

sudden and violent impulse has been given within the terrestrial crust, the origin of this sudden blow can only be conjectured. Various conceivable causes may, at different times and under different conditions, communicate a shock to the subterranean regions. Such are the sudden flashing into steam of water in the spheroidal state, the sudden condensation of steam, the explosions of a volcanic orifice, the falling in of the roof of a subterranean cavity, or the sudden snap of deep-seated rocks subjected to prolonged and intense strain.

In volcanic regions, the frequent earthquakes which precede or accompany eruptions are doubtless traceable to explosions of elastic vapors, and notably of steam. As earthquakes originate also in districts remote from any active volcano, and, so far as observation shows, at comparatively shallow depths, these cannot be connected with ordinary volcanic action, though it is possible that by movements of molten or highly-heated matter within the crust and its invasion of the upper layer, to which meteoric water in considerable quantities descends, sudden and extensive generation of steam may occasionally take place.¹⁸⁶ In minor cases, where the tremor is comparatively slight and local, we may conceive that the collapse of the roof or sides of some of the numerous tunnels and caverns dissolved out of underground rocks by permeating water may suffice to produce the observed shocks.¹⁸⁷ The copious discharge of materials from a volcanic vent may produce a cavity within the

¹⁸⁶ Pfaff, "Allgemeine Geologie als exacte Wissenschaft," p. 230.

¹⁸⁷ In the Visp Thal, Canton Wallis, for example, where there are some twenty springs carrying up gypsum in solution (one of them to the extent of 200 cubic metres annually), continued rumblings and sharp shocks are from time to time experienced. In July and August, 1855, these movements lasted upward of a month, and gave rise to the fissuring of buildings and the precipitation of landslips. In the honeycombed limestone tract of the Karst, also, earthquakes of varied intensity are of constant occurrence.