PROCEEDINGS OF THE GEOLOGISTS' ASSOCIATION.

THE GEOLOGY OF BELGIUM.

PLATE I.

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I. OUTLINE SKETCH OF THE GEOLOGY OF BELGIUM IN THE LIGHT OF RECENT RESEARCH.

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A. INTRODUCTION.

THE last visit of the Geologists' Association took place in 1885, and since that time much progress has been made in the study of Geology in Belgium:—

(1) The whole country has been geologically surveyed on the scale of 1:20,000 and maps published on the scale of 1:40,000. These maps have replaced those on the scale of 1:20,000, which were originally intended to have been published and were in preparation in 1885.

(2) A map of mines has been prepared and published.

(3) A large number of deep borings and numerous cuttings for railways, canals, etc., have been made.

(4) The two important Geological Societies of Belgium have been active. (Société géologique de Belgique, Liège; Société belge de Géologie, de Paléontologie et d'Hydrologie, Bruxelles).

A pamphlet was prepared for the 1885 Excursion, and is still of very considerable use as an introduction to the geology of the country. Whilst the detailed descriptions of many of the beds are quite correct, our ideas as to the condition of formation of the strata and broad principles of their stratigraphical relationships have undergone, in many cases, a fundamental change. An attempt will be made, in the paragraphs which follow, to show where the older geologists erred, and thus to render the 1885 pamphlet of service by pointing out its misconceptions.

*I am indebted to M. A. Renier, Director of the Geological Survey of Belgium, for suggesting several of the points embodied in the following remarks.

B. PHYSICAL GEOGRAPHY.

Belgium falls into three natural geographical units (1) a northern lowland, (2) a southern upland region (Ardennes*), separated by (3) a long narrow coalfield—the Namur Basin.

(1) **The northern lowlands** consist of a small thickness of Cretaceous and Tertiary strata resting on a Palæozoic platform. Three sub-regions can be separated:—

a. *The western plain of Flanders.* A low-lying district, even marshy in places, consisting largely of Eocene Clay (Argile des Flandres) with a superficial covering of sand and “limon” and on the west a fringe, termed the “*plaine maritime*,” of recent marine muds and sands. The plain is relieved by a few prominent hills, consisting of the higher Eocene deposits and capped by ironstones of Diestian (Pliocene) age. Such hills form a chain stretching from Cassel in France, through the hills north of Bailleul (Mont des Cats, Monts Noir, Rouge, and Aigu) to Mont Kemmel and then to the central region.

b. *The central region* occupying the province of Brabant and portions of the surrounding provinces. Low hills of Eocene sands cover the platform of Palæozoic rocks of the “Brabant anticline” The Palæozoic strata are exposed in most of the river valleys (*e.g.* Dender, Senne and Dyle); sometimes they are covered directly by Eocene beds, at other times (away from the centre of the Ardennes-Brabant ridge) there is a thin representative of the Cretaceous.

c. *The eastern region* coinciding roughly in extent with the district known in the north as the Campine where the surface consists of Miocene or Pliocene sands, giving rise to stretches of barren heath. Further south Oligocene sands and clays give rise to the agricultural region of the Limbourg and then the loess-covered district of Hesbaya stretches southwards to the Meuse. The slope of the Palæozoic floor from south to north is shown in fig. 1.

(2) **The Ardennes*** form a pretty upland region deeply trenched by the magnificent valley of the Meuse. Geologically they are formed by the Dinant Synclorium of Devonian and Carboniferous rocks bounded on the north by the Silurian rocks of the Condroz Anticline. On the south the anticline of the Ardenne brings up Cambrian strata, and still further south is the western continuation of the Eifel Basin. The strike of the rocks in the Ardennes is from N.E.—S.W. and then E.—W. Outliers of post-Palæozoic sediments—especially Upper Cretaceous and Tertiary—occur here and there.

*This name is sometimes used in Belgium in a far more restricted sense.

FIG. 1.—DIAGRAMMATIC SECTION ACROSS BELGIUM.

P = Pliocene and Miocene. E + O = Eocene and Oligocene. C = Cretaceous. J = Jurassic and Trias. Black = Coal Measures. L = Carboniferous Limestone. Dev. = Devonian. S-C = Cambro-Silurian. F = Fault. (Grande faille du Midi).

Notice the Cambro-Silurian rocks of the Brabant anticline are only seen in certain valleys, elsewhere they are covered by Cretaceous and Eocene rocks with Pliocene outliers as at L. (e.g. Louvain).

(3) **The Namur Basin** stretches from Douai and Valenciennes in France to Liège and Aix-la-Chapelle. Geologically a long narrow synclinalium much faulted, of Devonian and Carboniferous strata, it is structurally a part of the Ardennes massif. It is the great coalfield of Belgium, and along it are situated most of the manufacturing towns—Dour, Mons, Charleroi, Namur, Huy, Liège, etc.

The annexed diagram illustrates the general structure of the country. On the south one sees the Ardennes emerging from the Mesozoic of the Lorraine, and formed by the Eifel syncline, the Ardennes anticline and the Dinant Syncline. The latter is thrust northwards over the Namur syncline, which in turn is folded against the Brabant Cambro-Silurian massif. One notices that the surface of the Palæozoic platform then plunges northwards under an increasing thickness of Cretaceous and Tertiary strata. It was below a considerable thickness of these later beds that the Campine coalfield was discovered early in the present century. Although not shown in the figure, representatives of the Upper Permian, Trias and Jurassic occur between the Coal Measures and the Cretaceous to the north of a fault which traverses part of the coalfield from E. to W.

C. GEOLOGICAL HISTORY.

Cambro-Silurian.

Rocks of this age occur in four principal areas :—

(i) the anticlinal massif of Brabant, exposed in the valleys of the Dender, Senne, Dyle, etc. (Cambrian, Ordovician and Silurian).

(ii) the anticlinal ridge of the Condroz, between the Dinant and Namur synclinoria (Silurian).

(iii) the anticlinal fold of the Ardenne, forming the southern border of the Dinant synclinorium, and exposed in the "massifs" of Rocroy, Serpont and Stavelot (Cambrian).

(iv) the anticlinal fold of Givonne.

The Cambrian deposits are still very imperfectly known. The oldest are metamorphosed sediments (Phyllades with *Oldhamia radiata*) which may possibly even be pre-Cambrian. Several groupings have been proposed for the Cambrian rocks. Little can be added to the account given by Prof. Bonney in the 1885 pamphlet, though the beds are now usually divided into Devillian (predominantly quartzites), Revinian (quartzites and killas) and Salmian (slates yielding *Dictyonema flabelliforme*).

The Ordovician and Silurian rocks are also insufficiently studied, though beds ranging in age from Arenig to Lower Ludlow are known to occur, and some bands are fairly rich in fossils. It is hoped that a careful study of the graptolites will lead to a more accurate classification.

The Brabant massif is of especial interest as having formed the "stable block" against which the Devonian and Carboniferous rocks were folded by pressure from the south. Its stability may be due to a plutonic base, since intrusive masses of considerable size do occur, as at Lessines and Quenast. The igneous rocks are extensively quarried for paving stones. The rock from Quenast may be described as a quartz-porphyrite; it is epidotized and thin sections afford excellent examples of epidote

Devonian.

At the end of the Silurian period considerable elevation seems to have taken place, accompanied, naturally, by a retreat of the sea. At the commencement of the Devonian period extensive submergence took place, and the history of the Devonian in Belgium may be summed up as that of a great marine transgression from south to north, or perhaps S.S.W. to N.N.E. Fig. 2 A shows this diagrammatically; the basal Devonian strata—littoral in character—belong to successively higher horizons northwards. The same phenomena are seen further west in the Boulonnais, and, it would seem, also in Devonshire. The transgression in the lowest Devonian—the Gedinian—was very extensive and well marked, and I regard it as having taken place

at the same time as the transgression of the Downtonian* sea from north to south in Wales, and from south to north in Scotland (Kincardineshire, etc.). I am unable to agree with those writers who consider the Lower Gedinnian is equivalent to the Ludlow Beds.

FIG. 2.—DIAGRAMS SHOWING THE GREAT DEVONIAN TRANSGRESSION.—L.L.D.S.

- A.—The successive overlap of the Devonian beds, due to marine transgression from the south. Notice the coastal deposits (indicated by dots) and the principal limestones and reefs (deeper water).
 B.—The beds folded and denuded, as seen at the present day, ignoring minor folds.
 C.—The old conception of the conditions of deposition with a ridge of Silurian rocks separating two marine basins. Notice that the supposed ridge is not bordered by coastal deposits, but by deep-water limestones.

In each case—in Belgium, Wales and Scotland—the lowest Devonian beds are succeeded by red shales and sandstones indicating shallow water conditions. It is as though the waters of enclosed basins, in spreading over a wider area, became much shallower.

**Sensu stricto*, meaning beds above the Ludlow Bone Bed; i.e., the Downton Sandstone and Teme-side Shales. See Stamp, *Geol. Mag.*, vol. lvii., 1920, p. 164.

In Great Britain the shallow-water, unfavourable conditions persisted and the Downtonian rocks pass up conformably into the Old Red Sandstone. In Belgium, however, depression again occurred and the marine waters spread further to the north; the red Upper Gedinnian (of Old Red Sandstone type and with Pteraspidean fishes) is succeeded by the varied marine deposits of the higher Lower Devonian, Middle and Upper Devonian. There are some geologists who have pointed out the widespread occurrence of shallow-water deposits of middle Devonian age in Belgium and urged that the Devonian be divided therefore into two systems. In reality the Devonian transgression was not a perfectly continuous one. It suffered temporary checks and slight retrograde movements of the sea. I have constructed a diagram, fig. 3, showing two minor movements of regression that can be traced on the eastern border of the Dinant syncline. It is based to some extent on the work of Dr. Asselberghs and I am much indebted to him for permitting me to incorporate observations as yet unpublished. It should be clearly understood that these local movements do not affect the unity of the Devonian system, or of the general trend of the Devonian transgression.

Fig. 2B, shows how the Devonian deposits of A have been folded so as to give the disposition of the beds as seen at present. It will be noticed that this modern conception of the Devonian differs fundamentally from the ideas of Gosselet detailed in the 1885 pamphlet. He considered that the Condroz "ridge" already existed in Devonian times and formed a barrier to the encroaching sea; he also considered the anticlinal masses of Cambrian rocks existed as islands in the Devonian sea (*e.g.* Ile de Serpont, etc.). This old conception is illustrated by means of a section in fig. 2C.

The Devonian to be visited in the Couvin district is described below; sections will also be seen in the Namur synclorium where, as seen in fig. 2B, the Lower Devonian is absent.

Carboniferous.

Speaking generally the Devonian transgression was continued in Carboniferous times and is frequently spoken of as "Devono-Carboniferous."* It is unnecessary to add anything to the accounts given below of the Carboniferous Limestone and the Coal Measures. Towards the close of the Carboniferous the country south of the Brabant massif was intensely folded, the folds running N.E.—S.W., becoming E.—W. towards the French border. From that time onwards there existed a Palæozoic ridge, running from the Ardennes through Belgium to the mouth of the Thames and under London, which has played a very important part in the history of Mesozoic and Tertiary times.

*The highest Devonian indicate shallow-water, even "Old Red" conditions, thus separating the Devonian and Carboniferous.

Permian and Trias.

Coarse conglomeratic deposits probably of Permian age occupy old valleys in the Palæozoic massif towards the German border (Poudingue de Malmédy). Upper Permian and the complete series of Trias occur in the Campine (northern border of the coalfield); Triassic beds are also found in the extreme south.

Jurassic.

The Liassic sea reached the southern side of the Palæozoic ridge and deposits of Liassic and later Jurassic age occur in the extreme south of Belgium. Jurassic rocks have also been touched in the Campine.

FIG. 3.—DIAGRAMMATIC SECTION FROM NORTH TO SOUTH ACROSS THE EASTERN END OF THE DINANT SYNCLINORIUM.

The lithology of the beds is indicated by the usual conventional signs. The diagram shows two minor movements of regression (R) which interrupted the great marine transgression (T) of Devonian times. These minor movements explain the presence of conglomeratic shallow-water deposits at various horizons and of red shales of "Old Red Sandstone" type. The reasons for the local absence of the *Calceola* Beds at Gileppe and for lateral variations in lithology are also apparent.

Cretaceous.

Wealden beds are found in old depressions or solution pockets on the west (Bernissart, etc.). On the east the sands and clays of Aix-la-Chapelle are now known to be of Senonian age.

The shore line of the Cretaceous sea during Albian, Cenomanian and Turonian times lay along the south-western margin of the Palæozoic ridge a short distance within the Belgian border, so that one finds littoral deposits of these periods banked up against it. The ridge sank in western Belgium (as it did in the London area), and was covered by Lower, Middle and Upper Chalk. Thus the Chalk sea encroached on the ridge from the south-west, from the west and also from the north-east. The highest Cretaceous waters probably covered the whole of the

Ardennes, and one can find traces of the deposits scattered over even the highest part of the "Hautes Fanges" or upland moors.

Tertiary.

Again in Eocene times the Ardennes formed part of the eastern shore of the Anglo-Franco-Belgian Basin, though the sea then covered the extension northwards of the ridge. The Lutetian deposits seem to have encroached most extensively on the Ardennes highlands, and the coastline may have lain even to the east of the Meuse between Namur and Dinant.

In Miocene times the Ardennes massif seems to have formed the southern limit of the sea, but the Pliocene sea probably covered practically the whole.

D. TECTONICS.

Much might be written on the very interesting tectonic phenomena, but space forbids anything but a brief mention.

Main periods of folding.

(1) Late Silurian, forming the Cambro-Silurian massifs against which the Devonian and later beds were deposited. The folds seem to be mainly Caledonian (N.E.—S.W.) in trend.

(2) Late Carboniferous (Hercynian or Armorican), a period of very intense folding, during which the Devonian-Carboniferous was crushed into the synclinalia of Dinant and Namur by pressure from the south forcing the rocks against the Brabant Cambro-Silurian massif. The pressure was so intense that the southern synclinalium (Dinant) was thrust right over the Namur synclinalium. The main thrust-plane is known as the Grande faille du Midi, and gives rise to the curious phenomenon of Coal Measures being worked beneath a considerable thickness of Devonian as is the case south of Mons. The Namur synclinalium itself is an overfold shattered by numerous thrust-faults such as the faille d'Ormont, of which the eastern border will be visited. Hence the conditions of coal mining are very different from those in England, and the coal is often entirely powdered, rendering briquetting necessary. It is said that generally the Armorican thrust-planes are fairly steeply inclined near their outcrops, but become more nearly horizontal when traced underground. They are not all of exactly the same age and some have been folded by later movements. Masses of rock, sheared off from some underground source, sometimes occur in the thrust plane; thus a block ("lambeau de poussée") of Tournaisian limestone may be found in the midst of a thrust where Devonian rests on Coal Measures. These "lambeaux" are of all

sizes, sometimes a great mass of rock, large enough to form a hill some 500 feet in height and two or three miles long ; for example the hill of Chevreumont south-east of Liège is a mass of Upper Devonian (Famennian), occurring between an overthrust of Lower Devonian above, and a surface of Coal Measures below. Again, the overthrust mass may have been partly denuded and the rocks under the thrust-plane exposed, giving the curious feature of a patch of newer rocks, entirely surrounded by older. Such a patch is known as a "fenêtre" or "window," A fine example is the great "Fenêtre de Theux," south-west of Verviers.

North of the Brabant massif (in the Campine coalfield) the Armorican folds are much gentler in character and normal faults occur.

(3) Late Cretaceous and Early Tertiary (Alpine). That the movements which culminated in the great "Alpine storm" of Miocene times commenced before the end of the Cretaceous period has been proved by the relative thickness of Chalk zones in England, when traced southwards towards the Wealden uplift. The movement is still more clearly shown in the Mons district by the unconformity between the *Actinocamax* Chalk and the zone of *Micraster cor-testudinarium*. In early Eocene times the Wealden-Artois anticlinal ridge was sufficiently uplifted to give off small streams in the Upper Landenian period. The later folding of the Eocene Beds, e.g. in the Mons syncline, may be due to Alpine movements ; at Mons the roughly E.—W. fold is superimposed on an Armorican syncline (Namur Basin). Some of the normal or ordinary reversed faults in the Palæozoic rocks may belong to the Alpine foldings, others may be "tears" associated with Armorican thrusting.

II. THE PALÆOZOIC FORMATIONS OF THE SOUTHERN PART OF THE DINANT BASIN.

By EUG. MAILLIEUX, of the Royal Natural History Museum, Brussels.

THE southern border of the "Bassin de Dinant" rests against the Cambrian massif of Rocroi, the plateaux of which reach heights varying from 320 to 376 metres in Belgium.

The Armorican or Hercynian synclinorium, known as the Dinant Basin, commences with the Mondrepuits Beds, the base of which consists of rocks indicating the littoral character of the beginning of the period (conglomerate and coarse sandstone or "arkose"). The succeeding Lower Devonian constitutes a broad band, essentially arenaceo-argillaceous, with a somewhat varied relief of which the highest points slightly exceed 335 metres. The Middle and Upper Devonian, consisting especially of limestones and shales, exhibit lines of low hills—