upright fold. It would be interesting to know whether comparable relations between small conjugates and major structures, folds, or thrusts exist elsewhere.

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THE MALVERN LINE

SIR,—Drs. Phipps and Reeve, knowing of my interest in the Upper Llandovery rocks and fossils of the Welsh Borderland kindly allowed me to see their paper before publication. They dispute the field evidence (Reading and Poole, 1961, 1962) for an unconformable junction of Silurian on Pre-Cambrian in the Gullet Quarry, maintaining that the west flank of the Malvern hills is marked by a continuous major fault.

Their arguments are based (1) on structural mapping, (2) on stratigraphical interpretation and (3) on their interpretation of the Gullet Quarry exposure.

To take the last point first, Reading and Poole's description of the Gullet Quarry exposure is complete and accurate leaving little to be added. In their second communication (published after Phipps and Reeve had submitted their manuscript) they state that undistorted fossils surround the boulders and that regularly stratified sediments are in contact with the Malvernian, whereas Reeve and Phipps found fossils only on the upper surface of the conglomerate band and imply that clay occurs everywhere at the contact between the boulders.

The mapping evidence propounded by Phipps and Reeve is inconclusive in spite of their claims that Groom's mapping " demonstrated unquestionably " a fault or that the western boundary line is " manifestly a fault ". Everyone who has mapped in the Welsh Borderland will agree that, with the very poor exposure available, the mapping is largely a matter of interpretation. Phipps and Reeve say that the " outcrop " of the western boundary of the Malvernian rocks from the top of North Hill to Colwall forms an unbroken line and they go on to argue that it appears beyond dispute that this line is the outcrop of a fault plane. Yet the only place where this line is today exposed is at the " sycamore tree exposure ", West Malvern, which, as Reading and Poole (1961, 1962) indicate, is clearly a stratigraphical junction. Phipps and Reeve do not mention this exposure at all, although it is the only currently exposed Malvernian/Llandovery contact apart from the one in the Gullet Quarry.

Now to look at the stratigraphical evidence : Phipps and Reeve attempt a reconstruction of the Upper Llandovery situation from the stratigraphy and argue that the sediments observed could not have accumulated in an environment of the dimensions implied by the unconformity interpretation. I would like to suggest, by contrast, that the sediments are not only consistent with the unconformity, but that variations within them indicate that vertical movement along the Malvern Line occurred in pre-Upper Llandovery times and that it had an important effect on the palaeogeographic situation.

Before the beginning of Upper Llandovery time, the Cambrian deposits were tilted and eroded ; pebbles of shale and quartzite are abundant in Upper Llandovery conglomerates, as are examples of Pre-Cambrian rocks, and the upper unit of the Cambrian, the shale, seems to have been stripped from the Birmingham region. It seems quite reasonable then, that the Cambrian was also eroded from the Gullet—West Malvern strip, but it is necessary then to assume down-faulting immediately to the west of this strip to account for the presence of a complete Cambrian sequence in this direction. In other words, a north–south scarp is postulated with Pre-Cambrian rocks laid bare on the eastern upthrown side, and Cambrian shale existing on the west and forming the the low ground much as it does today.

Supporting evidence for this proposed scarp, or at least some similar topographic feature, is found in the Upper Llandovery sediments. To the west of the " scarp ", the Cowleigh Park Beds, and further afield at May Hill, the Huntley Hill Beds, began to accumulate about the beginning of the Upper Llandovery (zone C_1), but to the east of the " scarp ", at Walsall, Rubery, West Malvern, Gullet, and Tortworth, no deposits formed until relatively late in the Upper Llandovery (zone C_5) suggesting a positive area in this region. Within the Upper Llandovery units there are marked facies changes. The Cowleigh Park Beds about the Malvern Hills area contain red beds and fossils appear at one horizon only, belonging to a very restricted marine community characterized by abundant *Lingula* and " *Camarotoechia* " *decemplicata.* Further afield, however, to the north and west at Old Storridge Common and Ankerdine Hill, and to the south and west at May Hill, the equivalent age beds contain abundant species of articulate brachiopods which appear to represent a normal marine environment.

The picture is, then, of an early Upper Llandovery land mass in the present Severn Valley area and extending as far west as the Malvern Hills. Adjacent to this occurred a shoreline, but much of the sequence in this area, including the fine-grained red beds at the very base, and the coarse, unsorted, cross-bedded conglomerates at the top possibly accumulated in non-marine conditions. The great bulk of the sedimentary material was derived from Malvernian rock ; even at May Hill, the great abundance of Malvernian rock types, especially the orthoclase and quartz rock, is remarkable.

Throughout the Welsh Borderland, there seems to have been renewed transgression towards the end of the Upper Llandovery (zone C_5) and it is no accident that geologists mapping in such areas as May Hill, Malvern, and Shropshire have distinguished two stratigraphic units within the Upper Llandovery. There is a sudden stratigraphic break at this point and the Yartleton Beds, Wyche Beds, and Purple Shales, are all distinctly finer in grain size than their predecessors. Also, to the east of these areas, sediments began to accumulate for the first time. These late Upper Llandovery deposits represent a very consistent environment, topographic irregularities such as the supposed scarp having been levelled. However, it may have been some time before sediment completely covered the crest of the marine ridge of the Gullet—West Malvern area. Currents apparently swept away all but the largest boulders which remained to form the unique conglomerates. Unique also is the extremely rich fauna of these conglomerates which has no parallel elsewhere in the region. The suggestion is that the fauna includes forms adapted to the rocky bottom.

To sum up, there are two distinct stratigraphical successions in the Welsh Borderland and English Midlands. To the west the fuller " Cowleigh Park

Bed " sequence is developed as at May Hill, Old Storridge Common, Ankerdine Hill and in Shropshire : complete Cambrian successions are often present in these areas. To the east, at the Gullet, in West Malvern and Walsall, Rubery and Tortworth, early Upper Llandovery beds do not occur and the Cambrian is partially or completely eroded. The controlling factor of these differences was vertical movement along the Malvern Line in pre-Upper Llandovery times. This Line appears to be a major structural feature and has been active at different periods, although its exact position at the surface has varied from the west side to the east side of the present Malvern Hills, and movement along it has been different at different times. This line is subparallel with the Church Stretton Line and like it, seems to have controlled sedimentary patterns from time to time.

Phipps and Reeve have argued that the quick change in stratigraphy from the Gullet—West Malvern area to the Cowleigh Park area is proof of a post-Silurian fault on the west side of the Malvern Hills and that the Cambrian sequence and the Cowleigh Park Beds are cut out by the fault. My conclusion is that these units are missing through erosion and non-deposition.

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THE LUXEMBOURG COLLOQUIUM

SIR,—The report on the Luxembourg Colloquium on the Jurassic by Dr. Lloyd (*Geol. Mag.*, **101**, 249–59) is of importance not only to specialists in the geology of the Jurassic but to all who are interested in the whole complex of problems in stratigraphic correlation.

I discuss in detail elsewhere (*Palaeontology*, 8, in the press) the nature and status of the biostratigraphic zone and stage in relation to so-called " time-stratigraphy ", and wish here to refer only to some general points raised in Dr. Lloyd's paper. The first concerns the apparent contradiction implied by the statements (1) that " by implication, no element of time need be considered in formulating a zone " ; and (2) that " Zones were isochronous throughout their area of development " (op. cit., p. 257).

I prefer at this stage to disregard the " Copenhagen rules ", and to consider the problem *ab initio*. It is clear from the difficulties that have arisen in various recent attempts to codify the fundamentals of stratigraphic classification that at least one fallacious assumption is being rather generally made. This fallacy concerns the boundaries or limits of biochronologically significant zones. (I deliberately refrain here from attempting a rigorous definition of the term *zone*. It will be enough to emphasize that the kind of zone under discussion is used in " recording the passage of time "—i.e. it has to do with some sort of chronology ; it is defined mainly in terms of organic assemblages ; and it has a meaning in relation to other zones of the same kind from which it can be distinguished). It appears to arise through a failure to consider the essentially relative nature of the " time-scale " based on a succession of discrete zones. This relativity of zones must of necessity imply that no zone, with upper and lower boundaries, can exist by itself, or can be given precise correlational definition in isolation, as if it were, for example, a number.