Humberside Geologist No. 16

A note on the occurrence of ironstone in the Hunstanton Formation (Red Chalk) at Rifle Butts Quarry SSSI, East Yorkshire.

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Rifle Butts Site of Special Scientific Interest (SSSI) is a small exposure near Goodmanham, East Yorkshire (SE89704271) (Figure 1) where a major unconformity is exposed showing the Hunstanton Formation (Early Cretaceous, Albian) (Red Chalk) lying directly above the Lias Group (Early Jurassic, Toarcian) (Mitchell, 1996; Horne and Dutton, 2021). Figure 2 shows the complete section exposed in the quarry (taken from Horne and Dutton, 2021). A detailed section is also given in Mitchell (1996).

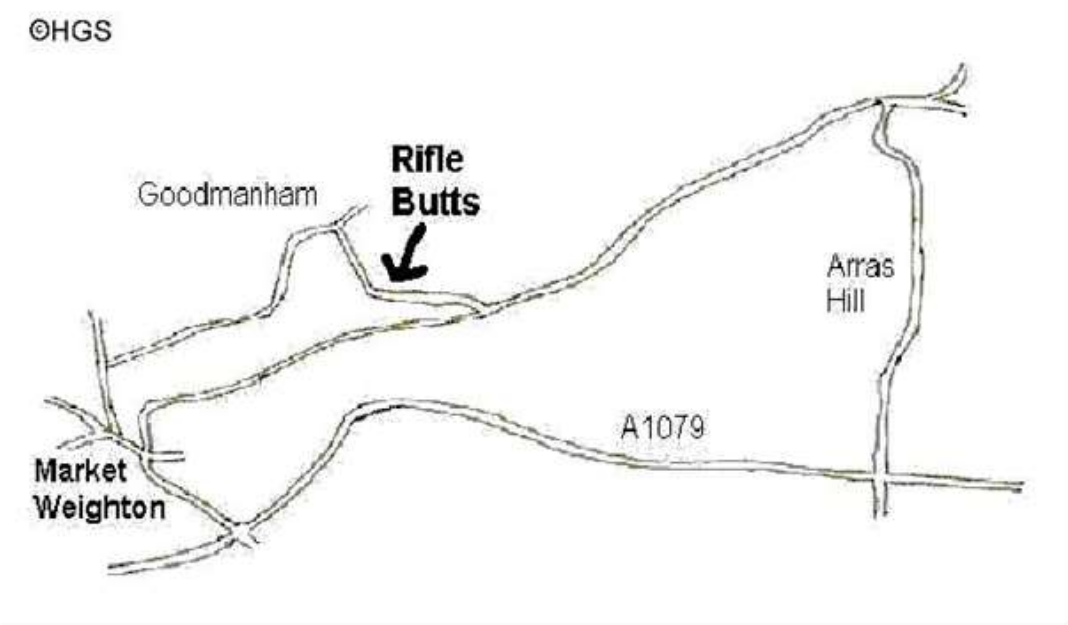


Figure 1. Location map for Rifle Butts Quarry.

The Hunstanton Formation is made up of nodular, pebbly and massive yellow to pink and red chalk interbedded with thin marls. The ironstone occurs towards the base (Figures 2 and 3) and stratigraphically below a stromatolitic horizon (Figure 4). The ironstone occurs as a band about 4cm thick and is impersistent. It can be traced as a single bed for approximately 0.5m. Mitchell (1996) divides the Hunstanton Formation into five beds, the first (lowest) one containing occasional pebbles of quartz and ironstone derived from the underlying Upper Lias. The ironstone band described here is a little higher in the sequence probably in Mitchell's (1996) second or third bed, both of which he shows as having a stromatolite at the top.

Small samples of the ironstone were obtained for determination of the petrography, mineralogy and chemistry. X-ray diffraction traces of the samples show almost entirely goethite (Figure 5), occasionally with small amounts of calcite and quartz. Two chemical analyses of the ironstone are given in Table 1. Fe_2O_3 is the major component, as expected, accompanied with small amounts of CaO, SiO_2 and Al_2O_3. Other elements are present in very minor amounts. The CaO is accounted for by the presence of calcite. Minor amounts of quartz and clay minerals, probably kaolinite and/or illite account for the SiO_2, with Al_2O_3 also accounted for in the clay minerals.

Thin sections in transmitted light are almost opaque brown, although some concentric structures are visible within a very dark matrix (Figure 6). Polished surfaces in reflected light show a dominance of rounded concentric grains of goethite averaging 0.5mm in size (ooliths) (Figures 7 and 8). Some of them are broken, some show cracks (shrinkage?), others coalesce into multiple grains, and some have a homogeneous material in the core. These grains are bound together in a matrix, also of goethite. The matrix proportion varies within and between the samples. There are some variations in reflectivity which probably reflects the different crystallite sizes of the goethite in the different textural elements in the sections.

The origin of the ironstone and its oolitic nature could be similar to that discussed by Mitchell (1996), namely that it is derived from an ironstone that he describes as present in the Lias immediately below the unconformity. However, although impersistent, its extent and that it does not appear to be an accumulation of pebbles suggests that it is not directly derived from underlying Lias. The presence of adjacent stromatolite horizons suggests that deposition and accumulation of sediment at that time was in a low energy environment in shallow water. Thus, this and its high density relative to the surrounding chalk sediment suggests that it is unlikely to have been transported as a single extant bed. This leads to the conclusion that the ooliths forming the ironstone are an integral part of the Hunstanton Formation, probably accumulating *in situ* or derived from a contemporaneous nearby source.

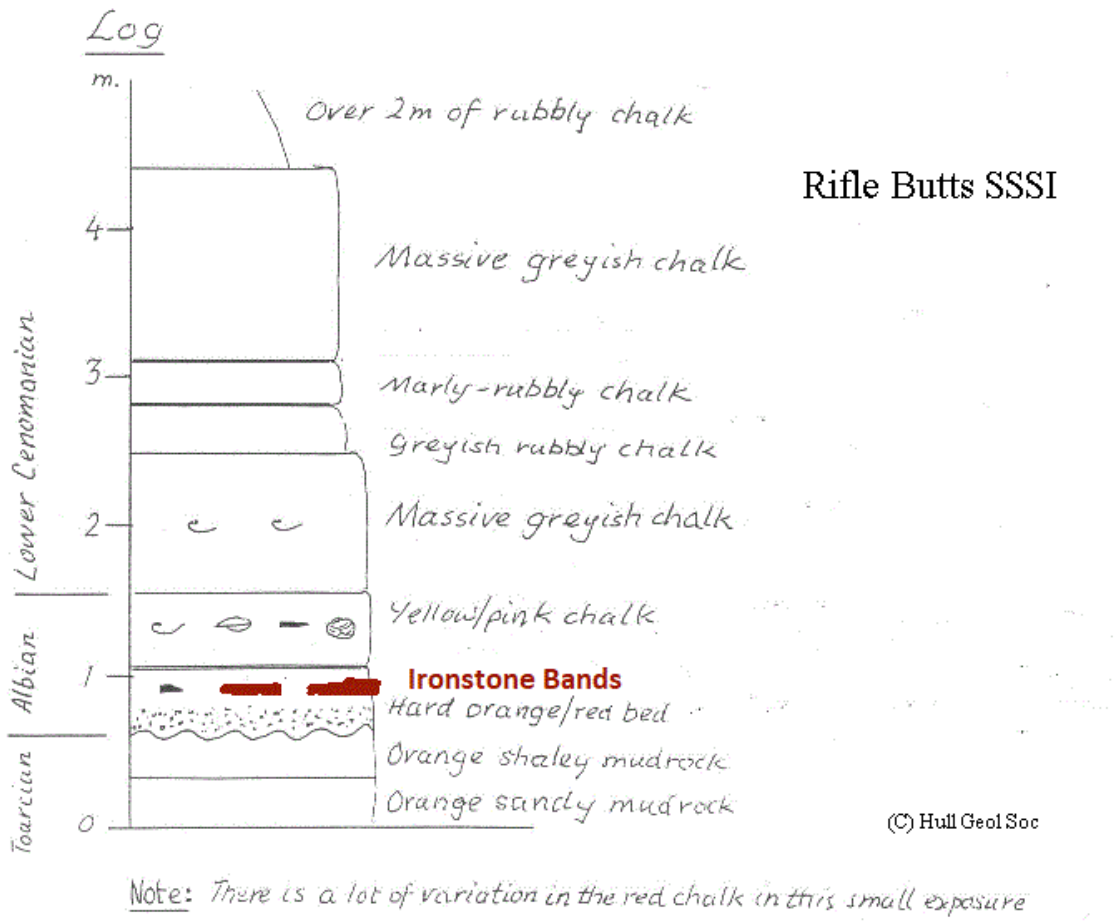


Figure 2. Measured section of the exposure in Rifle Butts Quarry after (Horne and Dutton, 2021).

Figure 3. Section of Hunstanton Formation at Rifle Butts Quarry. The band of ironstone is immediately below the penknife, which is 6cm long.

Figure 4. Red chalk with well-developed stromatolitic horizon adjacent and stratigraphically slightly above the ironstone band. Penknife 6cm long.

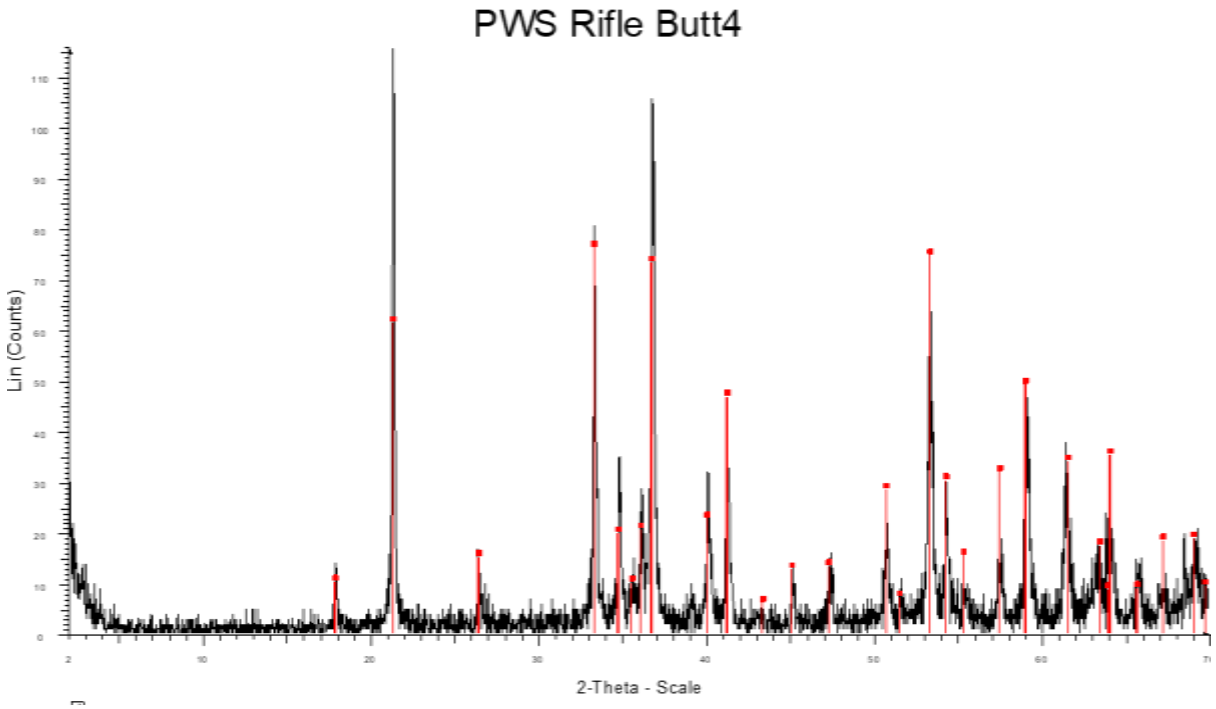


Figure 5. X-ray powder diffraction pattern of the ironstone from 2-70°2θ, using CuKα radiation and a Siemens D5000 Diffractometer. All of the hkl reflections of varying intensities correspond with goethite (red sticks). Analyst: Peter Scott.

Sample Rifle Butt 1	
oxide	%
MgO	0.41
Al_2O_3	2.82
SiO_2	5.41
P_2O_5	0.36
S	0.02
K_2O	0.32
CaO	3.78
TiO_2	0.12
Cr_2O_3	0.04
MnO	0.24
Fe_2O_3	69.36
element	PPM
Ni	487
Zn	338
Zr	93

Sample Rifle Butt 2	
oxide	%
MgO	0.35
Al_2O_3	3.55
SiO_2	5.41
P_2O_5	0.50
K_2O	0.34
CaO	0.55
TiO_2	0.14
Cr_2O_3	0.04
MnO	0.11
Fe_2O_3	69.90
element	PPM
V	400
Ni	187
Zn	274
Zr	82

Table 1. Chemical analysis of two samples of the ironstone. Analyses made using a fusion bead technique for major elements and pressed powder pellet for trace elements and a Bruker XRF. Analyst: Fiona Thomas, Camborne School of Mines, University of Exeter.

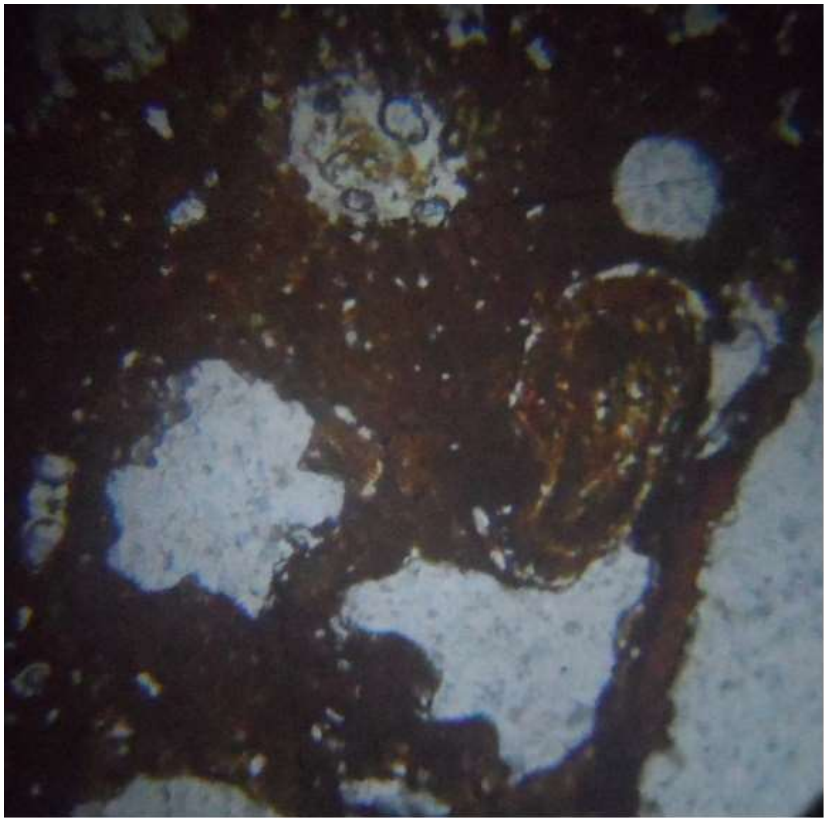
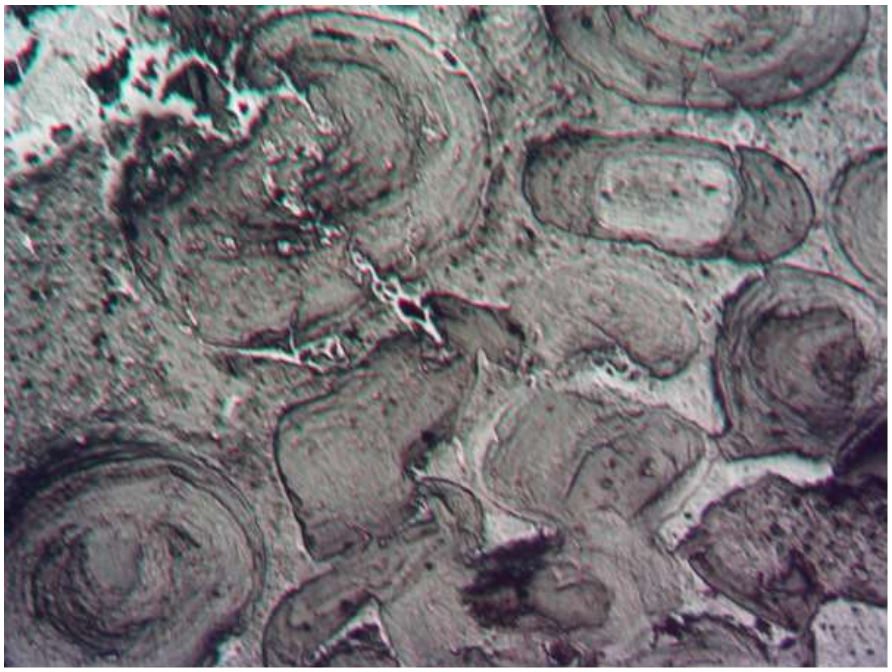


Figure 6. Photomicrograph of the ironstone in thin section (UOH2020.01TS), plane polarised light showing ooliths of goethite. Field of view approximately 2.5mm wide.



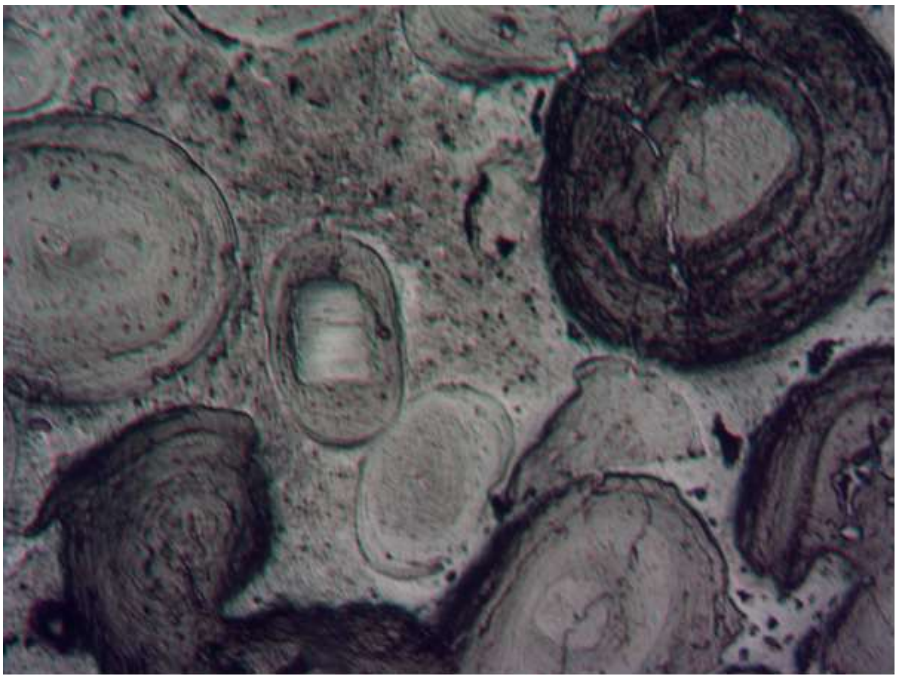


Figure 7a and b. Photomicrographs of ironstone in reflected light showing ooliths with concentric growth rings. Some are fragmentary, some are fractured. Field of view approximately 2mm across.

Acknowledgements
Mark Anderson is thanked for making the thin section. A sample collected in 2020 for this study has been deposited in the geology collection of the University of Hull, along with the new thin section (Catalogue numbers UOH2020.01 and UOH2020.01TS).

The samples were collected from loosened or loose material with the consent of the owners. Collecting *in situ* material without the permission of the owners is prohibited.

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References

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Mitchell S M 1996. The Jurassic-Cretaceous succession at Rifle Butts Quarry (SSSI) and its implications for sedimentation on the Market Weighton Structure. *Proceedings of the Geologists' Association* 107, 161-166.