# Archdeacon Pratt and the theory of isostasy

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The internal constitution of the earth reveals that it has a core composed largely of metallic iron and nickel covered by lower mantle and an outer layer of thin crust and upper mantle together constituting the lithosphere. It is usual to give the analogy of an egg to picture the constitution of the earth. The yellow portion at the centre is compared to the core, the white albumen part to the mantle and the outer egg shell to the rocky crust. In reality, this outer crust is not uniform but is thick beneath the continents and thin below the oceans.

The upper part of the mantle, the asthenosphere, is believed to behave like a viscous fluid, with the result that in a mountain range like the Himalayas, low-density matter gets piled up, fold upon fold, with its root extending in depth, in much the same way as an iceberg, which has an extensive mass of ice beneath the water level and only the top projecting above the surface. The lithosphere, made up of continents and oceans, is conceived as floating, in a sense, above the lower mantle. One consequence of this concept is that when the crust gets loaded with either thick layers of ice, sediment or volcanic flows, it gets depressed. Conversely, when load is removed by way of erosion or by melting of the ice sheet, that portion gets uplifted. Such changes or adjustments take place to maintain equilibrium. The name 'isostasy' has been given to this condition of equilibrium. Excess mass above is balanced by a deficiency in density below and vice versa. Holmes (*Principles of Physical Geology*, 3rd edn, 1978, p. 19) has thus defined isostasy as the ideal condition of gravitational equilibrium that controls the heights of continents and ocean floor and, therefore, a very important geological and geophysical concept.

This idea appears commonplace today but the basic concept was enunciated a long time ago and the name of John Henry Pratt, Archdeacon of Calcutta, is closely associated with it. Col. George Everest (of Mt Everest fame), Surveyor-General of India (1830–1847), had observed, during a triangular survey of North India, differences between the astronomic observations and measurements across the land at stations Kaliana near the Himalayan foothills and Kalianpur in Central India. Astronomically, the distance between Kaliana and Kalianpur was found to be 5° 23′ 37.058″, while from triangulation measurements, the distance was 5° 23′ 42.294″. There was thus a difference of 5.236″ between the two measurements amounting to 168 m, which had to be accounted for. John Henry Pratt was requested in 1852 to find a solution to this anomaly. How an Archdeacon at Calcutta was selected for such a study is not known. Pratt gave thought to this problem and came out with two papers published in *Philos. Trans. R. Soc. Lond.* in 1985 (vol. 145, pp. 53–100 and 101–104). He pointed out that this difference was due to mass deficiency underneath the Himalaya and not due to any error in measurement. His solution has since come to be known as Pratt's hypothesis. At about the same time, Sir G. B. Airy, who was the Astronomer-Royal, also examined the 'Indian puzzle' and came out with the convincing explanation that the height of the Himalayan mountain is compensated by a deeper root below. In other words, the gravitational attraction by the extra mass of the mountain was compensated by a deficiency of mass beneath. The higher the mountain the deeper the root and thicker the crust. These two hypotheses have formed the starting point for much of modern research on isostasy and mountain building. The principle of isostasy has come to be considered as the geological version of the Archimedes principle of buoyancy.

As now understood, it is this principle of isostasy which makes the continents and mountains stand high because they are thick and composed of lighter material (density 2.7 g/cm$^3$). Oceans, on the other hand, lie low because the crust beneath the ocean is thin, formed of a rock with high density (3.2 g/cm$^3$). The oceans and the continents can, therefore, be considered as blocks having different densities floating on a viscous and dense asthenosphere.

Weight added to the ocean basins on account of sediment load makes them sink providing room for further sediment accumulation. Similarly, when erosion removes material from a mountain, the weight gets reduced and isostatic adjustment takes place causing the mountain to slowly rise. Earth is pictured not as an inert mass but a dynamic entity pulsating with life and movement. It is this feature of the earth not probably found in any other planet which makes it unique in the solar system.

A visual demonstration of the principle of isostasy is provided by Fennoscandia. Because of excessive load of ice during the last ice age the continent slowly sank. When the ice melted and the load was removed, the continent slowly began to rise and it is stated that the continent is still rising. Former beaches are now found at differing heights above sea level. It has been estimated that land has been rising at an average rate of 2 cm per year for at least 5000 years. Similar evidence of uplift are to be found in different regions of the Himalaya.

The discovery of low-density roots to mountains has many practical applications. Gravity anomalies are now being used to provide information on conditions at the subsurface. The existence of a rock body below surface which has a different density from the surrounding is indicated by a gravity anomaly on the map.

We should be proud of the fact that this universally accepted principle of isostasy which so satisfactorily explains the topographic differences on the surface of the earth and presents a picture of a dynamic and throbbing planet emanated on Indian soil a little more than hundred years ago.

Ancient legacies often tend to act as dead weight and burden. This should not be. Ancient legacy and modern concept should blend together. This will happen only when we keep on ploughing, making the two blend harmoniously. It is only then, a seed falling on such a ploughed up and fertile soil has a chance to grow and yield a rich harvest.

Archdeacon Pratt is remembered for his great contribution which has been accepted as a framework of development of earth science these last hundred years.

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