

CORRESPONDENCE

PALAEOZOIC OROGENY IN NORTH-WEST MALAYA—A REPLY

SIR,—In answer to Mr. Burton's letter (*Geol. Mag.*, 103 (4), p. 364) discussing my article "Structural Evidence for a Palaeozoic Orogeny in North-West Malaya" (*Geol. Mag.*, 102 (6), 501–520) I should like to make the following comments.

Burton's criticism is mainly centred around palaeontological and stratigraphic observations from Pulau Langgon and north-west Malaya, which favour a younger, probably Middle to Upper Carboniferous age, for the Langkawi folding phase. As I have dealt only briefly with the stratigraphy in my paper it seems justified to elaborate here on this point. Our knowledge of Malayan stratigraphy is advancing rapidly, but there are still large hiatuses.

Burton pointed out that in north-west Malaya, including the Langkawi Islands, a similar sedimentary environment occurred during Ordovician to Middle Devonian time, resulting in a continuous sequence of sediments of an euxinic basin facies. In this "Mahang Formation" no fossils of Middle or Upper Silurian age have been found. This "palaeontological hiatus" he attributes to isolation of the euxinic basin from the open sea rather than to a break in sedimentation. On Pulau Langgon in the Langkawi Islands this hiatus included also the Lower Devonian.

The disagreement in interpretation between Burton and me for the age of the Langkawi folding phase is based mainly on differences in interpretation of age for fossils found in the black siliceous shales and mudstones (euxinic basin facies). On the north-west coast of Pulau Langgon black siliceous shales and siltstones occur overlying limestones of Upper Ordovician age. This "Lower Detrital Band" (Kobayashi, Jones and Hamada, 1964 and Jones, in press) contains a graptolite-trilobite fauna of Lower to Middle Llandovery age. It is followed by about 200 metres of limestone, in turn overlain by shales, siltstones and quartzites, forming the "Upper Detrital Band". Near the base a fauna was collected, according to Burton of Middle Devonian age, comprising *Monograptus clingani* and *Styliolina clavula*. *Monograptus clingani* according to Jones (in press) indicates a Middle to Upper Llandovery age. *Styliolina* on the other hand is characteristic for the Devonian of Bohemia. Both fossils occur abundantly together in the same horizon and no indications were found which point to reworking and later mixing of the older fossils with the styliolinids. It is interesting to note that a similar "mixed" fauna is described from the Silurian of the Northern and Southern Shan States of Burma. The Zebingyi Series in the Northern Shan States contain *Monograptus dubius*, *Tentaculites elegans*, *Styliolina loevis* and *Tentaculites cf. ornatus*. To quote Pascoe (1959, p. 650) "As a whole, the Zebingyi fauna . . . is remarkable in that it comprises Silurian graptolites and the typical Lower Devonian *Tentaculites elegans*, and is evidently a transitional fauna between the two systems". In the Southern Shan States *Tentaculites elegans* is found in the same horizon with *Styliolina clavula*, *Orthoceras* sp. and *Monograptus vomerinus*, which horizon has been dated as Ludlow (Upper Silurian), and equivalent to the Zebingyi beds (Pascoe, 1959). The fauna of *Styliolina clavula* and *Tentaculites elegans* from Na Suan in Thailand to which Burton refers as probably Devonian, has been dated by Duncan (Brown *et al.*, 1953) as "highly probably of Silurian age".

From the foregoing it can be seen that age determinations of these tentaculitid fossil beds are controversial and a direct correlation with fossil horizons from Bohemia seems unwarranted. The graptolite-tentaculitid horizon in West Malaysia seems to be of Silurian age as stated in my paper (Upper to Middle Llandovery according to Jones and Ludlow if correlated to the Zebingyi fauna) and therefore the basis of Burton's arguments is unsound.

The "euxinic basin facies" seems to be restricted to Ordovician and Silurian only and consequently the hypothetical geanticlinal barrier, to explain a palaeontological hiatus in Upper Silurian and Lower Devonian, is not necessary.

Although the chronological position of the Upper Detrital Band based on fossil determinations is still uncertain, a Silurian age is most probable from field evidence. The Upper Detrital Band is closely related to the Lower Detrital Band. The epineritic sedimentary environment has not changed; the top part of the Upper Detrital Band is more arenaceous, indicating instability as a result of an imminent orogenic phase.

The Upper Detrital Band is overlain at the north tip of Pulau Langgon unconformably by a red pebbly mudstone of Middle to Upper Devonian age. Burton states that these Devonian strata were "apparently unbeknown to Koopmans". In my paper (p. 515) I have, however, clearly stated: "Recently a small outcrop of red fossiliferous mudstone and pebbly sandstone was found on Pulau Langgon, of probably Devonian age." At present the fossil collection is being studied by Japanese palaeontologists. The trilobite *Cyrtosymbole* (*Cyrtodechenella*) indicates Middle Devonian to Lower Carboniferous age (Kobayashi, written communication); according to Hanai the associated ostracodes suggest a Middle to Upper Devonian age. Lithologically the red pebbly mudstones differ largely from the Upper Detrital Band and have a post-orogenic character. Unfortunately Burton in his letter gives the impression that the trilobite *Cyrtosymbole* and the styliolids occur together in one and the same formation (see also Burton, 1965, p. 788). The presence of the red pebbly mudstone is an additional argument in favour of a Late Silurian-Early Devonian orogenic phase.

The Carboniferous Singa Formation is overlain conformably by the Permian Chuping Formation in the Langkawi Islands and nothing indicates that these are separated by a folding phase. Jones (written communication) believes, in contradiction to Burton, that the Kampong Sena Formation on the mainland appears to be continuous from Upper Devonian to Lower Permian. This view is supported by determinations of goniatites found near Pokok Sena (Kedah) of probable Upper Carboniferous age (D. J. Gobbett, personal communication).

My arguments for an orogenic phase during Late Silurian to Early Devonian time were based on tectonic evidence in metamorphosed and non-metamorphosed rocks. The pre-Devonian formations do show a different mode and history of deformation from the Middle-Upper Devonian and post-Devonian rocks. Burton's argument that this might be due to the exclusion of intense deformation on the stable platform does not hold. As I have pointed out, the deformation pattern in the Ordovician-Silurian Setul Formation in the north-eastern part of the Langkawi Islands is different from that in the south-eastern part. Folding on Pulau Langgon and Tembus Dandang is of an open cross-fold type, without any regional metamorphism, whereas we find low-grade regional metamorphism with recumbent cleavage folding in the same formation on Pulau Tuba-Timun. These differences in intensity of deformation, whether due to regional metamorphism, stable platform, or differences in lithology, have been taken into account. Nevertheless it has been found that rocks of the Machinchang and Setul Formations (pre-Devonian) have been acted upon by several deformation phases, resulting in a more complicated structural pattern than that of the post-Devonian Singa and Chuping Formations, including the small Middle-Upper Devonian outcrop on Pulau Langgon.

Support for a more extensive sphere of influence of the Late Silurian-Early Devonian Langkawi folding phase comes from Jones (in press) for Perlis and Kedah, and Gobbett (1964) for Selangor.

With a more accurate dating of the fossil fauna derived from the upper part of the Setul and Mahang Formations in future, we might be able to pinpoint more exactly the age of the Langkawi folding phase.

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