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Correlation of the Post-Triassic History of Tasmania with Secular Variation in Temperature and Viscosity of the Sub-Crust.

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WITH 1 TEXT FIGURE

ABSTRACT

The Post-Triassic igneous activity, sedimentation, epeirogeny, peneplanation, and faulting of Tasmania may be correlated genetically with secular variation in the temperture of the sub-crust.

The sequence of geological events in Tasmania since the Triassic, which has been summarised elsewhere by Carey (1946), may be tabulated as follows:—

1. Permian: Shallow transgressive sea over a region of substantial relief.
2. Triassic: Lacustrine sediments including coal seams. This sequence may extend into the Lower Jurassic.
3. Widespread invasion of Permian and Triassic sediments by thick sills and sheets of dolerite, resulting in plateau mountains perhaps 3000 feet above sea level.
4. Peneplanation lasting eighty million years or more which carved deeply into the Permo-Triassic sediments with their dolerite sills, producing a fairly mature peneplain.
5. Early Tertiary epoch of violent epeirogeny with strong block faulting and tilting, producing new relief some 5000 feet high, and a series of deep fault lakes which rapidly filled with sediments.
6. Early Miocene(?): Widespread extrusion of basalts over a surface of sharp relief.
7. New cycle of erosion with little subsequent movement.

In Figure 1 these events are correlated with the changing conditions of the sub-crust. The top curve shows qualitatively the implied temperature variation, indicated by the two epochs when the sub-crust was hot enough to produce very large volumes of basaltic magma. This is of course greatly oversimplified, for both these culminations probably had lesser culminations and there may well have been lesser intermediate fluctuations. But there can be little doubt that this curve represents the variation to the first harmonic which would be made more irregular by the changing temperature. Viscosity varies exponentially with plot them. The second curve shows qualitatively viscosity as implied by the changing temperature. Viscosity varies exponentially with temperature, hence the downward troughs in this curve would be necessarily sharper than the corresponding temperature curve drawn with the same amplitude. (In this paper viscosity is used in its broad sense to include pseudo-viscosity of crystalline solids which is not Newtonian.) Let us follow out how this fluctuation in viscosity is expressed, in the sequence of geological events. During the early Permian the sediments themselves and their relation to basement indicate quite substantial relief which declined progressively into the Triassic, when well sorted and well rounded quartz sandstones and shales indicate subdued terrains and slow subsidence. The late Triassic includes tuffs, the first indication of the heating substratum. Meanwhile the declining viscosity of the substratum (and in consequence the crust) meant that stress differences which had been supported before could not be supported, so uplift commenced. By the time the sub-crust was hot enough to produce the dolerites the viscosity had declined to its minimum and the isostatic adjustment was as near perfect as it could be. The new relief was immediately subject to a new cycle of erosion, which would have resulted in some new departure from isostasy commencing from near zero and rising with time. But meanwhile the viscosity, at first at a minimum, was increasing rapidly with time, so there was increasing viscous resistance *pari passu* with the increasing isostatic load. By the late Cretaceous, peneplanation had reached an advanced stage so that very substantial uncompensated isostatic loads had been built up, but as the viscosity of the sub-crust was then at its maximum these loads could be borne without significant movement. However, the viscosity began to decline again whereas the isostatic load continued to increase (though at a diminishing rate), so the coming epeirogeny was inevitable.

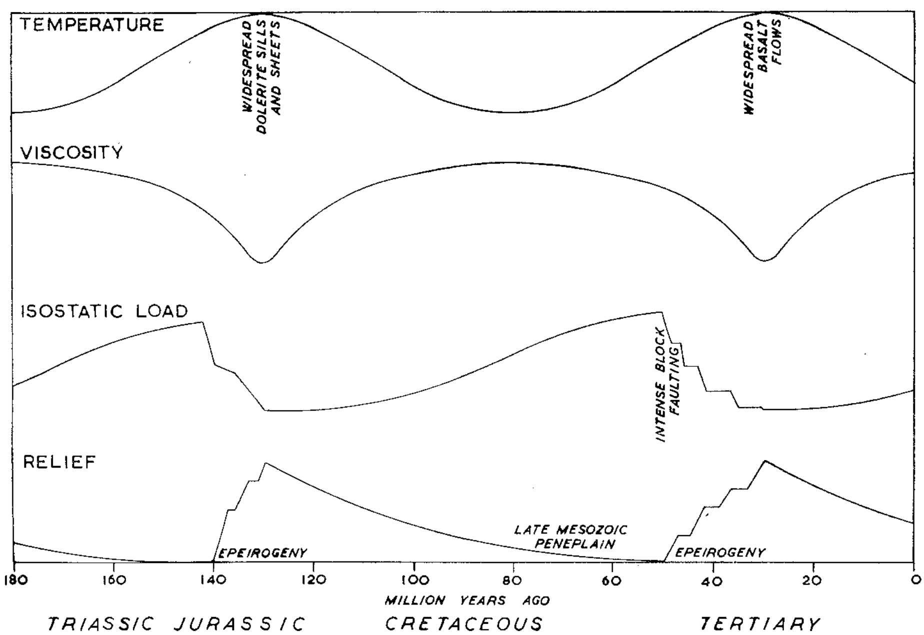

FIG. 1.—Post Triassic tectonics of Tasmania

This would appear first as an increasing rate of upwarp then, as the viscosity dropped steeply, the rate of adjustment would be too fast for quiet relaxation of the stresses, so the violent early Tertiary faulting ensued. By the time the highest temperature was reached the isostatic adjustment would be as complete as it could be, so the basalt floods in the main followed the epeirogeny (though very closely) and hence the basalts show very little sign of the epeirogenic disturbance.

The secular fluctuation in rheidity as illustrated above is of importance in interpreting large areas of one-sign gravity anomaly as evidence of strength of the earth's crust. Prior to the early Tertiary orogeny the cold crust below Tasmania was bearing the load which was subsequently adjusted at time of lower viscosity by a general uplift of 1000 metres. Since the density of the fluid displaced in the sub-crust is over 3, this means that the uncompensated load which the crust can bear in those regions where its secular temperature is low is at least of the order of 300 kg. per sq. cm. greater than in those sectors where higher subcrustal temperatures prevail. Further, since it may be fairly assumed that the isostatic load was reduced to negligible amount at the time of the extrusion of the basalts, the total isostatic uplift indicates that loads equal to the weight of 1000 metres of substratum material (weight of fluid displaced) are ample to cause continuous flow in the substratum, and to rupture the crust at times of low viscosity, but are not sufficient to cause geologically rapid flow in the substratum in times or regions of secularly high viscosity. This means that the threshold for geologically rapid flow in the substratum varies from 10^8 dynes per sq. cm. or more, to perhaps 10^7 dynes per sq. cm. or less according to the secular condition of the crust.

Reference

CAREY, S. W., 1946.—" Geology of the Launceston District ". *Recs. Queen Vic., Mus.*