Chapter 1 Dalradian

(Table 2)

Excursion 2 The Highland Border Complex

Excursion 4 Comrie Igneous Complex

Within the area covered by the guide book the oldest rocks present belong to the Dalradian Supergroup, a suite of metamophosed sedimentary and igneous rocks, now known to be entirely Precambrian in age (Rogers *et al.* 1989). Much general background information on the Dalradian can be found in Harris and Pitcher (1975) and in Johnson (1991), but the view expressed in both these publications that the Dalradian extends from the Precambrian up into the Cambrian is no longer tenable.

Throughout most of the area the Dalradian sediments consist principally of shales or slates and quartzo-feldspathic grits in which graded bedding is the commonest sedimentary structure. They belong to the Southern Highland Group, the uppermost group of the Dalradian, and have generally been correlated with the Aberfoyle Slates and Ben Ledi Grits of the Perthshire succession. However, in Upper Glen Esk older parts of the Dalradian are developed and extend down to the underlying Tarfside Limestone, assigned to the Argyll Group of the Dalradian (Harte 1979).

Structure

The Dalradian rocks have a broad regional NE–SW strike and have been subjected over a prolonged period of time to more than one phase of folding see (Table 2).

Expressing this in very simple terms: a major, early, recumbent fold, the Tay Nappe of D_1/D_2 age, was overturned to the south-east until the limbs were approximately horizontal. Much later (D_4), this fold, and other similar folds in the South-East Highlands, were refolded so that the front of the Tay Nappe was bent down to the south-east.

This has led to two contrasting structural areas on the ground. Further to the north-west, and lying some kilometres north-west of the Highland Boundary Fault, is the 'flat belt' in which grits and slates are disposed in folds with long, nearly flat, limbs and short, steep limbs. Adjacent to the Highland Boundary Fault is the 'steep belt', an apparently monotonous sequence of steeply dipping grits and slates. The boundary between these two belts is known as the 'down-bend' and marks the axial plane of a major late D_4 fold (Harte *et al.* 1984, figs 3, 4, p. 156).

By using graded bedding to determine the correct way up it has been possible to demonstrate that in the steep belt the rocks are isoclinally folded and, in addition, overturned to the south-east.

On the Stonehaven coast the downbend, the change from the flat belt to the steep belt, takes place over a few hundred metres some 3 km north of the Highland Boundary Fault. South-westwards the downbend gradually diverges from the Highland Boundary Fault until it lies 5–10 km to the northwest, e.g. in the Comrie area.

Harte *et al.* (1984) have summarized in more detail much research work particularly for Glen Esk (Excursion 2), but also for Comrie (Excursion 4) in a geological succession involving an earliest D_1/D_2 set of structures of which the Tay Nappe and the underlying Tarfside Nappe are the principal features in this area. The Tay Nappe is a major recumbent anticline closing to the south-east in which the inverted limb is coincident with the surface of the ground except in Upper Glen Esk where the Tarfside Culmination, a later D_3 or even D_4 structure, has brought up to higher levels the 'right-way-up' rocks of the underlying Tarfside Nappe.

Metamorphism

Not only are the rocks highly folded, they have also undergone major regional metamorphism of varying intensity. It is believed that this developed gradually after the D_2 deformation and reached its peak during the D3 period of deformation. This metamorphism was first described by Barrow (1893, 1912).

The low grade chlorite and biotite metamorphic zones adjacent to the Highland Boundary Fault are rapidly succeeded to the north-west by the garnet, staurolite and kyanite zones and the highest, the sillimanite, zone is recorded on the east coast within 7 km of the fault. This is in marked contrast to the wide metamorphic zones 80 to 150 km to the south-west. Two contributory causes for the narrowness of the metamorphic zones have been recognised. Firstly, the zones, originally near to flat lying, have been rotated through nearly 90° at the D_4 downbend, which is younger than the metamorphism, so that they are now approximately vertical. Secondly, even allowing for the D_4 downbend, Harte *et al.* (1984, pp. 157–8) have drawn attention to the very high thermal gradients pointing to a rapid drop in temperature to the south-east at the time of metamorphism. This they attribute to possible downfaulting on the south-east at that time. The cause of metamorphism is still disputed, but Harte and Hudson (1979, p. 333) suggest that 'regional metamorphic gradients, migmatites and older granite bodies are all related to extensive regional magma intrusion in the deep crust'.

Isotopic age dating has allowed a timetable of events to be worked out, thus permitting correlation of periods of deformation, intrusion of igneous bodies and establishment of metamorphic zones. These are summarized in (Table 2).

During the late D_4 movements retrogressive metamorphism took place, especially near the downbend and the axes of minor D4 folds, white mica, biotite and chlorite being produced (Harte *et al.* 1984, pp. 153–4). More detailed comments on the appearance of the rocks are contained in the itineraries for Excursions 2 and 4.

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Time (My)	*Structures*	*Metamorphism*	*Uplift*	*Igneous Events*
pre 590	D1/D2 Tay and Tarfside Nappe	Low grade		
550				
500	D3	Peak metamorphism	Local in Upper Glen Esk	
450	D4 Highland Border Downbend	Retrogressive Metamorphism	Regional Uplift	
400				Post-tectonic Granites, e.g. Comrie

(Table 2) Dalradian evolution (After Rogers et al. 1989 and Harte et al. 1984).