Mauretania by torsion meters directly applied to each shaft. Two wheels are fitted on the shaft at some distance apart, each of which in its rotation makes an electrical contact. The contacts are exactly in line, and therefore are coincident in point of time when the shaft is at rest. When the shaft is rotated it suffers torsion, and the aft contact lags behind the forward one. The angle of the lag measures the torsion. The instrument is calibrated by determinations made in the shops of the twist which the shaft suffers from couples of known magnitude. In the navigating house of the *Mauretania* are four dials, on each of which a hand revolves in the direction and at the speed of the particular propeller shaft to which it is attached. It is obvious that the torsion meter might be so adjusted as to give direct records on the bridge of the work of each turbine from moment to moment.

The two most impressive parts of the machinery are the controlling platform, already mentioned, of the engine-room, where a few small levers control the gigantic forces pent up in the long polished barrels of the turbines, and the small, easily manipulated wheel in the wheel-house, which, by means of a small hydraulic motor, controls the enormous steering engine sunk below water level some 650 feet distant!

The plates of the *Mauretania* were delivered rolled to a guaranteed thickness. This is, I believe, a new departure in the building of English merchant ships, and it enabled the builders to save 500 tons of dead weight. The use of silicon steel in the boilers effected a further saving of 500 tons, making a total of 1000 tons, which, reckoned as cargo, represent a gain to the Cunard Company of about 22,000*l.* a year in the earning power of the vessel. An interesting saving in dead weight was also effected in connection with the decoration. The lifts in the well of the main staircase are enclosed by a beautiful piece of metal work adapted from existing sixteenth-century wrought-iron work. It is carried out in aluminium instead of iron, and thereby 20 tons weight is saved. One wonders whether the high affinity of the metal for chlorine and the presence of chlorides in sea air have been adequately taken into account.

The engine-room of the *Mauretania*, despite the absence of the main reciprocating engines, is very closely packed, and the greatest ingenuity is manifested in the arrangements. The four main turbines, each of 15,000 h.p., are controlled from a tiny platform by six small levers. Over the great engine-room steam pipes arch large enough for a boy to walk through, and the exhaust from each low-pressure turbine passes through a "pipe" 14 feet by 16 feet! The distinctive noise of the engine-room is the continuous roar of the steam passing through the main steam pipes. The engine-room, counting main turbines, turbo-generators, and auxiliary engines, holds machinery capable of developing something over 80,000 h.p., and the rotating mass of the main turbines amounts to about 600 tons, and rotates about 200 times a minute.

The gigantic low-pressure turbines receive the steam at nearly atmospheric pressure, which falls to a condenser pressure of about minus 27 inches of mercury. Ingenious gauges are fitted on each turbine, which record the pressure at different steps in the expansion, so that, should some of the blades become stripped, the injury can be at once located.

The stokeholds are so efficiently ventilated by powerful fans as to be cool save when the furnace doors are actually opened, in spite of the presence of 192 furnaces.

The magnitude of the strains which a ship nearly the length of the Houses of Parliament must experience in a heavy head sea is brought to mind by the provision which has been made for bending. The boat deck, together with the deck houses on it, which contain the long suite of public rooms, are cut completely through in three places, so as to allow the ship to give longitudinally.

No description can give the effect of the stately progress of so great a ship down the narrow Tyne. The grey autumn day, the cheering crowds piled on the hill-sides to their summits, and the anxious pilot striving to make his orders heard amid the clamour of steam whistles and fog signals, are vivid recollections. So, too, are the raucous blasts of welcome flung to us from the great headlands as we passed them by. The sombre cliffs of the Pentlands in the grey dawn, Cape Wrath under the autumn sun, lonely light vessels, tiny fishing craft, and liners, each after its own fashion wished us the freedom of the seas.

W. B. HARDY.

THE GEOLOGICAL SUCCESSION IN SOUTH AFRICA.¹

EVERY year our knowledge of the geological succession in South Africa becomes more extended as a result of the labours of the Geological Commission of the Cape, the Geological Survey of the Transvaal, and the host of private workers who contribute to the Transactions of the Geological Society of South Africa. The newly published Report of the Cape Commission for the year 1906, and the Transactions of the Geological Society for the period January to June of this year, are full of interesting matter. The Cape surveyors have been working in Bechuanaland and Griqualand West, and have thus come into close contact with the work of the Transvaal geologists; for although the operations of the official Survey of the Transvaal have as yet been confined to the Pretoria and Middelburg districts, the Marico district and the neighbourhood of Mafeking have been explored by unofficial geologists in the employ of big land companies. Pioneer work of this nature, although unsanctified by official publication, is not to be contemned, since in many cases it is done, under conditions of considerable difficulty, by enthusiastic geologists and keen observers whose labours have often laid the foundation for the detailed work of the Government surveyors.

The earliest work in Griqualand West was by Mr. G. W. Stow, who communicated some of his results to the Geological Society of London (Q.J.G.S., vol. xxx., pp. 581-680, 1874). Unfortunately, a considerable proportion of his observations was embodied in reports to the Griqualand West Government, which since they were handed in have never emerged from their pigeon-holes. However, his classification of the Griqualand West rocks has, with the exception of the Keis series, been adopted by the Cape Survey. It is as follows:—

Matsap Series...	...	Quartzites and conglomerates (unconformity)
Griquatown Series...	...	Magnetite-jasper rocks
Campbell Rand Series...	...	Limestone and quartzite
Keis Series...	...	Quartzites and mica schists

¹ Eleventh Annual Report of the Geological Commission of the Colony of the Cape of Good Hope, 1906. (Capetown, 1907.)

Geological Map of the Colony of the Cape of Good Hope. Sheet xlv. (Published by the Geological Commission, 1907.)

Transactions of the Geological Society of South Africa. Vol. x., January to June, 1907. Pp. 1-68. (Johannesburg, 1907.)

The next step was the tracing by Mr. E. G. Holmes in 1904 from the Transvaal into Bechuanaland of the Black Reef, Dolomite, and Pretoria Series (Trans. Geol. Soc. S.A., vol. vii., p. 130). He followed these well-known Transvaal formations near enough to the original localities of the Keis, Campbell Rand, and Griquatown Series described by Stow to suggest the correlation which was proposed in the following year by Hatch and Corstorphine in their "Geology of South Africa" (p. 311), namely, in the following manner:—

Griqualand West	Transvaal
Matsap Series	= Waterberg Series
(unconformity)	(unconformity)
Griquatown Series	= Pretoria Series
Campbell Rand Series	= Dolomite Series
Keis Series	= Black Reef Series

Mr. Rogers appears to doubt whether Stow, by his Keis Series, referred to the quartzites which succeed the Campbell Rand Series in downward succession. He therefore substitutes the Transvaal name—Black Reef Series—and with this modification accepts the correlation; but he points out that the Matsap and Waterberg Series present marked points of difference, especially in regard to their volcanic rocks, which are of a more acid character in the latter than in the former.

The Matsap Series is subdivided by Mr. Rogers as follows: an *upper* group of quartzites and sandstones, developed in the Langebergen proper; a *middle* group of quartzites, lavas, and fragmental rocks of volcanic origin; and a *lower* group of quartzites, slates, and conglomerates forming the foothills east of the Langebergen, north of Pad Kloof. The basal bed contains many boulders and pebbles of quartzite, quartz, and red jasper in a quartzite matrix which is sometimes highly ferruginous.

In the Transvaal, Mr. Mellor has recently shown (Trans. Geol. Soc. S.A., vol. x., p. 44) that while the base of the Waterberg System is often marked by the presence of coarse conglomerates, in the Middelburg district a series of acid and intermediate lavas, interbedded with tuffs, agglomerates, shales and sandstones, underlies the usual sandy types of sedimentation. The whole volcanic series attains a thickness of approximately 8000 feet.

The Griquatown Series is divided by Mr. Rogers into an *upper* group, consisting largely of slaty rocks, together with some brown and red jasperoid rocks and thin beds of chert and limestone; a *middle* group, consisting for the main part of the Ongeluk volcanic beds, together with some banded jasper beds; and a *lower* group, comprising banded jaspers, quartzites and mudstones. The conglomeratic rocks that occur at or near the top of the lower group in the Hay district contain "striated and flattened pebbles and boulders," which, according to Mr. Rogers, "certainly owe their characteristic shape and scratches to glacial action" (Rep. for 1905, p. 162). Seeing that these beds belong to a geological period considerably older than the Dwyka Glacial Series (they occur at least 15,000 feet lower down in the succession—even more if the Matsap Beds are considered to be older than the Table Mountain Sandstone), this is an interesting contribution to the fast-growing history of glacial action in the remotest periods of geological time.

The Campbell Rand Series occupies practically the whole of the Kaap plateau. As in the Transvaal, this formation consists mainly of dolomitic limestone with which cherts are often associated. The shales which occur near the bottom of the series were searched by

Mr. Rogers without success for fossils. Conformably underlying it is the Black Reef Series, consisting of quartzites, ~~gribs~~ felspathic quartzites, conglomerates, shales, &c. An exact divisional line between the two formations cannot be drawn owing to the alternation of beds of quartzite and limestone near the junction.

The three series—Black Reef, Campbell Rand, and Griquatown—are grouped together by Mr. Rogers as the Transvaal System, a term introduced by Molengraaff for the corresponding series in the Transvaal. The name is scarcely a happy one; but since it has also been adopted by the Transvaal Geological Survey, it will probably remain. Below the Black Reef Series is a basic series of amygdaloidal lavas—the Pniel series of Stow—and this is succeeded by an acid volcanic series to which the Cape geologists have given the name Zoetlief Beds. There is an unconformity between the two series; but Mr. Rogers has decided to include them in one group under the name of the Ventersdorp System, which name is used for the equivalent formation in the Transvaal.

The Ventersdorp, Transvaal, and Matsap Systems lie on a floor of granite and schists, and have been folded during pre-Dwyka times into arches and troughs, the axes of the folds embracing a wide area of low mountains, the principal range of which is the Langebergen. The underlying schists are grouped as the Kraaipan Series; they are equivalent to the Swaziland Series of the Transvaal, and consist largely of magnetitic schists and thin quartzites. The Cape geologists have found no evidence of the granite being intrusive into the schistose formation, although this has been clearly proved in the Transvaal (Abelskop, Monte Maré, &c.). In this connection it is interesting to note that the Geological Survey of the Transvaal has recently recognised that the granite mass which lies north of Johannesburg is younger than the schists of the Swaziland Series (Moodies Series), while it also admits the correctness of the view that it constituted an older floor on which the basement beds of the Witwatersrand Series were deposited (Trans. Geol. Soc. S.A., vol. x., pp. 55 and 57; *cf.* also "Geology of South Africa," p. 93).

Summarising, there is in South Africa, lying on an old floor of schists and granite (which is almost certainly of Archæan age), a succession of sedimentary rocks, older than the Devonian, and including the Waterberg or Matsap, the Transvaal, the Ventersdorp and the Witwatersrand Systems, all separated by strong unconformities. In this accumulation of sediments, which is estimated to have a thickness of between 50,000 and 60,000 feet, not a single fossil has as yet been found.

With regard to the Karroo rocks of the Transvaal, a further step in their elucidation is marked by the conclusion arrived at by the Survey, that the Bushveld Sandstone Series (a succession of red marls, shales, and fine-grained sandstones), together with the overlying amygdaloids, are the equivalent of the Red Beds, Cave Sandstone, and Volcanic Group of the Stormberg Series of the Cape, the Orange River Colony, and Natal (Kynaston, Trans. Geol. Soc. S.A., vol. x., p. 34). The recent discovery by Mr. J. Mitford Bowker, in the Zoutpansberg district near the Limpopo River, of fossil bones, which Dr. Broom has determined to be of Stormberg age, shows that the Bushveld Sandstone Series extended far to the north; for it is found to cross the Limpopo River into the Victoria district of Mashonaland, where coal-seams have been reported to occur in it (Proceedings of the meeting of the Geol. Soc. of S.A. held on June 24, 1907).

F. H. HATCH.