EARTH EXPANSION REQUIRES INCREASE IN MASS

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Research in one field of scientific endeavour can re-direct another. Geological evidence for an expanding earth is now at a point that a fundamental change in physics is imminent. Mass is being created within the Earth.

In 1915 Wegener (1966) postulated that the continents were originally a single unit, Pangaea. The scientific world incorrectly dismissed Wegener's hypothesis. In 1956 Carey (1958) rekindled continental drift using tectonic evidence. This resulted in the deep-sea drilling of the 1960's which led to the theory of "plate tectonics". That theory not only solved many problems in geology but also in several other branches of science.

Yet "plate tectonics" has a fundamental flaw; it assumes that the rate of new oceanic crustal creation at the spreading ridges is equal to the rate of oceanic crustal disappearance, or subduction, at the oceanic trenches. An excess of creation over subduction was postulated by Owen (1983) with his 180Ma (180 million years ago) Earth radius (R_{180}), 80% of the present, that is, $R_{180} = 0.8R_0$. This has been termed "slow" expansion compared with the "fast" expansion of Carey (1976) who had no subduction, that is, $R_{180} = 0.55R_0$.

This paper presents evidence for expansion at a little less than the "fast" rate and in which the mass (and volume) of the Earth has increased at an accelerating rate while average density has fluctuated.

ASYMMETRIC EARTH EXPANSION

The angle between the Earth's rotational axis and the plane of the ecliptic has usually been greater than at present. Increasing tilt from 45Ma to the present formed polar ice-caps and relatively well defined climatic zones. This situation last occurred in the Late Carboniferous/ Early Permian, approximately 280Ma. Four climatically controlled Early Permian floras were recognised by Wegener as important in continental reconstructions. These included the southern and northern cool-temperate to polar Glossopteris and Angaran floras and the tropical and subtropical Euramerian and Cathaysian floras (Figure 1a).

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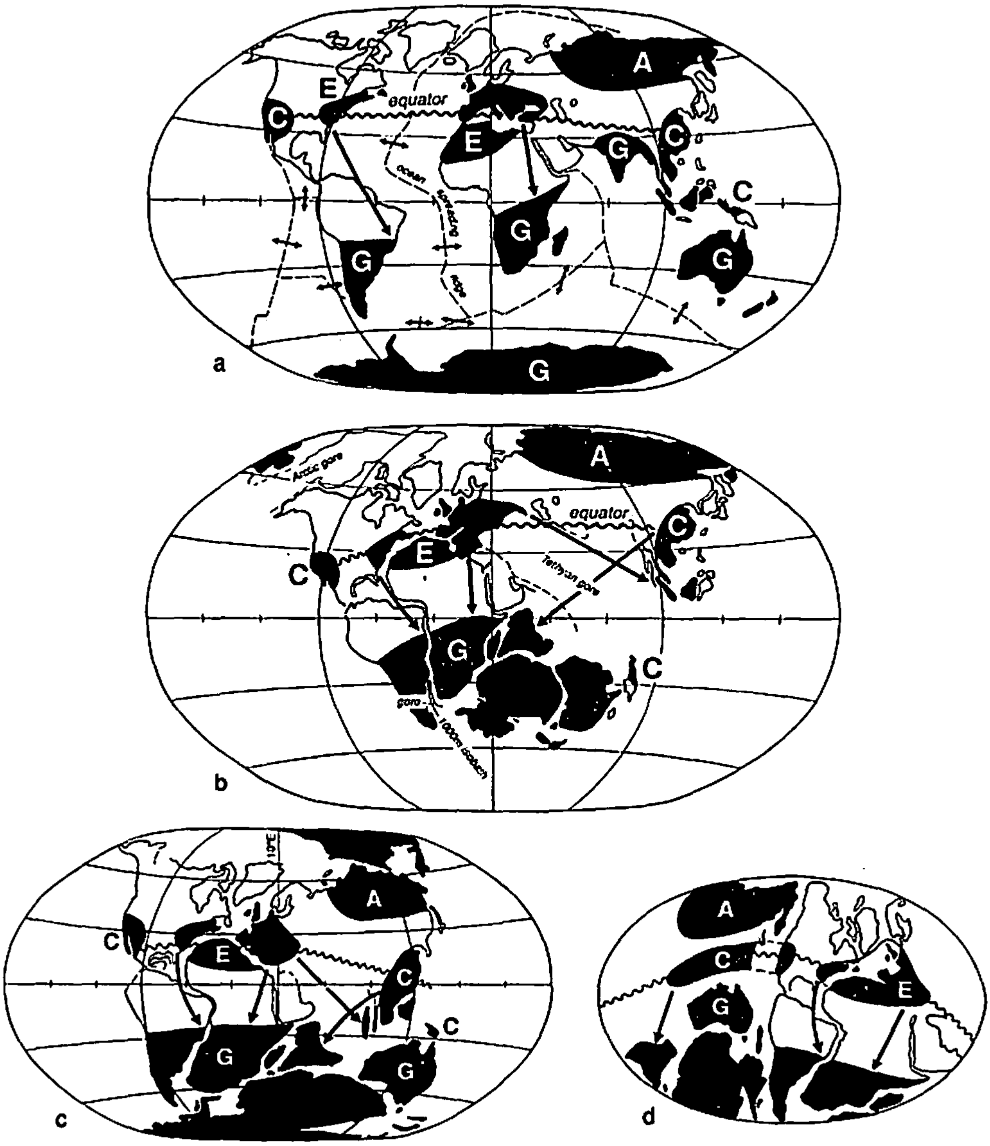

Figure 1. Distribution of Early Permian (280Ma) floras. (a) present Earth radius, R_0 = 6400 km; (b) Early Jurassic (180Ma) Earth radius, $R_{180} = R_0$; (c) Early Jurassic (180Ma) Earth radius, R_{180} = 80%R_0 (a-c, after Owen, 1983); (d) Early Jurassic (180Ma) Earth radius, R_{180} = 55%R_0 (after Carey 1988). Cool temperate to polar: G = Glossopteris, A = Angaran. Tropical: E = Euramerian. Sub-tropical: C = Cathaysian (after Davidson 1983).

Owen (1983) reconstructed the continents at 180Ma on a present radius Earth (Figure 1b). This reconstruction partly solved the problem of large oceanic expanses separating each non-marine flora imposed by the current distribution of the continents. Not only were the dispersed floras joined in a single continental mass (Pangaea) but the excursions of tropical forms into the southern cold flora were also partly explained, for example, Euramerian flora to Brazil and Zimbabwe. Owen used both dated oceanic crustal information and the edges of the continents in order to cartographically accurately re-assemble the globe. However, he found small oceanic "gores" for which there was no accounting, for example, between southern Africa and South America. He made six reconstructions using progressively smaller Earth radii (Figure 2a). The smallest was 80% of the present radius at 180Ma ($R_{180} = 0.8R_0$) which totally removed these small "gores" (Figure 1c). It is surprising that the removal of such relatively small gaps had the cumulative effect of removing the geologically unacceptable Tethyan and Arctic "oceanic" gores. His non-continent area or palaeo-Pacific Ocean was 50% of that in the present radius reconstruction (Figure 1b). Owen considered there were no oceans 700Ma on an Earth of 50% present radius (Figure 2a) because layered ophiolites (oceanic crust) are not known prior to that time.

The Figure 1c closure of "Tethys" further reduced the 280Ma floral distribution problem by placing the Cathaysian floras of China adjacent to those in Iryan Jaya. It also provided elements of the same flora with a land-bridge for mixing with the Glossopteris flora in India. However, the 80% radius is too high because the shape of each continent has changed; Owen did not take into account the tensional features within continents largely resulting from expansion-induced changes in radius of curvature. Further, his pre-100Ma reconstructions around Antarctica are interpretative due to lack of detailed sea-floor spreading data. He may have used too much subduction. Figure 1c shows the Euramerian and Cathaysian floras, 0° to 20° north of the 180Ma equator, about 30° from their current position 30° to 50° north of the present Equator. Therefore the 180Ma Earth circumference was approximately 240 present degrees, that is, $R_{180} = 0.67R_0$ (Figure 2a, Davidson) using Owen's reconstruction, not $R_{180} = 0.8R_0$. If the radius of curvature of the continents were increased the reconstruction would be on a smaller Earth, suggesting the 0.67 value might reduce further, the real value being nearer Carey's $R_{180} = 0.55R_0$ than Owen's $R_{180} = 0.8R_0$.

Davidson (1983) required the Cathaysian floras of China/SE Asia and western North America to be in communication, possibly as in Carey's (1988) draft reconstruction (Figure 1d). If the axis of the Euramerian and Cathaysian floras lay on the 280Ma equator, the 40° northwards migration of that axis, supported by palaeo-magnetic data (Carey, 1976), equates to a circumference of 200 present degrees, or Carey's $R_{180} = 0.55R_0$. However, the area of the cold Glossopteris flora is considerably greater than its northern equivalent, the Angaran flora. Hence the 280Ma equatorial floral axis may have been located slightly north of the geographic equator. The Earth may therefore have had a 280Ma radius, a little more than 0.55R, with the Cathaysian flora possibly encircling a small palaeo-Pacific, as in Vogel's (1983) $R = 0.6R_0$ reconstruction.

While Carey (1988) emphasised the preliminary nature of Figure 1d, the north/south asymmetry in the polar floras is not solved by other reconstructions, for example, Vogel's (1983) Pangaea differs little from Carey's in moving Australia/Antarctica south relative to South America and in rotating North America anticlockwise by moving Asia/Siberia southwestwards. The asymmetry is probably real, greater areal extent of the southern Glossopteris flora reflecting a broadening non-marine area due to the developing southern expansion bulge 280Ma. Davidson (1992) has related this expansion asymmetry, so clearly seen in the current distribution of spreading ridges (Figure 1a), to the 97%/3% northern/southern distribution of world oil reserves; an enormous asymmetry.

Figure 2a shows that in this paper $R_{180} = 0.67R_0$, possibly less than $0.67R_0$ and there were no oceans before 700Ma. Broad platformal depressions were present pre-1500Ma. From

1500Ma to 700Ma extensional grabens were common possibly representing slow expansion from $R_{1500} = 0.5R_0$ to $R_{700} = 0.55R_0$.

INCREASE IN MASS

The initial assumption of earth expansion is that increased volume is achieved by decreased density under constant mass and possibly with changes in G, the gravitational constant. The latter is very tightly constrained within a 10^{-11} variation per annum by astronomical observations (Napier, pers. comm.) which, over the last 180 million years in inadequate by three orders of magnitude in accounting for the rate of expansion of the Earth. The constancy of mass presents both chemical and physical problems. If the whole Earth were composed of dynamite its internal energy would be inadequate by an order of magnitude to generate the required expansion from $R_{180} = 4000km$ to $R_0 = 6000km$ (Napier, pers. comm.) suggesting chemical energy is inadequate. Even if this could be achieved, physical constraints are imposed by g, the acceleration due to gravity, variation of which over geological time has only recently been substantiated by Mann and Kanagy (1990). They noticed that the maximum angle of bedding

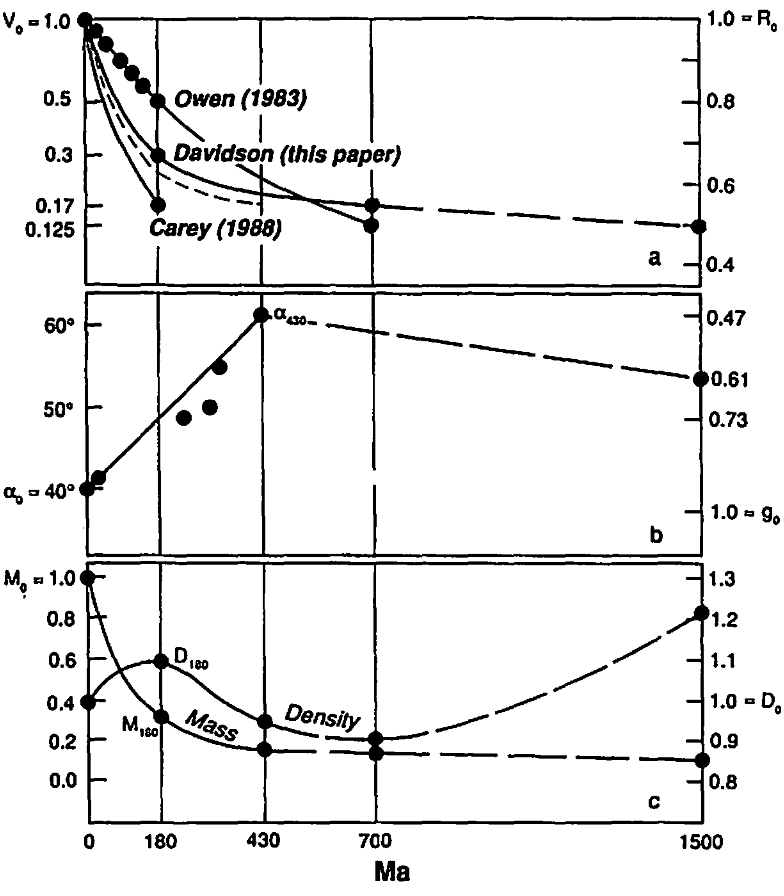

Figure 2. (a) volume (V) and radius (R) of the Earth against geological time (Ma = millions of years before present); (b) maximum angle of repose of cross-bedded sandstones (α) (after Mann and Kanagy, 1990) and acceleration due to gravity (g) against geological time; (c) mass (M) and density (D) of the Earth against geological time.

repose (α) increased from 40° on present sand-dune faces to 61° at 430Ma (Figure 2b). Intervening measurements indicate the angle of repose is almost linear from the present to 430Ma. Four very consistent maxima of 53° to 54° were reported at 1450Ma to 1500Ma.

The angle of internal friction (ϕ) of slope deposits is related to the shear stress on the potential sliding surface (s), the pressure exerted by the material (p) and the cohesion (c) by

$$s = c + p \tan \phi$$

For uncemented, dry sand grains and water-immersed sand grains c is zero. Therefore, for wind and water-deposited sands

$$s = (M/A)\, g_0 \tan \alpha_0$$

where M = mass, A = area and g_0 and α_0 are the present acceleration due to gravity and maximum angle of repose.

α_0 is less than 30° for rounded, well-sorted grains and increases to 40° for angular, poorly sorted grains. These variables in the Mann and Kanagy data sets can be eliminated in determining the variation in g with time by only considering the maximum value of the angle of repose in cross-bedded sandstones. Therefore, assuming the shear stress at the point of sliding has not changed since 430Ma, that is, the physical properties of sands have not changed

$$g_0 \tan \alpha_0 = g_{430} \tan \alpha_{430}$$

$$\text{or} \quad g_0 \tan 40° = g_{430} \tan 61°$$

$$\text{or} \quad g_{430} = 0.47 g_0$$

Note that this is conservative as 61° is the cross-bed angle after compaction.

Since force $F = (Gm_1m_2)/R^2$, $g_0 = (GM_0)/R_0^2$ and $g_{180} = (GM_{180})/R_{180}^2$, where M_0, M_{180}, R_0 and R_{180} are the mass and radius of the Earth at the present and 180Ma, respectively.

From Figure 2b,

$$0.73 g_0 = g_{180},$$

$$\text{therefore } (0.73GM_0)/1^2 = (GM_{180})/0.67^2$$

$$\text{or} \quad M_0 = 3M_{180}.$$

Also, $M_0 = D_0 V_0$ or $M_0 = D_0 (3.3V_{180})$, where D_0, V_0, V_{180} are the density and volume now and 180Ma. Therefore,

$$M_{180} = 1.1 D_0 V_{180}$$

Thus the mass of the Earth has increased three-fold since 180Ma and average density has decreased about 10% (Figure 2c).

The Earth mass/density relationships with time can be traced to 430Ma but prior to that are a little conjectural due to limited data (Figure 2c). Although Carey has no oceanic crust prior to 180Ma, the absence of ophiolites prior to 700Ma places a limit on the first appearance of oceanic crust. It seems likely that from 1500Ma to 700Ma the Earth's radius increased about 10% (Figure 2a) with a small increase in mass, but volume and mass increase began to accelerate exponentially from 430Ma. The current expansion rate is very rapid and gives rise to questions like, how is the extra mass being created (it seems to be occurring in the core as there is no evidence at the surface); will the Earth ultimately explode and form another asteroid belt or will it become a Jupiter, then a Sun and so on up the Main Sequence of stars?

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