the unique solution is the Mercator projection. On the other hand, if the scale curves are circles, the only solution is stereographic projection.

In the most general conformal mapping of a sphere upon the plane, the scale function is never harmonic; but it may be a function of a harmonic function. We prove that this phenomenon occurs only in the stereographic and Mercator projections.

The double infinity of scale curves which we find for the general non-conformal mapping of a sphere (or any surface) has special geometric properties. If we consider the curves of the family passing through a fixed point, the locus of centers of curvature is necessarily a *cubic curve*. In a particular case this locus becomes a straight line, that is, the scale curves form a velocity family. This can happen only for a certain class of surfaces, which will be described in detail elsewhere.

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VITAMIN C FROM EVERGREENS

IN the interesting and informative letter by B. Shishkin to the American Association of Scientific Workers published in a recent issue of SCIENCE[1] there is a description of the search by Soviet botanists for a plentiful supply of vitamin C.

> Quite recently it was discovered that needles of ordinary pine trees contain large quantities of vitamin C. . . . During the long siege of Leningrad lack of vitamin C made itself particularly felt, and the decoction made from pine needles played an important role in the prevention of scurvy.

This is an interesting example of the rediscovery by modern scientists of a fact known to a primitive civilization. Francis Parkman,[2] in "Pioneers of France in the New World," written in 1865, describes the trials of Cartier and his men during the winter encampment of 1535–36.

> A malignant scurvy broke out among them. Man after man went down before the hideous disease, till twenty-five were dead, and only three or four were left in health. The sound were too few to attend the sick, and the wretched sufferers lay in helpless despair, dreaming of the sun and the vines of France. The ground, hard as flint, defied their feeble efforts, and, unable to bury their dead, they hid them in snow-drifts. . . .
>
> Cartier, walking one day near the river met an Indian, who not long before had been prostrate like many of his fellows with the scurvy, but who now, to all appearance, was in high health and spirits. What agency had wrought this marvellous recovery? According to the Indian, it was a certain evergreen, called *ameda*, (a spruce, or, more probably, an arbor-vitae), of which a decoction of the leaves was sovereign against the disease. The experiment was tried. The sick men drank copiously of the healing draught,—so copiously indeed that in six days they drank a tree as large as a French oak. Thus vigorously assailed, the distemper relaxed its hold, and health and hope began to revisit the hapless company.

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SPANS TWO CONTINENTS

AS a result of extensive studies I have discovered that Hokan, an American Indian language spoken in California and other parts of North America, extends to South America. Hokan previously had been found to extend only as far south as the Subtiaba language of the Pacific slope of Nicaragua, Central America. Evidence for this discovery has been put in the form of a report to the Bureau of American Ethnology which demonstrates the affinity of Hokan to Quechua, an American Indian language spoken in Peru and adjacent parts. This affinity was discovered to comprise completely the phonetics and morphology, and to the identity with Hokan of 258 Quechua words. Quechua wi-qe, tear, is found for example to mean eye-water, and to be composed of wi-, eye, compare Pomo ui, eye, and -qe, water, compare Pomo -xa, water.

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SCIENTIFIC BOOKS

STRUCTURAL GEOLOGY

Structural Geology. By MARLAND P. BILLINGS. 473 pp. 336 text figures. 19 plates. New York: Prentice-Hall, Inc. 1942. $4.50.

THIS carefully designed and executed new text devotes sixteen chapters (331 pages) to structural geology, grouped as follows (chapter numbers in parentheses): Mechanical principles (2); Folds (Description, 3; Field study and representation, 4; mechanics and causes, 5); Failure by rupture (6); Joints (7); Faults (Description and classification, 8; criteria for recognition, 9; thrust faults, 10; gravity or normal faults, 11); Secondary foliation and lineation (12); Unconformities (13); Salt Domes (14); Plutons (15); Granite tectonics (16); Extrusive igneous rocks (17).

[1] B. Shishkin, SCIENCE, 97: 354, 1943.

[2] Francis Parkman, "Pioneers of France in the New World." Little, Brown and Co., nineteenth edition, p. 194, 1882.

Two additional chapters give a concise introduction to two borderland fields of rapidly growing importance to Structural Geology—Structural Petrology (23 pages) and Geophysical Methods (41 pages).

As this table of contents shows, primary structures of sediments are dealt with only incidentally in connection with the "determination of top of beds" in the chapter on field study and representation of folds. The compaction of sediments and the resulting structures are given twenty lines and a sequence of three purely diagrammatic text figures. The plains' type of folds is neither mentioned by name nor distinguished adequately in word or illustration. The scanty treatment of structural features which dominate the relatively undisturbed regions must disappoint the petroleum geologist. But this is more than offset by the refreshingly new and comprehensive treatment of plutonic and volcanic rock structures (71 pages) which had been correspondingly neglected in some text-books. This must please the ore geologist.

There is no chapter on the problems of isostasy, epirogenesis and orogenesis and speculations concerning their ultimate causes, subjects which have always been popular among young students and have furnished topics for innumerable "bull sessions." The whole subject has been avoided deliberately by the author because it "can be intelligently studied only by geologists with a broad background in many fields of geology." This is eminently true. Nothing, in fact, tends to discredit geological thinking more in the minds of gifted students and endangers the mental processes of all more than the recital of spectacular hypotheses without a thorough analysis of all the elements of observation and reasoning from which they have grown.

To the reviewer it seems, nevertheless, that the broad facts concerning the structural patterns of continents and oceans, the distribution of the major zones of folding and faulting, of earthquake and volcanic activity deserve a place in such a text-book, divorced from all speculation concerning causes. One good reason for their omission suggests itself: Our undergraduates can not be expected to possess any knowledge of place geography or to own an adequate atlas.

While this particular thought may not have influenced the author, concern for the undergraduate mind is evident throughout the book. It is deliberately and effectively designed for instruction at the undergraduate level in United States colleges. Correspondingly, no knowledge of the basic sciences is assumed. For the college student in these United States can not be counted upon to possess any, as those responsible for the training of technicians in the Armed Forces have found out. Moreover he must not be made painfully aware of his deficiency, and he is not apt to have learned as yet to make it up on his own initiative. Accordingly, such physical concepts and knowledge as are needed in structural geology have to be explained explicitly. The chapter on mechanical principles, for instance, devotes three full pages to the definition of "force" and to the "composition and resolution of forces."

Under the circumstances this is as it should be. With so low a start in basic knowledge, one can not, of course, go far in the attempts to explain structural geological phenomena in terms of the modern physics of materials. This the author has recognized.

But there is an enormous contrast between the physics required for the understanding of the second chapter and the last one. The student who needs the elementary explanations of the former simply can not grasp the latter. This constitutes no blemish of the book. It merely means that the last chapter (perhaps the last two chapters) should be fully assigned only to students with sufficient preparation.

The undergraduate in the United States is also accustomed to receive his mental food meticulously prepared in the most digestible form. The author has, accordingly, taken great pains to write as simply as possible, to reduce all illustrations to the simplest form, and to avoid, as far as possible, or reduce to a minimum all critical discussions of matters that are as yet little understood.

To the reviewer this process seems to have been carried farther than is necessary. Structural geology is but in its youth. Its uncertainties are a constant challenge to active minds. Somehow that side of it does not crop out as much as the reviewer should like to see it. Similarly, the preponderance of generalized diagrams, over three fourths of all text figures, tends to give a final and abstract air to the matters discussed.

The same characteristics, on the other hand, enable the instructor to introduce concrete illustrations and discussions from his own experience without largely duplicating the contents of the chapters. It is evident that the book was cast deliberately in that form with that end in view. The book is, thus, an efficient tool for college instruction and not primarily a book for self-study. This is shown also by the collection of practical exercises which conclude the book. These occupy 55 pages and constitute an integral and eminently valuable part of the work.

Turning to individual items, the reviewer is glad to see the words "pitch" and "plunge" given fixed status as technical terms for angles between lines in space; the former, to designate the angle between the line of strike of an inclined plane and another line in the same plane; the latter, for the angle between the horizontal and an inclined line, measured in a vertical plane. Thus, striations "pitch" with reference to the

line of strike of a fault, and "plunge" with reference to sea level.

The reviewer is also glad to see a false statement, "commonly made in geological literature," sharply corrected, having once, in good faith, helped to spread it in print, *viz.*, that the angle of shear is greater than 45 degrees in "ductile" materials.

In other respects, however, the discussion of failure by rupture is open to criticism. If the angle of sheer is "always less than 45 degrees" in the direction of greatest shortening (p. 102) it is not feasible to interpret systems of rectangular joints as shear planes (pp. 126 and 127) or to say that the shear fractures are "approximately parallel" to the circular sections of the strain ellipsoid which form a strongly obtuse angle in the direction of the greatest shortening (p. 109).

In general, the strain ellipsoid is given the lip service usual among American geologists, but it is not introduced where it belongs first of all: in the explanation of the results of laboratory compression and tension tests. For such cases an obviously megascopic "imaginary sphere" is introduced inside the cylinder or square prism that is undergoing compression (p. 101). In both objects it is said to be deformed into an oblate spheroid.

This is, of course, not true in the case of the square prism. The "imaginary sphere" does not explain why the fractures form a cone in one case and a four-sided pyramid in the other. The absence of the concept of the strain-ellipsoid from so basic a discussion shows that it is not introduced at all in the truly valid sense.

Actually in this text, as in most writings of geologists who use it, the word "strain ellipsoid" stands for a two-dimensional figure of an ellipse, which is placed on the picture of a geologic structure in such a way that its axes point respectively in the directions of greatest (relative) shortening and lengthening. Into this figure diagonal lines are drawn to suit the writer's imagined needs: now intersecting at right angles (Fig. 109, p. 127) now at highly obtuse angles which face in the direction of greatest shortening, both strictly contrary to all laboratory evidence, and never, not once, in the only direction justified by the facts set forth at the start.

No wonder this devise is praised as "exceedingly useful if it is employed with discrimination." This matter obviously needs revision in the second edition.

In the discussion of the larger aspects of rupturing, of thrusts and faults, the rôle that plastic deformation, solid flow, plays in rock deformation seems to the reviewer too much neglected. Thrust sheets and fault blocks are more than lumps of inert matter that are set in motion by forces wholly outside of them. They are invariably parts of larger rock bodies every particle of which is in active upward, outward, or sideward movement, the planes of rupture representing discontinuities in the rate of movement. Seen in that light, the author's general use of the term "gravity fault" appears downright indefensible. Failure to give it the attention it deserves accounts for the wholly inadequate treatment of the structures that characterize the folding in the Swiss Alps. It also explains why the author has given over 90 lines and 8 text figures to the discussion of drag folds, while he refers in only four and a half lines to the type of minor folding that abounds in crystalline limestones and schists.

Further recitations of differences in bias or emphasis between the reviewer and author would tend to obscure the basic fact concerning this book: It is a text-book of high merit, written in simple language, easy to read (being printed in large type), forthright in its approach to the concrete matters of terminology and basic principles, methods and technique in structural geology which are indispensable as a foundation for practical work.

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SPECIAL ARTICLES

BIOLOGICAL EFFECTS OF A TOXIC AND A SENSITIZING SUBSTANCE ISOLATED FROM PARAFFIN OIL EXTRACT OF DEAD TUBERCLE BACILLI[1]

IT is a well-known and remarkable fact that killed tubercle bacilli retain many important properties characteristic of the living organism. The nature of the lesions which develop at the site of inoculation and the sensitization to old tuberculin (an almost infallible test of infection) which it confers on animals, has always shown clearly that the dead bacilli have the same specificity of action as that of living ones.

The effects of dead tubercle bacilli become quite comparable to those of living organisms with regard to lesions and sensitization if the dead bacilli are suspended in paraffin oil instead of saline solution. The experiments of Hagan and Levine,[2] Opie and Freund,[3] Coulaud,[4] Saenz[5] and Noel Rist[6] established clearly

[1] This study was carried on under a grant from the Josiah Macy Junior Foundation.

[2] Hagan and Levine, *Jour. Am. Vet. Med. Asn.*, 8: 728, 1932.

[3] E. Opie and J. Freund, *Jour. Exp. Med.*, 66: 761, 1937.

[4] Coulaud, *Rev. de le Tub.*, p. 850, 1934.

[5] A. Saenz, *Revue d'immunologie*, p. 530, 1937.