

per square inch for every 12° Fahrenheit. Though there are no data that I know of on which to estimate the stress set up in gneiss or terra-cotta by a given rise of temperature, we can see that it cannot be otherwise than severe.

This is the suggestion that I have to make:—The direct heat of the sun in Brazil must greatly exceed that in this country, and the range between the temperature of the gneissic rocks with the sun in the zenith and the temperature of the same during midnight radiation must be very considerable. Now, according to my studies, this is the very thing wanted to produce disruption. The surface of the gneissic rock becomes greatly heated during the day, but this daily range of temperature cannot extend far into the rock (unfortunately I know of no experiments to determine the depth); consequently the difference of expansion between the upper and under layers creates shearing stresses, which, being renewed daily year after year, eventually shears the rock, quarrying out a bed or sheet of a thickness determined by several factors, in the same way that the cement bed of a terra-cotta coping by recurrent daily expansion of the coping is sheared along its whole length. Once the minutest fracture occurs, water and chemical agents, as so well set forth by Professor Branner, detach the large sheet or scale from its parent rock.

Shortly stated this appears to me to be the origin of these huge exfoliated scales and the “sheets of rock, sometimes 15 feet thick,” “utilized by the quarry-men in breaking out blocks of convenient sizes,” but which “sheets are more commonly from 2 to 10 feet thick,” and “often as thin as a knife-blade.”

It is the recurrent stresses that eventually break up the rock, for on each expansion the rock is strained, and it does not recover its exact original condition on contraction. As field-geologists, we all know that an obdurate rock may resist one great blow of a hammer, but yields to repeated lesser blows; and it is this daily and yearly recurrent straining of the gneissic rocks of Brazil that in my opinion finally shears off large plates, and produces the topographic features so characteristic of that country.

VIII.—THE RANGE OF SPECIES IN THE CARBONIFEROUS LIMESTONE OF NORTH WALES.¹

By G. H. MORTON, F.G.S.

ATTENTION having recently been directed to this subject, I have been induced to present the results of many years' collecting in the Carboniferous Limestone of North Wales. The formation there presents four well-defined subdivisions, each of them, with the exception of the highest, having distinct lithological characters, viz.: Lower Brown Limestone, Middle White Limestone, Upper Grey Limestone, and the Upper Black Limestone. Lists of the fossils have been made, collected more or less continuously along the country from each subdivision.

¹ Read before the British Association, Section C, Liverpool, 1896.

In North Wales the occurrence and succession of the species in the subdivisions vary in different areas, and the larger the area examined the more difficult it becomes to find species peculiar to certain horizons. In order to obtain a definite result I have compiled three separate lists of the species obtained in that number of distinct areas. There are the Llangollen, the Flintshire, and the Vale of Clwyd Lists. Each of the lists shows the relative scarcity and abundance, and the range of the species in the subdivisions; and although future search will doubtless add to the rare and occasional species, the number and range of the common and very common must be very nearly correct. Neither the rare nor the occasional species are of much use in defining distinct horizons in consequence of their rarity, and it is only the common and very common species that can be expected to indicate a definite horizon or zone. In North Wales a great difficulty arises from the occurrence of all the common and very common species in the Upper Grey Limestone, with the exception of *Productus comoides*, and although all pass downwards, they become scarce in consequence of the general paucity of fossils in the inferior subdivisions.

In the Llangollen List there are 69 rare, 28 occasional, 16 common, and 27 very common species. Deducting Foraminifera, which are not in the other lists, there are 36 species that are common and very common, and they all occur in the Upper Grey Limestone, with the exception of *Posidonomya Gibsoni* from higher strata, and *Productus comoides* in the Lower Brown Limestone, all the other species in the list being rare and occasional forms.

In the Flintshire List there are 92 rare, 35 occasional, 30 common, and 11 very common species; and of the 41 common and very common, 37 species occur in the Upper Grey Limestone, 3 of the remaining species, *Posidonomya Becheri*, *Aviculopecten granosus*, and *A. papyraceus*, occurring in the Upper Black Limestone, and *Productus comoides* in the Lower Brown Limestone.

In the Vale of Clwyd List, which includes the Great Orme's Head, there are 16 rare, 22 occasional, 12 common, and 10 very common species; and of the 22 common and very common, 21 species occur in the Upper Grey Limestone, the exceptional species being *Productus comoides*. None of the 21 species are peculiar to the subdivision, for they all occur in the underlying Middle White Limestone. The number in the list is less than in the others, on account of the Upper Grey Limestone having been considerably denuded in the Vale of Clwyd.

Nearly the whole of the common and very common fossils occur in each of the three lists, for there are few that are not found in all the areas.

Of the numerous common and very common species found in the Carboniferous Limestone of North Wales, it is impossible to find any that are restricted to horizons of less importance than the subdivisions into which the formation is naturally divided. An examination of the first appearance and continuity of the species seems to indicate that they were introduced from some pre-existing

area, and that the upper beds of the formation are more recent than in Derbyshire and Yorkshire, where the thickness of the Limestone is very much greater.

The sudden appearance of species in restricted areas, like those found in the Upper Grey Limestone at Axton, in Flintshire, where 20 species occur, and at Graig-fawr, in the Middle White Limestone, where six species occur, not found elsewhere in North Wales; and the early appearance of three species in beds of Black Limestone and shale at the base of the Middle White Limestone at the Great Orme's Head, seem to indicate migration from some other area. The latter species are *Orthis Michelinia*, *Spirifera humerosa*, and *S. rotundata*. *Spirifera humerosa* had only been previously found at Llangollen and in Flintshire, while *S. rotundata* was rare in North Wales; but none of the three species had been previously found at a lower horizon than the Upper Grey Limestone. *Productus giganteus* first appears in the Lower Brown Limestone, and very large specimens occur within 50 feet from the base at Moel Hiraddug, a few miles from Rhyl. The species occurs all through the Carboniferous Limestone, and thousands may be seen in the Upper Grey Limestone.

In this paper the range of the species found is confined to North Wales, but when the subdivisions of the Carboniferous Limestone in other parts of the country are worked out, and the species from each tabulated, it will be interesting to compare the result with that obtained in North Wales.

R E V I E W S.

I.—PUBLICATIONS OF THE PALÆONTOGRAPHICAL SOCIETY. Vol. I, 1896.

THE fiftieth issue of this well-known Society maintains the high character of the previous annual volumes, and augurs well for the future prosperity of this useful body. The volume contains, in addition to the usual catalogue of memoirs already published, and other matter of general interest, an extract from the Report of the Council to the Annual General Meeting held on June 19, 1896. This Report was noticed by us in the *GEOLOGICAL MAGAZINE* for September last (Dec. IV, Vol. III, 1896, pp. 385–388, Pl. XIII); we only call attention to it here in order to reproduce the portrait of another of the founders of the Society therein referred to, namely, Dr. J. Scott Bowerbank, F.R.S., F.G.S., who was Secretary from May, 1847, to 1862, and President from 1865 to 1876.

Like most of its predecessors the volume is a composite production, containing—

1. *Part III* of "The Crag Foraminifera," by Professor T. Rupert Jones, F.R.S., F.G.S.; assisted by Messrs. H. W. Burrows, C. D. Sherborn, F. W. Millett, R. Holland, and F. Chapman. (pp. 211–314 and pls. ix–xii; the plates do not accompany this part of the text.)