quently modified and squeezed into discordance with the foliation of the metamorphic rocks. A magmatic origin of the rare-earth-bearing carbonate rock by differentiation of an alkalic magma from shonkinite to syenite to granite, with a carbonate-rich end product containing the rare elements, is in harmony with the field relations. This late differentiate might have been introduced either as a relatively concentrated magmatic fluid, highly charged with volatile constituents such as carbon dioxide, sulfur, and fluorine, or as a dilute hydrothermal fluid.

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Navajoite, a New Vanadium Oxide from Arizona

NAVAJOITE, hydrated vanadium pentoxide, is a new mineral found in the Monument No. 2 mine, on the Navajo Indian Reservation, Apache County, Arizona, and named in honor of the Navajo Indians. The mine is in a vanadium-uranium deposit just north of Comb Ridge in Monument Valley. The ore occurs in a channel that is filled with Shinarump conglomerate (Triassic) and that extends down through the Moenkopi formation (Triassic) into the DeChelly sandstone member of the Cutler formation (Permian).

The mineral, navajoite, occurs in highly oxidized ore in one part of the Monument No. 2 mine. It impregnates conglomeratic sandstone and silty sandstone, forms seams in the sandstone and crescent-shaped coatings above and below pebbles, and fills small fractures in clay lenses. The associated minerals include only one with V^{+4} and V^{+5}, corvusite; the rest are fully oxidized: tyuyamunite, rauvite, hewettite, steigerite, and limonite.

Navajoite is dark brown, soft, and fibrous, with a silky luster and brown streak. The specific gravity measured on the Berman balance is 2.56. The mineral is optically biaxial, probably negative, has parallel extinction and α is 1.905 ± 0.003, β about 2.02, and γ slightly above 2.02, with pleochroism X yellowish brown, Y yellowish brown, and Z dark brown and parallel to the fiber length. The chemical analysis, by A. M. Sherwood, shows 71.68 percent V_2O_5, 3.08 percent V_2O_4, 3.58 percent Fe_2O_3, 20.30 percent H_2O, 1.20 percent SiO_2, 0.22 percent CaO, and a total of 100.06 percent, and it indicates the formula $V_2O_5 \cdot 3H_2O$. Navajoite is readily distinguished by x-ray powder pattern from hewettite and corvusite, which it may resemble in physical appearance. Although the silky fibers of navajoite are too small for single crystal x-ray study, a rotation photograph of a small bundle of fibers indicated that the unit cell length along the fiber is about 3.65 A (H. T. Evans, personal communication, 1953). A large-scale photograph of the zero layer, obtained by placing a fiber bundle in a powder camera and using chromium radiation, shows many lines. Study of the photograph indicates that the two axes other than the fiber length are not at right angles and that navajoite is probably monoclinic, with the fiber length parallel to the *b*-axis. The best graphical solution of lattice constants found by plotting the reciprocal lattice spacings of the *h0l* lines suggests that $a_0 = 17.43 \pm 0.1$ A, $b_0 = 3.65 \pm 0.05$, $c_0 = 12.25 \pm 0.1$, and $\beta = 97° \pm 30'$. This unit cell would hold approximately 6 formula weights of $V_2O_5 \cdot 3H_2O$.

Navajoite would be an excellent vanadium ore mineral because of its high vanadium content, but unfortunately the mineral is probably not abundant in the ores of the Colorado Plateaus. This is because V^{+5} readily combines with other elements such as Ca, K, Na, Mg, Fe, Al, and U that are commonly present in the ore and because the hydrated vanadium pentoxide may form only under unusually acid conditions.

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Studies of River Morphology

A NUMBER of generalizations concerning the behavior and natural characteristics of river channels have been developed by the U.S. Geological Survey in several recently completed studies of river morphology. Measurements of parameters such as the discharge, suspended load, bed material, velocity of flow, channel slope, and channel shape indicate that many river channels are characterized by an orderly, progressive change of these variables from their headwaters to their mouths. The interaction of the variables and the establishment of a stable channel suggest that the morphology of the stream is controlled by a kind of equilibrium.

This concept of the interaction of a number of variables constituting a kind of equilibrium is the basis of present studies of the origin and operation of meanders, braids, and straight channels. These studies are in four principal parts:

(1) From field measurements of the aforementioned parameters, an effort is made to separate (isolate) the distinguishing physical features of each pattern. For example, in addition to their characteristic islands, braided streams frequently have steeper slopes, wider and shallower channels, and coarser bed material. On the other hand, detailed studies reveal marked similarities in the profiles and patterns of flow in meanders and straight channels.

(2) To understand the mechanics controlling the meander pattern, measurements are being made of the distribution of velocity and discharge in successive cross sections in the direction of the flows.

(3) Where possible, model studies supplement the

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