

should not be greatly alarmed at present developments concerning electrical phenomena.

We know that molecules on the sun are in constant wireless communication with molecules on the earth. We can partially interrupt this communication by interposing a screen having a diameter of a centimeter or two. The molecules within the shadow now receive impulses transmitted to them by those outside of the shadow.

Here we have an action which is sufficiently amazing. Any explanation which we might make of it could not involve anything more wonderful than the action itself.

After we admit the existence of matter and of electrical phenomena, as we now know them, why may we not assent to the proposition that all atoms of matter are composed of positive and negative electricity or of positive and negative ions? This is essentially Franklin's hypothesis, deprived of its occult features, by reason of what has since been learned. The conductors in a power service are then aggregations of positive ions, or of positive electricity. The negative ions, or, as Franklin would have stated it, the electrical fluid, flows through what we now call the positive ions. Their rhythmical transfer from atom to atom accounts for the Joule effect. In addition we may have conditions which involve an actual and sudden transfer of kinetic energy from the moving negative ions to the positive ions. Such a case we have in the electric arc, which seems to me to be mainly a Thomson effect.

It is now established that the positive and negative discharges, which Wheatstone examined with the revolving mirror, are in the nature of compression and rarefaction waves. They are waves in Franklin's fluid. The negative terminal of any battery or dynamo is the compression terminal. From this terminal Franklin's fluid flows.

The writer has obtained photographs of the Wheatstone sparks and Wheatstone's conclusions concerning direction of propagation of the discharges from the terminals have been fully verified.

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SCIENTIFIC BOOKS

Research in China. In three Volumes and Atlas. Vol. I., Part I. *Descriptive—Topography and Geology.* By BAILEY WILLIS, ELIOT BLACKWELDER and R. H. SARGENT. 4to, pp. xiv + 353 + index. Pls. LI.; figs. 65. 1907. Vol. II. *Systematic Geology.* By BAILEY WILLIS. 4to, pp. v + 133 + index. Pls. VIII. July, 1907. Published by the Carnegie Institution of Washington.

These admirably written and illustrated volumes should be read by all scientists interested in the geology of Asia and also by those interested in the larger problems of diastrophism and geologic history. The first and larger volume will be used more especially as a work of reference for details of Chinese geology; the second volume treats the same material in a condensed and systematic manner, following the course of geologic history and covering to some extent the whole of eastern Asia. Applying throughout the recently developed principles of diastrophism and physiography, a field of research in which the senior author has previously done distinguished work, these volumes mark a distinct advance over the previous comprehensive treatises dealing with this region, von Richthofen's "China" and Suess's "The Face of the Earth." The atlas, by the incorporation of Chinese characters, has been made readily available to the Chinese, and in the modern educative awakening of China such a publication dealing with that portion of the world may be of material aid in stimulating an interest in the earth sciences. It must not be thought, however, with national self complacency that the general educative effect need be restricted to China. The photographs and descriptions of certain districts bring home the desolation which may result from reckless deforestation, with the consequent sweeping of soils from the hill-sides and burial of valley alluvium beneath sand and gravel. This is a lesson the American people still need to learn and the material has already been utilized by the *Outlook* and the *National Geographic Magazine*.

The route of the expedition lay first into the Shantung peninsula, thence from Peking southwestward through north central China.

to the Yang-tzi-kiang. In so far as the survey was necessarily rapid it partook of the nature of a reconnaissance and was restricted to type areas and to limited widths of territory, but it was of a character greatly superior to most reconnaissances in that the topography and geology within these limits were accurately mapped and comprehensively studied. Future work, therefore, needs simply to extend what has been already so well begun.

A brief summary is not included in the publication and a review may, in passing, mention the prominent features of the geologic history as set forth in the second volume. The Archean is restricted by the author to the metamorphic schists and gneisses of indeterminate character associated with a large proportion of metamorphosed igneous rocks, which by their intricate structure and inferior position to the oldest pre-Cambrian recognizable sediments are marked as belonging to a distinct and older system. The overlying Proterozoic was chiefly studied in the Wu-Tai-Shan and is divided into two systems, the eo- and neo-Proterozoic, the local Chinese names being omitted in this review. The eo-Proterozoic embraces three series separated by two unconformities.

Von Richthofen placed this system in the Huronian, using the latter term, as was commonly done thirty years ago, to suggest pre-Paleozoic rocks of green color. He did so with reserve, however, and the stricter usage of the term as it is now adopted does not permit us to maintain an exact correlation.

Willis points out, however, the strong similarities of these three series to the three Huronian series of the Lake Superior region and Van Hise has more recently compared them with still other formations of other regions similar in lithologic character and age relations. As Willis states:

The general relations to the Archean and neo-Proterozoic are similar in both continents, and the effects may well have been due to a general terrestrial cause which became active at about the same time, in regions remote from one another.

Between the eo- and neo-Proterozoic occurs a stratigraphic break of the first order, indicated both by a great unconformity and by

the folding and metamorphism of the lower system which are absent from the upper. The little altered, slightly slaty beds of the neo-Proterozoic resemble the Paleozoic above far more than the eo-Proterozoic below. At least 10,000 feet of slates, limestones and quartzites are embraced in this system. After a period of diastrophism the wide-spread land surface was reduced to a nearly perfect plain over which finally passed in places the Cambro-Ordovician sea. This pre-Paleozoic peneplanation was observed over a stretch of a thousand miles and is a feature of southeastern Asia.

The fact that Asia at the opening of the Paleozoic era was a featureless continent has important bearings. It limits the antiquity of mountain ranges, some of which have been discussed by eminent writers as of pre-Cambrian date, as elevations which have survived since that remote time; and it affords a basis of inference regarding a cycle of inactivity, which was common to other continents as well.

The marine invasion which initiated the Paleozoic sedimentation began in the late Lower Cambrian and gave rise to the Sinian group, extending to the Middle Ordovician. In central China the Sinian is composed of limestone, apparently to its very base, but in north China the characteristic strata of the Lower Sinian are red deposits. In south China, latitude 31° north, near the base of the Sinian and conformably interbedded between a quartzite below and marine limestone above occurs the bed of tillite which has attracted so much attention on account of the profound significance of this early glaciation near the level of the sea.

The Lower Ordovician strata are overlain by Upper Carboniferous, but without discordance of dip, implying prolonged quiet with most of the continental surface lying near sea level. The Carboniferous is characterized by marine deposits in the south, by continental deposits in the north. The transition to the Mesozoic is not marked by a sharp division plane, but by shrinkage of the seas and an increase in the proportion of continental deposits. At the same time Permo-Mesozoic diastrophism was pronounced and the present

structure lines of Asia were largely established. By the Cretaceous, however, Asia was again a low and featureless continent.

The Cenozoic history is one of erosion and land deposit. The Cretaceous peneplain conditions were continued at least in southern Asia through the Eocene and Oligocene and well into the Miocene, when occurred the epoch of mid-Tertiary compression resulting in folding. Since then there have been extreme effects of vertical warping unaccompanied by folding and chiefly of Pleistocene age. The evidence of the latter is largely physiographic and indicates "one of the most remarkable diastrophic movements of which we have knowledge." The Neocene and Pleistocene warping and faulting are believed to have produced differences of elevation exceeding 20,000 feet. Davis and Willis are thus in accord and stand in opposition to the earlier views of European geologists, in that these American investigators hold that the elevations due to Permo-Mesozoic folding or older epochs of diastrophism were long since planed away by erosion and are not the causes of the present relief. These views, developed first in America, are thus made of circumterrestrial application and may be regarded as the great contribution of physiography to geologic theory.

The paleogeographic maps are a feature of this report, as is also the map showing the results of the recent diastrophism.

In the final chapter Willis considers the bearing of the previous facts and conclusions upon the problem of the continental structure of Asia. No adequate outline of this chapter can here be presented. In brief, however, he finds that the continent may be resolved into positive and negative elements, the former areas tending to stand high, the latter tending to stand low. These tendencies are latent during comparatively long periods of quiet and resultant peneplanation, but become operative during epochs of diastrophism. The compressive movements, on the other hand, have pressed and welded the positive elements together, the axial directions of folding representing the compression of the negative zones lying between.

The cause of the diastrophism Willis ascribes to differences in specific gravity, restricted according to Hayford's determination to the outer hundred miles of the earth's body; the vertical movements being chiefly due to isostatic readjustment between the several continental elements, the compressive movements being due to the tendency of the heavier oceanic segments of the earth to spread and underthrust the outer portions of the whole continental mass.

For more than a third of a century the incompetency of secular cooling of the outer crust to account for diastrophism has been pointed out,¹ though it still finds credit in many text-books. Chamberlin, recognizing this, has constructed a hypothesis by which periodic compressive movements are ascribed to a shrinkage of the centrosphere and not the lithosphere. Willis goes still farther and obviates the necessity of postulating shrinkage of either the inner or outer earth. His hypothesis thus belongs to that group to which O. Fisher and Dutton have previously contributed.

This must be regarded as a most suggestive working hypothesis, opening the field still wider to investigation, and may serve to destroy still more the false confidence regarding the cause of crustal movements which was felt by geologists of a previous generation, owing to the narrowly limited hypotheses then in vogue.

The hypothesis advanced by Willis is an extension of that proposed by Dutton, who ascribed folding to that subcrustal horizontal creep from the low toward the high elements which is necessary to isostatically restore the initial elevation of the high and the initial depression of the low.²

In the form in which Dutton stated the hypothesis it appears insufficient, since the

¹ C. E. Dutton, "A Criticism upon the Contractual Hypothesis," *Amer. Jour. Sci.*, Third Series, Vol. VIII., pp. 113-123, 1874.

² C. E. Dutton, "On Some of the Greater Problems of Physical Geology," *Bulletin of the Philosophical Society of Washington*, Vol. XI., pp. 51-64, 1889.

horizontal movement shown by folding seems far in excess of the subcrustal creep in the outer fifty or hundred miles of the earth's crust needed to restore the isostatic adjustment between the regions on the two sides of the zone of folding. Furthermore, the vertical readjustments which take place in epeirogenic movements are not simultaneous in origin with the horizontal movements.

Somewhat similar difficulties seem to face the larger hypothesis of Willis in which continental and oceanic segments are concerned rather than adjacent geanticlines and geosynclines. The average continental surface stands about three miles above the average ocean bottom, owing to the lighter subcontinental matter. The isostatic compensation, as Hayford has shown, is complete at a distance of about seventy to a hundred miles from the surfaces. A column of matter on the edge of an oceanic segment and extending to this depth will consequently have its top pressed seaward by a pressure due to the greater height of the continental mass, a pressure resisted by the rigidity of the surface of the oceanic segment. The foot of the column, however, will not be strained in either direction, since the weights of the continental and oceanic segments at this depth are equal. Any intermediate point in the column will be pressed seaward with an intermediate pressure.

The initial cause of that horizontal movement which is due to isostatic adjustment on the continental margins would, therefore, be an outward spreading of the continental margin by flowage and normal faulting. The surface being lowered by this means, the subcontinental pressures would be lessened and a landward movement of the lower zone of the oceanic segment would in turn tend to take place, restoring in this manner a part of the initial height. It is difficult to see, however, how compression of the continental surface could ever occur as a result from this spreading except for local and minor adjustments, since the flowing outward of the surface is the operating cause. In so far as sediment from the continents is deposited on the bottom of the oceanic segments, however, and the surfaces of the two are brought toward a common

level, the tendency of the top of the continental segments to spread outward will be checked and a tendency for the lower part of the oceanic segment to underthrust the land will arise. But the greater part of terrigenous sediments have been deposited within continental geosynclines, or upon the lower continental elements, or as submarine deltas building slightly outward the continental shelves. The isostatic readjustment should, therefore, be largely between the high and low continental elements and it is not clear that sedimentation could account in any large measure for such a crowding together of the continental elements by pressure from the oceanic segments as the structure of Asia seems to suggest. Furthermore, Willis has shown that the present great relief of Asia is the result of a very recent movement unconnected with the Permo-Mesozoic folding and but partly originating in the mid-Tertiary period of orogenic activity. It seems best, therefore, to consider that vertical movements, bringing about isostatic adjustment, are but indirectly connected with the great compressive movements, following after them to a greater extent than accompanying them; due to a seeking for an equilibrium destroyed on the one hand by erosion and sedimentation, on the other by changes of specific gravity from within, induced partly by the previous horizontal compression. Horizontal compressive movements, on the other hand, characterized by their large amount and brief duration and separated by relatively long periods of quiet, seem to have found as yet no better explanation than that advanced by Chamberlin, as due to a progressive shrinkage of the entire central portion of the earth, resisted by the rigidity of an outer unshrinking zone many hundred miles in thickness. This gives the necessary mechanism for the gradual storage of compressive stress and its periodic discharge by yielding of the outer zone, a yielding characterized by the mashing of geosynclines and other lines of weakness in the outer shell, and the underthrusting of the continental surfaces by the lower and structurally stronger oceanic segments.

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