Meetings

Polar Wandering and Continental Drift

The ultimate goal of earth scientists is to integrate and collate evidence of apparently separate phenomena known about the physico-organic history of the earth into a rational, coherent, and demonstrable explanation of these facts. Attainment of this goal probably lies far in the future—or may be unattainable, because of a constant evolving conceptual relationship with unknown finite limits. Nevertheless, by necessity, periodic attempts are made to summarize existing knowledge and to visualize the complex as a whole, for it is by a process of establishing multiple working hypotheses that the validity of ideas can be tested. Unfortunately, too often a disciplined, rigorous, and impartial weighing of the evidence for and against a particular idea, or theory, is delayed because of preconceived ideas, inability to separate fact from theory, lack of information, or plain prejudice. But, on the other hand, great caution must be exercised before one of the "multiple hypotheses" is unequivocally accepted as a true conclusion: facts must be sought, and their interrelationships shown. Obviously, then, the first step in testing a hypothesis is presentation of the data in context; the second step is interpretation; while the third is attempted refutation of the interpretation or examination of the consequences of its acceptance.

Earth scientists have been and are confronted with a nearly infinite quantity of detail which is subject to arrangement in a great many ways. Often, the patterns used to categorize information are modes of convenience or experiency and, as such, are "working" hypotheses proposed for a practical purpose. Sometimes their immediate practicality is not obvious and their applications are not readily apparent, but many principles have been established or rejected only through trial and error over long periods of time.

Numerous familiar examples of long-delayed or reluctant acceptance of theoretical ideas subsequently shown to be true are easily recalled in connection with evolution, organic origin of petroleum, hydrothermal alteration, continental glaciation, and many other fields. But on the other hand, bold, courageous partisanship is to be desired only when it serves to bring forth truth from both protagonist and antagonist. As the stimulus of argument becomes the foil of truth, so diligent investigation denies unwarranted acceptance or rejection of possibly superficial evidence.

The concepts of continental drift and polar wandering should, therefore, be placed in proper perspective and attempts should be made to prove or disprove them scientifically and dispassionately. The demagogic and insincere approach is always that of introducing personalities into an impartial discussion for the purpose of concealing some deficiency of investigation or knowledge. As Longwell states: "We know too little about the Earth and its history to indulge in such final judgments . . . while we admit great gaps in critical geologic knowledge . . ." ["Continental Drift Symposium," Univ. of Tasmania (1958), pp. 1–12.]

The April symposium of the Society of Economic Paleontologists and Mineralogists in Atlantic City, N.J., on the "Mineralogic and Paleontologic Aspects of Continental Drift and Polar Wandering" was conceived to present a review of investigations in this field in recent years. Numerous workers have invested large quantities of effort and time in the physical and biological sides of this idea and have succeeded in raising a once disreputable hypothesis to a creditable position in which it becomes deserving of a complete re-examination and re-evaluation. Final proof, of course, has not been established, but, just as obviously, the recent studies have made it unwise to dismiss the concepts without added careful scientific investigations. The symposium was thus designed to stimulate work in this field by pointing out some of the problems to be solved. (See list of contributors to the symposium at end of this report.)

Hypothesis of continental drift. The idea of continental drift was originally proposed by A. L. Wegener [*Origin of Continents and Oceans* (Braunschweig, 1922)] in connection with his analysis of the origin of continents and oceans as a method to help explain anomalous distributive patterns of ancient climate zones [Koppen-Wegener, *Die Klimate der geologischen Vorzeit* (Borntraeger, Berlin, 1924)]. The implications of this proposal seriously challenged many of the beliefs and theories of the constitution of the earth, its physical properties, tectonics, and biologic developments. As a result a considerable furor of opposition arose on all counts, but, in particular, the geophysicists alleged that drift was out of the question because the crust could not endure such forces. Others denied the need for moving the continents to explain either mountain chains or animal and plant disposition in space and time relationships.

Many of the main objectives were directed toward the mechanisms of drift suggested by Wegener and subsequently to the geodetic studies of longitude determinations designed to demonstrate the westward drift of Greenland. These criticisms were and are quite valid insofar as the physical principles are concerned, but the basic and real question is not so much *how* but *has* shifting occurred? What evidence exists in support of this contention?

Evidence for continental movement. The demonstration of the possible actuality of continental shifting may be resolved by following several routes and attempting to integrate them individually into a mutually accordant whole. The usual avenues have been: geodesy, paleontology and stratigraphy, paleoclimatology, and geophysics. However, in latter years the quality of investigations in these areas has greatly increased because of added data, techniques, and new types of research.

Geodesy. The mensuration of the earth's surface—with determination of exact locations of geographic points—has long been used to "fit" the continental masses together. The commonly quoted concordance of South America with Africa has led to efforts to "fit" all land masses into an original or proto-continent called "Pangea." Much work by Carey on spherical projections and globes with various bathymetric levels led him to his orocline hypothesis and acceptance of the idea of an expanding earth.

Paleontology and stratigraphy. The fossil occurrence of warm-water faunas in present-day cold latitudes, of similar flora on separated continents, of glacial deposits in equatorial zones, and of many other apparently anomalous biologic situations has led to numerous investigations. K. E. Caster has contributed much on the Devonian and upper Paleozoic faunas of the Southern Hemisphere to show a good probability of contiguity of continents in the past. Ting-Ying H. Ma has studied Paleozoic coral distributions over the world and has concluded that continental shifting occurred on a grand scale. Through coral "belt" correlations in the various geologic periods, he has indicated their confinement to particular latitudinal zones, and, consequently, is able to locate inferred pole positions at successive times. However, he further notes that there are discrepancies in such pole positions which may only be resolved by assuming relative shift between continents as well as entire crustal shift.

S. Nordeng, working with stromatolites of the Huronian age in Michigan, shows they may have a preferred direction of growth and orientation seemingly directly dependent upon the angle of incidence of sunlight. Thus he feels it possible to locate the pole position at the time of growth in terms of present day latitude and longitude. During Lower Huronian time, by this method, he states one pole was at 4 degrees north latitude and 40 degrees west longitude. Later, in the Middle Huronian, a polar position was 5 degrees south latitude and 48 degrees west longitude.

As far as can be determined now, these data do *not* confirm the paleomagnetic observations of either Irving or Runcorn, both of whom have contributed extensively to the cause of paleomagnetic measurement and to its concomitant result of polar wandering through the ages [Irving, "Rock Magnetism: A new approach to the problems of polar wandering and continental drift," symposium, Univ. of Tasmania (1958), pp. 24–57; Runcorn, *Advances in Phys.* **4**, 244 (1955)]. Probably no other single line of investigation has done so much as this geophysical procedure to advance the cause of continental shifting and polar wandering. Certainly such confirmation studies by many eminent and thoroughly competent workers such as Runcorn, Irving, E. R. Deutsch, B. W. Wilson and R. H. Nanz, Jr., J. Hospers, A. Cox and R. R. Doell, and many others have elevated the hypothesis to a respectable level from its limbo of derision.

Strong support for the hypothesis of continental shifting and polar wandering has also been derived from many other sources. One of the more spectacular contributions are the paleoclimatic studies of G. W. Bain based on the "inalienable characteristics of the different latitudinal zones" which control life types, air circulation, ocean currents, and energy distributions in a major sense. When these characteristics are applied to ancient environments, interpretations show "shifts in the zones of high and low sun of about 90 degrees. . . ."

Finally, the oceanographic investigations by M. Ewing and B. Heezen of Lamont Geological Observatory have shed great light upon the geophysics of the ocean floor and the crust, as well as upon the ubiquitous oceanic ridges which more or less bisect the major oceans. These data have supplied precise and provocative knowledge of a once largely unknown quantity and seem to have added support to the contention of an expanding earth. As a result, a positive mechanism has been suggested by S. Warren Carey by means of which not only continental shifting may be accomplished, but also many of the observable tectonic features of the earth's surface may be rationalized.

It must be reiterated in conclusion, however, that these propositions and *hypotheses are not yet proved*, persuasive and inviting as they may be. Much rigorous and critical work remains to be done in many areas, but major avenues of investigation have now been suggested and the way for future work has been clearly indicated. I sincerely hope that an ever-increasing number of workers will be stimulated and encouraged to undertake some facets of these studies. The challenge is cast and the goals are nearly infinite in scope and size. The quantity of data is enormous, but it is hoped that the forthcoming volume of the Society of Economic Paleontologists and Mineralogists giving the papers of the 1960 symposium will be an anchor point for future investigations.

The 1960 SEPM symposium brought together leading authorities in these fields of study: S. Warren Carey, University of Tasmania, geodesy and tectonics; S. K. Runcorn, University of Durham (England), geophysics; B. W. Wilson and R. H. Nanz, Jr., Shell Development Co., geophysics; E. R. Deutsch, Imperial Oil Co., geophysics; B. C. Heezen, Lamont Geological Observatory, oceanography; G. W. Bain, Amherst College, paleoclimatology; Ting-Ying H. Ma, Taiwan University, paleontology; K. E. Caster, University of Cincinnati, paleontology; S. C. Nordeng, Michigan Tech., paleontology; W. L. Donn, Lamont Geological Observatory, glaciology; W. C. Gussow, Union Oil Co., tectonics; D. Swartz and D. D. Arden, Sohio Petroleum Co., tectonics.

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