one of the most marked characteristics of some of these boulders was their containing large garnets, similar to those in a rock found in the neighbourhood of Fiskernäs, in South Greenland. It is perfectly correct that some of the boulders I met with in Grinnell Land were of garnetiferous gneiss, and the difference between them and the blue Silurian limestone or dark Azoic slate, the rock *in situ*, on which they were lying, could hardly fail to attract attention. From Lady Franklin Bay, on the west side of Robeson Channel, as far north as Cape Joseph Henry, I did not meet with this garnetiferous gneiss as a rock of the country. It does not occur as such in Hall Land, neither do I think it can be found *in situ* along the lands visited by Aldrich in his journey along the north shore of Grant Land, nor on the northern shores of Greenland traversed by Beaumont, Lockwood, Brainard, Peary, and Astrup, for this rock is of such a striking character that such intelligent observers as I have mentioned could not well have passed over it without remarking its garnetiferous structure. There was a fine example of an ice-rounded boulder of this remarkable rock lying stranded a little above high-water line, not far from the "Alert's" winter quarters, in 82° 27′ N. Fortunately I brought away with me fragments of this boulder, which are now in the British Museum; I am informed that the fragment is a "coarse-grained aggregate of large garnets, orthoclase, cordierite, fibrolite, and quartz, with a little biotite. A peculiar feature of the rock is the enclosure of rounded quartz crystals in the felspar. It is probably a garnetiferous cordierite-fibrolite gneiss, but the fragment is too small to show the foliation."

The conclusion I arrive at is, that this erratic boulder and its fellows, scattered over the shores of Grinnell Land and North Greenland, cannot by any possibility have been derived from South Greenland, and floated up through Davis Strait, Baffins Bay, Smith Sound, and Robeson Channel, to the Polar Sea. Such a supposition is as much at variance with fact, as to cast a bladder into the sea at Cape Clear, and assure us that it reached the West Indies; and I cannot understand how a man of Bessels' ability could formulate such a theory. It is far more reasonable to presume that these erratics are derived from some land within the unknown region of the Polar area. If so, the land that produces them must support glaciers, for these ice-worn boulders have passed through the mill of a glacier, to give them their present shape and wear. There can be little doubt that the drift-wood stranded on the shores of the Polar Ocean, along the coast of Grinnell Land, is derived from the great rivers of Siberia, and the same drift and current that transports it is equally capable of drifting ice-borne erratics from unknown Polar lands.

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EXPANSION THEORY OF MOUNTAIN EVOLUTION.

Sir,—Mr. Davison, in a "Second Note on the Expansion Theory of Mountain Evolution," quoting Prof. Le Conte, restates what he thinks to be a fundamental objection to the expansion theory.

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He does not, however, allude to, and therefore possibly has never taken the trouble to read, the several direct replies I have given to this very objection when made by people who had failed completely to understand what my theory, as originally published in 1886, really is. One such complete refutation is contained in a paper in this MAGAZINE in May, 1894, entitled, "On the Result of Unsymmetrical Cooling and Redistribution of Temperature in a Shrinking Globe as applied to the Origin of Mountain Ranges," in which I have dealt broadly with the whole subject, and have shown that the effect of sedimentation is to check the Earth's cooling in the area in which the sediments are being laid down. The form in which the case is stated, both by Le Conte and Davison, shows an entire misapprehension of the whole problem. It is not that the sediments abstract heat from the portion of the Earth's crust upon which they lie or with which they are in contact, but that they simply prevent the outflow and consequent loss of that heat from the nucleus which would otherwise be dissipated into space, and this heat thus retained expands them. I have shown in the paper referred to that it is to the *redistribution* of heat in the crust, and the consequent alteration of stresses and strains, that we are to look for the effective cause of mountain folding and upheaval. To say, therefore, that the "*increased heat must be taken from somewhere else*" is an obvious truism which conceals the implied fallacy that sedimentation at a certain point will cause a greater loss of heat at that point than at the surrounding points whereon no sedimentation has taken place, and this is not true—it is exactly the reverse—less heat will be lost at that point.

Mr. Davison, thinking to strengthen his objections to the expansion theory, now quotes Herschel and Lebour to show that wet rock is a better conductor than dry rock. This was well known to me, through their admirable researches, before I penned a line of the "Origin of Mountain Ranges." Doubtless superficial layers of wet sediment may be better conductors of heat than the average earth-crust, but consolidated sediments miles thick are not likely to be in the moist condition common to surface-rocks. Herschel and Lebour's investigation, so far from supporting Mr. Davison's contentions, are on the whole distinctly in favour of my views. Indeed, I cannot do better than reproduce here some of their extremely acute observations on the results of their experiments, which have so far not received from geologists and physicists the attention they deserve—"In the first place, it seems to be proved by our experiments that the conducting-power of different rocks varies strictly according to their lithological character. Very crystalline rocks, such as granite and serpentine and statuary marble, allowed heat to pass rapidly through them; slate-plates, with their uncrystalline compact structure, had a still higher degree of conductivity. The crystalline nature of a rock alone is not, therefore, the lithological test of its conductivity. The lowest powers of conductivity were found to belong, among the specimens experimented on, to shale; the black shale, which was lower than the grey, is softer and more

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argillaceous than it, the grey shale having a considerable admixture of arenaceous matter and mica. The difference, however, between these two was so slight that, in the present preliminary researches, when much must be allowed to error, it may be left out of consideration altogether. It would appear, then, from these facts, that a certain compactness, accompanied by cleavage, is favourable to the passage of heat through rocks; and if it be admitted that what is true for small thicknesses is also true for great ones, we may be justified in supposing that the vast masses of clay-slate, and perhaps to a still greater extent their more metamorphosed and crystallized schists (which we know to extend to great depths), are so many points of weakness which must have their influence in the secular cooling of the earth. On the other hand, points of resistance may be assumed to exist, and to be formed by the great sedimentary accumulations of shale, and probably also of clay and other argillaceous unaltered rocks. In a column, therefore, composed in part of cleaved clay-slate and in part of shale, the easy passage of the internal heat outward through the first would be checked through the other in the ratio, roughly speaking, of five to eight. This becomes a stupendous difference when we apply it to the thicknesses we are acquainted with. If we imagine a thick covering of shale or clay or some other rock with a very *low* conductivity which has arrested in its course the heat passing up to it through underlying rocks with a high degree of conductivity—if we imagine such a surface-covering removed (as we know that they frequently have been) by denudation, it is evident that the equilibrium of the heat-resisting covering of the earth will be altered, not only at this particular spot but also wherever the material removed is being redeposited."[1]

It is obvious that the drying and consolidation of sediment goes on concurrently with its increasing depth, and it is probable that the piles of horizontal sediment miles thick which are laid down as the materials out of which future mountain-ranges are built possess a lower conductivity than the substratum of the crust, largely crystalline, upon which they rest.

But whether these sediments are better or worse conductors of heat than the average crust does not in the least affect the principle of their action as intercepters and accumulators of the heat outflowing from the nucleus; and if Mr. Davison had correctly apprehended this fact, instead of confusing the issue by the repetition of a fundamental misstatement, we might not have been favoured with No. 2 note on the "Expansion Theory of Mountain Evolution."

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[1] British Assoc. Report, 1873, Appendix p. 226: "Notes on the Conducting-power of certain Rocks," by Herschel and Lebour.