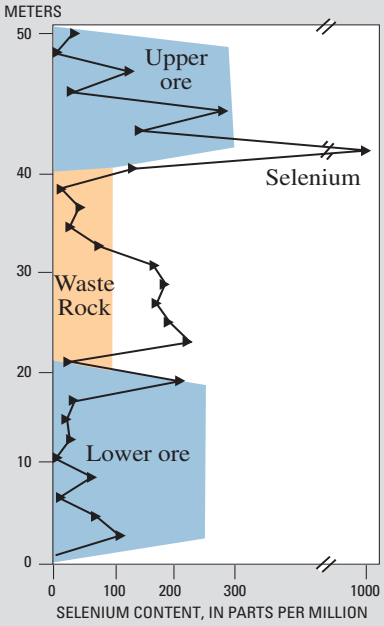


Figure 2. *Selenium content is variable in different rock layers and was measured in the upper and lower ore zones of the Meade Peak Phosphatic Shale Member, as well as in the middle zone that contains only low-grade phosphatic shale. The black line indicates selenium concentration in amounts ranging from 1 to more than 1,000 ppm (parts per million) and compares it with the amount of phosphate in each unit (color bars).*

Selenium is widely but unevenly distributed in the Earth's crust and is commonly found in sedimentary rocks. Although the abundance of selenium in shales of the Earth's crust generally averages only 0.6 parts per million (ppm), results of the current research reveal selenium contents that range from 1 to greater than 1,000 ppm in samples of the Meade Peak Member (fig. 2). Selenium is present in several phases including native selenium, sulfide minerals such as pyrite and sphalerite, iron oxides, and organic matter. The selenium content of the different rock layers are variable, but results indicate that selenium is more abundant in less-weathered rock.

In soils, selenium combines with oxygen to form soluble compounds such as selenite and selenate. The selenate compounds that occur in water are absorbed by some plants, which transform them into organic forms. Some of the plants that were sampled were found to have concentrated selenium levels that may be harmful to wildlife and livestock. Selenium is able to migrate from the natural state into the water and through plants and animals into the food chain. The USGS is working with other Federal and State agencies to identify the sources of selenium and provide information on how it affects plants and animals in the region.

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