While therefore the actual physical and zoological distinction can be traced in a westerly direction for more than twelve hundred miles, and in a north-easterly direction for six or eight hundred miles, and for an equal distance in a southerly and south-westerly direction, I can scarcely suppose that the few facts observed within limited areas, and not yet submitted to the test of comparison, will change the views of geologists upon the distinctive character of these formations.

In bringing this brief *résumé* before the Geological Section of the British Association, I have indulged in the hope that the facts might be of some use in a comparison with British Middle and Upper Silurian formations, which can be so clearly recognized in Canada and the United States.

V.—NOTE ON THE MIDFORD SANDS.

By H. B. WOODWARD, F.G.S.,
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THE term "Midford Sands" suggested by Professor Phillips¹ for the Sands which occur between the Inferior Oolite and the Upper Lias Clay, gives us a very happy name, and one that has been long wanted for these beds; for hitherto although they have been called by many names, not one has been generally adopted. They were first discovered and studied, so Professor Phillips tells us, by William Smith, in the picturesque cliff which overhung his house at Tucking Mill, near Midford—a little hamlet about three miles south of Bath, and situated in one of those delightful valleys formed by the river Avon and its tributaries. The deposit was called by him "Sand of the Inferior Oolite," and so it was known until Dr. Wright in 1856² called the classification into question on palæontological grounds, and maintained that the fossil evidence indicated that the Sands belonged rather to the Lias than to the Inferior Oolite. He gave them the name of "Upper Lias Sands," by which they have since been usually designated. The classification of Dr. Wright has, however, been objected to, and it may therefore be interesting briefly to review some of the opinions in regard to this question, stating also that most recently given by Professor Phillips.

Dr. Wright pointed out that wherever the Sands are well exposed (and he gave sections in Gloucestershire and Dorsetshire), they are overlain by a brown iron-shot marly limestone containing "an immense quantity of individuals of several species of Ammonites, Nautili and Belemnites, with a few shells of other Mollusca," and he maintained that this "Cephalopoda Bed" in its organic remains belonged rather to the Lias than to the Oolite formation. The Sands below he found to pass insensibly into the clays of the Upper Lias.

Mr. Moore,³ however, has disputed these conclusions. He remarks

¹ *Geology of Oxford and the Valley of the Thames*, p. 109.

² *Quart. Journ. Geol. Soc.*, vol. xii., p. 292.

³ On the Middle and Upper Lias of the South-west of England. *Proc. Somerset Arch. and Nat. Hist. Soc.*, vol. xiii., 1865-6.

that the faunas of the Upper Lias and Sands are very distinct in general facies, and that many Ammonites pass from the Sands into the Inferior Oolite above. The Sands, moreover, he states, are often inseparable from the Inferior Oolite into which they pass gradually upwards; while he mentions that at Compton, near Sherborne, the upper surface of the Upper Lias, composed of thin bands of clay and stone, "was much eroded before the deposition of the Oolitic bed above, a circumstance observable wherever the junction of the Upper Lias with the Sands is exposed."

This last statement, however, is at variance with that of other observers, who regard the beds as passing one into the other; and as the fossil evidence tends to confirm the opinion, we are inclined to regard the appearance of erosion as a local peculiarity. Unfortunately the junction of the Sands with the Lias is very rarely seen in section, although usually it is clearly marked by springs which are thrown out by the Upper Lias Clay.

Judging solely from Dr. Wright's list of fossils we find that taking into consideration the Cephalopoda alone; the Sands are more nearly related to the Upper Lias; while arguing from the Gasteropoda, Conchifera, and Brachiopoda, they are more closely allied to the Inferior Oolite.

Therefore the palæontological evidence cannot be looked upon as decisive for referring the Sands more particularly either to the Upper Lias or the Inferior Oolite, but that it agrees with the evidence afforded by the rocks of a gradual change.

This is indeed the opinion arrived at by Mr. Lycett¹ in the Cotteswold Hills. Here he has called the Sands the "Cynocephala stage," from their being characterized by *Rhynchonella cynocephala*, which occurs in the "Ammonite bed" (= "Cephalopoda bed" of Dr. Wright). He observes that it is a stage "possessing some features both petrographic and zoological, which seem to claim for it a position intermediate and connecting the Lias with the Inferior Oolite." He considers that the group of fossils found in the "Ammonite bed" differs very materially from the Upper Liassic fauna, and that even the evidence afforded by the Ammonites is "transitive" in its character. He also alludes to the division between the "Ammonite bed" and the Oolite above, as being often very indistinct.

Professor Phillips² has pointed out the transitional character of the Midford Sands as a very general fact in Yorkshire, Lincolnshire, Gloucestershire, and Dorsetshire; that they were "deposited on the Upper Lias clay in such a manner as often to defy the geologist to draw a hard line between them," and that "the Oolite above seems to connect itself with equal affinity to shelly calcareous rock [the Cephalopoda bed] at its base." And in regard to the organic remains, he remarks that, "before the Liassic life has come to an end, the Oolitic life has begun."

It is important, however, to notice the statement of Mr. Moore in

¹ The Cotteswold Hills. Hand-Book introductory to their Geology and Palæontology. pp. 16-33. (London, 1857. 8vo.)

² *Op. cit.*, p. 118.

regard to the indication of a slight lapse of time between the conclusion of the Upper Lias and the commencement of the Midford Sands in the Somerset and Dorset area, where we have such a feeble representative of the former. Indeed, but for Mr. Moore's patient investigations it would be but little known in this area, for his observations show that it attains but an average thickness of 8 feet in Somersetshire and the adjoining portions of Dorset. It has therefore been generally too thin to trace out on the small scale of the Geological Survey Map; but its presence was indicated and a small exposure mapped near Sandford Orcas more than twenty years ago by Mr. Bristow.

Although, as Mr. Moore points out, these Upper Lias beds "present a remarkable variety in lithological condition, indicating that they must have been deposited slowly, and that there were probably periods of rest during their accumulation,"¹ yet it becomes an interesting question when we compare this feeble representative of the Upper Lias with the great thickness it reaches in the north of England, to speculate as to whether Oolitic conditions may not have commenced somewhat earlier in this part than elsewhere.

Professor Buckman has recently given his opinion in regard to the Sands near Sherborne in Dorsetshire, that they belong to the Inferior Oolite series; that the concretionary masses interbedded with the sands contain fossils essentially Oolitic, and not Liassic. He considers them to be the equivalents of the Middle and of a portion of the Upper division of the Inferior Oolite of Gloucestershire, and the "Cephalopoda Bed" of this district he states to be at the top, instead of at the base of the Oolite.²

This opinion shows the difficulty of correlating these divisions of the Secondary rocks with any exactness. Indeed we are inclined to think it impossible, and to look upon the whole of the rocks, the Keuper, the Lias, and the Oolites, as one conformable series, marked for convenience into certain stages of sedimentary deposit, which are also characterized by certain assemblages of organic remains; but we do not think that these stages continued uniformly, or that they were of a like duration over any large area, the conditions changing at different times in different places. In this way we may understand some of the marked differences in thickness of the rocks, which do not seem always to be accounted for by rate of deposition, and certainly do not admit of denudation to account for their attenuation. We may mention the Fuller's Earth, which attains a thickness of 400 feet in Dorsetshire, which entirely disappears to the north-east beyond Gloucestershire, as an instance of a deposit contemporaneous with others of a different character.

The subject requires much study before we can look upon the Lower Mesozoic rocks as a series of interlacing sediments.³

¹ *Op. cit.*, p. 17.

² *Proc. Geol. Assoc.*, vol. ii., p. 249.

³ Mr. Bristow has prepared an interesting Table, showing the thicknesses of the Secondary strata in the Southern counties of England, which is published in the Report of the Coal Commission.