North Newton Shore, Isle of Arran

[NR 933 518]

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Introduction

The North Newton Shore GCR site (Figure 3.45) in the north-west of Arran is a locality of international and historical importance, exposing what is widely known as 'Hutton's Unconformity'. The discovery of this site by James Hutton in the summer of 1787, and its recognition as an unconformity, resulted in a major advance in the concept of geological time and helped form the foundations of modern geology. This site is one of several in Scotland made famous by Hutton, which have subsequently been the focus of attention by many generations of geologists. Hutton later discovered similar unconformities in the River Jed, near Jedburgh ((Figure 4.2), Chapter 4) and at Siccar Point on the Berwickshire coast (see Siccar Point to Hawk's Heugh GCR site report, this chapter). At all three, steeply dipping low-to medium-grade Caledonian metamorphic rocks are overlain by shallow dipping Late Devonian-Carboniferous sedimentary rocks. The North Newton Shore site displays an angular unconformity between steeply inclined metasedimentary rocks of the Precambrian to early Cambrian Dalradian Supergroup and younger sedimentary rocks of the latest Devonian-earliest Carboniferous Kinnesswood Formation of the Inverclyde Group. Subsequent studies have revised the precise position of the unconformity from that originally described by Hutton, and identified calcretization at the unconformable surface.

Description

North Newton Shore lies approximately 1.5 km north of the village of Lochranza, forming part of the prominent post-glacial emerged beach. The unconformity is exposed along the foreshore for a distance of 325 m, about 0.5 km north-east of Newton Point, with a series of scattered smaller outcrops just north of Newton Point itself (Figure 3.45), (Figure 3.46).

The first published description of the site appeared in Hutton's 'The Theory of the Earth' (Hutton, 1795). He described the unconformity thus: 'the schistus and the sandstone strata both rise inclined at an angle of about 45 degrees; but these primary and secondary strata were inclined in almost opposite directions; and thus they met together like the two sides of a lamda (λ), or the rigging of a house, being a little in disorder at the angle of their junction.'

The site was described and illustrated in more detail by Geikie (in Hutton, 1899) and Tyrrell (1928), the former based on Hutton's original unpublished manuscripts. The metamorphic rocks underlying the unconformity were described by Gunn (1903) as 'Highland Schists' and their micaceous nature was commented on by Jameson (1800). They are greenish grey, schistose metasedimentary rocks that are steeply inclined (40°–60°) to the south-east and contain common quartz veins. The lithology is dominantly a greywacke grit, with bands of finer-grained, more micaceous, chloritic slaty material. The metamorphic rocks are overlain by red and yellowish sandstones containing lenticular calcareous beds, breccias and distinctive beds of white, pedogenic concretionary carbonate (calcrete). The sedimentary rocks stretch for approximately 325 m along the shore and continue about halfway up the width of the emerged beach. At the south end of the exposure, they dip about 30° to the NNW and at the north end 25° to the WNW the strike curving across the outcrop. The intervening plane of unconformity appears planar and sub-parallel to the overlying sedimentary rocks.

The metamorphic rocks beneath the unconformity form part of the North Sannox Grits of the Southern Highland Group, the uppermost stratigraphical unit of the Dalradian Supergroup. These rocks are tentatively assigned to the Lower Cambrian Series (British Geological Survey, 1987). The overlying sedimentary rocks have been attributed to the Kinnesswood Formation of the Inverclyde Group of latest Devonian-earliest Carboniferous age, based on the predominant upward-fining cycles of sandstones and red-brown, silty mudstones with nodules and thin beds of calcrete (Hall *et al.,* 1998; Browne *et al.,* 1999).

Interpretation

North Newton Shore is one of the most important localities in the development of modern geology. Hutton recognized that the juxtaposition of two lithological units displaying very different geological characteristics could not be explained by normal continuous rock-forming processes. This led him to propose that a gap in deposition had occurred, during which erosion took place, prior to deposition of the overlying rock mass. This interpretation and the concept of 'unconformability' eventually became widely accepted by the geological community, and unconformities are recognized as fundamental to the study of geology and geological time.

Several workers examined the site during the twentieth century, resulting in a re-assessment of the precise location of the plane of the unconformity. Anderson (1944, 1954) established that the lower 1.2 m of the calcareous sedimentary rocks were in fact 'calcitised' grits belonging to the underlying metamorphic rocks, thereby re-positioning the plane of unconformity at the base of the overlying 0.6 m-thick calcrete (cornstone) that underlies the calcareous, red, pebbly sandstones. This was subsequently confirmed and illustrated by Tomkeieff (1953) (Figure 3.47).

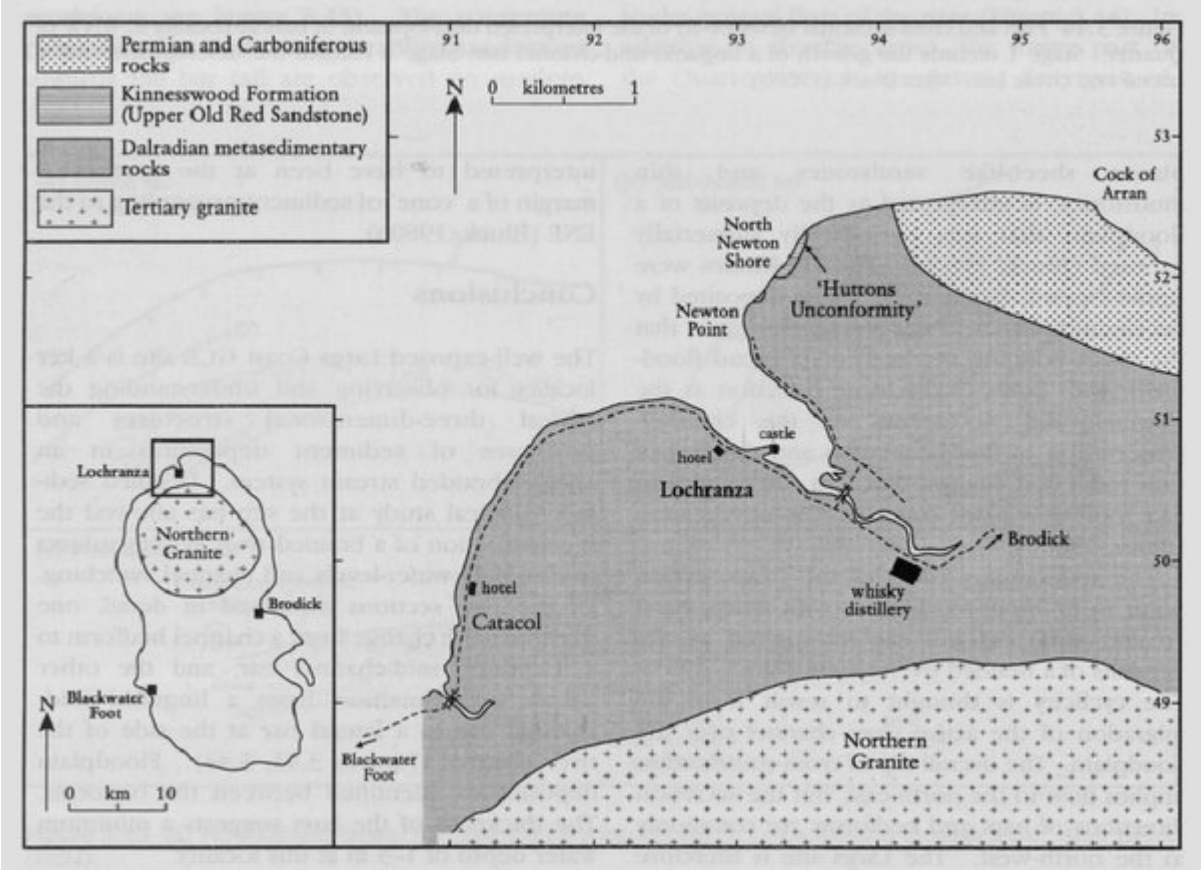
More recently, the importance of the 'calcitised' horizon has been recognized and it has been re-interpreted as having formed by carbonate pedogenesis during Late Devonian to Early Carboniferous times. Intensive fragmentation of the metamorphic rocks at and below the unconformity surface resulted from displacive and replacive carbonate formation, which is strongly developed along the schistosity planes in a bed up to 50 cm thick (Bucheit *et al.,* 1997; Donovan *et al.,* 1998). This zone of altered and calcretized metamorphic rock is parallel to the overlying unconformable surface. Interpreted by earlier workers as a 'sedimentary' cornstone deposit containing clasts of gritty material, it is a calcified regolith. Donovan *et al.* (1998) identified two higher calcretized horizons. The lower overlies the calcified regolith and is a 25 cm-thick calcretized schist pebble breccia containing angular clasts up to 8 cm in length, supported within a carbonate matrix dominated by dolomite spar. The uppermost pedogenic layer is a calcretized quartz pebble conglomerate containing abundant rounded clasts up to 3 cm in diameter, and a few schist clasts.

The geological features exposed at the site provide clear evidence for a time interval between the formation of the underlying deformed and metamorphosed Dairadian rocks and the deposition of the overlying latest Devonian-earliest Carboniferous sedimentary rocks. In addition, the unconformity exhibits features that indicate the geological environment and climate immediately prior to deposition of the overlying sediments. The interpretation of the carbonate-rich horizons as calcretized regolith and pedogenic horizons invokes a long period of subaerial weathering in a semi-arid environment with seasonal rainfall prior to the deposition of the mineralogically mature alluvial deposits of the Kinnesswood Formation.

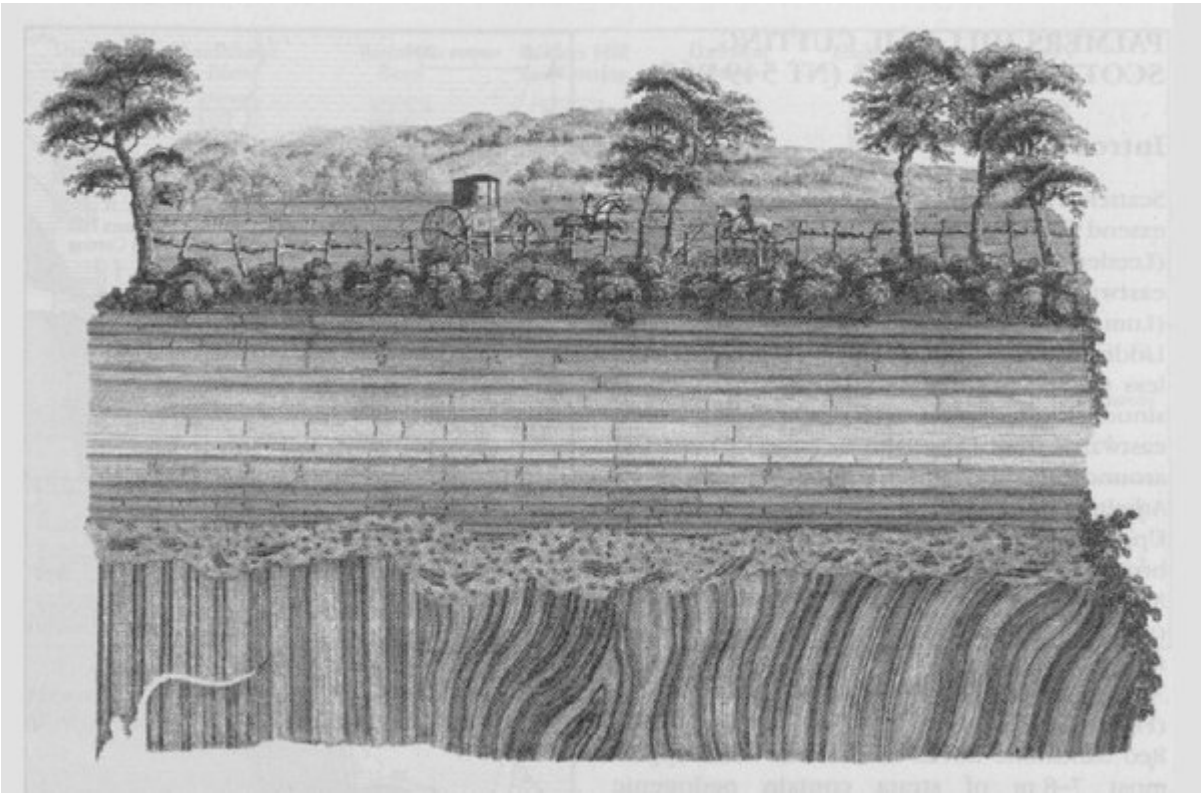
Conclusions

The North Newton Shore GCR site is recognized internationally as an important site in the history of geology, discovered by James Hutton in the 18th century. The site provides a superb example of an angular unconformity where the age relationships between two distinct superimposed rock masses can be demonstratedclearly. The steeply inclined Caledonian metasedimentary rocks of the Dalradian Supergroup are directly overlain by much younger sedimentary rocks belonging to the latest Devonian–earliest Carboniferous Kinnesswood Formation. The more recent recognition of a calcrete horizon at the unconformity has resulted in the re-positioning of the unconformable surface and increased the under standing of the pedogenic processes that occurred at the surface during a prolonged period of non-deposition. 'Hutton's Unconformity' has long been used as a teaching site to demonstrate a typical angular unconformity, first recognized over two centuries ago. The site has provoked some controversy and has been the subject of evolving interpretation of the detail of the unconformable junction ever since.

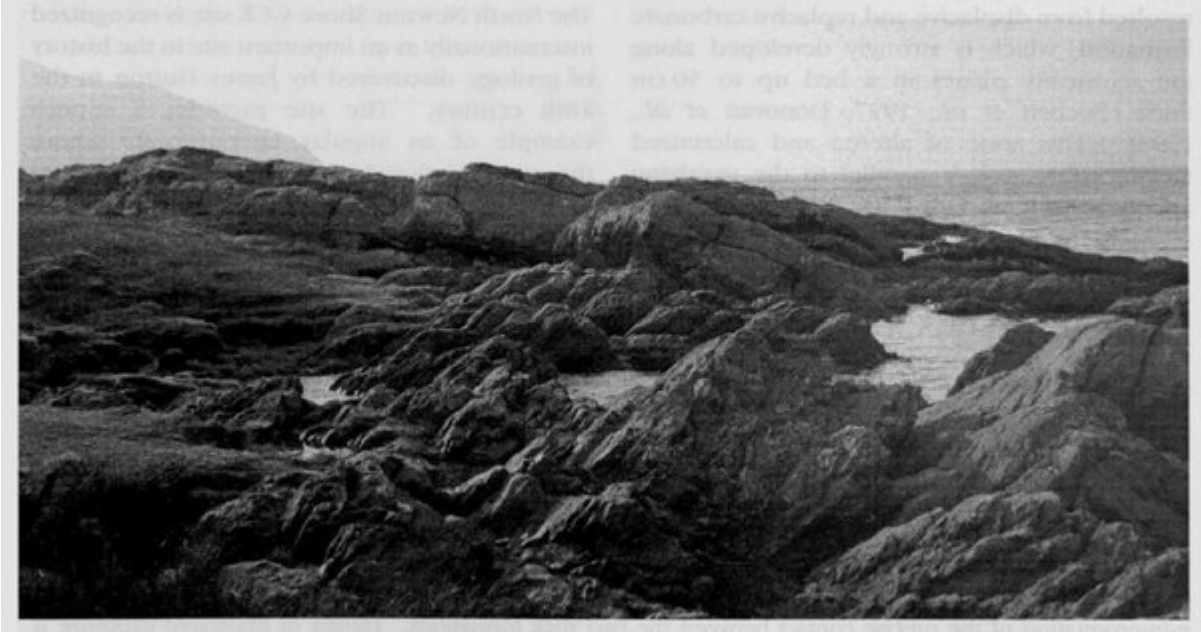
References



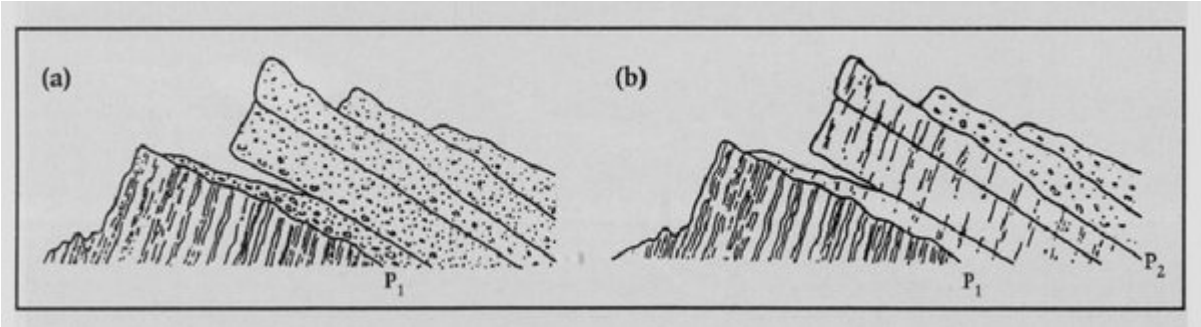
(Figure 3.45) Geological map of the area of North Newton Shore and Hutton's Unconformity, Isle of Arran. Inset shows location of map.



(Figure 4.2) Engraving after a drawing of the unconformity at Jedburgh [NT 652 198] by John Clerk of Eldin (1787), used for Plate III of the Theory of the Earth, Volume 1, by James Hutton (1795). Vertical Silurian greywackes and shales are unconformably overlain by Upper Old Red Sandstone basal breccia and overlying sandstones. From Craig et al. (1978), reproduced by permission of Sir R.M. Clerk Bt.



(Figure 3.46) Hutton's Unconformity. Steeply dipping Dalradian metasedimentary rock in the foreground (lower half of image), overlain by more gently inclined thicker-bedded Upper Old Red Sandstone sedimentary rocks dipping towards the sea. (Photo: S.L.B. Arkley.)



(Figure 3.47) Sketches of Hutton's Unconformity at North Newton Shore from Tomkeieff (1953) showing his re-interpretation of the precise contact between the two rock formations. Height of illustrated exposure is about 1 m. (a) — position of plane of unconformity as placed by Hutton (P_1); (b) — new position as suggested by Tomkeieff (P2).