

tion and ice action. The Trappean rocks of the County Limerick are naturally harder than the associated Limestone, therefore, as the land rose, and came under the influence of Marine denudation, the Limestones would have been much more rapidly worn away, leaving the Trappean rocks standing up as Skerries, Carricks, and Carrickgeens; and also when the country was covered with ice, they would have resisted its grinding action much more than the Limestone. Similar results would occur in the hills of the N.W. of the County Galway, as the Granites and Altered Traps are naturally harder than the Gneiss and Schist, and the Vein Quartz than the Quartzite. Some of the Limestones were naturally harder than the Schist and Gneiss, but not all; therefore some parts of it project above the other rocks, while other parts were cut away equally with the Gneiss and Schist.

Yours truly,

G. H. KINAHAN.

OUGHTERARD, IRELAND.

ON THE DENUDATION OF SOUTH AFRICA.

To the Editor of the GEOLOGICAL MAGAZINE.

SIR,—That part of the interior of South Africa extending from the eastern slopes of the Zwartebergen and Zuurbergen, and the continuous chain of hills which dies out on the sea-coast, near the mouth of the Qualana River, to beyond the Vaal River, and from Bean, far west to some undetermined line a long way to the north of Faure-smith, is occupied geologically by a series of nearly horizontal beds of hard Sandstone, Clays, and Marls, intersected by numerous dykes of Greenstone, Syenite, and Basalt. These strata contain, throughout their whole extent, as far as it is known at present, numerous bones of Reptiles, stems of *Calamites*, leaves of *Glossopteris* and other ferns; shells of a species of *Iridina*, and some Fish with heterocercal tails have been found at Fort Beaufort, Spitzkop, and elsewhere. All these remains concur to prove that Mr. Bains' conjecture that these beds were of lacustrine origin is correct. No fossil of any kind, even possibly marine, has yet been found in them. Professor Owen inferred, from a pretty extensive series of reptilian bones and fish remains, that the age of the formation corresponded nearly with the Triassic of Europe.

Now, with the exception of a few beds of Recent or Tertiary Limestones, where the Lacustrine strata reach the sea-coast, there is no evidence of any part of this formation having been covered by the sea at any time since the desiccation of the lake; and, therefore, it is clear that the denudation which the country has undergone is not due to marine action. It may, I think, be safely inferred, that had the ocean rested upon these strata sufficiently long to produce any serious amount of denudation, some beds of rock, containing sea-shells, would have been left. The action of Glaciers may, I think, be left out of our estimate of denuding forces, considering the latitude, and probably not very great elevation of the country. The denudation

undergone, then, is probably due to that series of causes comprised in the term subaërial, and into which the action of sun and wind, rain, ice, and the erosion by river and streams, enter as principals. I will proceed briefly to describe the amount of this denudation, and to notice some facts bearing upon its cause, more especially with reference to the action of rivers and the formation of their valleys.

It has been stated that these "Lacustrine strata" reach the sea at the Qualana mouth; and, as everywhere they are nearly horizontal, and we have at no place been able to discover faults of any considerable extent, the elevation of the higher ranges of mountains will give the thickness of the formation. This, unfortunately, we can only give approximately, as there is no reliable survey of the Quathlamba Range that I am acquainted with. Where I saw the continuation of it, the Wittebergen, it is about 3,000 feet above the elevation of the great plateaux among which the Kei and Tsomo take their rise; but I believe the more northern parts reach a still greater elevation. The Wittebergen are 6,000 to 7,000 feet above the sea: the highest point of the Quathlamba is said to be 10,000 feet. The plain through which the Orange and Caledon Rivers run is about 5,000 feet above the sea; and a series of plains, of various elevations, interrupted by mountains, reach thence to the sea on the north, and to the Karoo plains, bounded by slopes of the Zwartebergen and Zuurbergen. The heights of these plains above the sea is probably, on an average, about 1,200 to 1,500 feet, and they vary from 30 to 20 miles in breadth. The whole of this denudation must have been due to subaërial agents; and that the large periodical torrents must have borne the chief part in it, the following facts will, I think, show. The Orange, the Caledon, and the Krasi Rivers, traversing the elevated plains, have all their sources in the same ranges, whose geological structure is but imperfectly known at present; but it is certain that a large mass of amygdaloid, containing agates, cornelian, and other silicious minerals, forms part of it. The rivers carry numbers of pebbles of amygdaloid and its agates, and as these are wholly unlike the rocks and minerals of the country they traverse, it is easy to find their traces; and these I have seen on the plains and hills many miles (certainly five or six) distant from, and 300 to 500 feet above, their present course. Now these minerals, though comparatively imperishable, must be subject to decay, and to be washed away by the heavy rains of these regions, so that, when found in the sites indicated, they must prove that amount of denudation by the river within a recent date. The manner in which these rivers travel over the plains is shown by the presence of the *Iridina*, which inhabits them in all parts. This is the case, for instance, in Graff Reinett. In whatever part of the plain a well is sunk, the river-alluvium and pebbles, with the *Iridina*, will be found. The courses of the valleys in which the rivers flow show, as I think, incontestibly, that they have been made by the rivers themselves. Those which run down the steep mountain-sides of the Katriverberg have an extraordinarily sinuous course. A stream, two

or three feet in breadth, will take its course in curves, bearing something like its relation to its breadth of the sketch,—the stream being perhaps 10 or 12 feet deep in the alluvium of its valley,—and its course through the alluvium must be continually changing, as the silt is deposited in the receding angle, and the bank worn away on the salient one. The Kromme and Diep Rivers,

larger tributaries of the Kat, take the same course, as their names indicate, only with wider sinuations. These latter seem to have some definite relation to the steepness of the course and the volume of the rivers. With allowance for the different degree of erosion exerted on the various rocks, this character seems to be common to all the rivers of the country, and makes it impossible to believe that they originated in channels formed by oceanic currents, or in cracks by earthquakes, or the upheaval of land. As the rocks of the "Lacustrine," or, as they are locally called, from a genus of Reptile common in them, "Dicynodon formation," are supposed by Professor Owen to be referable to about the Triassic Age, it would seem that the time which has elapsed since the desiccation of the lakes is sufficient to account for the vast denudation that I have shown to exist. Some years ago I took advantage of a three days' detention by a freshet of the Sunday's River to collect evidence with a view to the calculation of the approximate amount of denudation affected by it. The data, particularly with the imperfect surveys of the country at our disposal, which are extremely unsatisfactory, led me to a result of about 8000 inch in a century over the area drained by the river. I have little doubt that the estimate is much too great, for it would require little more than 100,000,000 years to effect the amount of our denudation.

A better guide to the denuding power of our rivers is offered by the Bushman's River. Its circumstances are similar to those I have described of the Orange and Caledon, in that it conveys in its bed a quantity of pebbles of agates (from a layer of amygdaloid in the Zuurberg) over a formation in which they do not occur. After passing through the Zuurbergen, its course to the sea lies through a basin of Devonian Schists and Sandstones, on which rest 300 feet of Sub-Cretaceous Sandstone, Clays, and Marls, and these are surmounted by 50 to 80 or 100 feet of Limestone, which is called "Tertiary" by Mr. Bain, but which, so far as I am aware, does not contain any shells different from those now living in the Indian Ocean,—certainly, if any of its species are extinct, they are but few, though the *Ostrea*, *Pectunculi*, and *Pectines* are much larger than any I have seen living. These strata of the three formations I have mentioned have been cut through by the river to the depth of 500 feet, and a width of many miles; and all this since the deposition of the Tertiary or recent limestone; and the proof that this has been done by the river is that the agates, evidently rolled by its action, are found all the way up its banks to nearly the level of the plain.

I was struck with this fact of the occurrence of the evidence of the existence of the river-beds in all parts of the Bushman's and

Sunday's River Valleys, and on the overlying recent rocks especially, many years ago, long before the subject had attracted much attention from European Geologists, and I brought forward in a letter to Sir Charles Lyell most of the facts here given.—Yours truly,

R. N. RUBIDGE.

PORT ELIZABETH, SOUTH AFRICA.

ON THE GLACIAL CONDITION OF THE MOON'S SURFACE.

To the Editor of the GEOLOGICAL MAGAZINE.

SIR,—Allow me to send you the following results of some researches into the surface of the Moon. Viewed by the naked eye, the colour of the lunar disk is uniform, or nearly so, presenting to the spectator at night a disk or mirror of light, reddish-yellow when seen near the horizon, and in a hazy atmosphere, but of a much paler yellow, or almost white, when seen high up in the horizon under a clear atmosphere; and on a bright day, and in a blue sky, as white, or whiter, than the fleecy clouds which float past it. Seen with a telescope, the Moon loses much of its yellow appearance, which is due to our atmosphere, and has an apparent liquid electrum colour, still uniform, but revealing the mountains, with their apparent craters, and shadowy and dark patches, or non-reflecting surfaces. Neither of these visual observations are sufficient as yet to determine the nature of the surface; and, although the most powerful instruments bring it within 240 miles of the eye of the astronomer, even that distance does not seem sufficient to deprive the disk of its reflecting power, so as to enable the observer to distinguish the relative colours of which its surface is composed. Now, an inspection of the photographic and stereoscopic views of the Moon offer what I consider as a revelation of its condition, and demonstrate it to be completely Glacial. Of this I am firmly convinced, from a minute and careful examination of the lunar stereograph of Mr. H. De la Rue, and a careful comparison with a great number of Alpine photographs and stereographs in the possession of Mr. F. E. Blackstone. For not only does the former exhibit unequivocal proof of being taken from an object of which the dominant colour is white, but the surface exhibits all the peculiar transparency in textures of Snow, Ice, and Glaciers, seen in the latter. I cannot be deceived on that point, and I feel the more confident, since a great portion of my time has been spent in the examination of surfaces.

Now, although the stereoscope does not supersede the actual observation by the eye, it is a powerful aid to the determination of this question. The stereograph of Mr. De la Rue is $2\frac{1}{2}$ in. diameter, and gives 2,161 miles of the Moon's diameter, offering to the eye an optical model of the luminary about the size of a billiard ball, on which all the elevations of the mountains appear in relief. When looked at attentively, all the luminous parts of the Moon present the appearance of a Glacial country such as the wintry Alps or the Polar regions. Portions of it appear as extensive plains and ranges of elevated ground covered with snow and ice, while