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PLATE TECTONICS AND BIOGEOGRAPHY IN HISTORICAL PERSPECTIVE

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The uncertain relationship of plate tectonics and biogeography is but the most recent chapter of a history of geotectonics and biogeography which extends back to the middle of the last century. This history is largely unknown to Anglophone earth scientists, since most of it unfolded in Germany, Switzerland, France and Austria-Hungary. An outline sketch of this history is offered.

GEOLOGY AND ZOOLOGY -- A SYMBIOSIS

Darwin's Beagle Voyage and Galapagos Experience

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Darwin's South American fossil collections yielded many insights. in one section he recorded the *gradual* vertical change in shell characteristics of fossil oysters. The giant fossil vertebrates brought the realization that several were precursors of living species. Contrary to accepted Catastrophisr Theory, he inferred that all taxa found fossilized did not become extinct together since the living agouti, among others, had fossil precursors. He envisioned the way an existing molluscan fauna and its sedimentary matrix could be transformed into fossiliferous rocks reminiscent of the Tertiary, and also speculated about the kinds of fossils that the Galapagos biota would yield in some future rock column.

Volcanic islands (Galapagos Archipelago and others) were linked in Darwin's thought to the appearance of "peculiar" taxa inhabiting these "mere spots" in the sea. Were these migrants from the nearest continents? If so, why were they so distinctive while carrying the imprint of their place of origin? If not, how did these four-legged and other terrestrial creatures get to the islands? Were the archipelagos ever united to the continents? Gradually Darwin was led to a continent-archipelago-continent concept. Continents were elevated archipelagos. (He had the Andean volcanoes in mind.) Archipelagos were submerged remnants of continents.
He incorporated into this concept the rise and extinction of species: elevation of archipelagos were the "best nurseries" for appearance of new taxa, while subsidence of continents generally led to extinction of extant forms.

DEVELOPMENT OF WALLACE'S PERCEPTIONS OF BIOGEOGRAPHY, 1848-1859

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Alfred Russel Wallace produced his two-volume treatise, *Geographical Distribution of Animals*, the first comprehensive treatment with an evolutionary perspective, in 1876. His active interest in the subject, however, began three decades earlier. In 1848, he embarked for Amasonia to seek evidence for species formation by examining the relationship between the distribution and affinity of related species. A series of papers based on his discoveries in the following decade presented not only Wallace's theory of evolution but also his concept of the regional aspects of geographical distribution as the resultant of both physiographic events and the origin and extinction of species. These conceptual papers were all published before Charles Darwin's, *On the Origin of species* (1859).

THE REACTION IN CONTINENTAL EUROPE TO WBGBNRR'S TRBORY OF CONTINENTAL DRIFT

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The reaction in Germany indicates that in spite of World War I. the geological community was very much alive. Opinions ranged from violent and emotional rejections by prominent scientists, who saw their previously published theories challenged, to active acceptance of an exciting new concept to be tested in the various fields of geology.

The French reaction, delayed by the death of many geologists during the war, and hampered by the language barrier, remained provincial and chauvinistic. Only lofty and skeptical comments were presented against what was considered an amateurish theory by a geophysicist. In reality, nobody in France, with the exception of Philibert Russo and Boris Choubert, was at the time involved in any erogenic theory or prepared to accept the challenge. The idea of continental bridges prevailed.

In Switzerland, after the introducticn of Wegener's ideas by Emile Argand during the war, and in spite of strong anti-German feelings, the concept was accepted quickly and enthusiastically as the best framework for solving critical problems of Alpine tectonics. Several famous Austrian geologists had published erogenic theories for the Alps based on the contraction theory and rejected Wegener's mobilism, but later, under the influence of Swiss geologists, they showed partial acceptance.

Belgian geologists rejected Wegener's theory because they considered the beautiful symmetry of the present surface of the Earth incompatible with the assumed breaking-up of an original continental mass. Italian geologists, with a few exceptions, rejected Wegener's "aberration" while

Spain, unaffected by the war, had a positive attitude which was facilitated by an early translation and a receptive academic audience. Dutch geologists, deeply involved with the Indonesian archipelago, accepted widespread mobilism with enthusiasm since it provided a spectacular answer to their problems. The Scandinavians, supportive but unable to interpret Precambrian geology with Wegener's theory, concentrated their efforts on astronomical and geodetic studies of present-day drift in the Arctic region.

In summary, the reaction in Continental Europe was extremely diversified and dominated by an association of strong post World War I politics, the language barrier, the stifling of academic authority, passions of individuals, and regionalism of geology.

THE BRITISH RECEPTION OF ALFRED WEGENER'S CONTINENTAL DRIFT HYPOTHESIS

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Wegener's hypothesis was introduced to Britain in 1922. First heralded as a revolution in thought, possibly comparable with that initiated by Copernicus, it was quickly attacked as groundless speculation, negating all known facts about the thickness and solidity of the earth's crust. As advocates and opponents joined the battle, some British scientists saw how it could help to solve geological problems and adopted a cautiously favorable attitude toward Wegener's basic idea of continental motion, although they disputed the details. In 1928, a British geologist proposed convection currents as the mechanism for splitting continents and rafting apart the fragments, thus providing a crucial element to the model that, decades later, would aid in the transformation of continental drift to plate tectonics. At the time of Wegener's death in 1930, his hypothesis remained under strong attack, yet support was well-established among Britain's independently-minded scientists.

THE BIOGBOGRAPHICAL ASPBCT OF TEE DEBATE OVER CONTINENTAL DRIFT

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This paper examines the biogeographical component of the sixty-year controversy over the reality of continental drift. It begins with an examination of Wegener’s solution to the problem of accounting for the distribution of life forms having a geographically disjunctive distribution and traces the development of the problem through the work of the major as well as many minor participants in the controversy. It closes with a discussion of the most important impact of the acceptance of plate tectonics upon the biogeographical community, namely, the rise of metabiogeography.

A DECADE OF CHALLENGE THE FUTURE OF BIOGEOGRAPHY

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According to Croizat's global synthesis, the main biogeographic patterns include trans-Atlantic, trans-Pacific, trans-Indoceanic, Boreal, and Austral. Geological and geophysical theories vary, but agree that sea-floor spreading in the Pacific is different in its effect from that in other ocean basins. The difference allows for radial expansion of the basin and not merely east-west displacement of continental areas. Biogeographic data suggest that bipolar (boreal +austral) distributions are to be reckoned among the results of sea-floor spreading in the Pacific. Data from one group of inshore fishes (family Engraulidae) exemplify this notion and add, as terminal parts of the differentiation of the Pacific Basin, trans-Panama marine vicariance and a collateral occurrence in f r e s h w a t e r o f tropical South America. These findings corroborate Croizat's synthesis. They suggest that the critical evaluation of that synthesis will be the main task of biogeography over the next decade. They indicate that within the area of systematics, evaluation will require a cladistic approach and the elimination of paraphyletic groups from classification.