its waves and currents might exert some mechanical force.¹ Fine sediment would accumulate, and percolating water would deposit carbonate of lime. Secondary silica also occurs as in a flattened geode (about 3 inches long), lined with bluish mammillated chalcedony (resembling beekite), and in the opaline silica cementing the concretion in the section shown in Fig. 1.

III. SUMMARY.

This district belongs to the extended volcanic area associated with the line of the Great Rift Valley. The abrupt descent of the bed in the Red Sea to a central channel may mark a part of that long depression, the form having been modified by later river action. The rocks of Perim probably correspond in age with the Aden basalts (the later volcanic period so named by Dr. Blanford), and they were doubtless emitted from some crater to the west of that at Aden. This ejected the material forming the pumiceous tuff of Perim, followed by the more abundant basaltic lavas. During depression and subsequent elevations of the land, the sea helped to carve out the straits of Babelmandeb and the gullies and rifts of the island. Coral reefs grew in the surrounding waters, and finally the raised beaches were formed, which record in Perim an uplift of at least 12 feet. The outline and depth of the harbour lend no support to the view that it marks an ancient crater, and the lavas and ashy beds which form the cliffs around it have generally a roughly horizontal direction. The indentation north-west of the harbour seems the end or continuation of a valley (containing the quarry of Fig. 1), extending from a raised beach here towards the raised beach near Balfe Point. Thus the present form of the land is mainly due to the usual forces of denudation and to oscillations of level, acting on an island built up of volcanic masses, within a shallow coral-bearing sea.

IV.—ON THE CORRELATION OF THE PALÆOZOIC ROCKS OF SOUTH AFRICA.

By WALCOT GIBSON, B.Sc., F.G.S.

(Continued from the April Number, p. 165.)

THE ancient rocks of Prieska are extensively developed in Griqualand West, where they build up the elevated Campbell Rand plateau and the lofty ranges of the Langebergen Mountains situated to the west of the Orange River Colony. The order of succession, which is much disguised by faulting and folding, has been described in great detail by Mr. G. W. Stow,² whose descriptions render it evident that the rocks of these regions resemble the older strata which extend over such vast areas in the Transvaal.

Several attempts have been made to classify the ancient rocks of the Transvaal, the results being nearly as numerous as the observers. In his latest classification of the rocks older than the Beaufort

¹ One example is described where the boulders appear as if piled by the sea, forming a kind of island in the middle of the Birkhud Raised Beach to the north of Perim.

² Q.J.G.S., vol. xxx (1874), pp. 581-680.

Beds, Dr. Molengraaff arranges them in the following descending groups:—

TABLE OF STRATA BELOW THE BEAUFORT BEDS OF THE TRANSVAAL. ¹		
KARROO SYSTEM.	{ Ecca Series Dwyka Conglomerate	Shales and diabases. A coarse conglomerate of variable composition and of glacial origin.
Great Unconformity.		
Amygdaloid Rocks of the Boschveld (age doubtful).		
CAPE SYSTEM.	{ Waterberg Sandstones... ..	Sandstones, breccias, conglomerates, diabases.
	{ Plutonic Series of the Boschveld	Porphyroids, red granites, norites.
	{ Pretoria Series	Shales, quartzites, diabases.
	{ Dolomite Series	Cherts and dolomites.
	{ Black Reef Series	Sandstones, quartzites, shales, and conglomerates.
Great Unconformity.		
PRIMARY SOUTH AFRICAN SYSTEM.	{ Amygdaloid Rocks	Diabases, amygdaloidal lavas, porphyrites.
	{ Ancient Granite Series... ..	Grey granite.
	{ Barberton, Hospital Hill, and Witwatersrand Series	Schists, quartzites, gold-bearing conglomerates (Banket).

This table embodies the results obtained by Dr. Molengraaff during several excursions undertaken in the years 1898 and 1899 with the object of a future systematic study of the region, and is by far the most complete of any yet produced. Dr. Molengraaff's classification differs from nearly all others by including the Banket formation in the Primary South African System,² instead of considering it to be the northern equivalent of the Table Mountain Sandstone. Dr. Molengraaff further differs from many observers in regarding the granites and gneisses cropping out between Johannesburg and Pretoria and round Vredefort as intrusive into the Hospital Hill Series, whereas they have generally been considered to belong to a much older Archæan massif in which the gold-bearing rocks have been enfolded by earth-movements. Which view is correct can only be satisfactorily determined by systematic mapping. In the meantime it is of more service to draw attention to the results obtained in mining and especially from an examination of the area immediately round Johannesburg, of which considerable information has been obtained of late years.

Soon after the commencement of the gold industry the auriferous rocks were believed to be arranged in a uniline, comparable with an English coal-basin. In 1892 it was shown,³ chiefly from observations from surface outcrops, that overthrusting had taken place to a considerable extent, possibly disguising the succession and certainly causing much repetition. Since then the progress of mining, and especially the development of 'Deep Levels,' has conclusively proved the existence of several overthrust faults of considerable vertical displacement, resulting in the duplication at the

¹ Dr. G. A. F. Molengraaff: Bull. Soc. Géol. France, 1901, ser. iv, t. 1.

² See also W. Gibson: GEOL. MAG., Dec. IV, Vol. IV (1897), pp. 548-550.

³ W. Gibson: Q. J. G. S., vol. xlviii (1892), pp. 404-437.

surface of some of the reefs. The powerful effects of these overthrusts have been further demonstrated by the presence of shearing on the edges of the igneous dykes which are frequently situated along thrust planes; and also by the conversion, by dynamic action, of the smaller dykes into hornblendic and chloritic schists.¹ Minor movements are indicated by a conglomerate band known as the Main Reef Leader, being so firmly attached to the overlying quartzite that the reef is described as 'frozen' into it, while the footwall or underlay consists of a band of soft schist accompanied in many places by a vein of secondary quartz. These phenomena suggest a minor thrust plane coincident with the footwall. That this is so becomes more apparent in the Spes Bona Mine, where on the third level the conglomerate band known as the Main Reef is brecciated and is separated from the Main Reef Leader by eight feet of quartzite; while on the fourth level the two reefs are separated by a wedge-like mass, 40 feet wide, composed of a rock looking like a hard siliceous mudstone.²

Major thrusts have not been definitely proved underground, but there is little doubt that a dislocation of this nature separates the Hospital Hill Series from the Witwatersrand (Banket) Beds, as has been frequently described and figured since its existence was pointed out in 1892. Another major thrust of great intensity is indicated by the junction of the Hospital Hill Series with the granites and schists north of Johannesburg, where the two formations are so altered by dynamic action along their junction that all trace of a line of demarcation disappears (Molengraaff, *op. cit.*, p. 20). The disposition of the quartzite ridges of the Hospital Hill Series north of Johannesburg and their progressive metamorphism as they approach this major thrust, taken in conjunction with their apparent great thickness, 8,000–10,000 feet,³ strongly suggests that the various quartzite beds and intervening shales are due to duplication or even reduplication by overthrusting. Dr. Molengraaff denies the existence of anything more than a local duplication, though he acknowledges (*op. cit.*, p. 22) that the "orogenic movements from south to north have been very energetic against the granite massif, which plays the part of a buttress."

Whatever may be the extent of the overthrusting, it is evident that the simple basin theory does not receive the support of recent investigation. The theory was mainly deduced from the generally observed decrease in the inclination of the reefs when followed in the direction of dip. It now appears that a secondary steepening of the dip has an extended occurrence along the Witwatersrand. This is most marked in the Simmer and Jack Mine, where from the 3rd to the 4th level the dip is $10^{\circ} 40'$, from the 6th to the 7th level $0^{\circ} 30'$, from the 10th to the 12th level 37° , and from the 14th to the 16th $29^{\circ} 35'$.⁴ How vastly important to the future of the

¹ F. H. Hatch: *Q.J.G.S.*, vol. liv (1898), p. 85.

² S. J. Truscott: "The Witwatersrand Goldfields; Banket and Mining Practice," 1898, p. 109.

³ F. H. Hatch: *op. cit.*, p. 79.

⁴ S. J. Truscott: *op. cit.*, p. 13.

gold-mining industry overthrusts will prove by counteracting the effects of this secondary steepening, is at once apparent.

In the group of rocks succeeding the Witwatersrand Beds Dr. Molengraaff finds a fancied resemblance to the sequence from the Table Mountain Sandstone and succeeding beds; the Black Reef Series, Dolomitic Series, and Pretoria Series being compared by him with the Table Mountain Sandstone, Bokkeveld Beds, and Witteberg Series. The dolomite in the Transvaal is unfossiliferous, while the Bokkeveld Beds contain a rich fauna of a Devonian facies. The dolomite most resembling that in the Transvaal is the rock in the Cango district, where, as previously stated, it is probably in an inferior position to the Table Mountain Sandstone. In Cape Colony the Witteberg Beds pass up conformably into the Dwyka Conglomerate; in the Transvaal the Glacial Conglomerate is markedly unconformable to the Pretoria Series. The resemblance, therefore, between the two colonies does not seem very exact. Regarding the unfossiliferous nature of the Transvaal older rocks, and the movements to which they have been subjected, it seems futile to attempt a correlation with the undetermined succession at the Cape; while to draw any comparison with the European Palæozoic rocks, as is frequently done, is *a fortiori* valueless deductive reasoning.

Of the older rocks of Rhodesia, Zululand, and Natal the information is scanty. It appears that the Bokkeveld Beds, or at any rate strata containing the Bokkeveld fossils, die out before they reach Natal, just as they do in the north-west provinces of Cape Colony. A fact in favour of their being unrepresented in the Transvaal.

To briefly summarize the knowledge of the older stratified formations in South Africa. The geological record is very imperfect. There are many rock groups, but excepting the Bokkeveld Beds at the Cape their age has not been determined. There are no certain representatives of strata of Silurian, Ordovician, and Cambrian ages. South Africa, then, appears to be the relic of an ancient massif composed of Archæan rocks, into which are sunk, in the form of complex anticlines and synclines, several rock groups of undetermined ages, which exist at the present day as lofty mountain ranges or as high plateaux, enclosing the western portion of the Indo-African basin in which the Karroo deposits were laid down.

Note.—A Graptolite, *Diplograptus pristis*, is stated to have been found in the slates of De Kaap, but this discovery has not been confirmed. (Trans. Geol. Soc. South Africa, 1896, vol. i, p. 52.)

V.—SOME TRIAS SECTIONS IN SOUTH STAFFORDSHIRE.

By BEEBY THOMPSON, F.C.S., F.G.S.

AN occasional visit to a village on the western border of South Staffordshire has given me the opportunity of studying the Triassic deposits around there. Possibly the various sections I have visited are well known to local geologists, although, so far, I have not come across any description of them. One section in particular, I think, must have been overlooked, and this it is now proposed to