We may conclude our description of these remarkable phenomena with some remarks upon their causes.

Mrs. Somerville, in her admirable little work on Physical Geography, is of opinion that they are produced by fractures, sudden heavings, and subsidences in the elastic crust of the globe—these fractures and subsidences being due to the pressure of the liquid fiery nucleus of the earth's centre, and affording to its gases and vapours a number of needful vents. The tension acquired by the strata during their slow refrigeration is thus relieved, and an equilibrium restored. The shock, originated at the point where the impulse is first given by the upward movement of the vapours, is propagated through the earth's elastic surface in a series of circular or oval undulations, like those produced by dropping a stone into a pool; and like them, too, they broaden and weaken as they travel further from their point of departure. If the impetus be communicated in the interior of a continent, the wave is carried onward through the solid crust of the earth, as well as in sound through the air; and from the former is transmitted to the ocean, where it expands itself and disappears, or, if of great intensity, is continued on the opposite shore. The most disastrous earthquakes, however, have their origin in the bed of the ocean. In this case two kinds of waves or undulations are simultaneously propagated; one through the ocean-bed, forming the true earthquake-shock, and one on the ocean surface, forming a vast wave or tide which rolls onward to the shore, striking it after the earthquake-shock has been expended.

"The sea rose 50 feet at Lisbon and 60 at Cadiz after the great earthquake (of 1755); it rose and fell eighteen times at Tangier on the coast of Africa, and fifteen times at Funchal in Madeira. At Kinsale, in Ireland, a body of water rushed into the harbour, and the waters in Loch Lomond in Scotland rose 2 feet 4 inches—so extensive was the oceanic wave. The height to which the surface of the ground is elevated, or the vertical height of the shock-wave, varies from one inch to two or three feet. This earth-wave, on passing under deep water, is imperceptible; but when it comes to soundings it carries with it to the land a long, flat, aqueous wave; on arriving at the beach, the water drops in arrear from the superior velocity of the shock, so that at that moment the sea seems to recede before the great ocean-wave arrives."

The velocity of the great *wave* varies as the square root of the depth: hence it travels fastest through deep water. That raised during the Lisbon earthquake sped onward to Barbadoes at the rate of 7.8 miles in a minute, and to Portsmouth at the rate of a little more than two miles per minute. The velocity of the *shock* is proportionate to the elasticity of the strata through which it is transmitted. And it should be observed that the undulatory movements of the earth are governed by the same laws as those of light or sound; so that when the earth-wave is propagated through strata of different elasticity, it is partly *reflected*, and a wave thrown back which produces a shock in a different direction, and partly *refracted*, or changed in course, producing shocks both upwards and downwards, to the right or left of the original line of progression.*]

* [Mrs. Somerville, "Physical Geography," i. 260–266.]