September, snow-hurricanes may destroy rash travellers. Though English authorities had informed them that rain was impossible on this plateau, the party were drenched. Marmots and bears alone inhabit this solitude. Grass is rare, and, at one place where abundant, is said to be poisonous for animals. These regions offer a desolate grandeur, unsoftened by vegetation.

The descent to Baltistan and the sources of the Indus was through scenery equally wild and melancholy, so that the first signs of cultivation met the eye as grateful relief.

The Baltis are Mussulmans, and chiefly remarkable for their devotion to the game of polo; which, in fact, originated here, and for which their well-trained, tough little mountain ponies are admirably adapted.

Their capital is Skardo; but the purest type of the race is found in the Shigar valley, which contains the largest glaciers in the world after those of Greenland, and the highest mountains in the world after Mount Everest. The glaciers form an unbroken line for nearly a hundred miles. Mount Dapsang of the Karakorum range is only some two hundred feet lower than Mount Everest. But even here the Shigar River waters an attractive oasis of some six miles in extent, with fields of millet and beans, and orchards weighed down with fruit, among which nestle tombs, mosques, and picturesque though uncomfortable habitations. The apricots and melons of this region are delicious.

The party returned by another and very difficult route, which followed all the windings of the Indus; yet here and there little villages were set, like verdant nests, among the rocks. In spite of the incessant conflict with nature, which a residence here entails, the people are devoted to their country, and prefer it to any other.

The journey to Shigar was due to the munificence of the Maharajah Rambir Singh of Kashmir; and its scientific results, which remain to be published, are believed to be important.

## *THE ARTIFICIAL PRODUCTION OF RAIN.*

In his anniversary address delivered to the Royal society of New South Wales, Mr. H. C. Russell, the president and government astronomer, deals at some length with the subject of producing rain artificially. He begins with a few points in its history, telling first how Arago, finding the practice of firing guns common in some of the departments of France, had tried to trace the origin of the custom, which probably began in 1769. A retired naval officer, who at sea had seen water-spouts destroyed by cannon shots, made his home in a district that suffered from violent rain and hail storms, and determined to try the power of shot and shell upon these new foes; and, setting up his battery, his success was such that the district was protected from the violent storms. The practice became popular in France; and up to the year 1806, and even later, many communes kept a battery of small guns for this purpose, the commune of Fleury even going so far as to get a cannon which used a pound of powder at each discharge. Arago could not trace what the effect had been, but he at least was not convinced that it had had any good effect; and after a time the practice became obsolete. Volta's biographer says that "it is well known that Volta thought a possible advantage might be found in having large fires during thunder-storms;" his reason probably being, that the smoke would serve as a conductor for the electricity, and so prevent dangerous discharges.

To test the effect of the discharge of artillery on the weather, Arago examined the weather-record of the Paris observatory for many years, especially for the days adjacent to those on which the regular gun-practice took place in the fort, situate somewhat less than two miles from the observatory. The firing took place at this fort on certain days in the week, from seven to ten A.M., about one hundred and fifty shots being fired. Arago found, that, out of 662 days preceding the practice, 128 were cloudy; out of 662 days of practice, 158 were cloudy; out of 662 days following practice, 146 were cloudy; which he regarded as proof that the discharge of heavy artillery does not seem to have the effect of dissipating the clouds.

Struck at one time by the amount of destruction caused by hail-storms, Arago proposed drawing off the electricity by means of wires carried up to great elevations by captive balloons; but, when he came to the practical consideration of the scheme, it was soon seen that each balloon would not protect more than, perhaps, a thousand square yards, — a mere speck of France. In later years he was led to doubt the value of such a means of protection.

Arago relates, that, in tracing the history of the use of cannons, he found that bells, and especially church-bells, had preceded them; and it was at one time firmly believed that the vigorous ringing of church-bells was sufficient to dissipate dangerous storms. Mr. Russell finds that up to 1810, or later, the idea was popularly prevalent that storms might be destroyed or prevented by fire or guns; and he thinks that a complete change to the opposite opinion has taken place since then. He says, —

> "Australia, like Africa, wants the rain-doctor to make rain, not drive it away. It is not only in Australia, however, that the belief in the artificial production of rain exists. In America, during the civil war, it was a matter of common observation that rain followed the great battles; and the belief in this became so general, that farmers began the practice of making large heaps of brushwood on each farm, and, when they wanted rain, lighting them all together. I cannot find any reference to the results of this system in the Smithsonian publications, in which almost every subject of this kind is dwelt upon; but the practice seems to have been given up."

Mr. Russell then alludes to the well-known little volume by Mr. Edward Powers, published in 1870, and entitled 'War and the weather, or the artificial production of rain;' and to the review of this book in *Silliman's journal*, inclining to the opinion that great battles do exert some influence in the production of rain, but failing to accept Mr. Powers's incomplete discussion of the facts as proof. He turns next to Espy's conviction, that rain might be produced economically whenever it was wanted, and cites Professor Henry's opinion in the matter: —

"I have great respect for Mr. Espy's scientific character, notwithstanding his aberration, in a practical point of view, as to the economical production of rain. The fact has been abundantly proved by observation, that a large fire sometimes produces an overturn in the unstable equilibrium of the atmosphere, and gives rise to the beginning of a violent storm."

The opinion of Professor Everett, president of the Meteorological society, is also cited. He believed that great battles and great fires tend to produce rain, but that rain does not, of necessity, follow battles or fires.

The climate of Australia being peculiar, Mr. Russell has endeavored to collect the records bearing upon the question there; and, there having been no battles (except a mimic one, which produced no rain), he passes to an examination of the meteorological conditions of the times of the great fires which have occurred in Sydney since 1860, and assumes, that, if a fire produced rain, it would fall within forty-eight hours. His record embraces forty-two large fires (including two serious explosions), extending over a period of twenty-one years; and he concludes that there is not one instance in which rain has followed within the forty-eight hours as an evident consequence of the fire.

In cases where it is asserted or believed that rain has been produced artificially, it would be interesting to examine whether the rain was due to the fires or to ordinary meteorological changes. While it is evident that some of the most competent authorities in England and America think that under certain circumstances rain may be produced artificially, Mr. Russell thinks they all carefully avoided saying what the circumstances were; and he proceeds to develop some idea of what they are, from a consideration of the natural conditions under which rain is deposited, and adducing certain instances as illustrations, from nature, of the conditions under which the leading scientific meteorologists of the day tell us that rain is formed. He says, —

"If we can get a measure of these [observed] effects, it will serve as a guide in estimating what would be required to make rain. At Sydney the average relative humidity is 73, and at Windsor it is rather less; and we have just learned that such atmosphere lifted from Windsor to Currajong, 1,800 feet, deposits 60 per cent more rain. If we could make it rise up over Sydney 1,800 feet, we might fairly expect to get 60 per cent more rain. Now, a wall built 1,800 feet high, and of considerable length, so that a wind would not divide and go round it, but go over, would have the desired effect; i.e., to lift the air and cause rain: but any thing that would do this would serve the purpose, and it may be done by fire; but of course the fire must have the effect of lifting the atmosphere up. It will not do for the products of the fire to rise up slowly, mixing with the air, and making it drier as they rise. If it is to have the effect of a wall, — that is, making the whole of the air passing over rise up 1,800 feet, — it must act as an explosion would do, suddenly, or by a constant uprush of such violence that it would rise up 1,800 feet. The force necessary to do this is easily computed, and we can in this way get a money value for the work to be done. At Sydney the average velocity of the wind is 11 miles per hour; and all the air passing over is to be lifted, and the weight of it on the surface is, say, $14\frac{1}{2}$ pounds on the square inch, and $13\frac{1}{2}$ pounds at 1,800 feet high. At least, for our present purpose, these figures are sufficiently exact. The average weight to be lifted, therefore, is 14 pounds on the square inch. The fire must have the same length as the proposed wall, for the same reason, and a breadth equal to the forward motion of the air in a given time. We have therefore to lift a weight of 14 pounds on the square inch over a surface of 1,000 feet by 10 miles (52,800 feet), and raise it up 1,800 feet every minute. To do this we will assume that coal is employed, and that, as it is burnt in the air, the whole of its heat will be effective. The mechanical equivalent of good coal is 14,000,000 foot-pounds for each pound of coal used. We have, therefore, —

$$\frac{14 \times 12 \times 12 \times 1{,}000 \times 1{,}800 \times 52{,}800}{14{,}000{,}000 \times 112 \times 20} = 6{,}110 \text{ tons per minute} =$$

8,800,000 tons in a day, or nearly 9,000,000 tons of coal per day, to increase the rainfall 60 per cent, at a cost, at 10*s*. per ton, of £4,500,000.

"Of course this is only a theoretical experiment, and ignores all the heat lost by radiation and imperfect combustion; but it serves to give some idea of what is necessary to disturb the course of nature, and, I think, shows how utterly futile any such attempt would be, even near the sea, where the air is moist."

It would seem unreasonable, Mr. Russell concludes, to hope for the economical production of rain under ordinary circumstances; and our only chance would be to take advantage of a time when the atmosphere is in the condition called unstable equilibrium, or when a cold current overlies a warm one. If under these conditions we could set the warm current moving upwards, and once flowing into the cold one, a considerable quantity of rain might fall; but this favorable condition seldom exists in nature.

## *ROTATION OF JUPITER.*

MR. W. F. DENNING has recently published an investigation of the rotation of certain spots on Jupiter which confirms in a remarkable degree a theory already propounded that this planet resembles the sun in not only rotating in different times in different latitudes, but in having the period of rotation of its equatorial region shorter than that of regions in middle latitude. From the red spot which has formed so conspicuous an object on the planet for nearly five years, the following rotation periods are obtained at different times: —

| Interval. | Number of rotations. | Period of rotation. |
|---|---|---|
| | | *h. m. s.* |
| 1880, Sept. 27–1881, March 17 | 413 | 9 55 35.6 |
| 1881, July 8–1882, March 30 | 640 | 9 55 38.2 |
| 1882, July 29–1883, May 4 | 674 | 9 55 39.1 |
| 1883, Aug. 23–1883, Dec. 5 | 251 | 9 55 38.8 |

A gradual lengthening of the period is thus indicated. On the other hand, from a white spot near the equator the following times are obtained: —

| Interval. | Number of rotations. | Period of rotation. |
|---|---|---|
| | | *h. m. s.* |
| 1880, Oct. 20–1881, Sept. 30 | 842 | 9 50 5.8 |
| 1881, Sept. 30–1882, Dec. 23 | 1,095 | 9 50 8.8 |
| 1882, Dec. 23–1883, Nov. 25 | 823 | 9 50 11.4 |