

water to marine deposits, afterwards to be described. It will also appear, in the sequel, how much light the doctrine of a continued subsidence of land may throw on the manner in which a series of strata, formed in shallow water, may have accumulated to a great thickness. The excavation of valleys also, and other effects of *denudation*, of which I shall presently treat, can alone be understood when we duly appreciate the proofs, now on record, of the prolonged rising and sinking of land, throughout wide areas.

To conclude this subject, I may remind the reader, that were we to embrace the doctrine which ascribes the elevated position of marine formations, and the depression of certain freshwater strata, to oscillations in the level of the waters instead of the land, we should be compelled to admit that the ocean has been sometimes everywhere much shallower than at present, and at others more than three miles deeper.

*Inclined stratification.*—The most unequivocal evidence of a change in the original position of strata is afforded by their standing up perpendicularly on their edges, which is by no means a rare phenomenon, especially in mountainous countries. Thus we find in Scotland, on the southern skirts of the Grampians, beds of pudding-stone alternating with thin layers of fine sand, all placed vertically to the horizon. When Saussure first observed certain conglomerates in a similar position in the Swiss Alps,

he remarked that the pebbles, being for the most part of an oval shape, had their longer axes parallel to the planes of stratification (see fig. 61). From this he inferred, that such strata must, at first, have been horizontal, each oval pebble having originally settled at the bottom of the

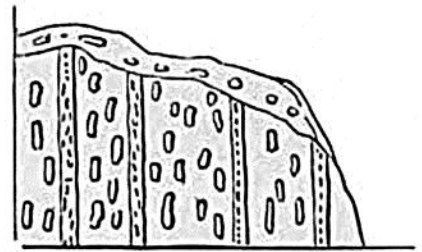


Fig. 61.

Vertical conglomerate and sandstone.

water, with its flatter side parallel to the horizon, for the same reason that an egg will not stand on either end if unsupported. Some few, indeed, of the rounded stones in a conglomerate occasionally afford an exception to the above rule, for the same reason that we see on a shingle beach some oval or flat-sided pebbles resting on their ends or edges; these having been forced along the bottom and against each other by a wave or current so as to settle in this position.

Vertical strata, when they can be traced continuously upwards or downwards for some depth, are almost invariably seen to be parts of great curves, which may have a diameter of a few yards, or of several miles. I shall first describe two curves of considerable regularity, which occur in Forfarshire, extending over a country twenty miles in breadth, from the foot of the Grampians to the sea near Arbroath.

The mass of strata here shown may be nearly 2000 feet in thickness, consisting of red and white sandstone, and various colored shales, the beds being distinguishable into four principal groups, namely, No. 1, red marl or shale; No. 2, red sandstone, used for building; No. 3, conglomerate; and No. 4, gray paving-stone, and tile-stone, with green and red-