blowing down the houses, whose walls were already weakened by the earthquake.

The geological characteristics of the country are described in the next article: it will therefore suffice here to say that the seismic phenomena seem to be intimately related to the geological growth of the mountain system, especially the Sierra Nevada, the elevation of which is apparently not yet completed. A commission, consisting of three mining engineers, under the presidency of Sr. D. Manuel Fernandez de Castro, has been appointed by the Spanish government to study this series of earthquakes, and has already distributed a list of thirty-three interrogatories relating not only to the time, direction, and other particulars of the earthquake shocks, but also to various atmospheric phenomena, such as the pressure, temperature, clouds, etc.

C. G. ROCKWOOD, Jun.

THE SIERRA NEVADA OF SPAIN: THE SCENE OF THE RECENT EARTHQUAKES.

THE Sierra Nevada of Spain, though full of interest for the tourist, the man of science, or the student of history, has been little visited, and almost nothing has been written about it.

This sierra forms a compact body, twenty-five miles wide and fifty miles long, completely isolated, and without directly connected lateral spurs or terminal ridges. Surrounded by an alluvial plain as it is, it has, nevertheless, certain smaller neighbors which seem, like itself, to have been ejected from below. Its crest has been denuded by the elements, and its sides scored by brooks or torrents which diverge in all directions from the central axis, fed by the rains of spring and the melting snows of summer. Four principal streams, descending to the north-west, meet at the very foot of the Alhambra, and unite their waters before traversing the renowned plain of La Vega. Their cascades and ripples, descending from the mountain crest above, give to the adjoining valley a delicious freshness during the torrid months of summer. To these waters is due the immense isle of verdure presented by the Vega at a time when nearly all southern Europe is scorched dry by the sun. At many points the rivers run in narrow, deep channels easily dammed. From their sources to the moment when they reach the plain, their average descent is one to ten, almost the maximum for running waters. At that point they are captured: not a drop escapes. All the irrigating works and canals, the customs governing the distribution of water, even the rules recalled by the strokes of the bell nightly from the minarets of the Alhambra, are the legacy of the Arabian civilization which blossomed on the plain before it was driven to a last refuge on the mountain.

On the north, three rivers descend to the plain of Guadiz; but, their sources not being fed by perpetual snows, when the rainy season has passed they dry away. In consequence this plain is as sterile, bare, and forbidding as that of the Vega is green and inviting. Wherever the eye wanders, apart from the sierras, lies a reddish-gray plateau of dusty alluvium, seamed and rent by precipitous cañons. Nothing recalls the idea of life: the desolation is as that of an unknown country, grand and terrible. All the valleys and plains of this part of Andalusia present the same impressive and melancholy features. Gustave Doré, who passed through this region many years ago, has profited by his experience to introduce memories of it in some of the most strange and fantastic productions of his pencil. This sterile region is poor, unpeopled, almost unknown, and practically cut off from communication with the rest of Spain.

Farther to the west is the country of the Alpujarras, so celebrated in Moorish history for the terrible conflicts of which it was the theatre. More than one poet has celebrated the combats of the Christian and the Moor in the narrow defiles and rocky gorges of the sierra; but all these imaginary descriptions fall far short of depicting the scene as it appears in reality.

The Alpujarras are composed of two cistern-like basins, absolutely closed to the outer world, except by two narrow gorges cut in the rock by the rivers which traverse them. The first of these rivers, the Rio Grande de Ujijar, descends directly from the heights of the Sierra Nevada, passes by the site of that town, and, with its affluents, waters the basin of Ujijar, the ancient capital of the little Moorish kingdom. It issues by a deep cañon, and falls into the Mediterranean by the little port of Adra at no great distance. The second, the Guadalfeo, runs between the Sierra Nevada and Contraviesa, close by the former, whose slopes it drains. Emerging from the basin, it turns abruptly to the south, reaching the sea near Motril. Just before entering the gorges of the Sierra Contraviesa, the Guadalfeo receives the brook of Beznar from a point elevated above the plain of La Vega, whence Boabdil, the last of the Moors, is said to have

taken his parting glimpse of his palace of the Alhambra, the rich Vega, and 'Grenada the marvellous.' It is appropriately named 'Suspiro del Moro' ('the Moor's sigh').

A very few men can safely hold the entrances to the Alpujarras; and they long remained the last stronghold of the Arab power in Spain, which has passed, leaving as its memorial little more than the names of a few villages, and the wonderful system of irrigating-works.

There can hardly be a doubt that the series of calamities, hardly closed, which has laid so many villages in ruins since last Christmas, is a continuation of the processes by which portions of the earth's crust are raised in mountain ranges above the rest. A few words on the geological structure of the sierra may indicate the possibilities of the locality. The structure of the sierra and its neighbors is quite simple. They rise like islands or domes of ancient mica schists out of a sea of later formations, which break like waves upon their flanks. These schists are of a silvery white, appearing like snow when distant and illuminated by the sun. They are absolutely sterile, but dip, in a general way, outward from the central axis of elevation in all directions. A belt of radiately dipping Silurian schists encircles the central part of the sierra, which, like the exposed part of the core, assumes rounded outlines, but is succeeded by another belt, rugged, precipitous, and craggy, of Permian limestones, which extends to the base on the eastward, but is nearly as irregular in height as in extent. The Alpujarra basins are excavated in these limestones, and protected by escarped cliffs. Against the base of the sierra, raised slightly near the mountains, but elsewhere horizontal, lie tertiary grits, clayey sands and clays, deposits of fine gypsum, etc., covered with two alluvial series of beds, — the lower composed of decomposition products of the Silurian schists, brought down by water and mingled with material derived from the subjacent tertiary; the upper and later, from the denudation of the fundamental mica schists now forming the crests of the sierras. Moule observes that the elevation of the sierras has, in part at least, taken place since the tertiary epoch, and even since the alluvial period, and that it may not yet have ceased. This observation, written before the recent disturbances, has found in them renewed support.

The people of the country, finding in the elevated blocks of argillaceous alluvium left isolated by the torrential rains of part of the year a soft but compact and resisting material, have carved in them whole villages of cave-houses, with doors and windows, and often with one story above another. These abrupt elevations, though of moderate height, are extremely numerous, entirely without vegetation, and of an ashy hue. The cave villages are numerous, and, as in the case of Purullana, contain sometimes several hundred inhabitants. One may imagine the devastation among these gnomes which an earthquake shock must produce, and which would go far to explain the great loss of life in these small places.

The shocks felt have been chiefly to the westward of the Sierra Nevada, and have been most severe along the junction of the tertiary rocks with the schists. Here towns have been almost or quite destroyed, and the ruin wrought has been largely proportional to the proximity of the town or village to the unconformability of the rocks, though the motion has been propagated over a much wider area.

THE WORK OF THE SWISS EARTHQUAKE COMMISSION.

THE Swiss earthquake commission was appointed by the Swiss society of natural sciences, in 1879, to secure more uniform and accurate observation and study of the seismic disturbances in and around the Alps. It included such men as Forel, Forster, Hagenbach-Bischof, Heim, Soret, and others of mark as physical-geographers and geologists; and they at once began an active campaign. Professor Heim of Zurich wrote several general articles[1] to call attention to the undertaking, and to outline the method by which intelligent persons could give effective assistance; and since then, he and Forel, both admirably qualified, have prepared a number of monographic reports on the results thus far reached. The official journal of publication is the *Jahrbuch des tellurisches observatorium* of Bern; but, so far as I can learn, none of our libraries possess a copy of it. Fortunately, the reports have mostly been reprinted in periodicals of more general circulation, and from these the notes here presented are derived.

Forel's entertaining papers[2] give the results of the

[1] Ueber die untersuchungen der erdbeben und die bisherige resultate. *Zurich vierteljahresschr.*, 1879.

Die erdbeben und deren beobachtung. Zurich, 1880. This appeared also in French, translated by Forel, in the *Arch. des sciences*, iii. 1880, 261.

Die schweizerischen erdbeben von November 1879 bis ende 1880. *Jahrb. tellur. observ.*, 1881; with an appendix giving important corrections.

[2] Les tremblements de terre étudiés par la commission sismologique suisse de novembre 1879 à fin de 1880. *Arch. des sciences*, vi. 1881, 461.

Id. . . . pendant l'année 1881. *Arch. des sc.*, xi. 1884, 147.

Les tremblements de terre orogéniques étudiés en Suisse. *L'Astronomie*, ii. 1883, 449; iii. 1884, 13.