

## CORRESPONDENCE

**Revision of the Dinantian stratigraphy of the Craven Basin, N England**

SIR – We are sympathetic to the view expressed by Fewtrell & Smith (1980) that new work involving carbonate sedimentology and micropalaeontological biostratigraphy of the Dinantian sediments of the Craven Basin demands a modern formalized lithostratigraphic classification of those sediments. We have serious misgivings, however, about the claim made by these authors that all five of the formations, as defined by them, are regionally mappable. Indeed it would have been helpful to the reader if the authors had indicated the extent to which they themselves had succeeded in mapping these formations within the basin.

Fewtrell & Smith have based their classification on the well known sections of the Pendle Hill–Chatburn–Clitheroe area, and have applied it to other parts of the basin largely on the basis of published work, notably that of Booker & Hudson (1926), Hudson (1944), Hudson & Mitchell (1937), Hudson & Dunnington (1945) and Parkinson (1926, 1936). Apart from their recognition (following Miller & Grayson, 1972) of the Clitheroe reefs and their associated sediments as a separate formation – the Clitheroe Limestone Formation – their division of the sequence differs little from that of Earp *et al.* (1961).

We have recently completed six-inch mapping of the northern part of the Craven Basin as part of the resurvey by the Institute of Geological Sciences of the Settle 1:50000 sheet. This mapping has highlighted the difficulties of classification of those parts of the sequence within the Chatburn Limestone and Worston Shale groups of Earp. Despite the strength with which Fewtrell & Smith dismiss the evidence presented by previous authors of unconformities within the Dinantian succession, our observations point to the existence of several breaks of sequence. Of these the most important is present in the Airton and Eshton-Hetton anticlines, where Mallardale Shales-with-Limestones (Hudson & Dunnington, 1945) rest directly on Hetton Limestones (Booker & Hudson, 1926). In the Slaidburn anticline N of Slaidburn, Phynis Shales (Parkinson, 1936) and an associated reef rest unconformably on limestones mapped by Parkinson as Clitheroe Limestone. Locally this relationship is markedly angular. Besides this, we confirm the existence of the unconformity described by Parkinson (1936) at the base of the Bowland Shales at Lamb Hill House, N of Slaidburn; and that identified by Hudson & Mitchell (1937) at the base of the Embsay Limestone in the Skipton anticline.

In this context, we wish to draw attention to what we believe to be an erroneous claim by Fewtrell & Smith that the various pebble and boulder beds of the Craven Dinantian have formed as a result of slumping and soft sediment deformation. Undoubtedly slump-ball structures do exist within the sequence, but in the boulder beds described, for example, from the lower part of the Embsay Limestone in Halton Gill, near Skipton, by Hudson & Mitchell (1937); at the base of the Mallardale Shales-with-Limestones at Coniston Cold and Haw Crag by Hudson & Dunnington (1945); and at the base of the Bowland Shales of the Slaidburn area by Parkinson (1936), the debris was clearly derived from lithified sediments.

It is our conviction that the recognition and understanding of the unconformities within the Craven Dinantian sediments are fundamental steps towards the application of any lithostratigraphic classification to sections isolated, as they are in the Craven outcrops, from the type sections. In view of what we consider to be an inadequate state of knowledge of these unconformities, we feel that the present attempt by Fewtrell & Smith to formalize the Craven Basin Dinantian lithostratigraphy is premature.

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SIR – We thank Arthurton and Jones for their interest in and discussion of our review of the stratigraphy of the Craven Basin. Our proposed lithostratigraphic scheme grew from the observation that the broad outlines of the lithostratigraphy of the part of the basin with which we were most familiar outcrop by outcrop (that is the area comprising the Skipton, Lothersdale, Broughton, Swinden, Hetton and Eshon anticlines) were remarkably readily matched with those of the classic Pendleside area as originally outlined by Phillips. Further work both on the literature and in the field confirmed, in our view, the practicality of recognizing certain lithological units, albeit at a coarse level of resolution, over much if not all of the basin; this leads logically to the definition of formations in contemporary stratigraphical practice, not so much with a view to erection of a permanent and unshakeable edifice as to the provision of a structure within which the interpretation of the geological history of the area can begin. It is only by looking at the entire basin that this interpretation can take place, and this is hampered by a profusion of local names. Earp *et al.* recognized the need for a set of regionally applicable units (their 'Groups'); we have updated their terminology and introduced what we regard as improvements based on more recent work. We are continuing a process begun by Phillips a century and a half ago when he recognized the regional extent of units such as the Bowland Shales, and we fully expect that others will improve on our suggestions.

The question of unconformities within the Craven Basin Dinantian is partly, though not entirely, a question of terminology. Arthurton & Jones point to our dismissal of the evidence for unconformities of other authors, pointing out that they (Arthurton & Jones) have abundant evidence for several *breaks of sequence*. We would be among the first to agree that the Craven Basin sequence is riddled with breaks of sequence (disconformities). However, we were careful to make clear that we were referring to *angular unconformities* (structural breaks of sequence), and we remain unconvinced that there is evidence for any of the latter. Individual outcrops are insufficient for the positive identification of angular unconformities in a region of such structural complexity, particularly in the neighbourhood of reef knolls; Earp *et al.* (p. 50), referring to structural breaks in the Slaidburn area from which Arthurton & Jones take one of their examples, drew a parallel with salt-dome tectonics although competence contrasts might be more aptly invoked as by Moseley (1962). On the question of lateral continuity, we would not deny that a unit such as the Pendleside Formation is not everywhere present, but its absence, given its turbiditic nature and hence presumed deposition in lobes and fans rather than sheets, can be explained by local non-deposition of that facies. Turbidites and other slope-related features can be recognized also within the Clitheroe Formation, as for instance in the Embsay Limestone (another of Arthurton & Jones's examples); they provide a more satisfactory interpretation of features such as lateral discontinuity or thinning of beds and the presence of conglomerates than do structural breaks of sequence. Extra-basinal derivation of lithified limestone by turbidity currents does not imply intra-basinal unconformity. If it did, then we should have to conclude that the Pendleside Formation, with its manifold succession of turbidite beds (with lithified limestone clasts)

is full of unconformities whereas it is in fact only full of bedding planes each of which of course marks a break of sequence. True angular unconformities should persistently cut out major lithostratigraphic units over significant areas. We believe that, despite undoubted local inconsistencies and difficulties of interpretation, the five formations we have defined can indeed be mapped from available evidence over the greater part of the Craven Basin. We eagerly look forward to the refinements which will certainly materialise when the remapping by the I.G.S. of the bulk of the Basin is undertaken.

#### Reference additional to the above

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### Chloritoid-staurolite assemblages in central Perthshire

SIR – My interest in the recent paper by Atherton & Smith (1979) concerning metamorphic mineral assemblages in central Perthshire was naturally tinged with apprehension when I read in the first sentence that the existence of these mineral assemblages “questions the concept of the ‘Stonehavian’ metamorphism of Harte (1975) and its corollary that pressure increased from NE to SW along the metamorphic belt”. Being reasonably certain that Harte (1975) had not attempted to assess pressure variation for the whole Dalradian metamorphic belt, I read on rapidly in order to discover how mineral assemblages from central Perthshire could possibly affect the mineral assemblages reported from the E coast near Stonehaven. Unfortunately I was not enlightened further on this point and it thus seems that some clarification is essential.

Harte (1975) noted that the pelitic mineral assemblages, as given in the literature, for the metamorphic zones near Stonehaven (Kincardineshire) showed certain differences from those known for the zones in and immediately adjacent to Barrow’s (1893) original area (essentially between Perthshire and Kincardineshire in county Angus). In particular, near Stonehaven the occurrence of chloritoid + biotite assemblages had been recorded (Chinner, 1967) along a narrow zone on the low-grade side of the staurolite zone (with staurolite + biotite assemblages). Such chloritoid + biotite assemblages have not been noted in the literature, as far as I am aware, for the original area mapped by Barrow (1893, plate xv). Partly on this basis Harte (1975) suggested a distinction between a Barrovian (*sensu stricto*) facies series (in which garnet + chlorite assemblages gave way directly to staurolite + biotite assemblages) and a Stonehavian facies series (in which chloritoid + biotite assemblages are interposed between garnet + chlorite and staurolite + biotite assemblages). The Barrovian facies series was placed on the high-pressure side, and the Stonehavian on the low-pressure side, of the [A C] invariant point in a pelite petrogenetic grid. This increase in pressure from Stonehaven to the type area of Barrow’s zones was supported by the independent evidence of the occurrence of andalusite and sillimanite at higher grades just N of Stonehaven instead of the kyanite and sillimanite of Barrow’s zones (Harte, 1975).

Since Atherton & Smith (1979) did not present data on mineral assemblages from the region considered by Harte (1975), they can hardly question both Harte’s distinction of Barrovian and Stonehavian facies series and the work of others who reported the mineral assemblages which Harte listed as being representative of Stonehavian metamorphism. The mineral assemblages from central Perthshire described by Atherton & Smith (1979) include both chloritoid + biotite and kyanite bearing assemblages. From this viewpoint they appear to belong to a facies series of intermediate pressure between Harte’s Barrovian and Stonehavian, and referred to as facies series B by Harte (1975).

Atherton & Smith (1979) appear to believe that similarities in certain mineral assemblages at two widely separated localities imply the existence of the same mineral assemblages in the intervening