selves. One needs only to look over the work done recently in the study of hookworm disease by the group organized at Johns Hopkins under the leadership of Cort, to recognize the full justification of this contention. May we not hope that in the immediate future many such undertakings may be similarly organized and be able to secure equally strong support Under such conditions one may safely prophecy rapid progress in the solution of the problems which present themselves in this field.

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A FAULT MAP OF CALIFORNIA

A MAP which shows the the distribution of earthquake risk in California has been published by the Seismological Society of America and can be obtained from the Secretary, Dr. S. D. Townley, of Stanford University, California. The base of the map was prepared by the U. S. Geological Survey in cooperation with the California State Department of Irrigation and is both accurate and on a scale to show details. It shows the mountains and valleys by relief shading, drawn by John A. Renshawe of the survey, and carries the net of township surveys and Spanish landgrant boundaries, so that any property in the state can be located. It also exhibits the submarine contours from the shore out to the depth of 2,000 fathoms as determined with unusual detail and accuracy by the U. S. Navy by means of the Sonic depth-finder in 1922. Upon this base the known faults, which traverse the Coast Ranges from Mexico to Humboldt County and encircle the Sierra Nevada, have been mapped by the undersigned.

The Fault Map of California, although neither complete nor perfect, presents a large array of facts, which may be useful in various scientific and practical ways. The research student who is occupied with problems in structural geology relating to faulting and folding will find in it examples of those structures actually in course of development. The isostatic equilibrium of the Sierra Nevada and of the great coastal scarp may be examined in the light of more complete evidence than we have previously had. The displacements of triangulation stations, recently determined by the Coast and Geodetic Survey to be of significant magnitude, may be accurately indicated on it in relation to the faults which limit the moving masses. The teacher of geology or geography who desires to illustrate some point connected with the relief of the earth's surface will find the facts clearly displayed in the beautifully shaded base map produced by Renshawe. The investigator of submarine relief is given an unusual opportunity to study the forms of the ocean bottom in the detailed contours drawn on the soundings secured by the navy with the cooperation of the Hydrographic Office. Here are forms attributable to faulting, to aggradation by terrigenous sediments, to submarine erosion, or to subaerial erosion, now submerged.

On the practical side the map serves to define the areas of earthquake risk in a way which may enable the dwellers in any given valley, or township section indeed, to determine the proximity or distance of a probably active fault. Engineers should no longer build in ignorance of the existence of dangerous rifts. Insurance men should no longer lay a blanket premium on buildings in California where the risk is quite as unequal in different parts as it is between Tokyo and New York. The conditions of building and the building regulations of communities should take account of the facts that are brought out in the Fault Map.

While we have sound reason for the opinion that these things are so, we recognize that the Fault Map as it now stands is a first attempt to present the facts on this scale and, like other first attempts, can be much better done another time. It is to be hoped that one of its principal services will be to stimulate the study of faults and their relations to earthquakes.

A noteworthy feature of the Fault Map is that it expresses a distinction between active faults and dead faults. This distinction appears to have been recognized first by Branner, Gilbert and Lawson, after the California earthquake of 1906, and the term "rift line" was used in the report of the Earthquake Commission to describe one type of outcrop of an active fault. The great San Andreas fault exhibits this type. Its relation to the shock of 1906 was evident throughout the entire distance, 190 miles, along which the disturbances of the ground were traced, and it exhibited peculiar topographic features, both in its relation to mountains and valleys and also in the peculiar occurrence of various minor features in longitudinal arrangement, by which it or other faults of like recent activity could be followed. The definition of an active fault is thus that it is a fault on which there has been a movement within a period so recent that sequential displacements may reasonably be expected to occur along it. It is obvious that the definition can not be applied with exactitude when it comes to distinguishing an active from a dead fault. There are active faults which are known to have suffered displacements within our experience, and there are dead faults which can be proved not to have suffered any displacement since the Pliocene; but between the unquestionable examples there is a wide range within which conscientious observers may differ as to the classification. It is also true that men are cautious in earthquake countries in ascribing dangerous activity to any feature that might give rise to an

earthquake. They would rather err on the conservative side and it follows that the average geologist, who as a rule has had but little training in recognizing the evidences of activity, usually describes faults simply as faults, without distinction as to their activity.

These conditions led to a difference of interpretation of the term active as it is used in separate sections of the Fault Map. Mr. Wood, who gathered from many generous contributors much of the fault data shown on the southeast, and the southern portion of the southwest, sheets of the map, subsequently examined many of these faults in the southeast region, and some elsewhere, and found it desirable to recognize a considerable number of grades of knowledge corresponding as nearly as might be to the degrees of certainty with which the faults, and their symptoms of activity, were determined. His manuscript map shows the following distinctions: active fault well located; active fault uncertainly located; fault probably active; line probably active fault (?); fault well located; fault uncertainly located; line probably active; line including all from probably fault to very doubtful; line including all from probably fault to very doubtful and uncertainly delineated. Mr. Willis, who is responsible for the mapping in the districts north of San Luis Obispo, with the assistance of Mr. Robin Willis, made a reconnaissance survey of the area between San Luis Obispo and Santa Rosa, and extended the application of the term active to faults which he recognized as such on physiographic evidence as well as on indications more commonly employed, whenever in his judgment the facts justified that classification. He thus classified as active many faults which he would not have identified as such without personal examination.

The task of transferring the manuscript data to the copy for the printer fell to Mr. Willis and involved the adjustment of the differences of interpretation in so far as it might be possible to bring them into accord. It was not possible, however, to reach that desirable unity of statement which might have been attained if all the evidence could have been reviewed by a single observer. It was necessary also to reduce the number of distinctions to that which could be shown by a moderate number of printings on the map. The adjustments were made by Mr. Willis on the eve of his departure for Chile and an explanatory note was inserted by him in the legend of the map just before sailing, without opportunity of consultation with Mr. Wood. The note falls somewhat short of a complete statement of the facts. On the southeast sheet it reads that the faults thereon shown as active "have been active during historic time" and it should further explain that the classification as active also includes such as "exhibit specific surface indications of recent activity, such as fresh scarps and trace phenomena." Furthermore, a considerable number of the faults shown on the southeast sheet, and also on the southwest sheet, that are marked dead, would better be indicated as, "probably active, but without definite indication of recent disturbance." Were these changes made in the map itself the number of active faults shown in the southern half of the map would more nearly approximate that of the active faults delineated by Mr. Willis in the northern half.

In making this compilation we have been placed under obligations to many individuals, corporations and institutions. Some of them have wished not to be named and the list of others who have contributed to the advancement of our knowledge of California is too long to be given here. It is appropriate to state, however, that the work was done in cooperation with the Advisory Committee on Seismology of the Carnegie Institution of Washington, with the U. S. Geological Survey, represented especially by Messrs. Noble and Kew, with the U. S. Hydrographic Office, with the Navy Department, with the University of California and with Stanford University. While the Seismological Society of America is directly responsible for the publication, it could not have accomplished it without the cordial cooperation given by these organizations.

BAILEY WILLIS,
H. O. WOOD

DETERMINATION OF THE CURVATURE INVARIANT OF SPACETIME

ON January 30, 1924, and on the two following days a remarkable series of lectures was delivered by Dr. Silberstein to the Physical Society of McGill University, Montreal. Not only did Dr. Silberstein present to his audience one of the vastest problems with which the human mind can grapple, but he gave for the first time in public an exposition of his own investigations of the intrinsic properties of spacetime as the frame of the universe.

The preliminary lectures dealt with the geometries of space and spacetime; the early attempts to formulate mathematical equations which would hold true not only for terrestrial measurements but also for planetary measurements; the discrepancies which invariably occurred between theory and observation in the latter class of measurements; the great conception of Einstein whereby the universe was to be treated mathematically as a four-dimensional "spacetime" continuum, and his later inspiration, whereby he conceived spacetime as finite according to the principles of elliptical geometry; the modification of the Einstein spacetime equation by de Sitter, whose beautiful theory has overcome the outstanding difficulty of