was published in the *Zoologisches Jahrbücher* (Vol. XII [1898]) in more than 90 pages of text and with five beautiful lithographic plates. This admirable study, and some six others on *Chitons* that followed it, tended to establish the Amphineura as the most primitive order of mollusks and to show their phylogenetic relations to annelids.

In his expeditions on the *Albatross* he had collected from dredgings in Hawaii, Alaska, and off the coast of California a beautiful lot of specimens of an aberrant and wormlike mollusk known as *Solenogastre.* He wrote four papers on the morphology and habits of this mollusk and a notable monograph on *The Solenogastres* (Memoir XLV, Mus. Comp. Zool. Harvard, pp. 179, pl. 40, with more than 400 figures [1911]).

He was also much interested in the group of beautiful pelagic gasteropods, the pteropods, and he prepared three papers on their anatomy and classification. He also prepared a monograph of some 25 pages and 10 lithographic plates on a primitive group of bivalves, *The Anatomy of Some Protobranch Mollusks* (*Mem. mus. roy. d'hist. nat. Belg.,* Deuxiem Ser., Fasc. 10 [1937]).

A group of bivalve mollusks of much interest to geologists for purposes of dating and identifying strata is the family of Arcidae, but the anatomy and classification of fossil forms were necessarily limited to their shells. Heath undertook a study of the anatomy of some 32 living species and thereby corrected certain errors in classification based on the shells alone. This work was summarized in a monograph entitled *The Anatomy of the Pelecypod Family Arcidae,* which was published by the American Philosophical Society (*Trans.,* 31, 287–319, 22 plates [1944]). This was his last major publication. A smaller paper, with which he was much pleased, was on "A Connecting Link between the Annelida and the Echiuroidea (*Gephyrea armata*)" (*J. Morphol.,* 49, [1930]).

Much of his work after his accident in 1917 had to do with material which he had on hand, or which could be found near his home; among these subjects the development of the castes in termites and their functions occupied a prominent place. In all, he published 42 articles in scientific periodicals and was a joint author with others of two books. He was a fine artist with pen and pencil and all his publications are beautifully illustrated.

In a minute prepared by one of his colleagues of the Stanford faculty, from which I am permitted to quote, it is stated that

> As a teacher he was preeminent; kindly, quizzical, and inspiring. He contributed greatly to Stanford's high position in the biological sciences. This was recognized by his "starred" position as one of the 1,000 outstanding scientists (150 zoologists) in the first edition of *American Men of Science.* He was a member of the Western Society of Naturalists, Phi Beta Kappa, Sigma Xi, American Society of Zoologists, and a fellow of the California Academy of Sciences. He received the honorary degree Sc.D. from his *alma mater,* the Ohio Wesleyan University, in 1919.

Dr. Heath married Elsie Shelley, of Son José, in 1897. She survives him, as do two sons (Ronald W. and James P.), a daughter (Phyllis Heath Walker), a sister (Mary Heath Lee), and seven grandchildren.

Technical Papers

A Possible Connection between Certain Metamorphic Phenomena and Anomalies in the Earth's Magnetic Field

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It has long been apparent that the reference of the various mineralogical changes and orientation effects that accompany metamorphism to the two variables temperature and pressure (which in their turn are referred to depth of burial or proximity to igneous intrusions) is inadequate to explain completely the phenomena observed. In several cases, geosynclinal sediments have been buried to depths of up to 10 miles without suffering any marked metamorphic effect, whereas in other instances—as, for example, the young metamorphosed rocks of the East Indies—strong metamorphism appears to have occurred without the rocks having been buried to any great depth. These examples illustrate the difficulties that are met in the endeavor to explain metamorphism on the basis of depth of burial alone.

To direct attention to additional factors that may enter into these problems, the following observations are brought together:

1) In 1934, Visser (*1*), in presenting the results of his analysis of magnetic observations carried out in the East Indies, indicated that certain anomalies in the earth's magnetic field appear to be related to areas that are disturbed geophysically; in particular, he refers to the line of the Lesser Sunda Islands and the Molluccas, a line coinciding with Vening-Meinesz' line of negative anomalies. Unfortunately, observations are too few to judge the validity of this correlation, though it would seem reasonable to anticipate anomalies in the magnetic field over areas beneath

[1] The writer is indebted to Walter H. Bucher for much helpful discussion of this subject.

which movements of subcrustal material are assumed to be taking place.

2) Kato (*2, 3*), in 1933–34, published the results of a considerable number of magnetic observations in the Japanese area and showed quite clearly a direct relation between the occurrence of earthquakes, volcanic eruptions, and local magnetic anomalies. He explained the anomalies as being due to variations in the permeability of the rocks following the rise of temperature resulting from the earthquakes and eruptions. However, in the case of the Sanriku earthquakes of 1896 and 1933, he pointed to the fact that the resulting anomalous fields were in opposite directions, and the first motions of the accompanying tsunamis were also observed to be in opposite sense. This would seem to suggest that the magnetic anomalies were not caused by temperature changes, but by the movement of crustal or subcrustal material. Further support is given to this supposition by the fact that, in the case of the Mauna Loa eruption of June 2, 1950 (*4*), the local magnetic intensity was found to have increased considerably between May 9 and June 9, the rise probably coinciding with the beginning of the eruption. Had the anomalies been due to temperature changes, one would have anticipated a decrease in intensity.

From these observations, it would seem reasonable to infer the possibility of fairly strong magnetic anomalies over areas that are tectonically active.

3) The synthesis of mica for commercial purposes has long been a major problem. Under the pressure of war requirements, intensive research was carried out by Dietzel and others (*5, 6*), at the K. W. I. Ceramics Institute, Ostheim, Germany. It was found that the growth of large sheets of mica, orientated in the required directions, was greatly facilitated by the introduction of a weak magnetic field (13 gauss) at right angles to the length of the crucible containing the melt. The mica formed in large sheets parallel to the magnetic lines of force. Dietzel attributes this effect to the paramagnetism of mica. However, it was found that, although in successive experiments the iron content of the melt was reduced considerably, the degree of orientation was not affected. It is suggested, therefore, that the effect is not due to the paramagnetism of the mica, but to some directional effect of the magnetic field upon the moving ions in the melt.

Taking these various observations together, the tentative suggestion is made that a further variable which should be considered in connection with metamorphic phenomena is that of the local state of the earth's magnetic field. It is clearly possible, from Dietzel's results, that the orientation, particularly of mica minerals, may be affected by comparatively small magnetic gradients; it is suggested further that such conditions may also have some directional effect on migrating ions.

It is emphasized that this suggestion is put forward very tentatively, with the object of encouraging research in these directions, which may prove extremely useful quite apart from the validity or nonvalidity of the hypothesis.

The lines of investigation proposed are:

1) Full and detailed study of magnetic phenomena in a tectonically active area, such as the West Indies, together with field investigation of young metamorphic areas in the same general vicinity.

2) Laboratory experiments to study the effect of magnetic fields on crystallizing minerals. This study might be extended to the examination of the effects of electrostatic fields, too, since it is felt that here also may lie an enlightening field of investigation.

Studies of this sort would be too extensive and varied in their nature for one man to carry through alone, and it is hoped that other persons interested in these topics may be encouraged to undertake and intensify investigations along these lines.

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The Action of Thrombin on Fibrinogen[1]

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Investigations of the author and his associates (*1–10*) aimed at elucidating the role of thrombin in clotting fibrinogen have shown that thrombin is not involved in the polymerization of the fibrinogen molecules, but that thrombin acting as an enzyme makes some alteration on the fibrinogen molecule (*2*). It was found that the enzymic action of thrombin does not involve oxidation or reduction (*3*); thus it is probably a hydrolytic enzyme. Experiments with papain showed that it clots fibrinogen just as thrombin does (*4*), and that it is the proteolytic enzyme itself that clots fibrinogen (*5*). These experiments and the finding that the fibrin molecule, otherwise identical with the fibrinogen molecule (*4, 6, 8–10*), has a different isoelectric point (*6*) suggest that thrombin may split a bond, such as a peptide bond, freeing a small molecule from the fibrinogen, leaving a slightly altered fibrinogen molecule. The final proof of such a mechanism would be the finding of this predicted small molecule in the supernatant after clotting.

Since the probability always exists that a small molecule may be adsorbed to fibrinogen as an impurity and might appear in the supernatant after clotting, iodinated fibrinogen (*7*) was prepared and the supernatant studied for the presence of a sub-

[1] Preliminary report.

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