14 Fraserburgh to Rosehearty

[NK 001 663]–[NJ 918 668]

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14.1 Introduction

This GCR site comprises the coastal section running westwards from Fraserburgh harbour to Rosehearty. It is separated from the *Cairnbulg to St Comb* GCR siteby the wide, sandy expanse of Fraserburgh Bay. Because the section runs for most of its length at almost right angles to the regional strike and the main structures, it provides an excellent geological profile. It is of interest for three main reasons. Firstly, it exposes a transition from the calcareous rocks and metagreywackes of the Tayvallich Subgroup (Argyll Group) into the overlying andalusite schists and metagreywackes of the Southern Highland Group. Secondly, it provides a section through the western limb of the Buchan Anticline (corresponding to the eastern limb of the Turriff Syncline) and clearly demonstrates the nature of the first and second deformational phases. Thirdly, the rocks display excellent examples of Buchan metamorphism and the transition from the andalusite schists to sillimanite-bearing schists and gneisses.

The geology of the area was first described by Grant Wilson (1882, 1886) but the basis of the modern interpretation lies in a series of papers by H.H. Read on the Buchan area (Read, 1952, 1955) that culminated in a paper on the Buchan Anticline (Read and Farquhar, 1956). The detailed sedimentology and structure of the area was first interpreted by Loudon (1963) as part of a wider study of the upper Dalradian. Subsequently important contributions were made on the structural and metamorphic history by Fettes (1968, 1970), on the nature of the metamorphism by Hudson (1975) and Harte and Hudson (1979), and on the sedimentology and structure by Kneller (1988). An excursion guide to the eastern part of the site was provided by Kneller (1987).

14.2 Description

The coastal section (Figure 6.31) provides almost continuous exposure along its length of *c.* 9 km, which comprises a series of low cliffs, rocky foreshores, small sandy bays and the rugged headland of Kinnairds Head. The stratigraphy youngs to the west away from the core of the Buchan Anticline, whereas the metamorphic grade rises to the east, towards the anticlinal core.

14.2.1 Stratigraphy and sedimentation

The eastern part of the section, from Fraserburgh harbour westwards to Broadsea at around [NJ 988 676], is dominated by calcareous turbiditic units, including some partial Bouma sequences (Kneller, 1987). Kneller also reported a slump breccia around [NJ 998 677]. The sequence is characterized by impure sandy metalimestones, calcareous psammites and calcsilicate bands and nodules that together constitute the Kinnairds Head Formation (Figure 6.32). Calcareous rocks also occur in an isolated exposure south of the harbour at [NK 002 664]. The contact with the underlying gneisses of the *Cairnbulg to St Combs* GCR site is not seen.

The section from Broadsea to Rosehearty consists of tubiditic rocks with graded units and typical elements of Bouma cycles. The bedding is on the centimetre to metre scale. Various sedimentary features can be seen including rip-up-clasts and convoluted bedding; coarse pebbly psammite units might, in part, represent channel fills. Good examples of sedimentary structures can be seen throughout the section, for example at [NJ 952 673], and partial and complete Bouma cycles may be examined around [NJ 986 673]. One rather spectacular rock type that dominates much of the section consists of regular graded units, which are characteristically 20–30 cm in thickness and consist of a finely

layered psammite base succeeded by pelite. The pelites, which comprise the greater part of the graded unit are now recrystallized to coarse-grained andalusite schist giving the appearance of reverse grading (Figure 6.33), (Figure 6.34). These rocks may be examined around Rosehearty and on the foreshore west of Sandhaven. In general the rocks provide excellent and abundant way-up evidence and allow the larger folds to be traced out. This part of the section constitutes the Rosehearty Formation.

The boundary between the Kinnaids Head and Rosehearty formations is marked by the relatively sharp disappearance stratigraphically upwards of calcareous material. However the background sedimentation remains essentially unchanged with partial and complete Bouma sequences identifiable throughout the section.

14.2.2 Structure

Minor folds ranging from centimetre scale up to amplitudes of tens of metres are abundant throughout the section. There are two generations of deformation present, defined as D1 and D3 on the regional classification. The F1 folds are present throughout the section. They trend approximately north to north-east, and are subhorizontal or plunge gently to the north at up to 20°. The characteristic structural profile shows a series of gentle vertical or subvertical folds. In places along the section, these become tightened to form asymmetric folds, which are steeply inclined or overturned to the west with inverted limbs. In some cases the axial planes become curved with fold noses ‘drooping’ to the west. Way-up and cleavage-bedding relationships show that the folds face consistently up to the west. The nature of D1 folding and cleavage relationships is well seen on the foreshore around Sandhaven and westwards to [NJ 950 679], as well as in the area to the west of Rosehearty harbour. Minor folds are spectacularly developed in the mixed calcareous lithologies to the west of Kinnaird Head. S1 axial planar fabrics are developed throughout the section. Cleavage planes that cross-cut the lithological banding in the andalusite schists are spectacular between Rosehearty and Sandhaven (Figure 6.33), (Figure 6.34).

The F3 folds are broadly coaxial with the F1 folds and are overturned to the west, as seen for example at [NJ 985 673] and [NJ 998 677]. They can be clearly shown to refold D1 structures and excellent examples of refolded folds can be seen below the foghorn at [NJ 998 677] (Figure 6.32). Kneller (1987) also reported refolded structures at [NK 001 675]. S3 axial planar fabrics are sporadically developed and in places are associated with microfolds of S1. S3 characteristically forms a spaced clevage, for example at [NK 001 675].

14.2.3 Metamorphism

Andalusite and cordierite are present throughout the section with spectacular coarse-grained andalusite schists characterizing the outcrops between Rosehearty and Sandhaven. Typical assemblages are quartz-plagioclase-biotite-andalusite-cordierite. At Kinnairds Head fibrolite appears, reflecting the general increase of grade to the east. Kneller (1987) reported mixed assemblages in the calcsilicate rocks, including calcic amphiboles, diopside, epidote and zoisite. Fettes (1968) showed quite clearly that the peak of metamorphism, marked by the major prophryroblast development, took place in a static phase between D1 and D3, the porphyroblasts overgrowing the S1 fabrics and being broken or rotated during D3 and mantled by the S3 fabrics.

14.2.4 Igneous and meta-igneous rocks

A coarse amphibolitic rock is shown on the BGS 1:10 000 sheets immediately south of Fraserburgh harbour. In addition, Kneller (1987) reported a number of igneous or meta-igneous rocks around Kinnairds Head. He described a large crag in the middle of a small bay at [NK 000 675], which is composed of biotite-actinolite schist and is apparently conformable with the bedding. Kneller also described a similar, although less mafic ‘greenstone’, below the harbour wall at [NK 001 675]. He noted that the mottled appearance of the first occurrence is reminiscent of metamorphosed basic tuffs found at similar stratigraphical horizons elsewhere in the Tayvallich Subgroup. A number of aplitic and pegmatitic leucogranite sheets (for example at [NJ 998 677] and [NJ 993 674]) have sharp contacts and post-date all the deformation structures; they most probably relate to the late-Caledonian granites.

14.3 Interpretation

Sedimentological features clearly indicate that the rocks are tubiditic and typical of the unstable conditions prevalent at the time. This background sedimentation persists throughout the section (see Kneller, 1987), although there is a relatively sharp junction between the part of the succession that includes calcareous rocks in the east and the part devoid of calcareous lithologies to the west. The section comprises the Kinnairds Head and Rosehearty formations (previously called ‘groups’ by Read and Farquhar, 1956). The Kinnairds Head Formation is correlated with the Tayvallich Subgroup (Argyll Group) and the Rosehearty Formation is correlated with the lower part of the Southern Highland Group. The Kinnairds Head Formation was previously regarded as equivalent to the Whitehills ‘group’ in Banffshire. However the BGS 1:50 000 Sheet 96 (Banff, 2002) has placed the lower part of the Whitehills ‘group’ in the Boyne Limestone Formation (Argyll Group) and the upper part in the Macduff Formation of the Southern Highland Group. This division is made on the first appearance, stratigraphically upwards, of distinct, coarse-grained turbiditic units, albeit within the part of the sequence that contains calcareous lithologies. This boundary has no apparent equivalent in the Rosehearty to Fraserburgh section, which obviously complicates stratigraphical correlations across the Turriff Syncline and questions the previously established criteria for delineating the top of the Argyll Group at the top of the calcareous sequence (Harris and Pitcher, 1975).

Read (1955) postulated that the rocks of the Buchan Block constitute the upper limb of a recumbent Banff Nappe, an allochthonous eastward-facing structure lying above a major dislocation (the Boyne Line). The nappe structure was seen as having been gently folded into the upright Turriff Syncline and complementary Buchan Anticline. Read and Farquhar (1956) argued that the Buchan Anticline was formed by an upsurging core of gneissose rocks related to the translation of the Banff Nappe. They postulated that the westward vergence and sense of movement of the folds indicated that the metasedimentary pile had slumped off the uprising anticline as a form of gravity slide. This view was questioned by Loudon (1963) and it is now generally discounted. The westward-verging F1folds are consistent with those found throughout the Aberdeenshire and Banffshire area and this is evidence against a major D1 structure in the area. The westward vergence of the D3 structures on the western limb of the Buchan Anticline is also inconsistent with that structure being of D3 age, suggesting, as noted elsewhere, that the Buchan Anticline might be a relatively late structure, possibly of D4 age.

Read (1955) and Read and Farquhar (1956) believed that the metamorphic pattern was imposed as a thermal aureole around the upsurging gneisses in the core of the Buchan Anticline and was essentially post deformation. Although the metamorphism is indeed superimposed on the main structures, it is obvious that the isograds are folded by the Buchan Anticline and the Turriff Syncline. It is also clear from microstructural studies that the metamorphic and thermal peak pre-dates the D3 and D4 structures (Fettes 1968, 1970).

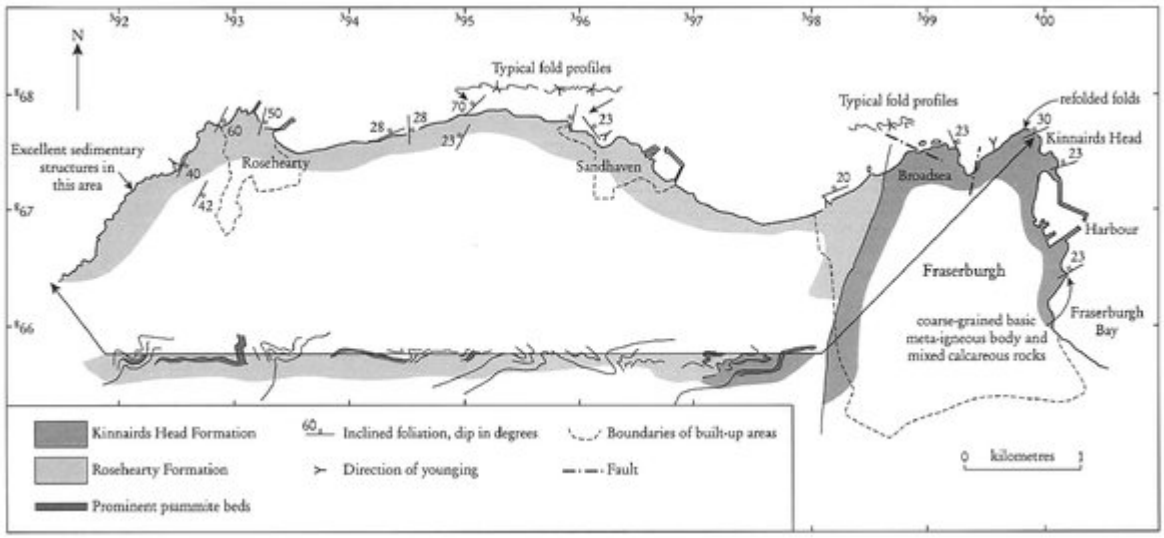
This coastal section, along with the adjacent *Cairnbulg to St Combs* GCR site, exhibits typical Buchan metamorphism, characterized by the zonal sequence cordierite → andalusite → sillimanite → sillimanite+K-feldspar. Along with the Ythan gorge to the south, these are the key exposures of the lowest P/T-style of metamorphism (i.e. the lowest pressure/temperature ratios) present in the Dalradian (the Buchan metamorphism as seen in Banffshire is characterized by higher P/T values and the zonal sequence cordierite → andalusite → staurolite → kyanite) (Harte and Hudson, 1979). The generally low P/T values of Buchan metamorphism compared to the Barrovian areas might reflect a relatively unthickened crust (Strachan *et al*., 2002): the role of the basic intrusions of the North-east Grampian Basic Suite in this situation, as either the cause or an effect of high heat-flow, is uncertain. However, it is reasonable to note that the basic intrusions, over much of their outcrop, are associated spatially with the gneisses that represent the culmination of Buchan metamorphism. Thus, Read and Farquhar’s suggestion of an aureole around a thermal gneiss dome might not be entirely wrong.

14.4 Conclusions

The superbly exposed coastal section between Rosehearty and Fraserburgh is critical to understanding the geology of the Buchan Block, which differs significantly in its structural and metamorphic history from the Dalradian successions to the west and south. It is of the highest national importance for three main reasons. The sedimentological and stratigraphical evidence demonstrates the nature of the Argyll Group–Southern Highland Group transition, highlighting both similarities and contrasts with the Perthshire and Banffshire successions. The structural history provides a major

piece of evidence to suggest that major D1 structures are absent from the Buchan Block, which is in marked contrast to the major nappe-dominated structures of Perthshire. The spectacular andalusite schists between Rosehearty and Sandhaven and the transition to the sillimanite schists at Fraserburgh constitute one of the type sections of Buchan metamorphism in the Grampian Highlands, which is of international interest as one of the first well-documented examples of low-pressure–high-temperature regional metamorphism in the world.

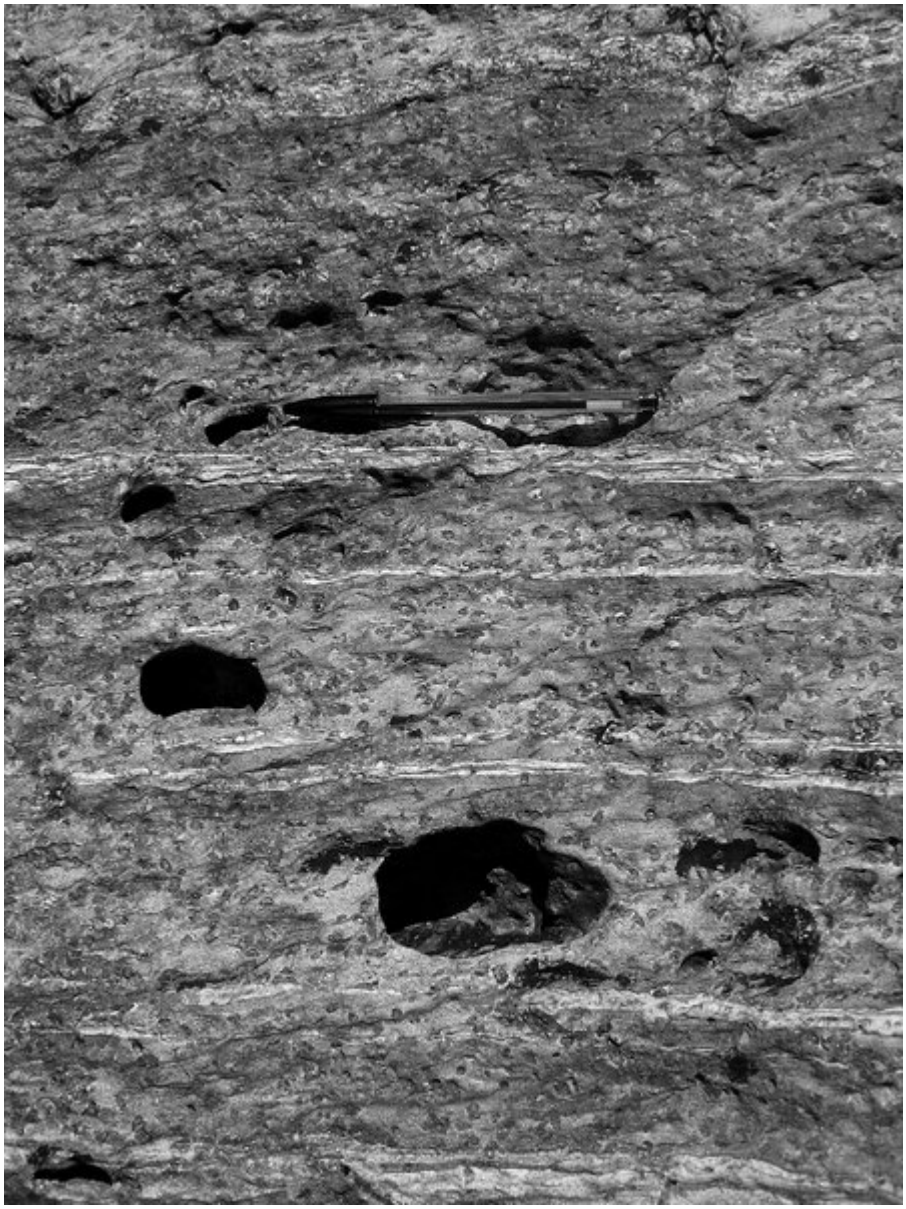
References



(Figure 6.31) Map of the coast section between Fraserburgh and Rosehearty, based upon the BGS 1:50 000 Sheet 97 (Fraserburgh, 1987). The diagrammatic cross-section is adapted from Loudon (1963) and is not to scale.

(Figure 6.32) Refolded folds (F1 + F3) in a mixed sequence of thinly bedded calcareous semipelites, calcsilicate rocks and impure metalimestones of the Kinnaird's Head Formation at Kinnaird's Head, Fraserburgh. (a) Tight F1 folds refolded by close to tight F3 folds, immediately east of the foghorn at [NJ 998 677]. A prominent S3 axial-planar cleavage and an L3 lineation are well developed in places. Hammer head is 16.5 cm long. (Photo: J.R. Mendum, BGS No. P 726599.) (b) Refolded folds (F1 + F3), viewed to the east, at [NJ 998 676]. Key fob is 4 cm in diameter. (Photo: D.J. Fettes, BGS No. P 726600.)

(Figure 6.33) Cyclic bedding with graded units in the Rosehearty Formation. Andalusite is abundant in the finer-grained units. Note the cross-cutting cleavage. West of Sandhaven, [NJ 952 679]. Key fob is 4 cm in diameter. (Photo: D.J. Fettes, BGS No. P 726601.)



(Figure 6.34) Graded units with thin sandstone layers in a dominantly pelitic facies of the Rosehearty Formation. Abundant andalusite is clearly visible. Location as (Figure 6.33). Pen is 15 cm long. (Photo: D.J. Fettes, BGS No. P 726602.)