



CONSOLIDATION OF CALCAREOUS OOZE

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THE MALVERN LINE

SIR,—I should like to add the following observations to the controversy on the relationship of Upper Llandoveryan strata to the Pre-Cambrian basement in the Gullet Quarry, Southern Malverns, as described by Reading and Poole (1961, 1962), Butcher (1962), Whitworth (1962), and now revived by Phipps and Reeve, and Ziegler in a recent issue of your journal.

In early 1962 I had the opportunity of examining a fresh exposure of the contact zone between the Upper Llandoveryan and the Pre-Cambrian, immediately after some blasting operations. The slightly undulating Pre-Cambrian surface exposed, dipped at about 55 to 60 degrees to the west, and the associated Llandoveryan showed an inclination of 70 degrees on a magnetic bearing of 275 degrees. There was evidence of slickensiding but this was confined to the Pre-Cambrian. Only one such surface actually intercepted the interface, and this almost at right-angles to it, with the striations fading out and showing general evidence of a smoothing-off immediately under the overlying Llandoveryan sediments, compatible with the development of an erosion surface.

On this occasion the section showed no well-defined conglomeratic base to the Upper Llandoveryan. Instead, within small hollows on the Pre-Cambrian surface there occurred at most about 1½ inches of brown and red-stained "earthy" clay with small vein quartz and Malvernian pebbles. Overlapping this material on to the higher parts of the hollows was a slightly "soapy" grey shale. The latter completely covered all that was visible of the slightly undulating Malvernian surface, except at one point where the base of the following stratum, a decalcified limestone ("rottenstone"), was in contact

with a small "knoll" feature projecting from the Malvernian surface through the shale layer. There was no indication of "neptunian dykes".

In the "Sycamore tree" quarry at West Malvern an undeformed horizon of laminated siltstone occurs as a persistent band within the more fossiliferous portion of the Upper Llandoveryian conglomerate close to the Malvernian contact. A dip measurement gave a reading of 60 degrees in a westerly direction. This suggests the possibility of a closely similar relationship to that which exists in the South Malverns.

These two exposures indicate that at least *two* unfaulted contacts between the Pre-Cambrian and Upper Llandoveryian exist on the western flanks of the Malverns; and in the absence of other exposures of the contact zone to confirm, or disprove, the general unconformable relationship suggested, I incline to agree with Ziegler that the absence of pre-Upper Llandoveryian strata along the Malvern line north of Gullet Quarry is due to pre-Upper Llandoveryian positive movement resulting in erosion and non-deposition. Field-mapping south of the Gullet Quarry indicates that the positive movement along the Malvern line took place after the deposition of the Upper Cambrian and was accompanied by faulting, the effects of which tend to be obscured by the Upper Llandoveryian transgression; more especially by the latest phase (C₅ zone) which finally submerged the Malvern marine ridge.

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CONDITIONS IN THE METAMORPHIC CALEDONIDES DURING THE PERIOD OF LATE OROGENIC COOLING

STR.—Dr. J. Watson (*Geol. Mag.*, 101, No. 5, 457-465) has made the interesting suggestion that the thermal pattern of the metamorphic Caledonides was retained until Newer Granite times and may thus account for variations in the character and contact effects of the Caledonian granites and their associated minor intrusives. From the pattern of Rb-Sr and K-Ar dates obtained from the Moine and Dalradian rocks, Dr. Watson concludes that a central region, coinciding very approximately with the "thermal anticline" of Kennedy, cooled to a particular stage at 400-420 m.y. while the more peripheral regions had reached the same stage some 40 m.y. earlier. If attention is confined to K-Ar ages on micas, so that variation in the diffusion rates of daughter products is minimized, a rather different pattern emerges, which invites an alternative interpretation of the Newer Granite phenomena.

Over 150 K-Ar ages on Moine and Dalradian micas have now been published. Very strong maxima occur between 420 and 430 m.y. in the frequency distribution for the Moines, and between 420 and 440 m.y. in the Dalradian (Brown, Miller, Soper, and York, in preparation). The possible significance of these maxima is fully discussed in the above paper; the interpretation which I favour is that the Dalradian rocks, occupying a generally higher tectonic level than the Moines, cooled through the temperature range of partial argon loss to that of complete argon retention some 10 m.y. before the Moines, following a metamorphic "event" which had affected both Series more or less synchronously. This implies a much shorter