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# SHALE UNITS IN THE GREAT SCAR LIMESTONE OF THE SOUTHERN ASKRIGG BLOCK

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(*Short communication*)

CONTENTS



SUMMARY

The Great Scar Limestone contains numerous thin shale units which are only revealed in the underground exposures in caves and potholes. The shale beds are correlated across the area and their distribution is described. Various features of their structure and petrography are noted and the environment of deposition is deduced to be very shallow water and locally sub-aerial.

## I. INTRODUCTION

The Lower Carboniferous Great Scar Limestone is about two hundred metres thick on the southern margin of the Askrigg Block and consists mainly of massive, grey, fossiliferous calcarenites. It ranges in age from $C_2$ to $D_1$, and usually just over a hundred metres are found to belong to the $D_1$ Zone. Garwood and Goodyear (1924) defined the limits of this zone by two horizons relatively easy to trace in outcrop; the Porcellanous Band of fine white calcilutite marks the lower boundary and the nodular *Girvanella* algal band is at the upper limit.

The limestone forms typical karst topography and the shale beds in the succession are very rarely exposed, consequently they are barely mentioned in the literature. Dakyns *et al.* (1890) state that "thin beds of shale do sometimes appear" in the Ingleborough area, and note a single prominent shale in the Ribblehead quarries, later described by Turner (1968), but do also state that the beds of limestone are each separated from the next by a few centimetres of clay in the Wharfedale area. Garwood and Goodyear (1924) also note the shale in the Ribblehead quarries but state that "shaly beds are, as a rule, entirely absent", while Dunham *et al.* (1953)







observe that films and impersistent beds of shale are present but seldom well exposed. Schwarzacher (1958), in his detailed description of the limestone stratification, never mentions the existence of the shales.

However, the Great Scar Limestone contains numerous caves and potholes which afford sections of exceptional clarity passing through well over a hundred metres of the limestone succession. These sections reveal many shale beds of considerable horizontal extent and with thicknesses ranging from a fraction of a centimetre to over two metres. This paper is intended to place on record the results of a preliminary study of some of these shale horizons.

## II. DISTRIBUTION OF SHALE BEDS

Shale units in the Great Scar Limestone are exposed in all the potholes formed in the limestone outcrops just north of the Craven faults between Barbondale in the west and Wharfedale in the east. It was inferred from a brief examination that many of the shale horizons were laterally greatly persistent and to test this hypothesis a detailed study was carried out in the potholes of Gragareth where accurate correlation is facilitated by the high density of good exposures. Fig. 1 shows the shale beds in nine measured sections in the potholes of Gragareth and Ingleborough (Fig. 2). Many of the shale horizon correlations proposed are also based on intermediate sections not shown in the diagram. The successions of the $D_1$ Zone only are shown as, although shale beds do similarly exist in the underlying $S_2$ Zone, the underground exposures below the Porcellanous Band are too restricted for meaningful correlation. Besides these shale units within the limestone succession there are also the variable clastic beds at the base of the Great Scar Limestone which are well exposed on the surface and have previously been described (Dunham *et al.*, 1953). Surface exposures are often poor and consequently the *Girvanella* Band has not always been traced, especially as it is locally not as prominent a feature of the succession as it is farther to the east.

In tracing the horizontal extent of the shale beds, the one just over thirty metres above the Porcellanous Band was found to be continuous almost right round Gragareth (Fig. 1, sections 4 to 8); it is represented by a narrow zone of shale beds in the Ingleborough sections, and is probably at the same horizon as a noticeably thick bed exposed in some of the Wharfedale potholes fifteen kilometres farther east. In contrast, however, while the same bed is up to two metres thick in Lost Johns Hole, it is completely absent in the

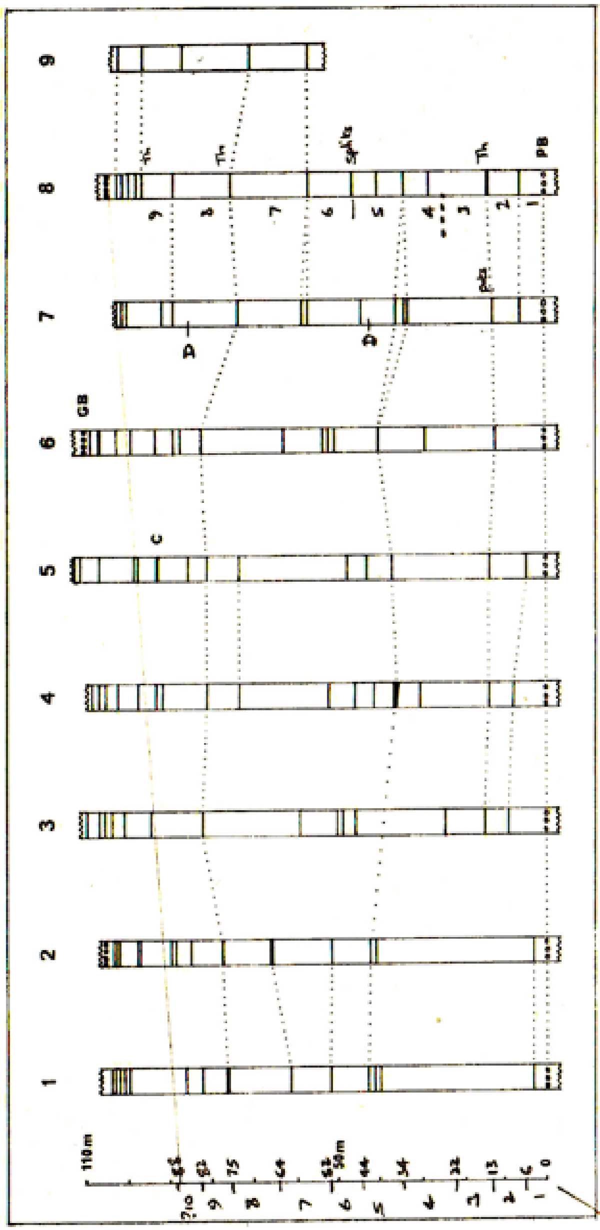

FIG. 1.—Pothole sections showing the shale units in the Great Scar Limestone of Ingleborough and Gragareth. C, coal; GB, *Girvanella* Band; PB, Porcellanous Band. *Location of sections*: 1, Nick Pot; 2, Juniper Gulf; 3, Rumbling Hole; 4, Lost Johns Hole; 5, Notts Pot; 6, Marble Steps Pot; 7, Swinsto Hole; 8, Rowten Pot; 9, Jingling Hole.



adjacent Rumbling Hole (Fig. 1, section 3). The two shale beds just above the Porcellanous Band are also traceable across most of Gragareth, but they do not maintain a constant height above the band owing to local variation in the thickness of the limestone beds. The very local extent of some shales is demonstrated by the five beds just below the *Girvanella* Band in Rowten Pot, of which only two extend the few hundred metres to Jingling Hole (Fig. 1, sections 8 and 9). Splitting of the shale beds has nowhere been observed, but may occur over a narrow zone, for example, between Rowten Pot and Swinsto Hole at an horizon thirty-five metres above the Porcellanous Band.

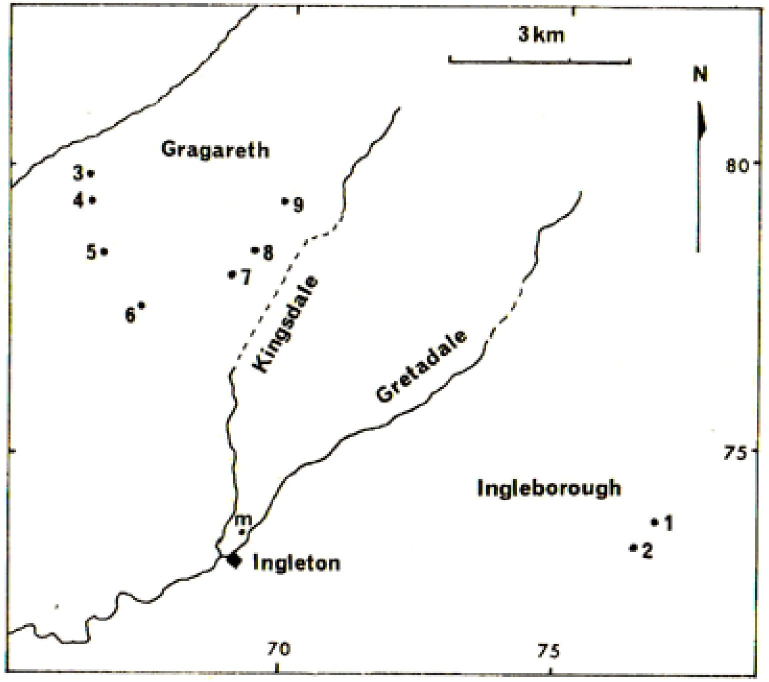


FIG. 2.—Map showing locations of pothole sections. Key as in Fig. 1; m, Meal Bank Quarry.

The vertical distribution of the shale beds through the limestone succession is distinctly uneven, as is apparent from Fig. 1. Most of the shales are concentrated in three relatively narrow zones: one occurs just above the Porcellanous Band and extends into the uppermost beds of the $S_2$ Zone also rich in shales, while a second zone is centred about forty-five metres above the band. The third zone is about twenty-five metres thick and immediately below the

*Girvanella* Band. In each of these zones the frequency of shale beds per unit thickness of limestone is about three times the frequency outside the zones.

## III. Description of Shale Beds

The thickness of the shale beds is generally between one and forty centimetres, but individual beds tend to vary in thickness, with the observed maximum being two metres. However, even one of the two-metre shale beds observed in Lost Johns Hole thins to less than half a metre within one hundred metres on each side of its maximum development.

These local thickenings of the shale may be interpreted as wash-out structures, particularly in view of some smaller scale features. At two locations in Lost Johns Hole, and at different stratigraphical levels, clear wash-out channels are exposed where the limestone has been cut down to depths of sixty to ninety centimetres and the channels filled with the overlying shale over a width of a hundred and fifty to two hundred centimetres. At one exposure the small-scale structures in the limestone adjacent to the shale channel include cross bedding in a small bank of shell sand, suggesting development of the channel very shortly after the limestone deposition. At the other exposures, and at a third washout in a Kingsdale pothole, the shale channel sides clearly cut the limestone laminations, suggesting their development after some degree of lithification in the limestone sediments.

At a number of the underground exposures the bases of the shale beds are very irregular, and in a few cases the shale infills widened fractures in the underlying limestone, which then appears to have the form of a buried pavement whose now infilled grykes developed during a period of sub-aerial erosion before deposition of the shale. The majority of exposed shale-over-limestone contacts are, however, so uniform that any minor irregularities may be ascribed to compaction folding.

Macroscopically the shale is a homogeneous, fine-grained, blue-grey rock which rusts rapidly on exposure. It is commonly well laminated and closely jointed, but is in some localities nodular and at some points so massive as to be better described as a mudstone. Small nodules and cubes of pyrite up to eight millimetres across are abundant, but in the weathered exposures are all altered to limonite. The shale consists dominantly of clay minerals with a considerable proportion of minute, mostly angular, grains of quartz and chert. Calcite is almost entirely lacking, but small mica



flakes and flecks of carbonized plant debris are present in small quantities in addition to the larger masses of pyrite and limonite.

No trace of macro- or microfossils, other than the plant debris, has been found in the shales after an extensive search.

## IV. Associated Coal Horizons

In the Ingleton district two exposures, both of limited extent, are known of coal beds occurring within the Great Scar Limestone. One seam is exposed in Notts Pot about twenty-two metres below the *Girvanella* Band and occurs in a very well developed shale horizon (marked C in Fig. 1). The coal is five to twenty centimetres thick and rests on a floor of either shale or limestone, but has a continuous limestone roof. The second coal exposure, in the Meal Bank Quarry at Ingleton, is well known (Dunham *et al.*, 1953) and the horizon of this seam appears to be around forty-five metres below the *Girvanella* Band. Here the coal is nearly forty-five centimetres thick and rests on a thick shale floor, again having a limestone roof. Analyses of samples from the two seams by Shelley (1967) showed that they are both high rank steam coals.

## V. Discussion

The existence of the described shale units in the Great Scar Limestone indicates important irregularities in the deposition of calcareous sediments on the Askrigg Block in Carboniferous times. The palaeogeography at that time cannot now be described as a uniform clear-water shelf region as so often cited in the literature.

The karstification of the limestone below the shale bands suggests periods of sub-aerial erosion, and the shales were probably deposited in very shallow water, or may even represent supratidal facies. The great horizontal extent of many of the shale beds demonstrates that the changes in level of the sea-floor were not merely local features. A temporary sub-aerial environment is also indicated by each of the two coal seams, for there is no evidence to suggest that these are not autochthonous. Furthermore the observed washout structures are thought to have originated in very shallow water, or even sub-aerially.

Minor earth movements or eustatic changes in sea-level must be responsible for the widespread but temporary development of different facies in the Great Scar Limestone, and these changes may correlate with the development of beds of rhythmic Yoredale facies farther north on the Alston Block. The shale units in the limestone of the Askrigg Block may therefore represent the southward continuation of the contemporaneous clastic facies on the Alston Block, particularly as the potential source of detritus on the Askrigg Block is from the north. Further very detailed stratigraphical studies will be required to substantiate this possible correlation.

In 1958, Schwarzacher described the Great Scar Limestone as consisting of a series of depositionary cycles, from evidence based on detailed studies of the limestone, and it is worthwhile correlating these cycles with the distribution of the shale beds, which Schwarzacher did not consider. Schwarzacher measured a section on Green Laids Scar, Kingsdale, and though he deduced a thickness of only eighty-five metres for the $D_1$ Zone, this may be compared with the shale beds in the adjacent measured sections of Rowten Pot and Jingling Hole (see above) where the thickness of the $D_1$ Zone is clearly measured at one hundred and four metres. Most of the "bedding planes" bounding the limestone cycles are in fact shale beds, but no shale exists at the base of cycle 4, and furthermore significant shale beds do occur within cycles 4, 5, 8 and 9. Also the study of the far superior underground exposures of water-polished limestone reveals that the lithological variations described by Schwarzacher are far more complex, with very distinct changes taking place repeatedly across zones only a few decimetres thick. Consequently the significance of this cyclic interpretation of the limestone deposition appears questionable when far more important sequences of environmental variation are indicated by the distribution of shale units.

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## VII. References

Dakyns, J. R., R. H. Tiddeman, W. Gunn and A. Strahan, 1890. The geology of the country around Ingleborough, with parts of Wensleydale and Wharfedale. *Mem. geol. Surv. U.K.*, vi + 103 pp. H.M.S.O., London.

Dunham, K. C., J. E. Hemingway, H. C. Versey and W. H. Wilcockson, 1953. A guide to the geology of the district round Ingleborough. *Proc. Yorks. geol. Soc.*, **29**, 77-115.

Garwood, E. J. and E. Goodyear, 1924. The Lower Carboniferous succession in the Settle district and along the line of the Craven faults. *Q. Jl geol. Soc. Lond.*, **80**, 184-273.

Schwarzacher, W., 1958. The stratification of the Great Scar Limestone in the Settle district of Yorkshire. *Lpool Manchr geol. J.*, **2**, 124-42.

Shelley, A. E., 1967. Analyses of two coals from the Great Scar Limestone near Ingleton, Yorkshire. *Proc. Yorks. geol. Soc.*, **36**, 51-6.



Turner, J. S., 1968. A note on the Meal Bank coal horizon around Ingleborough. *Trans. Leeds geol. Ass.*, **7**, 265-8.

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