of Trout Waters," emphasized conditions in the Inter-Mountain Region. Marion J. Madsen spoke on the objectives of management, chief of which is to "provide satisfactory fishing for the largest number of anglers at the most reasonable cost." James W. Moffett discussed environment and management, with emphasis on the fact that each body of water is a separate problem and that neither the general survey nor the intensive study is the sole approach. James R. Simon spoke on administrative considerations in the methods of management. He stated that "hatcheries still have a place in trout management but that the exaggerated claims for their success must be revised in view of the efficiency of natural reproduction."

A round table discussion on reptiles, "Seasonal Behavior Patterns," was led by A. M. Woodbury. The points discussed included the effects of temperature, humidity, light and other factors on such habits as denning and solitary hibernation, feeding, migration, breeding, etc.

Papers read at the general session included those on fish pigment by F. B. Sumner, fossil fish scales by L. R. David, proportion of scale length to fish length by L. D. Townsend and H. L. Connor, aboriginal use of fisheries by G. W. Hewes and the shark fishery by R. S. Croker.

Officers of the Western Division of the society for the ensuing year are: *President,* W. C. T. Herre, Stanford University; *Vice-President,* Raymond B. Cowles, University of California, Los Angeles; *Secretary,* Richard S. Croker, California Division of Fish and Game, Terminal Island, California.

(*To be concluded*)

THE RESOURCES OF THE CONTINENTS[1]

By Dr. KIRTLEY F. MATHER

PROFESSOR OF GEOLOGY, HARVARD UNIVERSITY

ANY consideration of the changes that are likely to occur during the next few years in the social and political life of man must include the inescapable fact that the demands upon mineral resources are certain to increase. Not only in war but also in peace, human efficiency and comfort are increasingly dependent upon metallic ores, mineral fuels and the products of the ground. No matter what may be the nature of the new order for which men fight and plan and work, it can become a reality only if it is adjusted both to the peculiarities of human nature and to the characteristics of the physical resources available in this terrestrial environment. It is worth while, therefore, for all concerned with the fate of man to give careful thought to the nature and distribution of the raw materials with which Mother Earth's storehouse is stocked.

These basic requisites for modern civilization occur under certain well-defined geological conditions. Their distribution is by no means haphazard or unpredictable. Now that the general geological structure of all the continents is known and the specific occurrence of many valuable mineral deposits has been studied, it is possible to estimate with some degree of accuracy the total stores of the more important metals, fuels and other minerals that are available for human use, and to compare the relative wealth of the several continents with regard to mineral resources.

It may help in making such a survey to group the rocks of the earth's crust in three categories. First there are the very old, and generally much contorted or compressed rocks of the Basement Complex or Pre-Cambrian terrane. These include vast bodies of granite and other igneous rocks, many of them intensely metamorphosed, as well as sedimentary rocks that likewise have been greatly altered by heat and pressure during the many vicissitudes of crustal movement and volcanic eruption that have affected them throughout the long ages of subsequent geologic time. These ancient rocks contain many rich bodies of metallic ores, such as those yielding gold, silver, copper, nickel and iron. Nowhere do they contain coal, petroleum or the ores of such metals as aluminum and magnesium.

There are extensive areas of Pre-Cambrian rocks in every continent, and no large unit of these rocks has thus far failed, when adequately prospected, to be the source of essential metals. The Canadian Shield surrounding Hudson Bay in North America is matched by the Scandinavian Shield of northwestern Europe and the Angara Shield of north-central Siberia in Asia. In the southern hemisphere, the Brazilian Shield of South America is matched by the extensive bodies of Pre-Cambrian rock in south and central Africa and the Basement Complex of Australia.

The second group of rocks in this very loose classification of mine includes the sedimentary formations of Cambrian and post-Cambrian age. These may be flat-lying beds beneath the plains and in the plateaus or they may be wrinkled into mountains like the

[1] World-wide broadcast of the American Philosophical Society and WRUL, Philadelphia, July 17, 1942.

Appalachians. It is from these that the world's resources of coal and petroleum are secured, as well as much of the potash and magnesium and some of the iron and non-ferrous metals. Here too it should be noted that every continent has its share. The wide-spread basin of the Mississippi Valley in North America is matched by the extensive area of sedimentary rocks in central Europe between the Alps and the Scandinavian highlands. The vast lowland of the Amazon in South America finds its structural counterpart in the interior basin of Australia and the broad plains of north central Asia.

The third major type of geologic structure is that resulting from and associated with volcanic activity. Here the geologist has in mind not only the outpoured lavas and erupted cinders, ash and bombs of volcanic cones and plateaus. He thinks also of the intruded masses of igneous rock that crystallized in the conduits leading to the volcanic vents, or spread out in sheets or dome-shaped bodies in the upper part of the earth's crust without ever actually breaking through to the surface. It is in association with such rocks, especially those of Tertiary age, that some of the world's most important reserves of precious metals, of copper, lead and zinc, and of such metals as tungsten, vanadium, molybdenum and manganese, essential in the production of modern steel alloys, are found. Here, again, we observe that nature plays no favorites, so far as continents are concerned. The volcanic terranes of North America's western mountains have their equivalent in the Andes of South America, the festooned arcs of many a mountain system in eastern and southern Asia, the plateaus and cones of central Africa.

The fact is that every continent displays almost the entire gamut of possible geologic structures and therefore may be expected to contain extensive deposits of almost every kind of mineral resource useful to-day or likely to be useful in the future as a raw material of industry. Although the United States alone has thus far produced more than two thirds of the world's entire production of petroleum, this is because Americans have been more successful than any other people in finding and using this type of fuel. There is no chance that a century ago two thirds of the world's supply of petroleum was concentrated beneath the surface of the United States. On the contrary, with the exception of Australia, every continent probably contains petroleum reserves proportional to the entire total of the world's supply, as the area of each continent is proportional to the total land of the earth.

Similarly, the fact that, to date, Continental Europe, the United States, Great Britain and Russia have produced over 80 per cent. of the world's steel does not mean that the rest of the world contains only 20 per cent. of the earth's ores of iron. Instead it means that the inhabitants of the regions first mentioned have been most ingenious and efficient in discovering and utilizing the iron ore deposits that they possessed. The iron ores of Asia, Africa, Australia and South America for the most part await future development.

In other words, for the overwhelming majority of basically important minerals, each continent may be expected to have domestic sources, adequate when properly developed, to supply most of the needs of its inhabitants when the standards of living and the way of life everywhere attain the characteristics of modern industrial civilization. Mother Earth provides equality of opportunity; it is man that differs in responding to opportunity.

But this is not to say that nature favors continental isolation or regional self-sufficiency as the pattern for world organization. There are several significant exceptions to this glittering generality of equalized distribution of mineral wealth, continent by continent. Even when we remember that, for many purposes, molybdenum may be substituted for tungsten, coal for petroleum, and magnesium for aluminum, we find that at present and probably for a long time in the future, the inhabitants of no continent and therefore of no one country can "live to themselves alone," without sacrificing many of the benefits of modern civilization.

Outstanding among these exceptions is tin. Nature has played a strange trick in making tin ores scarce in the highly industrialized regions where the tin can is an essential item. There are practically no ores of tin in all North America, and the puny deposits of that metal in all Europe are competent to meet only 5 per cent. of the needs of Europeans.

Much the same can be said about the ores of nickel and of radium. These are found in only a few rare localities in only two or three of the six continents.

Even this hasty survey of the resources of the continents therefore leads us unerringly to the conclusion that if man is to make full use of the available mineral wealth, his social, economic and political organization must be on a planetary rather than a continental basis. Each continent has sufficient stores of raw materials to give it a place of equality with every other continent. From the geological point of view there is no basis for rating any continent as inferior to any other. But no continent can provide sufficient amounts of every ingredient of modern civilization to satisfy the needs of man. Only as each contributes freely and without hindrance to the welfare of all mankind can the resources of any be utilized to the best advantage.

The geologist can not escape the conclusion that the earth is far better adapted for occupation by men organized on a world-wide scale with maximum opportunity for free interchange of raw materials and finished products the world around, than for occupation by men who insist upon building barriers between regions even so large as entire continents.

OBITUARY

WILLIAM JOHN PETERS

THE death of Captain William John Peters on July 10 removed from American geophysics an outstanding scholar and investigator whose unselfish achievements in the field and laboratory are internationally recognized. He took part in almost every phase of research in earth physics and in quest of data he covered a large part of the earth's surface. Preeminent in his contributions was the geomagnetic work at sea and for which he invented and improved instruments making for more rapid and more accurate determinations.

Captain Peters was born in Oakland, California, on February 5, 1863, and was educated in the public schools there. After a short time as a student at the University of California, he was appointed as observer and computer on a survey of the boundary between two western states; in this work he gave much study to methods of astronomical determination not frequently used.

His important professional life began with appointment as assistant topographer in the U. S. Geological Survey in 1884. His advance through various grades was rapid. For several years he was engaged in geodetic work in the western states. During 1898–1901, as chief of party, he successfully completed difficult and important exploration in Alaska for the Survey and again during 1902 in Utah and Alaska.

This extensive experience, much of it in polar regions, fully qualified him for appointment as chief scientist and second in command of the Ziegler Polar Expedition of 1903–1905. Despite unusually severe meteorological and ice conditions, coupled with the loss of the expedition's vessel, Captain Peters succeeded in obtaining valuable 11-month series of geomagnetic data at Teplitz Bay, Rudolph Island, Franz Josef Archipelago, along with other material at Teplitz Bay, Cape Flora, and Alger Island, on aurora, meteorology, tides, geomagnetism, astronomy and map construction and surveys. In this his organizing ability and training of those associated with him were paramount factors. The extensive and detailed accounts of this work and of the resultant valuable geophysical data and discussions were published by the National Geographic Society in 1907 in a 630-page quarto volume entitled "The Ziegler Polar Expedition, 1903–1905: Scientific Results." The fact that the entire burden of the scientific program, except for only occasional assistance by other members of the expedition, was carried by Captain Peters and four assistants, makes this really a marked achievement in the history of polar exploration. Commander Anthony Fiala, of the expedition, regarded the amount of scientific work accomplished in the scant time available as "sufficient evidence of the indefatigable and persistent prosecution of the observations on the part of the scientific party."

Shortly after the return of the expedition, Captain Peters was appointed as chief magnetic observer and commander of the *Galilee* for the Department of Terrestrial Magnetism of the Carnegie Institution of Washington on her second and third cruises of over 52,000 miles in the Pacific Ocean and thus entered upon his second major service to geophysics. While on the *Galilee,* whenever possible, he experimented with the object of improving instruments and methods of magnetic observations at sea. As a result he developed the marine collimating-compass, which was destined to become the standard instrument for determining the magnetic declination on board the *Carnegie.*

As the result of the work done on the *Galilee* the special non-magnetic vessel *Carnegie* was designed along lines largely suggested by Captain Peters. He superintended her construction and commanded her first two cruises of over 100,000 miles, the second of which extended around the world with a total length of 92,829 nautical miles in 798 days. Important corrections to geomagnetic charts were found on this second cruise, particularly in the Pacific and Indian oceans. The detailed results and discussions obtained were published by the Carnegie Institution of Washington as the third volume in the series "Researches of the Department of Terrestrial Magnetism." These constitute a lasting memorial to the long labors and scientific genius of Captain Peters.

In 1914 Peters secured observations along the coasts of Labrador, Hudson Bay and Hudson Strait as well as at sea in Hudson Bay. Here again most valuable geophysical data were obtained despite unusual difficulties of season and navigation in the small three-masted schooner *George B. Cluett.*

Upon completion of the work in Hudson Bay, Captain Peters entered upon his third major service to geophysics in the direction at the Department of Terrestrial Magnetism of the compilations and discussions of the accumulated results at sea, the oversight of the continuing surveys at sea by the *Carnegie,* and the