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ON THE NEOCOMIAN AND THE WEALDEN ROCKS IN THE JURA AND IN ENGLAND.

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In June, 1827, Dr. W. H. Fitton read before the Geological Society of London the following statement:—"It is obvious that, during a period of time sufficient for the accumulation of the Wealden, the deposition of matter in the adjacent seas could not have been inconsiderable; so that we might expect to find, interposed between the strata which then formed the bottom of the sea and the Lower Greensand, a series of beds coeval with the Wealden in point of date, but differing from it in possessing the characters of a marine deposit, and including marine shells and other productions of salt water; with which, near the shore, the productions of the land, or even the fresh-water shells of the rivers, might be occasionally intermixed. . . . . 1st. That the Wealden and its marine equivalent could not both be found in the same place; and consequently (since we have the former in England) that the *marine* beds of that date are not to be expected generally in this country; 2dly. That the marine fossils of the beds cotemporaneous with the Wealden would probably be distinct, both from those of the Portland group beneath, and of the Greensands above them; a consideration which gives peculiar interest to the cossils of this intermediate group."* Since that day, the Neocomian

* See *Observations on some of the Strata between the Chalk and Oxford Oolite in the South of England.* Transact. Geol. Soc. 2 Ser. vol. iv. p. 329.

formation has been found and named; its rocks and fossils have been described; and the Purbeck beds have returned to their former associates—the Jurassic rocks.

During this period of time several geologists have tried to find the marine equivalents of the Purbeck and Wealden rocks, without, however, arriving at results satisfactory to all observers. The question is still very far from a solution; but I have lately learned several new facts on the subject which perhaps may be of some assistance in facilitating a recognition of the marine deposits coeval with the Wealden.

In order that my references and data may be clearly understood, I will first give a short description, or *résumé*, of the strata in the Jura Mountains comprised between the Portland stone and the Lower Greensand. This *résumé* is also graphically presented in the *Abstract section of the series of strata comprised between the Banné Limestone and the Rhodanian group, in the Jura Mountains* (Pl. I., Fig. 1)—under the form of a tabular and proportional view.

The Jurassic divisions known under the names of Banné Limestone (*Calcaires du Banné*) and Salins Marls (*Marnes de Salins*)* contain a fauna identical with that of the Portland beds, with the addition of some new species peculiar to the Jura, and a few fossil shells common to the Kimmeridge clay. The Salins Marls are succeeded by a series of compact limestone strata, very thick (100 feet at least), of a whitish-grey, and sometimes clear yellow colour, containing beds of lithographic stone a little above the middle of the division, and always capped by a sort of magnesian limestone (Dolomite). This series, called Salins Limestone (*Calcaires de Salins*), contains numerous fossil remains, all of marine animals, especially Corals, Echinodermata, Nerinea, and Natica; two hundred different species at least. The *Leitmuscheln* (guide-shells) are:—*Hemicidaris Purbeckensis*, Forb.; *Pygurus Jurensis*, Agass.; *Pinna Barrensis*, Buv.; *Trigonia gibbosa*, Sow.; *Natica Marcousana*, D'Orb.; *N. Athleta*, D'Orb.; *Rostellaria Barrensis*, Buv.; *Nerinea Salinensis*, D'Orb.; *N. Elea*, D'Orb.; *N. subpyramidalis*, D'Orb.; *N. grandis*, Volt.; *N. trinodosa*, D'Orb.; *N. cylindrica*,

* See, for explanation of these terms, *Lettres sur les Roches du Jura et leur distribution géographique, dans les deux Hémisphères*, par Jules Marcou; Paris, 1857.

D'Orb.; *Stylina intricata*, From.; and *Thamnastræa dumosa*, From. Typical localities; vicinity of Salins, Gray, Besançon, Montbéliard, and Borrentruy.

The Salins Limestone terminates the Jurassic strata, and a well-marked discordance of stratification exists between it and the Neocomian rocks; a discordance varying from 5° to 15°, and which may be seen on all the flanks of the different longitudinal valleys of the Jura.

The Neocomian rocks are divided into three groups: the Lower Neocomian, or St. Croix group; the Middle Neocomian, or Château group; and the Upper Neocomian, or Noirvaux group.

The Lower Neocomian has its type in the vicinity of St. Croix, a village in the Canton de Vaud, celebrated for the numerous and successful researches of Dr. Campiche, who has collected there the most complete set of Neocomian fossils in existence. Professor Pictet describes them in his *Matériaux pour la Paléontologie Suisse*, seconde série; *Description des fossiles du Terrain crétacé de Ste. Croix*, now in course of publication. The St. Croix group may be divided into three principal parts, (*a*) the Villars Marls, (*b*) the Auberson Rocks, and (*c*) the Métabief Limonite.

(*a*). The Villars Marls (*Marnes de Villars*), forty feet thick, consist of very hard, grey marls, alternating near the top with marly and very compact limestone. In some places, such as Renaud du Mont, La Rivière, and Foucine, the marls become green and even variegated, and then contain layers of white gypsum and dolomitic limestone. Professor Lory of Grenoble has found freshwater shells in this division, such as *Planorbis Loryi*, Coq.; *Physa Wealdina*, Coq.; *Paludina*, *Cyclas*, *Anodonta*, &c.; and M. Renevier has lately discovered the *Corbula alata*, Sow., which indicates a mixture of brackish-water animals. The typical localities for fossils are, Villars-le-lac near Morteau, Charix near Nantua, Jongue, Les Rousses, and Cinquétral near St. Claude.

(*b*). The Auberson Rocks (*Roches d'Auberson*), eighty feet thick, are composed of a series of compact, whitish, oolitic limestones, with beds of blue and yellow marls, varying in thickness from half-a-foot to ten or twelve feet, intercalated near the base. The marls contain in great quantity a small sea-urchin called *Toxaster Campichei*, Pic., and a small *Terebratula* related to the *Ter. biplicata*, var. *acuta*, von Buch. In the limestone beds are found, *Strombus Sautieri*, Coq.; *Sigaretus Pidanceti*,

Coq., and the *Natica Sautieri*, Coq. The typical localities are, the Auberson Valley, near St. Croix, St. Cergues, and Les Rousses.

(*c*). The Métabief Limonite (*Limonite de Métabief*), forty feet thick, is generally a reddish limestone, containing oolitic iron-ore; the strata are thin, and easily decomposed by atmospheric action. In some places, as in the valley of Nozeroy, blue marls exist at the base of this division. The fossils are very numerous, and beautifully preserved; those characteristic are—*Chelonia Valenginiensis*, Pict.; Crocodile; *Plesiosaurus Neocomiensis*, Camp.; *Pycnodus cylindricus*, Pic.; *Asteracanthus granulosus*, Eger.; *Ammonites Gevrilianus*, D'Orb.; *A. Marcousanus*, D'Orb.; *Nerinea Marcousana*, D'Orb.; *Pholadomya Scheuzeri*, Agass.; *Pygurus rostratus*, Agass.; *Hemicidaris patella*, Agass.; *Acrocidaris depressa*, Gras.; *Catopygus Renaudi*, Agass.; &c. Typical localities: Métabief, Boucheraus, and St. Croix.

The Middle Neocomian, or the Château group, as it is called in reference to the castle of the town of Neuchatel, the foundation of which rests entirely on this group, is composed of three divisions; (*a*) the Hauterive clay, (*b*) the Ecluse rocks, and (*c*) the yellow, or Neuchatel stone.

(*a*). The Hauterive clay (*Marnes d'Hauterive*), thirty feet thick, consists of blue and sometimes plastic clay, with more or less of a yellow tint and very numerous fossils; the most common are, *Toxaster complanatus*, Agass.; *Diadema rotulare*, Agass.; *Terebratula prælonga*, Sow.; *Ter. Marcousana*, D'Orb.; *Rhynchonella depressa*, D'Orb.; *Ostrea Couloni*, Defr.; *Corbis cordiformis*, D'Orb.; *Trigonia caudata*, Agass.; *Venus Dupiniana*, D'Orb.; *Panopea Neocomiensis*, Agass.; *Cardium Voltzii*, Leym.; *Pleurotomaria Neocomiensis*, Agass., &c. It is easy to distinguish three zones in these clays, characterised by different associations of fossils; the lower zone, or Censeau beds, the middle, and the upper zone. Typical localities: Hauterive, near Neuchatel, St. Croix, Censeau, Nozeroy, &c.

(*b*). The Ecluse rocks (*Roches de l'Ecluse*), forty feet thick, are composed of yellowish, often green, spotted limestone, alternating near the base with yellow marls. Characteristic fossils: *Rhynchonella depressa*, Sow.; *Ostrea Bousingaultii*, D'Orb.; *Lima Royeriana*, D'Orb.; *Pecten Cottaldinus*, D'Orb., &c. Typical localities: the Ecluse behind Neuchatel Castle, and Censeau.

(*c*). The Neuchatel stone, or yellow stone (*Pierre jaune ou Pierre de Neuchatel*), sixty feet thick, is the beautiful material which gives to the buildings of the town of Neuchatel that clear yellow colour so much admired by travellers. Fossils are rare in this division, and never in a good state of preservation. Typical localities: vicinity of Neuchatel and Pontarlier.

The Upper Neocomian, or Noirvaux, group is well developed in the Noirvaux valley near St. Croix; it is this group, or rather the fauna contained in its strata, that D'Orbigny has called *Urgonian*. Two divisions are generally found in it; (*a*) the Mauremont rocks, and (*b*) the Noirvaux-Dessus Limestone.

(*a*). The Mauremont rocks (*Roches du Mauremont*), forty feet thick, consist of yellow limestone, very difficult to distinguish from the division below; they become marly, and finally terminate with a bed of yellow marls containing numerous fossils. The characteristic fossils are: *Janira atava*, D'Orb.; *Toxaster Couloni*, Camp.; *Pygurus productus*, Agass.; *Cidaris clunifera*, Agass.; *Caprotina Dubuisii*, Mèr.; *Rhynchonella lata*, D'Orb., &c. Typical localities: Mauremont in the Canton de Vaud; St. Croix, Travers, Bôle, &c.

(*b*). The Noirvaux-Dessus Limestone (*Calcaires de Noirvaux-Dessus*), one hundred and ten feet thick, has been often called the *Caprotine Limestone;* it is a series of beautiful white and sometimes yellow limestones, affording a marble much employed at Thoiry, near Geneva. Characteristic fossils: *Caprotina ammonia*, D'Orb., and *Radiolites Neocomiensis*, D'Orb. Typical localities: Noirvaux-Dessus, near St. Croix, Thoiry, Les Rousses, &c.*

The strata of the Greensand formation lie directly above the Neocomian and in concordance of stratification. Eugène Renevier, who has made a special and very successful study of the Greensands in England and at the Perte du Rhône, considers the lower Pernabed, containing the *Natica rotundata*, Sow., &c., of the Lower Greensand of the Isle of Wight, to be the equivalent of the yellow clay (*Marnes jaunes*) containing *Natica rotundata*, Sow., &c., of his Rhodanian group of the Greensands of the Perte du Rhône.

* For a more detailed account of the Neocomian Strata, see *Sur le Néocomien dans le Jura et son rôle dans la série stratigraphique*, by Jules Marcou. Genève, 1859.

I have given a rough sketch under the form of a tabular and proportional view (Pl. I. Fig. 2)—*Abstract Section of the series of strata comprised between the Portland stone and the Lower Greensand, in the South-Eastern part of England*—for the sake of comparison.

The Banné Limestone and Salins Marls being the equivalents of the Portland beds, and the Rhodanian presenting exactly the fauna of the "*Perna-beds*" and "*crackers*" of the Lower Greensand, it appears rational to conclude that the Purbeck beds, the Hastings sands, and Weald clay, are fluvio-marine and terrestrial deposits coeval with the marine deposits known in the Jura under the name of Salins Limestone and Neocomian.

A few marine fossils, or, at least, belonging to brackish-water animals, have lately been found common to the two series in the Jura and in England, and they may serve as landmarks for future investigations.

In the first beds of the Salins Limestone, immediately above the Salins Marls, the *Trigonia gibbosa*, Sow., is quite abundant, and in a good state of preservation. Fitton says, that the last bed in the Portland quarries, called by the quarrymen "roach," contains a great quantity of *Trigonia gibbosa*. So we may suppose that the "roach" of Portland is equivalent to the first beds of the Salins Limestone, or a little older. I have indicated both suppositions by dotted lines uniting the two abstract sections. In both countries, the stratigraphical position of the *Hemicidaris Purbeckensis*, Forb., forbids the supposition that the "roach" may be younger than the Salins "Trigonia gibbosa beds." Until now, palæontologists and geologists have regarded the Echinodermata as more characteristic than the Acephala and Gasteropoda, and of equal importance with the Cephalopoda and Brachiopoda. As an example of their importance, it is sufficient to say that Forbes replaced the Purbeck beds in the Jurassic rocks, because he discovered a Hemicidaris in the "Cinder-bed" near Swanage. That Hemicidaris was new, and he called it *Hemicidaris Purbeckensis*.

A few years later, the same species was signalized in France by Cotteau, who had it from the Salins Limestone of Burgundy (see *Etudes sur les Echinides fossiles du département de l'Yonne*, vol. i. p. 300). But Cotteau says that his three specimens belong to a variety of the species described by Forbes, who found only a single complete specimen; and

the *Hemicidaris Purbeckensis* is regarded as a rare fossil in Purbeck, and also in Burgundy.

During my explorations of the Jura in 1844-47, I met with fragments of a Hemicidaris in the Salins Limestone several times; and when Forbes published his *Hemicidaris Purbeckensis*, I perceived at once the possibility of an identity with the Jura sea-urchin; and on making a rapid excursion to Portland in 1852, I saw immediately that the strata called in the Jura *Portlandian* were not equivalent to the Portland-stone of England, but a little younger. Having learned that a well-preserved Hemicidaris had lately been found by M. Perron, of Gray, in the Salins Limestone near that town, I wrote to call his attention to the subject; and the result of researches made by him and M. Etallon is, that the Hemicidaris of Gray is identical in all respects with the *Hemicidaris Purbeckensis*. MM. Perron and Etallon say that their specimens do not indicate any variations from the true *Hemicidaris Purbeckensis* of Professor Edward Forbes; and this beautiful fossil is quite common even with the spines adherent to the shell.

The exact position of the *Hemicidaris Purbeckensis* at Gray is about thirty feet from the base of the Salins Limestone. There are also some indications of the existence in the Salins Limestone of the *Exogyra bulla*, Sow., and *Ostrea distorta*, Sow., but nothing positive as yet.

Relying only on the *Hemicidaris Purbeckensis*, it is, however, quite probable that the Salins Limestones are the marine deposits coeval with the Purbeck beds; especially if we consider that in England a change of some note takes place in the distribution of deposits; for the Hastings Sands and Weald Clay range through a very different part of the country from the Purbeck strata. The discovery of the *Hemicidaris Purbeckensis* in the last division of the Jurassic rocks in the Jura mountains shows the soundness of Forbes' view when he replaced the Purbeck beds in the English Oolites.

The Villars Marls contain a fluvio-marine fauna, which will aid us in the endeavour to find the equivalents in the two countries, and the more as we now know that Professor Lory, of Grenoble, has found in Dauphiné the marine deposit coeval with them. Until now, only one species truly identical with an English fossil has been discovered in the Villars Marls: it is the *Corbula alata*, Sow., known in the Ashburnham beds of Pounceford, near Burwash, Sussex.

Professor Pictet has lately recognised among the fossils picked up at St. Croix, in the Métabief Limonite, a well-preserved spine of the *Asteracanthus granulosus*, Eger., a fish found by Mantell in the middle division of the Tilgate beds. It is interesting to add that Campiche, Pictet, and some other Jurassian geologists, have found in the same Métabief Limonite numerous vertebræ, teeth, and scales of Plesiosaurus, Crocodiles, and fishes, indicating that a rich fauna of vertebrated animals existed there during the deposits of the Métabief beds (see *Description des fossiles du Terrain crétacé de Sainte Croix*, par Pictet et Campiche. Genève, 1858). If we remark that the middle division of the Tilgate beds is precisely where Dr. Mantell found such numerous remains of Plesiosauri, Crocodiles, Iguanodons, fishes, &c.; it is not improbable that we may synchronize the Lower Neocomian with the Lower part of the Hastings Sands, from the Middle division of the Tilgate beds downwards, with some degree of truth. I have indicated this supposed synchronism by dotted lines. (See Pl. I. *Abstract sections*, &c.)

We have as yet no palæontological evidence that will permit us to identify the Middle and Upper Neocomian with the upper part of the Hastings Sands and the Weald Clay; but, if the preceding synchronisms be exact, we may accept this also on stratigraphical grounds.

At all events, it appears from the preceding remarks,—1st, that the Neocomian is not the equivalent of the Lower Greensand; 2d, that the Purbeck beds are coeval with the marine deposits called, in the Jura, Salins Limestone; 3d, that there is great reason to suppose that the Neocomian of the Jura is the marine equivalent of the Wealden of Kent, Surrey, and Sussex; and that the great gap existing in Great Britain in the marine deposits between the strata of Portland and those of the Lower Greensand will be filled up by the Neocomian and the Salins Limestone of the Jura Mountains.