field observations. The models are designed to simulate the characteristics observed in the prototypes.

(4) An attempt is being made to express the results of these studies in terms of rational laws. It is hoped that ultimately these rational laws can be arrived at independently and tested with the empirical data.

These studies are important for the control and regulation of rivers. Also, because rivers play an important part in the sculpture of the landscape, the studies of river morphology fit into the broader geological programs of the Geological Survey which are concerned with geological processes and their part in historical geology.

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## Geologic Map of Wyoming

A NEW full-color geologic map of Wyoming, which has been in preparation since 1946 by the U.S. Geological Survey, is now rapidly approaching completion. It will be an almost complete revision of the original state geologic map published in 1925, and a refined and slightly revised version of a black and white map of Wyoming published in a preliminary edition in 1952.

The new colored map shows the distribution, comparative thickness, and structural trend of various geologic units. Most of the major mountain ranges in the state are distinguished by a core of pre-Cambrian rocks surrounded by concentric outcrop bands of Mesozoic and Cenozoic rocks. Cenozoic rocks also cover a large part of the state outside of mountainous areas. Lava flows and related rocks are most common in the Yellowstone National Park–Absaroka Range area. Large-scale fold systems, delineated by parallelism of certain of the outcrop bands, are particularly noticeable in the west-central part of the state.

Of the 97,000 sq mi in the state of Wyoming, only the geology for 100 sq mi from the 1925 map was reused. Coverage for the remaining 96,900 sq mi was obtained from more than 200 detailed maps from diverse sources, all prepared since 1925. Many of these maps are published, but a large number are unpublished and the information is presented for the first time on the new map. The major sources of material for the new map are publications and files of the U.S. Geological Survey, the Wyoming Geological Survey, faculty and graduate students of the University of Wyoming, and several oil companies. An index map inset shows sources of material used in the compilation.

To emphasize the variation and changes in nomenclature of many of the geologic units in different parts of the state, a separate explanation is given for each of the four quadrants of the state. In many places where the outcrop of a formation is too narrow to be shown as a single unit, it has been included with another unit or a group of units. An outcrop so narrow that it would be less than 1/32 in. on a map could not be shown. Thus in an area where beds are vertical, only units that are thicker than 1300 ft could be shown as independent units.

Maps used in the compilation were mainly within the scale range of 1 : 24,000 to 1 : 63,360. These maps were reduced to the compilation scale of 1 : 400,000 either by photography or by means of a vertical projector. Maps of abnormally large scale were reduced to the compilation scale of 1 : 400,000 in two steps.

The new geologic map, which measures approximately 50 by 72 in. is at a scale of 1 : 500,000 (one in. equals about 8 mi). It is printed on a new base that shows county, state, and federal roads, land grid, settlements, and drainage. The map contains 142 geologic units, each identified by a pattern and by one of 17 different colors, depending upon the system to which it belongs. Seventeen different printing plates and as many press runs will be required to print the geologic map on the prepared base.

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## The Molybdenum Blue Reaction and the Determination of Phosphorus in Waters Containing Arsenic, Silicon, and Germanium

PHOSPHATE is an essential nutrient, and from a biological standpoint its determination provides a key to the understanding of one of the important biochemical cycles in the ocean. The accurate determination of phosphate in ocean waters is important to the geochemist because such data are essential to the formulation of possible mechanisms for phosphate rock deposition in marine environments and, similarly, are important to possible interpretations of the association and distribution of the small amounts of other elements usually found in phosphate rock.

Methods for the determination of small amounts of phosphorus are usually based on the formation of phosphomolybdic acid and its subsequent reduction to a blue compound. The molybdenum blue reaction is not specific for phosphorus, as arsenic (V), germanium, and silicon also form heteropoly acids with molybdenum and yield blue compounds on reduction. Although the literature on the molybdenum blue reaction is voluminous, basic data are lacking on all the conditions under which the molybdenum blue reaction for Si, As, P, and Ge can be obtained. One of the aims of the study reported here was to obtain these data, not only to fill some gaps in our knowledge of the chemistry of the heteropoly acids of these elements, but to reveal any differences in behavior that might be of analytical significance. When stannous chloride or 1-amino-2-naphthol-4-sulfonic acid was used as the reducing agent, no conditions could be found where silicon could be distinguished from germanium and where phosphorus could be distinguished from arsenic (V). Such differentiations probably cannot be made by the selection of some other reducing agent. Under certain acidity conditions, it is possible to minimize the interference of Ge and Si on the phosphorus determination, especially when the organic reductant is used, but such procedures are not recommended.

The recommended procedure for the determination of phosphorus makes provision for the separation of microgram amounts of phosphorus from at least 1 mg each of $AS_2O_5$, $GeO_2$ and $SiO_2$. The phosphate in ocean waters is concentrated by precipitating $Al(OH)_3$, which serves as a carrier for the $AlPO_4$ formed. The small precipitate is treated with a small volume of solution containing HF, HBr, HCl, and $H_2SO_4$ to volatilize any coprecipitated As, Ge, or Si. The phosphate is then determined by the molybdenum blue reaction according to specific optimum conditions. The total $P_2O_5$ content of several samples of sea water collected from the Gulf of Mexico ranged from 1.8 to $5.9 \times 10^{-6}$ percent.

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## Studies of Evaporation

THE lack of a direct method of measurement of evaporation from large land and water areas constitutes one of the basic gaps in hydrologic inventory. The need for direct measurement of evaporation is particularly keen in the western states where problems of allocation and distribution of available water supplies require accurate accounting.

Ordinarily evaporation (aside from pan estimates) is determined by hydrometric methods, as the difference between measured inflow and outflow. However, the large body of untested theory concerning evaporation processes themselves gives some reason to search for more direct measurements that could be used at the large number of places where hydrometric methods are not applicable or sufficiently precise. Thus it is desired that methods be developed whereby the proposed geophysical principles can be depended upon for primary measurement of evaporation under field operating conditions.

The first step, therefore, was to verify these untested geophysical methods at a lake where it was possible to obtain an accurate determination of evaporation by known and familiar hydrometric methods. Lake Hefner near Oklahoma City, Okla., was chosen for this purpose after an extensive survey of western reservoirs and lakes. Studies were made in 1950 and 1951 in collaboration with the Bureau of Reclamation, the Weather Bureau, and the Department of the Navy. As a result of that investigation it was discovered that good estimates of evaporation can be made by using an empirical equation involving standard meteorological observations together with the surface-water temperature of the lake (embodying some of the principles of the mass-transfer theory), or by using the energy-budget method for periods of 7 days or longer. The Cummings Radiation Integrator was found to be a satisfactory instrument for use with the energy-budget method. Coefficients for evaporation pans were found to have a pronounced seasonal variation so that they are considered useful only for determining annual evaporation.

The results of the Lake Hefner investigation were sufficiently conclusive to permit the determination of evaporation from Lake Mead, the original incentive for the Lake Hefner experiment. These studies, however, led to investigation of new problems, one of which is determining evaporation from reservoirs in advance of construction. Model studies, involving a model of Lake Hefner in the wind tunnel at Fort Collins, Colo., are being made to see if such an approach will solve the problem. Also, a pilot study is being made to see if heat-budget and mass-transfer methods can be used to determine water losses from land areas, including transpiration as well as evaporation. Other studies on various phases of evaporation are planned, but field work has not yet begun.

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## Developed and Potential Water Power of the United States and Other Countries of the World

THE development of water power in the United States as well as in the entire world has shown a phenomenal increase since 1920. At that time data on the installed capacity of water-power plants, with estimates of the potential water power available, were first compiled by the Geological Survey and published by the Department of the Interior in *World Atlas of Commercial Geology,* Part II: *Water Power of the World.* The average annual rate of increase in installed capacity from 1920 to 1945 was fairly uniform. The rate of increase has been considerably greater since 1945, and scheduled completions for the next few years indicate that it will continue into the future. The installed capacity of water power plants for the United States and the entire world for various years starting with 1920 and percentage comparisons are shown in Table 1.

The development of water power for the world as a whole increased 500 percent from 1920 to 1952, whereas the increase for the United States was slightly over 400 percent. This difference is naturally due to the fact that the United States had made more progress in water-power development than had the other coun-