

LITERATURE REVIEWS

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A VENTURE IN UNORTHODOXY

THE EXPANDING EARTH. 1976. S. Warren Carey. Amsterdam: Elsevier Scientific Publishing Co. 488 p.

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This book is the tenth volume in a series on Developments in Geotectonics.

S. Warren Carey is an internationally known geologist at the University of Tasmania in Australia. His publications on tectonics go back to his Doctor of Science thesis entitled *Tectonic Evolution of New Guinea and Melanesia* done in 1938 at the University of Sydney. He has regularly published in this area since that time, being a proponent of Wegener's continental drift theory when it was generally being ridiculed. In 1953 Carey sent a paper to the American Geophysical Union proposing "the transport of continental blocks on the back of convection cells" with subduction of the crust at "the downgoing limb of the convection cell." The paper was rejected at the time "on the grounds that it was naive" (p 9). In 1971 Carey resubmitted this paper with an attached letter that included the following paragraph:

Although I worked with subduction models for more years than any of the new generation of subducers has yet done, I have since moved on to what I think are more probable models (p 10).

And that is what this book is about, a "more probable model" which proposes "that the earth is expanding and that the separation of the continents by growth of new oceans is not extensively compensated by the swallowing of old crust elsewhere" (p 14). "That the diameter of the earth has increased with time at an increasing rate, is the theme of this book" (p 118). In fact Carey suggests that there is evidence that the surface area of the earth has doubled since the Paleozoic era (p 20, 47, 51).

The evidence that Carey cites necessitating an expanding earth are:

- a) gaping gores, which appear to be false artifacts, in even the best Pangea assembled on a present size earth (p 39). "A coherent integral assembly is only possible on a globe of smaller radius ..." (p 27).

- b) hierarchy of polygons into which the earth's crust is broken. Carey identifies nine first-order polygons (p 12) which are more or less equivalent to the plates of tectonic theory. He provides evidence that each of these are broken up into second order polygons which in turn, are broken into third order polygons, etc. (p 42). Carey suggests this is the natural consequence of the earth's crust accommodating to the increasing radius of the earth.
- c) increase in area of each of the first-order polygons (tectonic plates) since the Paleozoic and an increase in the distance between the centers of each plate (p 47).
- d) Pacific paradox associated with evidence that the Pacific Ocean doubled in size during the time that Pangea ruptured and dispersed and the Arctic, North Atlantic, South Atlantic and Indian Oceans developed (p 50).
- e) consensus that Australia, South and North America, Africa, India and Europe have moved to more northerly latitudes since the Mesozoic era and yet are generally further from the Arctic now than then (p 52, 116, 199). In fact, as a result of the mid-Atlantic ridge, the Arctic Ocean is still expanding today.
- f) young ocean floors. Carey feels that "it is incredible that no sizeable block of old ocean crust would be left anywhere" if the size of the earth has remained fixed but that this would be expected on an expanding earth (p 53).
- g) close geologic association of India with Antarctica, Australia and Africa. On a globe of the earth's current radius it is not topologically possible to assemble Pangea so that India fits all these neighbors (p 435) but "*all* these close connections emerge automatically when Pangaea is assembled on a terrella of appropriate radius" (p 436).

Carey also discusses the double-equator paradox during the Triassic period (p 209) and the paradox of paleopole overshoot for the Tertiary period (p 215) as evidence for an expanding earth.

Carey reserves some of his most scathing comments about standard plate tectonics for the subduction trenches. He states, "Subduction exists only in the minds of its creators" (p 16) and "the Pacific subduction zones like all other subduction zones are myths" (p 50). This is the crucial difference between standard plate tectonic theory and Carey's expansion model, for both schools of thought agree on sea-floor spreading but differ on the interpretation of the trenches (p 54). Arguments that he uses to support these contentions are:

- a) lack of off-scraping of trench deposits (p 56, 59-60).

- b) thinning and necking of earth's crust in area of trenches and other topographic evidence that indicates the trenches are tensional rifts, not compressional features (p 28, 52, 59, 63-65).
- c) increase in heat flux at trenches and orogenic belts which is not consistent with subduction (p 58, 69).
- d) trenches do not correlate with rifts as would be expected on a fixed radius earth (p 57).
- e) no indication from seismic data that the Moho bends down at the trenches (p 62).
- f) magnetic anomalies get older away from the Aleutian trench as though it were a spreading zone (p 59).
- g) paleomagnetic data fit expanding earth without trench subduction (p 183).

Carey cites studies which claim that seismic (p 74) and paleomagnetic data (p 195) have been screened and selectively interpreted to be consistent with assumed subductions.

In response to the question, "What causes the expansion of the earth?" Carey's first response is that he does not know. Suggested possibilities are:

- a) phase changes in the earth core (p 124, 450).
- b) secular decrease in the universal gravitational constant (p 451).
- c) secular change in e/m (charge/mass of electron) (p 457).

The scenario that Carey proposes starts with a dense earth with an Archean crust broken by tensional rifts over a slowly expanding interior. Heat and gas escaped from the interior via the cracks with rocks changing to less dense phases along these boundaries causing these polygonal boundaries to arch upward to form basins for shallow seas. Due to "the inherent feedback instability of the outgassing process, some undations [formation of mountains by huge waves in the crust of the earth] inevitably developed more than others" (p 126). This process eventually led to the formation of the Pacific basin and Pangea. During the Carboniferous period asymmetric expansion developed a "mantle tumour" under the southern part of Pangea which led to the break-up and dispersion of Gondwanaland (Australia, Antarctica, Africa and South America) (p 134, 135). This large megatumor also resulted in a rotational asymmetry of the earth causing an axial wobble which the gravitational torques of the sun and moon turned into an axial tilt which led to the Permian glaciation. Viscous drag dissipated this tilt by the Jurassic period (p 135).

Carey argues that the obliquity of the rotation axis of the earth is the most important variable for geologic history (p 131). These changes affect the intensity of the magnetic field because changes in the paleomagnetic poles

govern climate changes and affect the motion of the plates. These cycles are related to the inability of heat interior to the earth to escape by conduction and stable convection, and cause instabilities to develop with the formation of megatumors which cause wobble and tilt. Also, excess heat is expelled by magma floods, crustal disruption and explosions (p 138).

Presumably another bulge during the Eocene epoch caused the present $23\frac{1}{2}^{\circ}$ tilt of the earth and cause further dispersion of the continents (p 136). Greater expansion in the southern hemisphere tended to move the continents northward which increased the moment of inertia of the northern hemisphere tending to slow down the rotation of the north which created the “Tethyan shear” (p 271, 272). The fact that North America is west of South America is an evidence of this shear.

Carey suggests that two tests already demonstrate the validity of his model (p 443):

- a) convergence of continents on an expanding Arctic.
- b) convergence of continents on an expanding Pacific.

He proposes three more tests (p 443):

- a) Check the earth to moon distance from three locations on earth, Canberra, Honolulu and Tokyo. Carey’s model would show these places getting further apart whereas standard plate tectonics would suggest they are moving closer together.
- b) Very long based interferometry using radio sources located in Alaska, California, Hawaii and Japan. Expect similar conclusions as above.
- c) Direct measurement of the earth’s diameter by time of flight measurements of neutrinos from Chicago to Cocos Island in the Indian Ocean.

Carey feels that these tests conducted over several years would be able to test his model.

Carey critiques the concept of uniformitarianism (p 114). He distinguishes methodological or immanent uniformitarianism (uniform application of natural law) and substantive or configurational uniformitarianism (uniformity in the environment). He feels that the principle of uniformitarianism is much too rigorously applied (p 114) and that we must allow for changes in even fundamental physical constants. He states, “We have no right to assume that unique events have not occurred, but must be alert to recognise them if they are recorded. Unfortunately we see only what we know, so the probability is, that if faced with the evidence of a unique event in the geological record, we would fail to observe it. As Claude Bernard said, ‘It is what we think we know that prevents us from learning’” (p 118).

Much of the middle part of this book discusses technical details of paleomagnetism, rotational dynamics of the earth and solar system, and regional data.

Little reference exists in the literature about Carey's proposal of an expanding earth. There are a few geologists, in addition to Carey, who maintain an expanding earth hypothesis, including Krassilov, Owen, Shields and Stewart (Shields 1979). Among those who have criticized Carey's ideas, Cox claims that "paleomagnetic studies have now pretty well ruled out expansion large enough to account for the formation of all the ocean basins" (Cox 1973). Hess admits that an expanding earth removes some of the difficulties in dealing with the evolution of ocean basins, but he finds it philosophically unsatisfying. He does point out the difficulty of adding "an enormous amount of water to the sea in just the right amount...." Le Pichon notes that it would be necessary for the great circle of the equator and the great circles of longitude to expand at the same rate in order to maintain an approximately spherical earth. But "spreading rates" from axes of ridges would suggest that the equatorial circle is expanding more than twice as fast as the longitudinal circles on an expanding earth model (Le Pichon 1968). And with respect to the "subduction trenches" it is still not clear even with the conventional plate tectonic model whether the plates are being "pushed" or "pulled" down (Wyllie 1976). If the latter is the main mechanism, then these trenches would show tensional features even though subduction was occurring.

In conclusion, it does seem that Carey has raised some questions about plate tectonics and that his model does resolve some problems in the current theory. The three tests which he proposes are "do-able" and would provide essential evidence about the validity of the expanding earth hypothesis.

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