crust 1 or 2 inches thick. Beneath it, the most recent lava is comparatively solid and often columnar in structure. The outside lavas of the mountain which have been ejected through fissures have no such crust, but sometimes a solid glassy exterior of a fourth to half of an inch.

Volcanic glass usually contains moisture enough for making it a light scoria when it is heated to fusion before the blowpipe, as shown by J. W. Judd (1886), and also by Iddings, in the case of the Yellowstone Park obsidian.

(c) *Rupturing and other effects from expansive action.* — Vapors may also produce fractures in the walls of craters or in the sides of the volcanic mountain by their sudden generation within regions about or beneath the crater, and also by their slow accumulation within confined spaces, and thus may occasion volcanic eruptions. They produce the most violent projectile effects when water in large quantity gains direct access to the lava-conduit; for the conditions are then those that cause the most violent of boiler-explosions, except that they are on a scale as much greater as the volcano is larger than a boiler.

Vapors also bring pressure to bear on surfaces of liquid lava beneath them, and force the lava up fissures to levels hundreds of feet above the bottom of a crater.

The vapors are thus the chief source of power in the volcano. They may work quietly, but they are at the bottom of all violent work.

(d) *Vapors of deep-seated origin.* — While all the ordinary projectile work of volcanoes may be carried forward by vapors from waters that gain access from the sea, or the fresh waters of the land, it is a question whether vapors from the deep-seated source of volcanic action may not have aided explosively the first opening of the volcano. The lifting action of the ascensive force in Kilauea is so quiet, and its progress so slow, — 400 feet at the most in six years, — that we have no favorable answer from this source. Daubrée has experimented on the effects of steam, driven under high pressure along a fracture in blocks of granite, and proved the efficiency of such a course in making a tubular passage through it. The results are published in a volume entitled, *Les Regions invisibles du Globe et des Espaces célestes*, 1892, and in earlier papers read before the French Academy.

The *occurrence of volcanoes in long lines* implies dependence as to origin on great fractures, and mutual dependence of the volcanoes along any such line. The lines are often in parallel ranges or series of fissures, and must have opened through the earth's crust to the depths that supplied the melted rock. In some cases the volcanic action along such lines has continued longer at one end of the line, or of the several lines in a series, than at the opposite end, and extinction has been in like manner serial. An example is afforded by the Hawaiian group. The group, now so called, is about 400 miles long and west-northwest in trend. The islands consist either of a single volcano, or of two or more united. The prominent doublets are Oahu and Maui; and Hawaii is a quintuplet, in two lines. The map of Maui, on page 179, shows plainly by the aged appearance of its erosion over west Maui, that this western of the two volcanoes long since became extinct, while east Maui has the smooth face of youth and may have been active within two or three centuries. There is the same evidence that west Oahu was extinct long before east Oahu,