WEGENER AND CONTINENTAL DRIFT

i1 Evidence that continents float

< isostasy, gravity anomalies, hypsometric curve >

This is about the stillness in moving things. —Howard Nemerov (1920-1991), *Runes*.[1]

In 1740, Pierre Bouguer (pronounced *boo-gay*) confirmed that the deflection of a plumb line caused by the calculated mass of the Andean Chimborazo volcano is significantly *less* than expected. This result, published in *La Figure de la terre*, 1749, was found to be true for other mountains, and for the Andes it was confirmed by Alexander von Humboldt who made geodetic measurements along a trail that the Pan-American highway now follows. Humboldt even went so far, in his widely read book *Kosmos*, 1845, (first English translation: *Cosmos*, 1852), as to suggest that mountains are hollow.[2] However, the real explanation had begun to emerge when, in 1840, within the Pyrenees, a plumb-line's negative deflection (that is *away* from the mountain) was found by Ours-Pierre-Armand Petit Dufrénoy (1792-1857): the crust underlying the mountain can only be less dense on average than the rocks to either side. This realization came also to John Henry Pratt in 1855 when analyzing the data of a coordinated geodetic (triangulation-measured distances) and astronomical (gnomonic latitudinal distances) survey concluded in 1843 by George Everest, to measure the meridian to great accuracy[3] of peninsular India between Kalianpur and Kaliana, and which differed by 5' 236" of latitude. Evidently, Himalayas' pull on the plumb line was less than had been anticipated.[4] Ergo, mountains are not supported as a mass sitting on a strong and unyielding subcrust, but exist *because they float.*

Such an explanation for topography is memorably demonstrated (***Figure i1.1***) by the equilibrium flotation attitudes of blocks of wood, with different cross-sectional shapes, in water. By analogy, Earth's crust is comprised of blocks of rock that are buoyant (float) in the yielding and denser rocks of Earth's mantle.

Two differing, but complimentary "isostatic" (as these were later called, see below) hypotheses published in 1855 to explain the apparent deficit of gravity where mountains exist, are due to mathematician John Henry Pratt (1809-1871)[5] and astronomer George Biddell Airy (1801-1892).[6] In Pratt's physical model, a mountain is where floating crust is less dense than where there is no mountain, and in Airy's, a mountain is the surface expression of floating crust of thickness a multiple of the mountain's height. In both models the simple view is that above a level chosen to be deeper everywhere than the bottom of the crust, which Pratt in 1859 called the "level of compensation,"[7] rock columns of equal cross sections will be equal in weight (***Figure i1.2***).

Observations show that where weight is added or removed from the land, the response is a measurable sinking, or raising, of elevation. The rock below can apparently yield, and flow away when the weight is applied, and back when the weight is removed. The rebound of Scandinavia, North American Great Lakes, and Hudson Bay,[8] that is taking place where ice sheets were until ten thousand years ago, are examples. The study of the adjustment due to weighting of an elastic (brittle) crust on a yielding denser subcrust was called *isostasy* by Clarence E. Dutton in 1882. His conception of isostasy favored Airy's floatation principle and accorded to a physical model due to Osmond Fisher, and which Vening Meinesz later attempted to improve (***Figure i1.3***). ❑

Figure i1.1 [9] Experiment demonstrating tilting of floating blocks (Stephen Taber, *Fault Troughs*, 1927).

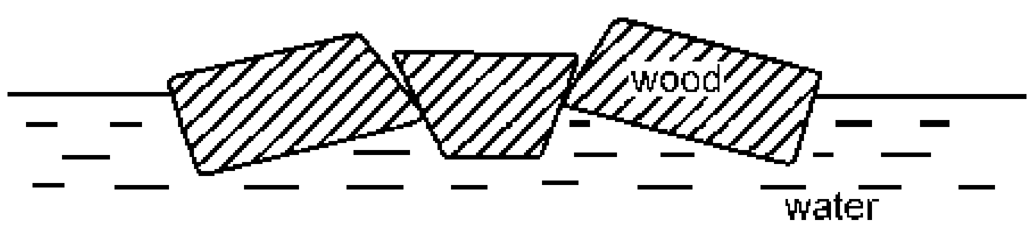


Figure i1.2
Pratt isostasy can explain thermal bulges such as the oceanic rise-ridge systems. Floating columns with the same horizontal cross section have the same mass and so they have a common level to their base. However, the overall density and so proportionally the height of each column can be different.

Airy isostasy (sial 2670 kg/m^3, sima 3270 kg/m^3) can account for young continental mountains that have roots. The analogy is that plains and mountains float like pack ice and icebergs respectively: crustal thickness determines topographic elevation.

Heiskanien isostasy [10] best accounts for the existing continental crust where density increases with depth. As the elevated part of a mountain is progressively removed by erosion, its rate of rise due to unloading will slow because the buoyancy of the remaining floating block of the ancient mountain becomes less as its overall specific gravity becomes closer to that of the sima.

At the level of compensation (~100 km depth assumed by Pratt) and (~30-40 km depth assumed by Airy), vertical columns of equal horizontal cross section have the same weight.

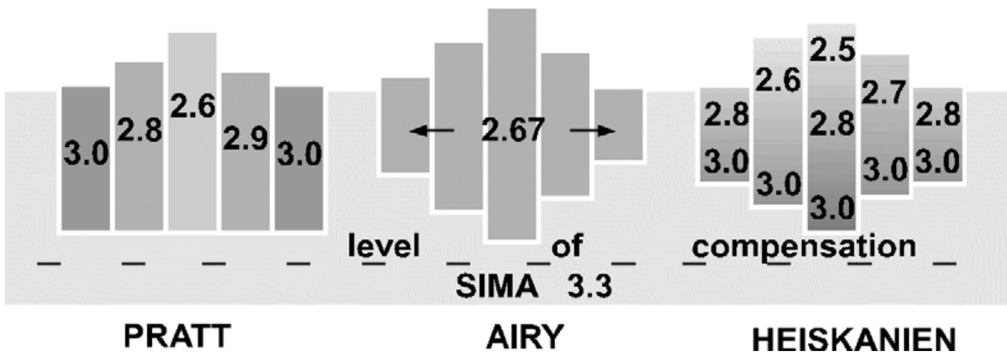
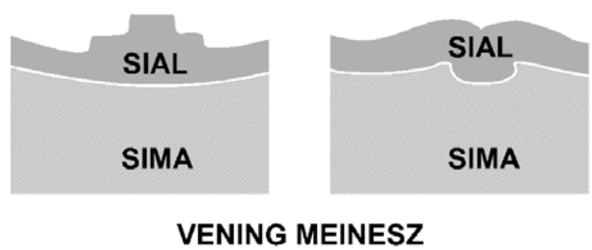


Figure i1.3 [11] The physical interpretation of isostasy by Vening Meinesz. Mountains made of crustal rock float Airy style in a denser but weak subcrust (asthenosphere). However, that rock elasticity distributes a mountain's weight of over an area wider than its visible self or its root [12] is false for such long-existing structures but does have application to the dynamics of faulting, folding, ice sheet loading & offloading, and bending of active lithospheric plates.



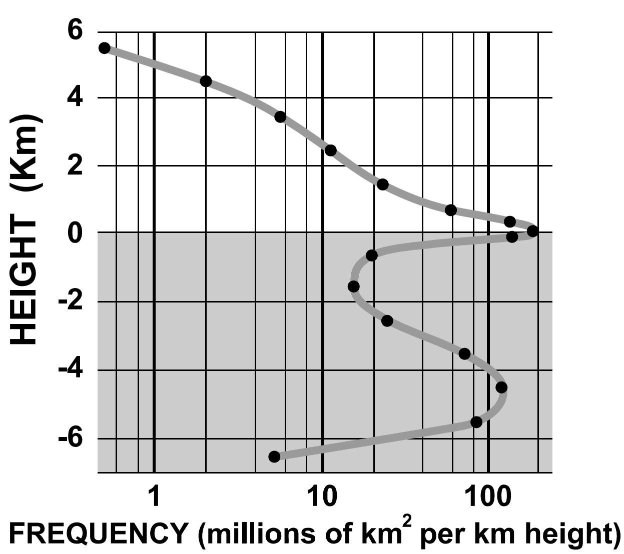


Figure i2.1 [1]
The hypsometric curve shows how much of Earth's land area (line in white field) and seafloor area (line in gray field) is at each elevation (height) relative to mean sea level (zero height).

The distribution frequency has maxima that correspond to the mean elevations of the continents (mean height of 125 m) and the ocean basins (mean depth of 4.5 km).