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## Excursion 3 Dundee to Perth

Time	Whole day
Maps	OS 1:50,000 Sheets 53, 54 GS 1:50,000 Sheets 48W, 48E, 49
Excursion map	(Map 7)
Walking distance	Eight kilometres in all with shore walking at Broughty Ferry (1.5 km) and hill walking at Mount Quarry (3 km) and Dunsinane (1.5 km), the rest largely at quarries. To examine (1) some of the extrusive and intrusive igneous rocks and sediments of the Lower Old Red Sandstone together with (2) the Upper Old Red Sandstone sediments and finally (3) the late-glacial clays of the area lying between Dundee and Perth. From the hill-top localities a good impression of the structural and regional geology can also be obtained.
Purpose	
Route	By A91 to Guardbridge before following A919 through Leuchars to join A92 and then to the Tay Bridge, 16 km. From the bridge follow the signs for A92 to Arbroath for 2.5 km east before following A930 for a further 2.5 km, signposted for Broughty Ferry, to Douglas Terrace with its narrow road bridge over the railway to the south. Dismount at the promenade [NO 455 310] and send the bus back to the roundabout on A930 2 km to the west where it should follow Broughty Ferry Road south and east for 500 m to a lay-by at which the party will rejoin it [NO 435 309].

### 1. Broughty Ferry — Stannergate shore section: volcanics of the Ochil Volcanic Formation

This section affords an opportunity of examining both lavas and volcanoclastic sediments within the Arbuthnott Group of the Lower Old Red Sandstone. The Ochil Volcanic Formation is the lateral equivalent of the sediments of the Dundee Formation and indeed the two are interbedded, e.g. at Wormit (Excursion 5) on the other side of the Tay. Structurally the whole section lies on the south-east side of the Sidlaw Anticline and dips are to the south-east throughout.

Walk west for 50 m to a flight of steps leading down to the shore. At the foot of the steps are displayed outcrops of south-east-dipping basic pyroxene-andesite lavas, the dip being determined by closely spaced (1 cm) joints paralleling the feldspars within the rock. Plagioclase feldspar phenocrysts up to 3 mm long occur within a fine-grained mid- to dark-grey matrix which in thin section can be seen to comprise plagioclase feldspar and pyroxene (Armstrong *et al.* 1985, p. 40).

Return to the promenade and walk 0.5 km west to the slipway [NO 448 310] at Grassy Beach Outdoor Education Resource Centre. Here a vesicular feldsparphyric basalt flow is exposed immediately west of the slip. It is less closely jointed than the andesite at the previous locality and the feldspar phenocrysts are larger and more abundant. Otherwise there is little difference between the two rocks in the field.

Continue along the beach to the west for 200 m to where the promenade is supported on concrete pillars [NO 447 309] above outcrops of pyroxene-andesite, much of which is autobrecciated such that blocks up to 2 m across lie in an unbedded matrix of angular andesite fragments from sand size up to a few centimetres across. In places the finer-grained matrix is green and chloritic. One hundred metres further west a small headland is composed of unbrecciated andesite though further autobrecciation can be seen in the lower parts of the flow in the remaining 40 m of the outcrop to the west. A large brick and concrete beach shelter stands 200 m further west along the coast path and 50

m beyond this to the west are good exposures of volcanic conglomerate. This comprises both rounded and angular clasts up to 50 cm in diameter of vesicular andesite, aphyric andesite and flow-banded andesite in a grey-green chloritic sandy matrix. The bedding is crude and the dip approximately 30° SE. Now walk west again for 400 m to rejoin the bus at the lay-by in Broughty Ferry Road.

From Broughty Ferry Road cross the A930 northwards at the roundabout and follow the A972 signposted for Perth. This joins the Kingsway dual carriageway in 700 m. Follow the Kingsway west for 4 km before leaving it where signposted for Downfield. After 1 km bear half left at a roundabout and continue for 5 km to the farm road leading to North Balluderon [NO 376 387]. From here follow the stony and then grassy road north-west on foot for 1.5 km, with an ascent of 200 m, to reach Mount Quarry, on Cairns Hill in the Sidlaws [NO 363 394].

## **2. Mount Quarry, Sidlaw Hills: sandstones of the Dundee Formation [NO 363 394].**

Twenty-three metres of strata are exposed in the quarry (Armstrong *et al.* 1985, Fig 6 and pp. 16–20). Although cross bedding is recorded from the sandstones it is not conspicuous. Plane bedding, often with micaceous partings, is widespread and many of these show current lineation and, in places, evidence of the sandstones sinking into the underlying siltstones; 'ball and pillow' structure resulting from this is widespread and is often well seen in loose blocks on the spoil heaps. Rip-up siltstone clasts are not uncommon in the sandstones. The siltstones display thin sandy partings, starved ripples and ripple cross bedding. Small plant fragments are common and *Parka decipiens* is present.

Armstrong *et al.* (1985) interpreted this type of sequence as in part lacustrine and, where coarsening upward sequences are present, as fluvial, the siltstone clasts being eroded from earlier overbank deposits.

As in all quarries care should be taken when examining the faces and a safety helmet should be worn. Much useful information can be obtained safely from loose blocks.

The south-west end of the quarry is in basic porphyrite, grey-brown in hand specimen, medium grained with scattered vesicles up to 3 cm across and occasionally chlorite filled. Under the microscope such rocks usually comprise labradorite feldspar and clinopyroxene. The rock which is columnar jointed is cut off to the south-east by a north-east-trending vertical fault which is well displayed at the south-west end of the quarry. Slickensides on the fault face are mainly horizontal; some are oblique.

On a clear day there is an excellent view to the south from the quarry edge. In the middle distance Dundee Law and Balgay Hill, porphyrite bodies, are conspicuous. To the southwest are the Braes of the Carse comprising, nearest, the Rossie Priory porphyrite sill (Location 4) and, beyond, volcanics of the Ochil Volcanic Formation standing high above the Carse of Gowrie. The Carse is underlain by Upper Old Red Sandstone sediments belonging to the Clashbenny Formation (Location 3), largely covered by the Quaternary Errol Beds (Location 7) and Carse Clays. Beyond the Tay Estuary the Ochil Volcanic Formation, dipping south-east, makes up the North Fife Hills on the far side of the Sidlaw Anticline. Further south still, the peaks of the East and West Lomonds are composed of Carboniferous volcanic plugs (Excursion 16). In the low ground of East Fife the underlying Carboniferous sediments are largely covered by glacial till.

Return by the same route to the bus and drive west through Kirkton of Auchterhouse to join the B954 and travel south to Muirhead. Just beyond the junction with A923 turn south and then west to Liff. In the village turn south for 200 m then west for 500 m to the Den of Fowlis [NO 328 326] and park the bus 100 m beyond the narrow bridge at the modern harled white cottages.

## **3. Den of Fowlis: Upper Old Red Sandstone Clashbenny Formation [NO 328 326]**

In the Carse of Gowrie the Clashbenny Formation is not seen in contact with the underlying Lower Old Red Sandstone. It is let down between the North and South Tay Faults in a graben within the older Sidlaw Anticline and indeed, although the bright red soils over the Clashbenny Formation are widely known in the Carse of Gowrie, there are few good exposures.

The Clashbenny Formation is exposed in a small stream which joins the main burn in the Den of Fowlis. It is reached from the corner of the field west of the Den and lies just 10 m south of the road. Within the wood 30 m of the bed of the minor stream consists of bright red, thin-bedded, soft, fine-grained, sometimes gritty, sandstones. They dip at 15° SE and lie a short distance south of an E–W fault within the Tay Graben.

Now take the bus west for 300 m, south for 400 m and then travel west for 3 km to join the road to Knapp and after 1.5 km park the bus at the beginning of a track leading to the premises of Knapp Farm Buildings Limited. These stand in a quarry.

#### **4. Hilton of Knapp Quarry [NO 282 317]: basic porphyrite**

Walk up the road and seek permission to enter at Quarryknowe, the house at the entrance to the quarry. Entry is at one's own risk. The quarry has been excavated in the major Rossie Priory basic porphyrite sill which extends 8 km north from Rossie Hill to Adamston Wood. Armstrong *et al.* (1985, p. 42) reported that chemical analyses of such porphyrites show them to be chemical equivalents of the basic andesite lavas of the Lower Old Red Sandstone. They describe these rocks as of 'doleritic aspect' (*ibid.* p. 44).

The rock at the quarry entrance shows good spheroidal weathering, is massive with poorly developed columnar jointing, and grey in colour when fresh. Balsillie (1934, pp. 135–7) described the rock as a hypersthene-dolerite with the hypersthene inconspicuous in hand specimen. Pink segregation veins, a few tens of centimetres thick and often coarse grained, occur with conspicuous, often albitised, feldspars and with interstitial quartz. Pyroxenes originally present are usually replaced by chlorite.

Return to the bus and drive 3 km north-west and west to join B953. Follow this west for 4 km before turning north-west for 800 m to the large Collace Quarry. (Permission to enter should be obtained from the Roads Department, Tayside Region Offices, Dundee). This part of B953 runs along a WSW-trending strike valley flanked on the north-west side by the steep scarp slopes, in Black Hill and Dunsinane, of the strati-graphically highest part of the Ochil Volcanic Formation, here comprising pyroxene-andesites and overlying sediments of the Arbuthnott Group. Such sediments also bottom the valley while the south-east side of the valley is composed of the dip slopes of pyroxene-andesites also dipping north-west into the Strathmore Syncline.

#### **5. Collace Quarry [NO 208 316] and Dunsinane [NO 214 317]: basalt of the Ochil Volcanic Formation and view of Strathmore**

Collace Quarry is cut into a single 40 metres thick pyroxene-andesite flow, very dark grey in colour and feldsparphyric. Olivine phenocrysts are usually replaced by serpentine and iron oxide, and flow banding parallel to the top of the flow can be seen on weathered surfaces. Fault surfaces within the flow show chlorite development.

Using the footpath that starts from the south side of the quarry ascend to the summit of Dunsinane, one of the vitrified forts of Scotland and one which receives a mention in Shakespeare's *Macbeth*. The summit furnishes an excellent view of the surrounding countryside and its geology. To the east the dip and scarp slopes of the volcanics of the Ochil Volcanic Formation can be seen on Black Hill while to the north-west the ground drops down-dip at 15–20° into the Strathmore Syncline, underlying Strathmore. There the lavas pass beneath younger sediments belonging to the Garvock Group and the topmost group of the Lower Old Red Sandstone, the Strathmore Group. The Syncline is asymmetrical so that when the volcanic rocks of the Arbuthnott Group reappear on the north-west side they are either very steeply dipping to the south-east or are even overturned. Beyond the Highland Boundary Fault, on the north-west side of Strathmore, rocks of the Old Red Sandstone unconformably overlie the Dalradian metamorphic rocks (Excursion 2). In clear weather the higher hills beyond the Highland Boundary Fault, comprising Dalradian metamorphic rocks, can be seen.

Now take the bus back to rejoin B953 and follow this for 5 km south-west to Balbeggie and then south-west on A94 for 6 km to Perth. There cross the River Tay and follow the A912 south for 1.5 km to an unclassified road on the west leading to Friarton Quarry belonging to Wimpey Asphalt, which company should be contacted at Barnton Grove, Edinburgh for

permission to enter the quarry (helmets required).

## **6. Friarton Quarry [NO 116 212]: basic pyroxene-andesite lavas, inter-bedded sediments and Late-Carboniferous dykes**

From the office follow the quarry road on foot south-west uphill to the higher levels of the quarry in which the lavas are cut by a 35 m thick E–W Late-Carboniferous quartz-dolerite dyke. In the lower, northern part of the quarry a 2–3 m thick Carboniferous tholeiite dyke forms part of the north face of the quarry and is also conspicuous in the east face. The lavas which occupy most of the north face of the quarry are brecciated adjacent to the tholeiite dyke, the breccia being cemented mainly by pink calcite. On the north side of the dyke in the east end of the quarry the lavas overlie at least 3 m of ripple-cross-bedded purplish and greenish siltstones with sandy partings, much of the material being derived from erosion of nearby volcanics. The dip is 15° NW.

In the highest part of the quarry the most conspicuous feature is the 35 m thick quartz-dolerite dyke (Armstrong *et al.* 1985, pp. 57–61). On the south side of the dyke the sediments underlying the lavas are again well exposed in the south-east corner of the quarry. Granules of lava occur in cross-bedded sandstones interbedded with siltstones. Rip-up siltstone clasts occur too. The basal 50 cm of the lowest flow has incorporated much sediment, though locally the contact is sharp.

The E–W quartz-dolerite dyke is well exposed in the east side of the quarry in the upper level and displays very coarse, horizontal, columnar jointing which becomes much more closely spaced approaching the margins. In hand specimen the rock is greenish-grey in colour, medium grained with plagioclase feldspar and augite conspicuous on the surface. The chilled margins are noticeably finer grained and darker in colour and are tholeiitic.

Armstrong *et al.* (1985, p. 57) have summarised the age data for such dykes as 290–295 My or late Westphalian to early Stephanian (= late Carboniferous). Francis (1991, p. 407), depending on the timescale used, has applied the term Carboniferous–Permian to the suite of intrusions to which these dykes belong. Under the microscope the rocks comprise plagioclase feldspar, augite, pseudomorphs after olivine or hypersthene and a glassy residuum. The tholeiites under the microscope usually have a more glassy matrix while the quartz-dolerites have few or no olivine pseudomorphs (after Armstrong *et al.* 1985, p. 59). Pink more feldspathic lenses are occasionally exposed in the quartz-dolerite.

From the high ground south-east of the quarry the form of the Sidlaw Anticline can be clearly seen to the south-east. The scarp slopes of NW-dipping lavas and conglomerates form Kinnoul and Kinfauns Hills on the north side of the Tay while 15–25 km to the east the scarp slopes of the lavas of the North Fife Hills belong to the south-east limb of the anticline. The intervening low ground of the Carse of Gowrie comprises mainly Upper Old Red Sandstone sediments, let down between the North and South Tay Faults, overlain by Quaternary sediments of the Tay Estuary. Northwards the view across Perth and Strathmore is similar to that from Dunsinane.

From Friarton Quarry drive back to the main A912 road, and return through Perth; cross the River Tay and join A93 to travel southwards before passing the foot of Kinnoul Hill with its spectacular cliffs of volcanic conglomerates at the base and andesite lavas above, all dipping north-west towards Strathmore. At the north end of Friarton Bridge follow A90 east for 7 km before following the unclassified road signposted for Errol through Pitfour for 2 km to Gallowflat on the south side of the road [NO 212 207]; the clay pit lies some 500 m south-east down the farm road beyond the farm buildings.

## **7. Gallowflat Claypit: Errol Beds, Late Devensian Quaternary [NO 212 207]**

This locality affords an opportunity of examining the late-glacial marine clays, the Errol Beds, formerly known as the 'Arctic Clays' on account of the polar aspect of the fauna collected in the clays of the same age at Errol 4 km further east.

The reddish-brown clays have been subdivided at Errol on the basis of both lithology and faunas, principally of foraminifera, e.g. *Elphidium* spp. and ostracods, a variety of molluscs of arctic aspect and arctic seal. Being further up the estuary the Gallowflat Pit has yielded a sparser fauna. Some 5 m of clays and silts are exposed in the pit; bedding can be

picked out after weathering and small calcareous nodules are scattered through the clay.

Of considerable interest are the dropstones of various Old Red Sandstone volcanics such as andesites, some autobrecciated, and metamorphic rocks including epidiorites, 'grits' and quartz-veined schists. These dropstones range up to 1.6 m across, though most are much smaller, and many are striated. They are interpreted as stones dropped from floating ice, calving from an ice front a few kilometres to the west, and melting in the marine waters of the Tay Estuary. More detailed accounts of the sediments are to be found in Paterson *et al.* (1981), Armstrong *et al.* (1985) and Duck (1990).

To return to St Andrews most directly drive back to the Pitfour–Errol road, cross it and take the minor road leading through Leetown then north-west to A90, back to Dundee and thence via the toll bridge to St Andrews.

Alternatively follow the Errol road through Errol and Kingoodie to Dundee and St Andrews.

Both roads cross the Carse of Gowrie which has few exposures. Most of the Carse is immediately underlain by Quaternary clays (see the chapter on the Quaternary) and below that the Upper Old Red Sandstone Clashbenny Formation, bright red sandstones which form the gentle 'inches' or islands which stood slightly above the peat which at one time covered much of the Carse. The Tay Estuary lies to the south and beyond it are the North Fife Hills of Lower Old Red Sandstone volcanics, e.g. Norman's Law (Excursion 7); they dip south-east and match those dipping north-west in the Sidlaw Hills to the north-west.

## References

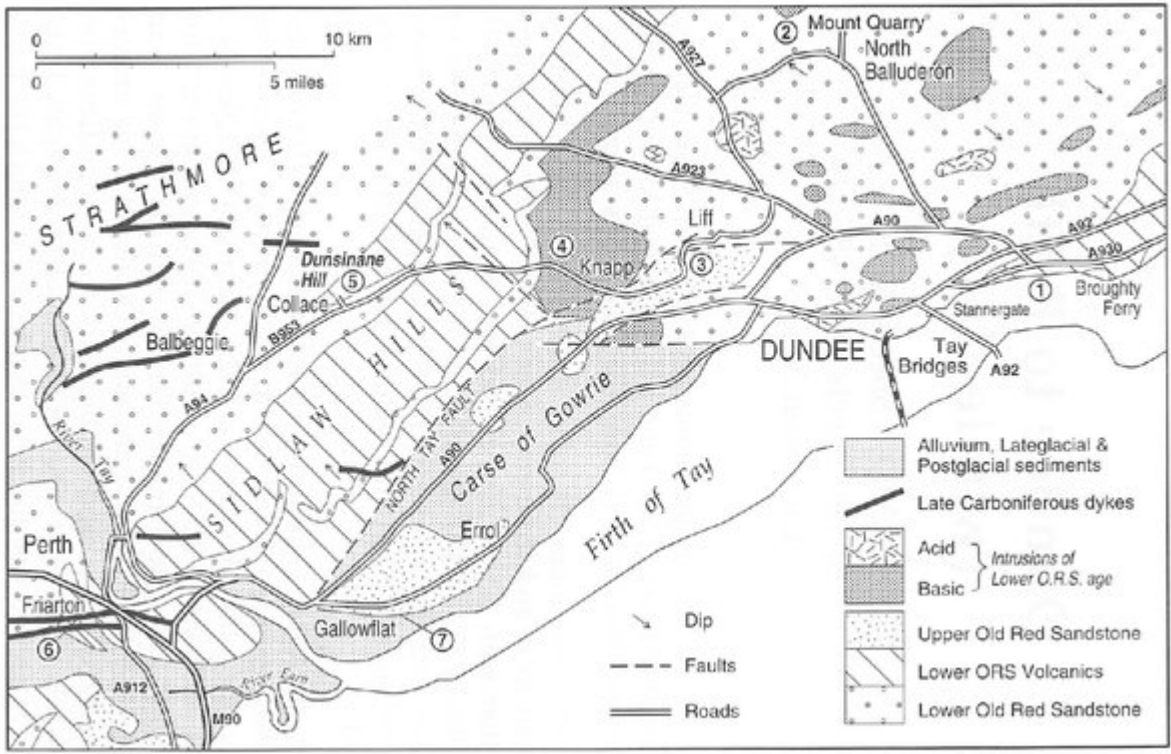
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(Map 7) Dundee and Perth district.