Elie–Anstruther, Fife

[NT 481 996]–[NO 566 036]

Introduction

The Elie–Anstruther GCR site extends for 11 km from just west of Elie [NT 481 996] eastwards past St Monance to Anstruther [NO 566 036]. It provides an almost unbroken sequence of Early Carboniferous (Asbian, Brigantian and basal Namurian) age and is the thickest known development (more than 2000 m) of Lower Carboniferous rocks in the Midland Valley. The first detailed account of these sections was by Brown (1860), and in the 1870s Kirkby made a careful detailed measured section of the sequence. This was incorporated in and first published in full in the memoir on *The Geology of Eastern Fife* (Geikie, 1902). A recent resurvey of the area led to the erection of a new lithostratigraphy for East Fife (Forsyth and Chisholm, 1977), and the name and type localities for components of the Strathclyde Group, namely the Pathhead, Sandy Craig, Pittenweem and Anstruther formations, all lie within the site. Sedimentological features from this section have been described by Greensmith (1961, 1965), Belt (1975), Fielding *et al.* (1988), Searl and Fallick (1990) and Kassi *et al.* (1998), while details of spore and trace-fossil assemblages have respectively been described by Neves *et al.* (1973) and Lees (1991). The site encloses within it the Ardross Castle GCR site described by Dineley and Metcalf (1999) in their GCR volume *Fossil Fishes of Great Britain.* An outcrop map showing the distribution of formations within the Strathclyde Group and the Clackmannan Group at this site is presented in (Figure 2.12).

Description

The lowest beds in the sequence occur at the eastern end of the site where, between Anstruther [NO 566 036] and Cuniger Rock [NO 557 027], faulted successions of the Anstruther Formation outcrop (Forsyth and Chisholm, 1977). These beds consist of cyclical sequences of sandstone and grey mudstones and siltstones. Root beds, thin coals and dolomitic limestones also occur. Sandstones are generally thin and may be cross-bedded. There are, however, a few thicker sandstones, such as that which forms Johnny Dow's Pulpit. The mudrocks often contain non-marine faunas rich in ostracodes, fish remains, and the bivalves *Naiadites* and *Paracarbonicola.* A few marine intervals with molluscan faunas or *Lingula* have also been recognized and named. These include the Anstruther Wester Marine Band, the Billow Ness Marine Band, and the Chain Road Marine Band. Kassi *et al.* (1998) published an account of exposures in the Billow Ness area [NO 562 028].

The Anstruther Formation passes up conformably into the Pittenweem Formation, which is very similar in character to the Anstruther Formation in being made up of at least 220 m of cyclical alternations of thin sandstones, grey siltstones and mudstones, which often contain a non-marine fauna. Significant differences are that in the Pittenweem Formation dolomitic limestones are rare, oil shales are occasionally present, and marine faunas are more diverse, with the incoming of crinoids and brachiopods. Four marine bands have been recognized: the Cuniger Rock Marine Band, the Kirklatch Marine Band, the Pittenweem Marine Band and the Pittenweem Harbour Lingula Band (Forsyth and Chisholm, 1977). Non-marine bivalves from the Anstruther Formation and Pittenweem Formation have been described by Bennison (1960), and Brand (1998) has commented on the distribution of species of *Paracarbonicola.*

The junction between the Pittenweem Formation and the Sandy Craig Formation has been faulted out and the outcrops of the Sandy Craig Formation have also been affected by a number of faults. The formation is at least 550 m thick (Forsyth and Chisholm, 1977) and consists of variegated sandstones, siltstones and mudrocks. Thin beds of oil shale, non-marine limestone and dolomite occur, but are rarer than in the Pittenweem Formation, and there is only a single marine band, the Boat Harbour Marine Band. A distinctive feature of the formation is the occurrence of nodular pedogenic caicretes.

The overlying Pathhead Formation is about 300 m thick and crops out on the shore between Pittenweem and Pathhead near St Monance. The lithological characters of this unit are similar to those of the Pittenweem Formation and the succession is made up of alternations of grey mudstones and siltstones and thin sandstones. Coals and seatearths occur

throughout. Although the base of the formation is defined by the West Braes Marine Band, marine bands become more common towards the top of the formation. Named horizons include the Ardross Limestones and Lingula Band, the Pathhead Marine Bands and the St Monance White Limestone. The top of the coral-rich St Monance White Limestone has been bleached and weathered penecontemporaneously and shows interesting lateral facies variations on either side of the St Monance Syncline (Macnair, 1917; Tait and Wright, 1923). Locally this unit appears to have been dolomitized (Figure 2.13). An interesting crinoid fauna has also been obtained from a lenticular band in the shales above the St Monance White Limestone on the western side of the St Monance Syncline (Tait and Wright, 1923; Wright, 1925, 1927, 1939, 1950–1960). Exposures of the Ardross Limestones and associated beds also recur on the west side of the syncline in the Ardross Castle area. A well-known and important feature of these outcrops is the 'shrimp band' below the Ardross Lower Limestone (Cater *et al.,* 1989; Clark, 1989; Cusack and Williams, 1996; Williams and Cusak, 1997). There is also a bed containing small starfish (Spencer, 1914–1940), and Wright (1925, 1939, 1950–1960) has recorded a unique and distinctive crinoid assemblage from above the Ardross Limestones.

The Pathhead Formation is overlain by the Lower Limestone Formation (150 m), which is exposed within the core of the St Monance Syncline and consists of a series of Yoredale-type cycles in which the marine intervals are often well developed. The principal marine intervals are the St Monance Brecciated Limestone (3.5 m), the St Monance Little Limestone (0.6 m), which contains gigantoproductids, the Five Foot (or Charlestown Main) Limestone, and, towards the top of the formation, the variable group of Kinniny Limestones and associated Millhill and Seafield marine bands (Forsyth and Chisholm, 1977). Coal seams occur particularly in the strata below and above the Five Foot Limestone and are representative of thicker seams inland. The shales above the Five Foot Limestone contain representatives of the Neilson Shell Bed Fauna (Wilson, 1966; Forsyth and Chisholm, 1977). The record of the goniatite *Sudeticeras* aff. *delépinei* from the Millhill Marine Band confirms the P_2 age of this interval (Wilson, 1980; Forsyth and Wilson, 1981) and helps to delimit the position of the P_2–E_1 boundary in Scotland. The Seafield Marine Band, which crops out by the St Monance Swimming Pool, contains a diverse marine fauna of brachiopods, molluscs and crinoids (Geikie, 1902; Wright, 1914a; Forsyth and Chisholm, 1977). This is the type locality for the trilobite *Paladin cuspidatus* (Reed, 1943; Osmólska, 1970). The sandstones above the Seafield Marine Band have been extensively bioturbated, and above these, mudrocks with a sparse marine fauna indicate the position of the Lower Kinniny Limestone. The sandstones and siltstones above the Lower Kinniny Limestone, which include a lenticular channel sandstone, have been variably bioturbated by the trace fossil *Teichichnus* (Chisholm, 1970). The Middle Kinniny Limestone is a distinctive finely crinoidal, dolomitic limestone with abundant traces of *Zoophycos.* The Upper Kinniny Limestone does not occur at St Monance but is found at Elie, where it is known as the 'Red Limestone' (Cumming, 1928). These exposures, which repeat the upper parts of the Lower Limestone Formation, also extend into the basal parts of the Limestone Coal Formation, consisting mainly of sandstones but including some coals (Cumming, 1928; Forsyth and Chisholm, 1977).

Interpretation

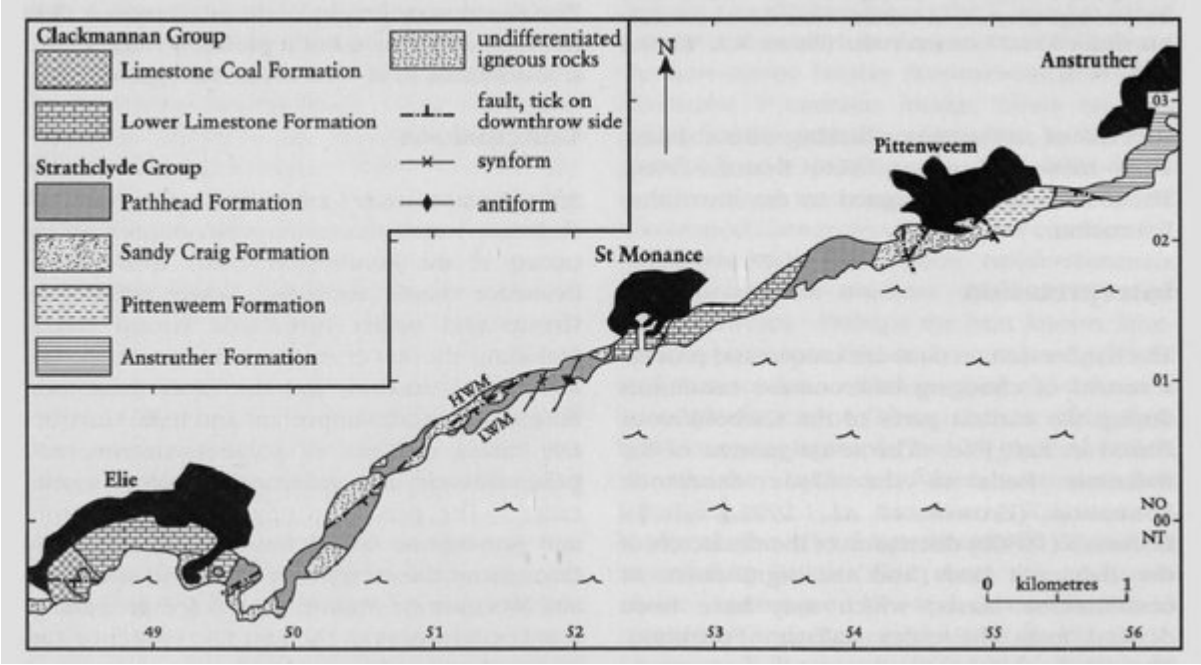
The extensive sequence at this site together with that at Randerston Coast (see GCR site report, this chapter) form a vital composite reference section from which to understand the complex and incompletely understood geology of East Fife. The Pittenweem Marine Band, formerly known as the 'Encrinite Bed', and some of the associated marine horizons of the Pittenweem Formation and the Sandy Craig Formation can for instance be traced northwards and used to elucidate the geology of the St Andrews area (Forsyth and Chisholm, 1977). However, within the St Andrews area the bands are fewer in number and less well developed. These marine bands belong to the MacGregor Marine Bands, which is the collective name for a very variable group of marine bands that can be widely detected in West Lothian, Fife, East Lothian and into northern England. These are the first extensive correlatable horizons within the Strathclyde Group and are of Asbian age. The higher marine bands of the Pathhead Formation and Lower Limestone Formation can be extensively correlated throughout the Midland Valley and are of Brigantian age (Wilson, 1989). The penecontemporaneous weathering of the St Monance White Limestone is comparable to the bleaching of the same horizon seen at Aberlady and Dunbar (Crampton, 1905, 1910; Tait and Wright, 1923) and at Corrie Burn (Macnair, 1917). The palynological zonation of Neves *et al.* (1973) could also facilitate correlation with other areas but problems in reconciling palynological and lithostratigraphical evidence (Forsyth and Chisholm, 1977) indicate that further work is required. The basal beds of the Limestone Coal Formation show a change in facies to one in which coals are better developed but marine limestones are absent.

Environmentally, the overall sequence represents a transgressive mega-sequence (Belt, 1975), with restricted lacustrine and lagoonal delta environments of the Anstruther Formation passing up through the Pittenweem Formation and Pathhead Formation, with increasing marine influence into the open marine-deltaic Yoredale cycles of the Lower Limestone Formation. The Sandy Craig Formation represents a departure from this trend and an extension of the delta to give a reduced marine influence. At this time and perhaps linked to the palaeogeographical changes, the climate also seems to have become more arid so that there is a recurrence of calcrete formation. Palaeogeographical changes with a reduction in marine influence also occur in the Limestone Coal Formation.

Conclusions

The Elie–Anstruther GCR site is a vital site for stratigraphical studies of Lower Carboniferous rocks in Scotland showing an almost complete Strathclyde Group to basal Limestone Coal Formation succession. The section is of national and international importance and includes the type sections of the upper Anstruther, Pittenweem, Sandy Craig and Pathhead formations. Excellent exposures of the Lower Limestone Formation and lower part of the Limestone Coal Formation are also present. In these formations a succession of faunas may be studied in their stratigraphical and palaeoenvironmental context. The site shows a remarkable range of both vertical and lateral facies variations and sedimentary structures, including penecontemporaneous limestone weathering. In addition, it shows a thicker succession than more northerly localities in Fife, with more marine bands present. It is a key Scottish Dinantian locality for palynological (spore) studies.

References



(Figure 2.12) Simplified geological map of the foreshore area at the Elie–Anstruther GCR site showing the outcrop distribution of formations in the Strathclyde Group and Clackmannan Group. Based on various sources and including information from MacGregor (1968, 1996) and Forsyth and Chisholm (1977).

(Figure 2.13) Dolomitization of the St Monance White Limestone (Pathhead Formation, Strathclyde Group, Brigantian) close to St Monance, at the Elie–Anstruther GCR site, showing zone of dolomitization (darker band) between two paler developments of thinly bedded limestone with shale partings. (Photo: C. MacFadyen.)