Ever Since Wegener:
A Brief History of the Expanding Earth Hypothesis

William Carnell Erickson

Ever since Wegener, many writers have advanced the idea of Earth expansion. Alfred Wegener's continental drift theory provoked intense debate during the 1920s; it also spawned a flurry of books and articles, written mainly in Russian and German, advocating Earth expansion.[1,2,3] The expansion concept "lies implicit within Wegener,"[4] but in the 1920s, most geologists had trouble enough with wandering continents; few were prepared to deal with an expanding earth. Besides, everyone 'knew' that the Earth was *contracting*. Earth expansion seemed so farfetched that those men who did take it seriously assumed that no one else had even considered the idea. Unaware of one another's work, each was convinced of his own priority. According to the American marine geologist H.W. Menard, Earth expansion was 'discovered' no fewer than eight times between 1920 and 1960.[5]

During the golden age of marine geology in the 1950s, when continental drift became respectable again after decades in contempt, interest in the expansion hypothesis was also revived. Earth expansion beneath the oceans during the last 200 million years could account for many of the new and surprising facts about the ocean floor – its relative youthfulness, the shallow sediments, and the worldwide rift system. For a time, a few North American geologists, including Bruce Heezen[6] and J. Tuzo Wilson,[7] flirted with expansion. But by the late sixties, most of these erstwhile supporters had abandoned expansion in favor of the new theory of Plate Tectonics.

The expansion hypothesis remains a minority view in geophysics[8] but it still has many supporters, especially among Earth scientists living in the southern hemisphere. Its most vigorous defender is S. Warren Carey, Emeritus Professor of Geology from the University of Tasmania and a past president of the Australian and New Zealand Association for the Advancement of Science. Though little known to the public outside Australia, Carey is widely regarded as a pioneer in modern Earth science. He came to believe in continental drift during his college days in the 1930s, long before it became fashionable. Unfortunately, anti-drift sentiment in those days was so strong that Carey felt compelled, for the sake of his D.Sc., to delete a controversial section on continental drift from his dissertation.[9] But Carey's youthful convictions were vindicated by professional experience. Working as an oil geologist in New Guinea, "where the drifting land masses become most self-evident",[10] and serving there during World War II, Carey became a confirmed 'mobilist' at a time when 'fixist' dogma was still firmly entrenched.

In the early 1950s, Carey developed a convection theory of continental drift that was strikingly similar to the Hess-Dietz model of seafloor spreading proposed a decade later.[11,12] But Carey's convection theory was never published: the referees at the American Geophysical Union rejected his paper[13] as "naive and unpublishable."[14] In the mid-fifties, Carey verified, with great accuracy and without the benefit of a computer, the close 'fit' between South America and Africa[15] – a full decade before Bullard.[16] Many of Carey's 'naive' ideas from the forties and fifties became the orthodoxy of the sixties and seventies. "Any of my older students will confirm that what I taught them in the mid-1950's differed little from what the Kuhnian revolution [in Earth science] had brought. They found little new in the 'new' global tectonics."[17] Though Carey may not have received the credit he is due, his work has not been completely ignored. Tuzo Wilson recalls that "the turning point" in his conversion to continental drift "was the receipt of a copy from Sam Carey of his mimeographed paper[18] from the [1956] Tasmanian [drift] symposium."[19] And Bullard never denied Carey's priority.[20]

Carey embraced the expansion hypothesis in the mid-fifties after attempting, without success, to reconstruct Pangaea, the ancestral supercontinent, on a globe of modern dimensions. No matter how the continents were arranged, huge 'gaping gores' would appear between regions with known geological connections. "I could make satisfactory sketches like Wegener's classic assembly [Carey recalls], but never accurately on the globe, or a rigorous projection. Starting from the assembly of Africa and South America, [...] a yawning gulf[*] appeared between Indonesia and Australia [which] belonged together." Years of frustration tempted Carey to abandon his ambitious project. "A crucial link seemed to be missing from the global synthesis." But in the end, Carey's zeal for accuracy paid off, and the solution was surprisingly simple. "It was not my method that was at fault, but my implicit assumption that the Earth of Pangaea was the same size as the Earth today. The assembly of Pangaea was not possible on a globe of present radius, but on a smaller globe, ...these difficulties vanished." [21] Carey had found the missing link.

The gaping gores reveal huge gaps in current thinking about the earth. Though psychologically comforting, the assumption of a constant-sized Earth is fraught with paradox – contradictions of geological fact – when attempts are made to reassemble Pangaea. In addition to the gaping gores, (subsequently verified by Owen in his *Atlas of Continental Drift*[22]) Carey also discovered many other geological impossibilities when Pangaea is assembled on a globe of present size. These include the Pacific Paradox,[23,24] the Arctic Paradox,[25] the India-Gondwana Paradox[26] and the Double Equator Paradox,[27] to name but a few. All of these enigmas disappear when the continents are assembled on a smaller globe. And they helped convince Carey that the Earth had expanded.

None of the positive evidence marshaled in support of Plate Tectonics is incompatible with Earth expansion. The expansion hypothesis can easily account for continental displacement, the creation of new oceanic crust, transform faults, the concentration of earthquakes at plate boundaries,[†] and many other well known geological phenomena. But which explanation is correct? One way of judging two competing theories is by measuring their predictive power; and in this respect the expansion hypothesis demonstrates its superiority. Crucial facts that Plate Tectonics must 'explain' – such as the youthful age of the Pacific floor, intraplate seismic activity (e.g. the New Madrid quake of 1823), or the Paleozoic geological links between India and Asia[28] – are predictable consequences of Earth expansion. (Indeed, the relative displacement of the continents is perhaps its most compelling prediction.) Conversely, many important predictions deduced from Plate Tectonics – such as the existence of accretionary

[*] This is the mythical Tethyan 'gore', still depicted on most maps of Pangaea, which falsely separates peninsular India from Asia and Australia, and Australia from Indonesia. Tethys certainly existed, but as a narrow equatorial sea separating Gondwanaland from Laurasia and not as a yawning gulf. Its closest modem analogs are the Mediterranean and Caribbean.

[†] Seismic tomography has shown that continental lithosphere is wedded to the mantle to a depth of several hundred kilometers. Accordingly, Carey rejects the term 'plate' because it implies that the lithosphere acts independently of the underlying mantle and instead favors 'polygonal prism' that includes the deep mantle and in which the lithosphere is merely the uppermost layer.

prisms of sediments scraped off subducted plates and the alleged compressional origin of oceanic trenches – have been refuted.[29]

Plate subduction is believed to occur primarily in the Pacific at the deep trenches in mid-ocean and along the continental margins. According to the plate theory, seafloor spreading in the Atlantic, Indian and Arctic oceans causes the plates to converge on the Pacific where they collide and overlap. When this occurs, one of the plates is subducted beneath the other and it descends back into the earth's interior (where it is 'made mantle again') along the seismically active Benioff-Wadati Zone. Subduction into the trenches supposedly eliminates crust as quickly as seafloor spreading creates it. For every square mile of new crust created by seafloor spreading, an equal amount of old crust must be consumed by subduction. Without subduction, or some other crust disposal mechanism, the earth's surface area would increase and the Earth would expand.

When the 'conveyor-belt' model of seafloor spreading *cum* subduction was first conceived in the 1960s, it was confidently predicted that the trenches would exhibit signs of compression, caused by the convergence of lithospheric plates and the subduction of thousands of square miles of oceanic crust. But this prediction proved wrong. “The seafloor spreading hypothesis may, for some geologists, require compression in the vicinity of trenches, but the data require horizontal tension.”[30] According to H. W. Menard, a specialist in Pacific geology, “the most troublesome aspect of the sea-floor spreading hypothesis was the absence of direct evidence of convergence. There was no problem if the Earth was expanding, but if it was not, enormous areas of old oceanic crust had to be plunging into the mantle along the line of oceanic trenches. It was generally expected that the sediment in trenches would show signs of this violent phenomena, but none could be found.”[31] In trench after trench, the sediments turned out to be completely undisturbed; and there were no outcrops from the subducted plates. Menard and his fellow oceanographer Maurice Ewing were mystified by all this. “Neither of us believed for a moment in an expanding earth, so we were left with a puzzle.”[32] But in the end, both men endorsed the troublesome subduction hypothesis. Perhaps they believed they had no choice.

The continental drift debate lasted, off and on, for nearly half a century. The reality of drift was proven geologically in the 1930s by the South African geologist Alexander L. Du Toit[33], but it was not until the 1960s that the majority of geologists (and the Americans in particular) were finally converted. Given the prolonged and agonizing struggle over continental drift – an idea with overwhelming evidence in its favor – it is rather surprising that subduction – an untested if not untestable hypothesis with practically no empirical support – was accepted sight unseen, and practically overnight. Geology is a science renowned for its conservatism. Why, then, did so many geologists convert so quickly to an idea so radical and unfounded? The reason is simple: subduction was the lesser of two evils. The alternative – Earth expansion – was “anathema to most geophysicists,” and it still is. Evidently, it is easier to believe in a super-efficient crust disposal mechanism that consumes oceanic crust at precisely the same rate as it is formed without leaving any evidence in its wake, than it is to consider the simpler (albeit still unexplained) alternative of Earth expansion. The universal rejection of Earth expansion led inexorably to the reification of plate subduction. Today, subduction is portrayed as though it were The Gospel Truth, unblemished by critical scrutiny. Unfortunately, subduction contains far more gospel than truth. Carey is more blunt. Subduction, he writes, "is a myth that exists only in the minds of its creators."[34]

Another point of contention between Plate Tectonics and Earth expansion is orogenesis – the origin of mountains and fold belts. According to the Plate Tectonic theory, orogenesis is a compressional phenomenon: folding results from crustal foreshortening caused by the collision of two lithospheric plates. But Carey denies this; he attributes orogenesis to vertical uplift and gravitational collapse on an expanding sphere. Once again, Carey has the geological evidence on his side. The Himalaya, the very archetype of compressional plate tectonics, "could not have been born of collision nor of subduction, but resulted from vertical uplift."[35] And in the Andes, "the fundamental tectonic style is extensional (east-west)."[36] Unfortunately, when faced with the choice between fact and doctrine – the fact of extension and vertical uplift versus the doctrine of compression and crustal foreshortening – most Anglo-American plate theorists opt for the latter. Naturally, they have devised all sorts of *ad hoc* explanations for these anomalous facts, a tactic that appalls many field workers[37] and which philosophers of science consider symptomatic of a 'degenerating research program.'[38] Noting that most German and Russian-speaking geologists have abandoned this doctrine, Carey dismisses compressional orogenesis as an "English-language obsession" – a legacy of Newton's Earth contraction theory.

The pioneers of the 'new global tectonics' have helped revolutionize Earth science. Unfortunately, they are still encumbered with many obsolete dogmas. The adherence to dogma in the face of contrary evidence, and the proliferation of *ad hoc* hypotheses to account for that evidence, is not at all unusual in science – especially during a scientific revolution. Consider, for example, Galileo. A courageous advocate of the new Copernican system, the great Italian scientist could never bring himself to accept Kepler's evidence that the orbits of the planets are elliptical and not circular. Still entranced by the ancient Greek idea of heavenly perfection, Galileo believed that the planets move around the Sun in perfectly circular orbits. Unable or unwilling to abandon this archaic doctrine – despite the evidence against it – Galileo, like Ptolemy and Copernicus before him, was compelled to invoke epicycles 'to save the appearances' of planetary motion. A similar situation exists in geology today. Advocates of Plate Tectonics have contributed enormously to the 'Copernican Revolution' in Earth science, but because they are unable or unwilling to abandon the dogma of a constant-size earth, these latter-day Galileos must invoke subduction – the modern equivalent of the Galilean epicycle – 'to save the appearances' of continental motion on an Earth of constant size.

Most geologists assume implicitly that the earth's size has not changed. But if that assumption is wrong – and the geological evidence suggests that it is – then any theory based on that assumption must also be wrong, regardless of its popularity or the extent of its corroboration.

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Although the cause of expansion remains a mystery,[39] several novel ideas have been advanced, ranging from phase changes at the core-mantle boundary[40] to a decrease in the gravitational constant.[41] The Russian scientist A.J. Schneiderov, for example, developed a new equation for gravitation from which he deduced terrestrial pulsation – expansion and contraction.[42] Carey has considered many possible causes of expansion; he cites growing evidence of a decrease in the gravitational constant,[43] but he remains unconvinced. In correspondence with Arthur Holmes (who anticipated Hess, Dietz *and* Carey in proposing convection-driven continental drift, [44] and who devoted an entire chapter to Earth expansion in the 1965 edition of his classic textbook[45]), Carey and the great English geologist listed fifty possible measures of paleogravity but decided that none was conclusive.[46] Nevertheless, Carey maintains that the possibility that gravity was once as "low as that now pertaining on the surface of Mars [0.38 g], or even less, or similar variation in the other direction, is not excluded by any fact yet stated."[47] Though empirically satisfied that the Earth has expanded, Carey cannot explain why. He exhorts physicists to search for the cause.

Among advocates of Earth expansion, there is considerable disagreement over the *rate* of expansion. Carey believes that expansion is as old as the Earth itself and has accelerated since Early Mesozoic time.[48] H.G. Owen, on the other hand, favors continuous post-Mesozoic linear expansion instead of accelerating expansion.[49] Despite their divergent views, Carey and Owen both evidently accept the orthodox version of gradual seafloor spreading based on the Heirtzler timetable of geomagnetic reversals.[50,51] Lester C. King, however, another longtime advocate of Earth expansion, does not. A former student of A.L. du Toit, and Emeritus Professor of Geology from the University of Natal in South Africa, King regards Carey as a "master mind in geotectonics."[52] But the two Gondwanalanders part company over the timetable of continental drift. Whereas Carey favors gradual and continuous expansion, with most of it occurring during the Cenozoic, after the end of the Mesozoic, King maintains that the Earth expanded very rapidly and reached its present size before the end of the Mesozoic. "Most post-Paleozoic continental drift [writes King] seems, on geological evidence, to have been accomplished during the Mesozoic era. Only small episodes of drift have been dated as (a) Mio-Pliocene, or (b) Pleistocene, and over most of the Earth the early Cenozoic was particularly free of such events. So it was from the Late Mesozoic mayhem that the modern pattern of continents and ocean basins has emerged."[53]

Rejecting the gradualism implicit in current doctrine, King is highly skeptical of continental drift timetables based on 'average' rates of seafloor spreading.

> [S]ea-floor spreading and Plate Tectonics became popular concepts immediately upon the acceptance of continental drift, which was already proven by geological data. But, following du Toit, geologists had been careful to relate continental drift to late Mesozoic tectonic activity, which was episodic. The neotectonicists disregarded this point and thought of Plate Tectonics as a general and continuous process of lateral change. They postulated average rates of horizontal movement in the several oceans – averaged over the past 100 million years. In geology, time is long and tectonic averages mean little. Tectonic happenings (both vertical and horizontal) are episodic and not infrequently of global extent, with long quiet intermissions during which wide planations developed upon the lands and ample depositions took place within the oceanic basins.[54]

Averages, writes King, "mean very little in geology. Most geological processes take place briefly when definite physico-chemical boundaries are passed"[55] – a view shared by many other geologists.[56]

King also questions the orthodox account of the geomagnetic anomalies; indeed, he disputes the very assumptions upon which it is based – such as the notion that the anomalies are "frozen" into the ocean floor. "That there is a pattern of polarity reversals is agreed; that these are 'frozen' into the rocks is assumed, and that the pattern demonstrates the physical transportation of rock masses beneath the sea-floor is also an assumption that will be true only if magnetism is 'frozen' into the sea-floor basalt and other rocks."[57] Wrongly interpreted, "the geomagnetic reversal patterns have generally led to the conclusion of smoothly continuing, slow spreading of the ocean floor. The geological record, however, is one of 'fits and starts' with short tectonic episodes followed by prolonged intermissions of relative quiescence."[58]

In King's estimation, "the hypothesis of continuous seafloor spreading from Jurassic to recent is not tenable."[59] Results from the Deep Sea Drilling Project indicate "that the ocean basins have not grown slowly through geologic time, but that there were Mesozoic phases of great activity and rapid ocean widening, followed by long intervals of quiet widespread deposition [...] through the early Cenozoic."[60] Indeed, King continues, "the more the geology of Cenozoic time is examined, the more reason appears for regarding the horizontal drift function as dominant mainly in late Mesozoic time, and the present configuration of continents as having been then designed with but little alteration during the Cenozoic era."[61]

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Earth expansion probably began beneath the Pacific, possibly as early as the Middle Triassic.[*] Continental displacement, caused by expansion, did not begin until Late Triassic or Early Jurassic time with the rupture of Laurasia, the northern supercontinent, and the initial separation of the New World from the Old. During the Middle and Late Jurassic, expansion and drift was extremely rapid, especially in the southern hemisphere. "Gondwanaland fragmented into the five southern continents – Africa, South America, India, Australia and Antarctica – all of which drifted centrifugally apart as though the parent supercontinent had 'exploded'."[62]

The plate theory attributes the dismemberment of Gondwanaland to seafloor spreading driven by convection cells within the mantle; and indeed the shattered remnants of Gondwanaland appear to have drifted apart horizontally. But according to the expansion hypothesis, the various continents remained *in situ* and rose vertically (radially outward on a sphere) as the Earth expanded beneath the oceans; strictly horizontal motions, including plate convergence and transform faults, are superficial and secondary consequences of this vertical displacement. "Each continent rode as if it were upon a cushion of levitating mantle. The power

[*] The Middle Triassic is somewhat earlier than current doctrine would indicate. Most continental drift (and expansion) timetables date the onset of drift (and expansion) as Late Triassic or later. But there is evidence – vertical tectonic activity or perhaps ocean-widening – that expansion began in the Middle Triassic beneath the EoPacific, the ancient ocean surrounded by Pangaea. Throughout the Paleozoic and into the Early Triassic, according to W.L. Stokes of the Utah Geological and Mineral Survey, the EoPacific coastline ran through Utah. "During Middle Triassic time a barrier of some sort seems to have come into existence in what is now eastern Nevada. The name, Mesocordilleran High, intentionally gives no clue as to whether it was a high mountain range, low highs, or only a gentle arching. In any case it was sufficient to prevent inward flooding of the ocean. The creation of this barrier was, in itself, a significant event but it was only the first step in a 220-million-year-long gradual westward shift of the Pacific coastline to its present position." Linking the event to the onset of continental drift, Stokes suggests that the "splitting of the Atlantic is near enough in time to the rise of the Mesocordilleran High that a cause and effect relationship is reasonable. During the time of maximum disturbance, the Middle Triassic, no sediments seem to have been deposited in Utah." (Stokes, W.L., 1986, *Geology of Utah*, Utah Museum of Natural History, Salt Lake City, UT, p. 106.)

source might be expected to fail ultimately, but to begin with each continent was powered like a rocket."[63] The rate of expansion was especially rapid in Late Jurassic time but became more episodic during the Cretaceous Period, slowing down in the Middle Cretaceous only to accelerate once more in the Late Cretaceous. But "by the end of the Mesozoic most of the original impetus of continental fragmentation was spent, and the several land masses had arrived near their present geographical positions."[64]

This timetable of extensive Mesozoic drift, caused by rapid Earth expansion, with very little post-Mesozoic drift, conflicts with current doctrine. However, if this timetable is accepted tentatively as a working hypothesis, it yields some very interesting consequences with respect to early Mesozoic history.

According to classical physics, Earth expansion would have been associated with a reduction in surface gravity; expansion would cause a decrease in surface gravity inversely proportional to the square of the increased radius. (Doubling the earth's radius, for example, would cause a fourfold reduction in gravity, although a reduction of this magnitude is not likely.) As noted above, some writers reverse this sequence and suggest that a gravity decrease preceded and caused expansion. Whatever the sequence, and whatever the cause, it is not unreasonable to expect a reduction in surface gravity if the Earth has expanded. This expectation assumes additional significance when combined with the timetable of Mesozoic expansion outlined above. Rapid Earth expansion beginning in the Middle Triassic implies a precipitous reduction in surface gravity during the latter half of the Triassic Period. Coincidentally, this corresponds with momentous events in the history of life. If Earth expansion began in Middle to Late Triassic time, it would have been contemporaneous with an upheaval in the terrestrial fauna – the demise of the mammal-like reptiles and the origin of dinosaurs. This topic will be fully examined elsewhere.[65]

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