

variations in temperature, which induce an alternate expansion and contraction that prevents the joints of masonry from remaining close and tight.⁶ If the daily thermometric variations are large, the effects are frequently striking. In Western America, where the climate is remarkably dry and clear, the thermometer often gives a range of more than 80° in the twenty-four hours. Thus in the Yellowstone district, at a height of 9000 feet above the sea, the author found the temperature of rocks exposed to the sun at noon to be more than 90° Fahr., and the thermometer at night to sink below 20°. In the Sahara and other African regions, as well as in Central Asia, the daily range is considerably greater. This rapid nocturnal contraction produces such a superficial strain as to disintegrate rocks into sand, or cause them to crack or peel off in skins or irregular pieces. Dr. Livingstone found in Africa (12° S. lat., 34° E. long.) that surfaces of rock which during the day were heated up to 137° Fahr., cooled so rapidly by radiation at night that, unable to sustain the strain of contraction, they split and threw off sharp angular fragments from a few ounces to 100 or 200 lbs. in weight.⁷ In the plateau region of North America, though the climate is too dry to afford much scope for the operation of frost, this daily vicissitude of temperature produces results that quite rival those usually associated with the work of frost.

⁶ In the United States, with an annual thermometric range of more than 90° Fahr., this difficulty led to some experiments on the amount of expansion and contraction in different kinds of building-stones, caused by variations of temperature. It was found that in fine-grained granite the rate of expansion was .000004825 for every degree Fahr. of increment of heat; in white crystalline marble it was .000005668; and in red sandstone .000009532, or about twice as much as in granite. Totten, in Silliman's Amer. Journ. xxii. p. 136. See ante, pp. 495, 508.

⁷ Livingstone's "Zambesi," pp. 492, 516. According to Stanley, cold rain falling on these sun-heated African rocks causes them to split open and peel off. Proc. Roy. Geog. Soc. xx. (1876), p. 142.