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RARE EARTH ELEMENTS
by Lloyd C. Pray

Although the rare earth elements are little known metals, they constitute about one-sixth of the known elements. Some of the rare earth elements are more abundant in the earth's crust than many of the more familiar metals such as lead, tin, and molybdenum. The rare earths are somewhat similar in their chemical properties, and the minerals from which they are obtained commercially ordinarily contain several of them. Most industrial applications of the rare earths have utilized such mixtures in the form in which they are recovered from the minerals. The rare earths are becoming increasingly significant in modern industrial technology as new uses for these elements are developed, and the demand probably will increase both for the mixture and for purified rare earth elements. At present the rare earths are used in industry principally in the production of special types of glass; in cores of carbon-arc electrodes for photographic and projection equipment; in pyrophoric alloy such as lighter "flints"; and as an additive to alloys of steels and lighter metals.

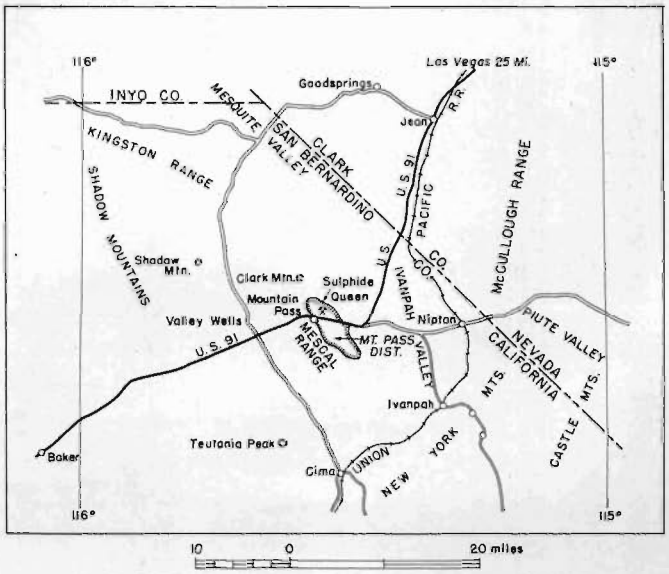
The largest deposit of high grade rare earth minerals known in the western hemisphere, and with but one possible exception in the world, occurs in the Mountain Pass district of southeastern San Bernardino County, California, where rare earths were discovered in 1949-50. Bastnaesite, a fluocarbonate mineral of the cerium group rare earths, forms about 10 per cent of a body which has an areal extent of about 20 acres, and a minimum proved thickness of 50 feet. This deposit has sufficient easily mineable reserves to permit a many-fold increase in world consumption of the cerium group, the most widely used rare earths at the present time.

Most of the rare earths of commerce have been obtained from monazite, a rare earth phosphate, which is also the major source of thorium. Large reserves of monazite occur in India and Brazil, where the mineral is recovered from "black sand" concentrates of beach or alluvial deposits. A monazite lode deposit of South Africa has been of major significance in recent years. The domestic reserves of placer monazite are now known to be appreciable, largely in Idaho and in the southeastern Atlantic states. California contains both primary and placer deposits of monazite, but there has been little or no commercial production from these to date.

Geochemistry

The major rare earth elements, as they are usually classified, are 16 in number. All of the elements with atomic numbers from 57 to 71 are in the rare earth group. In addition, the element yttrium (atomic number 39) is also generally included, owing to its chemical similarity to the other rare earth elements. Some authorities include the elements scandium (Sc, atomic number 21), and thorium (Th, atomic number 90) in the rare earth group on the basis of certain similarities. Scandium is not closely related in mineral occurrence to the rare earths, and therefore is not considered in this article.

Most naturally occurring rare earth-bearing minerals contain mixtures of several rare earth elements of very similar chemical properties. The general similarity of chemical behavior of rare earth elements is explained on the basis of their atomic configuration. In general, if elements are arranged in order of increasing atomic number, each successive element differs appreciably in its chemical be-



Index map of a part of eastern California, showing location of Mountain Pass rare earth district and Sulphide Queen mine.