Excursion 1 The Triassic and Lower Jurassic of Golspie

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Purpose

To examine the Triassic and Lower Jurassic (Lias) of the Golspie to Dunrobin shore section.

Access

The exposures can be reached by walking from Golspie or by combining the excursion with a visit to Dunrobin Castle. If starting from Golspie the workshops and excellent geological exhibition of the Orcadian Stone Company in Main Street can be visited. At the east end of Main Street the A9 bears sharp left into Old Bank Road; at this corner turn right into Duke Street in which there is parking space. Cross the Golspie Burn footbridge, follow the track into the fields, and walk about 1 km east to locality 1 which is near the low tide mark beyond the remains of an old stone pier and wood piling. If visiting Dunrobin Castle, a track leads to the shore down the hill past the western side of the castle and reaches the shore at locality 3 (Figure 1.1). Low tide is essential for this excursion, which takes 2–3 hours. In recent years exposure on the beach has been poor due to sand and seaweed cover, and a good winter storm is needed to reveal much of the geology.

Introduction

The general geology and regional features of the Triassic and Lower Jurassic strata are described in the Geological History section of this volume. For a broad account of Triassic rock in the Moray Firth see Glennie (2002), and for the Jurassic see Hudson and Trewin (2002).

Judd (1873) provided an early description of the section, and considerable detail of Jurassic faunas is given by Lee (1925). The geological succession is illustrated in (Figure 1.2). The Triassic is poorly exposed, but includes fluvial and aeolian yellow sandstones overlain by mudstones with extensive caliche development and some silcrete. This palaeosol horizon correlates stratigraphically with the similar 'Cherry Rock' of Lossiemouth.

The Jurassic section comprises the Dunrobin Bay Formation of Batten et al. (1986). Richards et al. (1993) modified the stratigraphic nomenclature (Figure 1.2), raising the Dunrobin Bay Formation to Group status and introducing new formation names. The descriptive terminology of Batten et al. (1986) is followed here.

The Dunrobin Pier Conglomerate Member of alluvial origin was discussed by Batten et al. (1986). The overlying Dunrobin Castle Member was described by Neves and Selley (1975) on the basis of borehole information, and they demonstrated that the lower, unexposed part of the Lias consists of shales and siltstones with occasional thin coals and rootlet beds. These strata were deposited in a dominantly coastal alluvial environment; however, some horizons containing dinocysts are indicative of marine influence (Lam and Porter, 1977). The White Sandstone Unit represents a coastal sand body and is overlain by shallow marine strata of the Lady's Walk Shale Member. The numbered bed-by-bed succession described by Lee (1925) cannot usually be demonstrated due to poor exposure, but some of the more prominent beds are usually visible at low tide and yield a varied fauna dominated by bivalves. The uppermost strata, consisting mainly of shales with calcareous nodules and some sandstone beds with a few pebbles and a shelly fauna, were possibly not exposed at the time of Lee's work.

Locality 1. Triassic sandstones [NC 849 003]

The lowest sandstones seen here are yellow, laminated, and have a bimodal grain size distribution with well-rounded and spherical 'millet seed' medium sand grains in a fine sand matrix. Lamination is a reflection of grain size and sorting variation. The strike of these sandstones varies between 190° and 280°, with dips to the west and north.

The overlying sandstones contain irregular concretionary patches with a siliceous cement and dip NE (035°) at 15–20°. It is possible that the variable dip and strike of the underlying sandstones represents poorly preserved, large-scale cross-bedding. These sandstones may be broadly equivalent to the aeolian Lossiemouth Formation of the Triassic of the Elgin area (Peacock et al., 1968; Gillen, 1987).

Locality 2. [NC 850 004]

The sandstones of locality 1 are overlain by poorly exposed red and green mudstones and marls (calcareous mudstones). At locality 2 extensive developments of concretionary carbonate are present in the mudstones. The carbonates are irregular concretions of pink to grey micritic limestones with white calcite veins. These limestones are caliche type carbonates formed in the soil profile of a semi-arid region where evaporation exceeded precipitation. Some examples of calcrete textures may be seen with multiple carbonate veining, brecciation features, altered clasts of country rock (mainly sandstone) and occasional carbonate pisoliths (Figure 1.3). Some of these rocks have been partly silicified to form a silcrete.

These calcrete- and silcrete-textured rocks have also been seen in the Golspie Burn near the rail bridge, and fragments noted some 300 m upstream of the bridge; thus, these rocks form an extensive unit near the top of the Trias. They can be correlated with the Stotfield Cherry Rock at the top of the Trias of the Elgin area (Phemister, 1960; Gillen, 1987) and form an extensive seismic marker horizon in the Inner Moray Firth (Andrews and Brown, 1987).

Locality 3. Dunrobin Pier [NC 8515 0050]

The Dunrobin Pier Conglomerate is now taken as the basal member of the Dunrobin Bay Formation (Batten et al., 1986, (Figure 2)). Exposures are now more extensive than in the past due to the destruction of Dunrobin Pier by storms. A diagrammatic section of the main exposure (sand permitting) in the small bay is given in (Figure 1.4). The three calcite-cemented units form reefs on the shore, but the poorly cemented sandstones and shales are rarely exposed. The prominent reefs on the shore consist of coarse sandstone and conglomerate with a poikilotopic calcite cement. About 90% of clasts are of sandstones, limestones and cherry rocks identical to underlying Triassic lithologies, and were clearly derived by local erosion of the Triassic. Other clasts are of vein quartz and metamorphic quartzite. It is probable that the Dunrobin Pier Conglomerate rests with an erosive contact on the underlying Triassic. The rapid local derivation of the Dunrobin Pier Conglomerate could be due to early Jurassic basin margin faulting uplifting Triassic strata and causing local erosion, possibly by movement on the Helmsdale Fault.

The conglomerate has been reported as unfossiliferous (Judd, 1873; Lee, 1925; Neves and Selley, 1975), but temporary exposures following a storm that stripped sand from the beach revealed carbonaceous shales and sandstones interbedded with the conglomerates. The shales yielded a rich terrestrial micro-flora and woody debris up to 20 cm long (Batten et al., 1986). There is no evidence of marine forms in the assemblages.

The conglomerates and sandstones were deposited under high-energy fluvial conditions, probably in braided channels on a small alluvial fan. Evidence from cross-bedding indicates transport to the NE (Figure 1.4). A marked climatic change at the end of the Triassic resulted in increased humidity and consequent vegetation. The age of the conglomerate is probably early Hettangian, but a Rhaetian age is not excluded (Batten et al., 1986).

Judd (1873) estimated the thickness of the conglomerate as 50 ft (c.15 m), a figure with which Hurst (1985) agreed. Lee (1925) mentioned that only 6 ft was exposed at the end of the pier; this seems to be the bed described as 2 m thick by Neves and Selley (1975), a thickness that has unfortunately been commonly repeated in the literature. Although the section is disturbed by faults it appears that at least 32 m of conglomerate and sandstone are present (Batten et al., 1986).

Locality 4. The White Sandstone [NC 856 009]

From locality 3 walk along the beach to the first prominent reef which is formed by the White Sandstone Unit of the Dunrobin Castle Member (Figure 1.2). The underlying Carbonaceous Siltstone and Clay Unit is rarely exposed. At locality 4 about 11 m of white, medium- to coarse-grained sandstone is exposed. Neves and Selley (1975) proved a further 12 m by drilling. The sandstone is cross-bedded and contains carbonaceous debris and thin shaly partings. Lee (1925) recorded marine bivalves including Grammatodon from clays some 5 m above the main sandstone, and Neves and Selley (1975) reported marine microplankton from the sandstone.

This sandstone, lying between dominantly non-marine alluvial coastal plain deposits and the shallow-water marine deposits of the Lady's Walk Shale Member, represents a coastal or estuarine sand body. It may represent part of an estuarine channel complex, or sandy barrier bar. Exposure is too poor for detailed interpretation.

The coarse sandstone has excellent porosity (23%) and permeability (1600 mD horizontal and 880 mD vertical measured on core plugs) and has some reservoir potential. Minor production in the Beatrice Oilfield (Linsley et al., 1980; Stevens, 1991) is from broadly equivalent sandstones of Lower Jurassic age, but the sandstones of this age in the Beatrice Field have much lower porosity and permeability due to quartz cement and greater burial depth.

Locality 5. Lady's Walk Shales [NC 858 009]

Between localities 4 and 5 there is usually variable exposure of the Lady's Walk Shale Member. The sequence is dominated by shales with calcareous nodules, but includes thin limestones, sandstones and bioturbated units with Shelly faunas. Several beds contain coarse sand and pebbles.

The numbered bed sequence of Lee (1925) cannot usually be verified and the thickness given by Lee (18 m+) seems too low, there being more than 32 m exposed, and a probable total of 48 m+ (Batten et al., 1986).

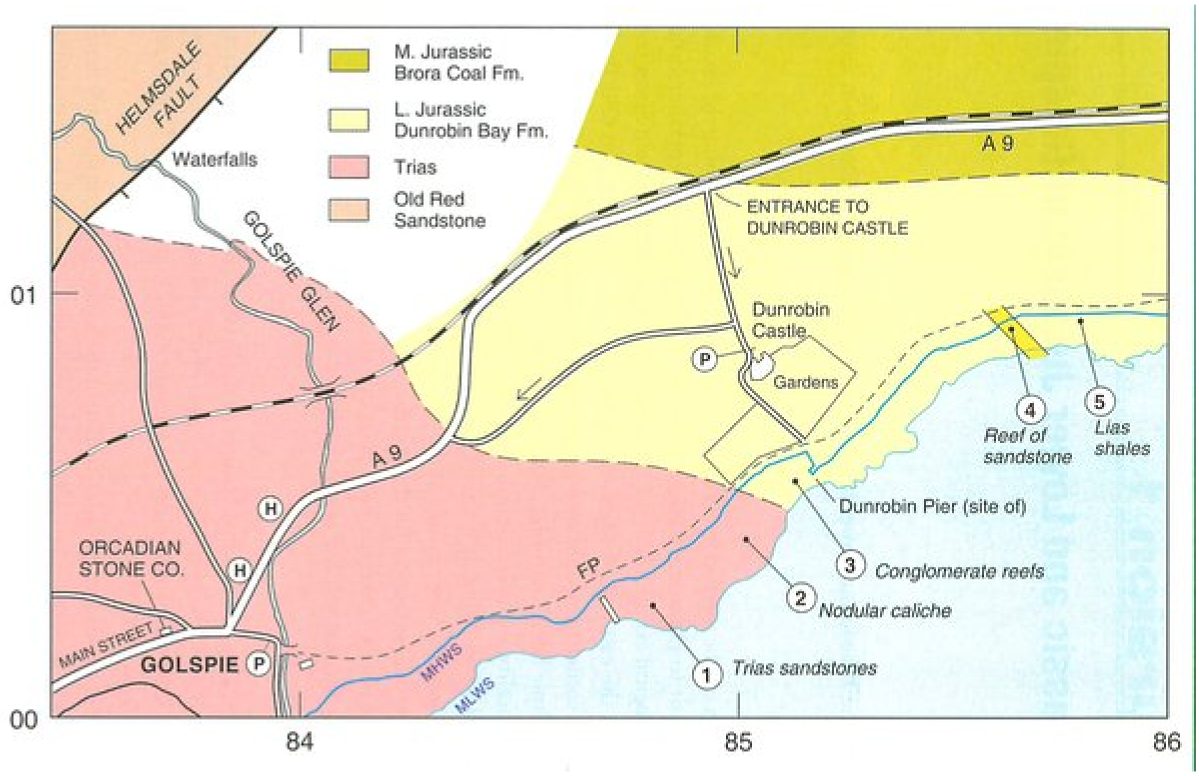
The exposed reefs of harder rock comprise calcareous sandstones, some with a rich bivalve fauna dominated by small *Ostrea*, and including *Gryphaea*, *Modiola*, *Pleuromya* and pectinids. Rhynchonellid brachiopods are also present. The harder beds are parts of small-scale coarsening-up units that start with micaceous shales with calcareous concretions and pass up into bioturbated sandstones in which some trace of ripple lamination may be preserved. Burrows present include *Rhizocorallium*, *Spongeliomorpha*, *Siphonites* and *Chondrites*. The tops of some beds contain scattered quartz pebbles. The cycles represent decreasing water depth and increase in wave energy, which resulted in winnowing of sands, and probably periods of non-deposition before further deepening initiated the next cycle. The presence of land-derived plant debris in most of the section attests to the closeness of the Scottish landmass.

The highest (stratigraphic) exposures occur in a low cliff at locality 5 and consist of dark blue-grey shales with calcareous concretions, and include several cemented sandstone beds with pebbles, belemnites, rhynchonellids, bivalves and wood debris. These sandstone beds are up to 40 cm thick, laterally impersistent, and appear to have been deposited in shallow channels or erosional gutters, probably at times of lower sea level. Subsequent bioturbation has resulted in mixing of sand, pebbles and bioclastic debris. Variations in the clay mineralogy of the shales are also believed to be indicative of local changes in sea level (Hurst, 1985). Rare ammonites from the Lady's Walk Shale are of Sinemurian (*raricostatum* Zone) and Pliensbachian (jamesoni Zone) age. The rarity of ammonites is a reflection of the nearshore environment of the sequence. The regional aspects of this Lias succession are discussed in the Geological History section, where the sequence is compared with the similar development in Beatrice Oilfield (Linsley et al., 1980; Stevens, 1991).

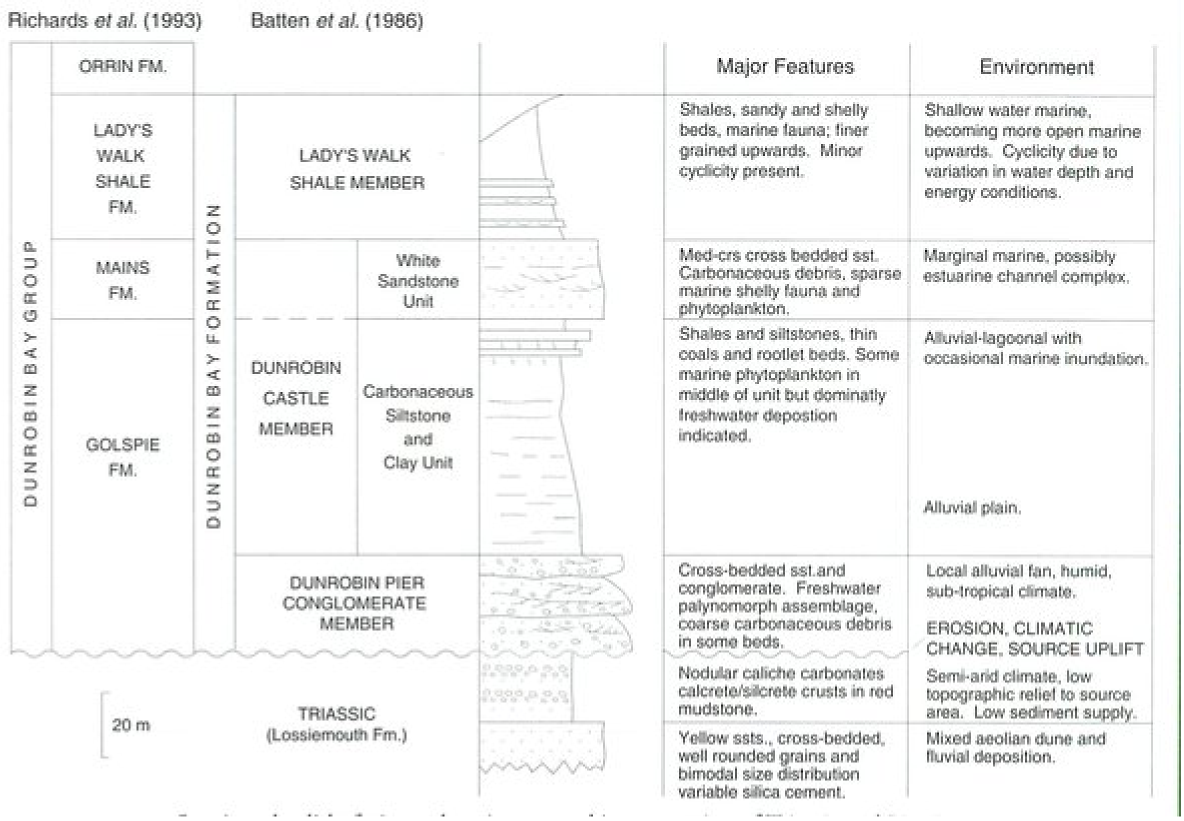
It is worthwhile to examine the many boulders on the beach, since a great variety of rock types and geological phenomena can be observed. Most of the boulders come from local boulder clays or were used in coastal defences which are now in a poor condition. Rock types present include ORS conglomerates and sandstones in which good examples of cross bedding and ripple lamination can be seen. Boulders of both foliated and non-foliated granites are common, and xenoliths of partly digested country rock are present in some. Gneissose boulders exhibit excellent folds and several phases of veins, both of quartz and granitic material. Quartzites and amphibolites from the Moines are also common.

From locality 5 a coastal footpath leads back to the track to Dunrobin Castle and on to Golspie. It is about 25 minutes walking from locality 5 back to the parking area at Duke Street.

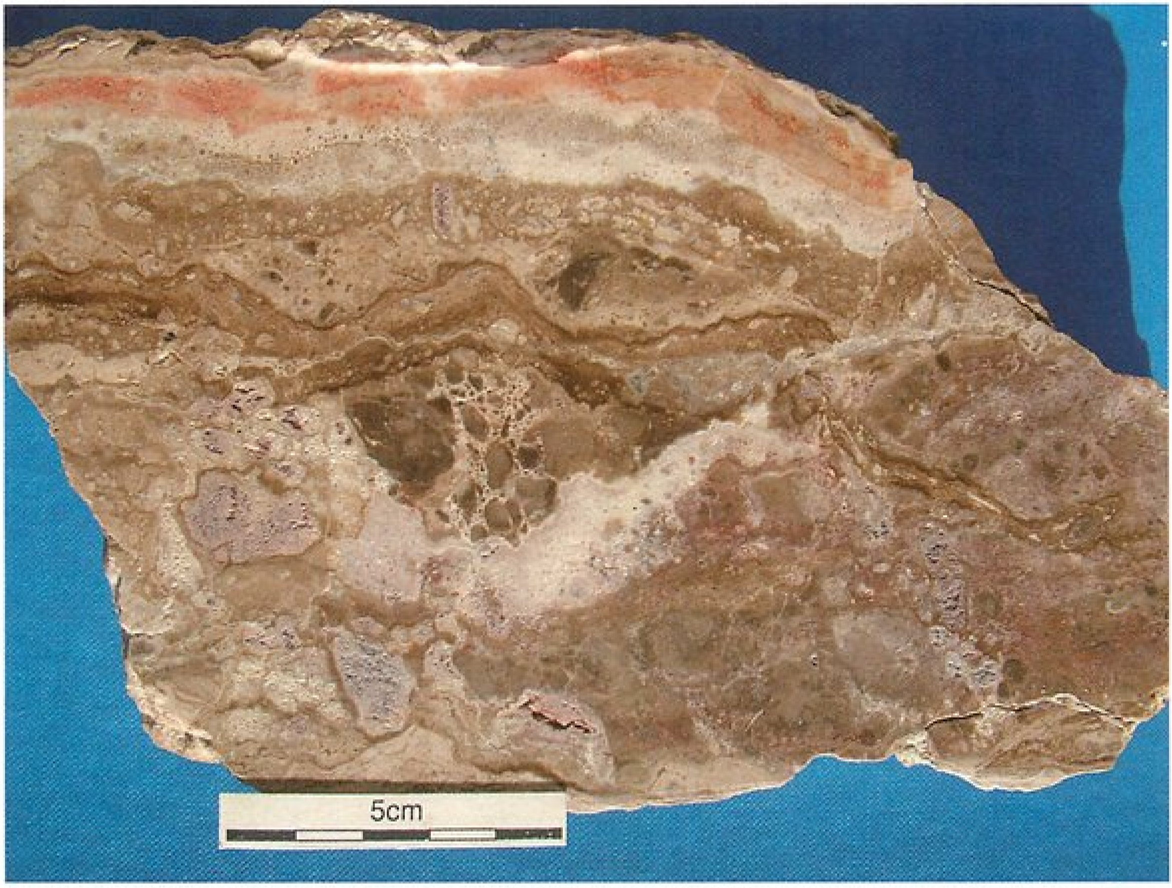
References



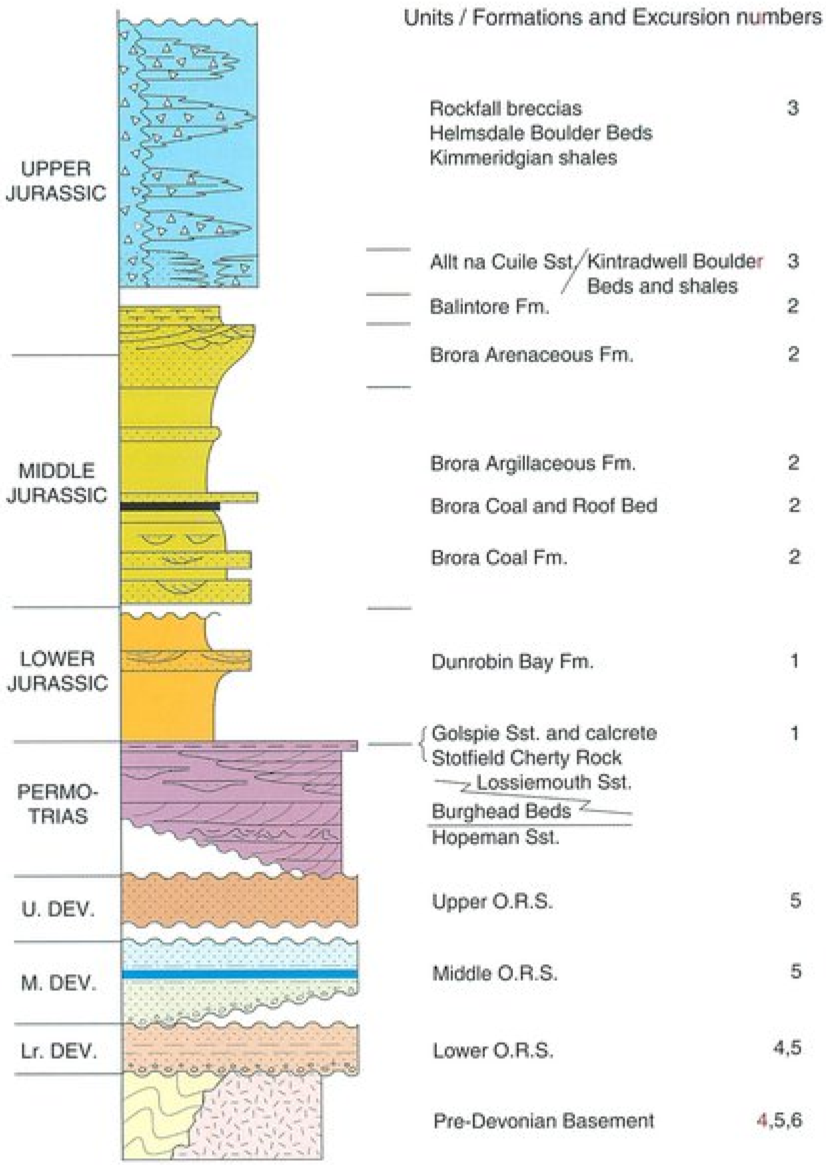
(Figure 1.1) Locality map Excursion 1.



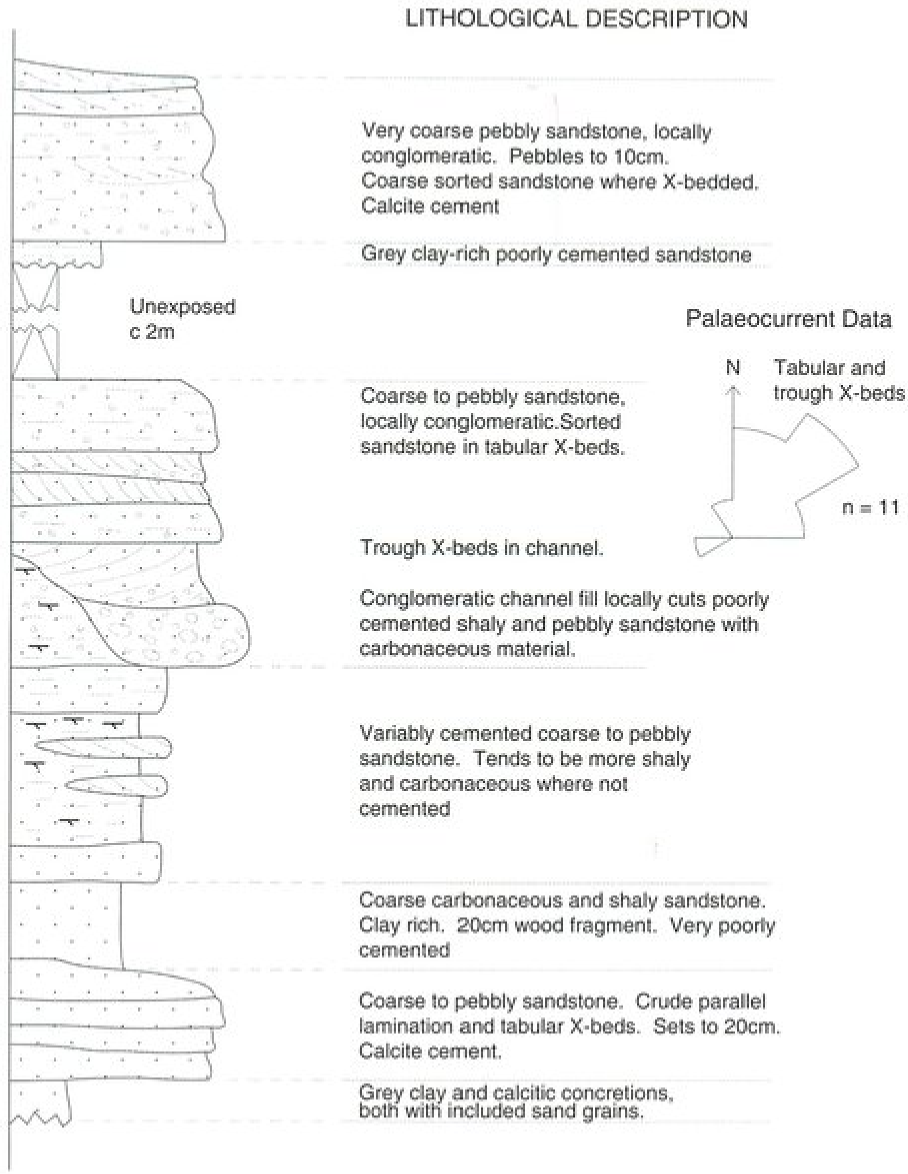
(Figure 1.2) Stratigraphy, lithofacies and environmental interpretation of Triassic and Liassic strata at Golspie (Modified from Batten et al. 1986).



(Figure 1.3) Cut section of caliche limestone from the top of the Triassic section. Specimen from Golspie Glen.



(Figure 2) Basic stratigraphic framework and relevant excursions.



(Figure 1.4) Log of the Dunrobin Pier Conglomerate Member (Modified from Batten et al. 1986).