TILLICOULTRY

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Introduction

The cliffs, ravines and hillside exposures associated with the Ochil Fault scarp around Tillicoultry display four diorite stocks that intrude related lavas and volcaniclastic rocks of the Lower Old Red Sandstone, Ochil Volcanic Formation within a 6 × 1 km thermal aureole (Figure 9.31). The stocks are cut by members of a contemporaneous radial dyke-swarm (Figure9.32) and are truncated by the Ochil Fault. They are also cut by the late Carboniferous quartz-dolerite fault intrusion (Figure 9.33). The diorites are notable for their locally heterogeneous and hybrid character and show both sharp and diffuse contacts with the hornfelsed country rocks. The diffuse contacts, reflecting contamination of the magma by incorporation of xenolithic material, are well seen in the deeply incised Harviestoun Glen where a number of poorly defined enclaves of hornfelsed volcanic rock are apparently disposed in layers within the diorite.

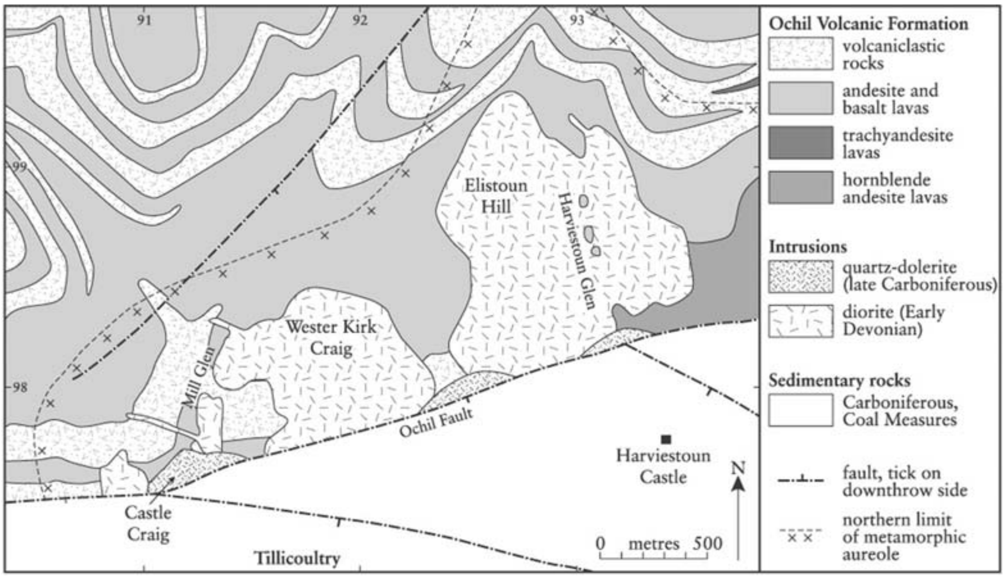

Figure 9.31: Map of the Tillicoultry GCR site. The general succession is similar to that shown on Figure 9.27.

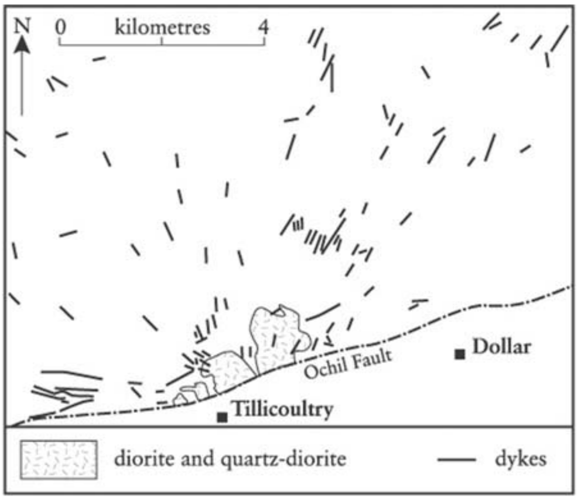

Figure 9.32: Sketch-map showing radial disposition of dykes relative to diorite stocks in the Ochil Hills, after Francis et al. (1970).

Figure 9.33: Castle Craigs Quarry, Tillicoultry. The quarry is along the line of the Ochil Fault plane; the back face exposes hornfelsed lavas and volcaniclastic conglomerates of the Ochil Volcanic Formation and the crags on the left are quartz-dolerite of the late-Carboniferous fault intrusion. (Photomosaic: M.A.E. Browne.)

Description

The diorite stocks are intruded into basalt and andesite lavas and volcaniclastic rocks of similar character to those in the nearby Sheriffmuir Road to Menstrie Burn GCR site. There are four masses of diorite; from west to east these are Castle Craig, Mill Glen, Wester Kirk Craig and Elistoun Hill. They are about 30–135 m apart and each is cut off to the south by the Ochil Fault. The Castle Craig and Mill Glen stocks are about 200 m in diameter, the latter with a 350 × 30 m westward-trending dyke-like extension, whereas those at Wester Kirk Craig and Elistoun Hill are 1050 m and 1250 m in diameter respectively. The diorites range in grain-size and colour from fine grained and grey to coarse grained and blue-grey or green with pink mottling. Transitions in grain-size occur on a metre scale and, although margins tend to be of fine-grained grey diorite, the latter's occurrence is not confined to contact zones. The heterogeneous nature of the diorites is further accentuated by the presence of numerous country-rock xenoliths, especially near to margins. As a consequence of the presence of xenoliths, there are only a few localities where the margins of the diorites are sharply defined. Where seen, the walls of the intrusions are vertical or highly inclined outwards. This suggests that the four masses may converge and unite at depth.

The Castle Craig diorite is fine- to medium-grained, with xenoliths of volcanic rock generally confined to the contact zone, some showing various stages of transition from hornfelsed lava to diorite. The Mill Glen rock is coarse grained and is mottled-pink and bluish-green. The dyke-like apophysis varies from fine- to coarse- grained, reflecting the presence of a chilled margin. The Wester Craig diorite is variable, being fine- to medium-grained in the north and west and coarser and of the mottled-pink form elsewhere. The Elistoun rock is also fine- to medium-grained in the west but is usually coarse grained elsewhere. It exhibits the best examples of rapid transition from hornfelsed lava into coarse-grained diorite.

The petrography of the diorites has been described byFrancis *et al*. (1970). They are composed largely of plagioclase feldspar with varying proportions of ferromagnesian minerals (clinopyroxene, orthopyroxene, amphibole and biotite), and with sufficient quartz to classify them as quartz-diorites. The coarse-grained diorites may be subdivided into four types, three of which are present in the GCR site. A two-pyroxene diorite with little amphibole occurs within all of the Tillicoultry stocks and a variant with uralitic amphibole but little pyroxene occurs in several. A granodioritic variant, with pink potash-feldspar and no pyroxene, is restricted to parts of the Mill Glen stock and its dyke-like apophysis. Francis described the fine-grained diorites as grey, saccharoidal rocks sharing many of the characteristics of both hornfelsed country rocks and coarse-grained diorites. In varieties most closely related to the hornfelsed lavas, plates of biotite are the only fresh ferromagnesian mineral. These fine-grained variants present some of the best evidence for the formation of some of the diorites by metamorphism of the country-rock lava. In general, the petrographical differences between the igneous and metamorphic/metasomatic varieties are that the former are relatively rich in quartz and potash-feldspar, whereas the latter tend to be richer in pyroxene.

Pink aplitic veins and segregation patches in the diorites and aureole are clearly a late-stage magmatic event. Diorites cut by the aplites show contact alteration but the veins themselves are not chilled and have gradational contacts with the host rock. Similar gradational contacts have been noted with some of the hornfelsed volcanic rocks.

Numerous small andesitic dykes (‘porphyrites' and ‘plagiophyres' on old maps) show a radial disposition relative to the diorite stocks (Francis *et al*., 1970) (Figure 9.32). Many are similar in composition to the lavas, consisting of olivine basalts, pyroxene- and hornblende-phyric andesites, trachyandesites and albitized equivalents. Within the diorites, the dykes usually have irregular, gradational and unchilled contacts, indicating near-contemporaneity and their radial distribution probably reflects the stress pattern generated by emplacement of the stocks.

The diorite stocks all occur within a single extensive thermal metamorphic aureole that is always at least 300 m wide. The degree of alteration of the country rocks depends on their permeability and their distance from the diorite. The volcaniclastic rocks and autobrecciated lavas are generally more permeable and they alter to pale-pink, grey or even greenish-grey, partly amorphous rocks. The outlines of clasts become indistinct at an early stage of alteration and pink feldspar porphyroblasts develop. Amygdales in lavas recrystallize to ill-defined pink patches. Some lavas become hackly-looking and, when traced into the diorite, they pass through massive hornfels into metasomatically produced fine-grained diorite.

Interpretation

There seems little doubt that the diorite bodies are genetically linked to the extrusive rocks into which they are emplaced. They are probably of similar age, accepting the radiometric age of 411.4 ± 5.6 Ma for a related small olivine diorite body at Glenfarg, about 20 km to the ENE of Tillicoultry, and of 416.1 ± 6.1 Ma for an andesite lava flow at NN 835 019 just north of the Sheriffmuir Road to Menstrie Burn GCR site (Thirlwall, 1983b, 1988). These, together with other dates from the north Midland Valley, suggest that the late Caledonian volcanic activity in this area occurred during the limited interval of 415–410 Ma (see theBalmerino to Wormit GCR site report).

Large strips of vaguely defined hornfelsed country rock that crop out in the floor of Harviestoun Glen are possibly enclaves within the Elistoun diorite. These enclaves and their associated hybridization underlie non-hybridized, coarse-grained diorite, giving a sub-horizontal layered effect and Francis *et al*. (1970) recorded that the diorites here show differences in composition from one layer to another. Further evidence of hybridization (and metasomatism) cited by Francis *et al*. (1970) is the presence of 'ghost' scarp-featuring inherited from the subsumed lavas on Elistoun Hill. The 'ghosts' dip at about 10° to the NW in conformity with the regional dip of the rocks of the Ochil Volcanic Formation. Francis*et al*. also noted the way in which different topographical and weathering features may be used to map the generally narrow hybridized zones that delimit the outcrop of the diorites; the lava crags are more angular and the non-hybrid diorite crags are more rounded and massive.

Conclusions

The importance of this GCR site lies in the excellent exposures of the late Caledonian diorites that are intruded into the lavas and volcaniclastic sedimentary rocks of the Ochil Volcanic Formation. These include purely magmatic quartz-diorites and hybridized pyroxene-rich diorites. The changes caused by thermal metamorphism of the country rocks are also a feature. In particular the often diffuse contacts between the altered country rocks (hornfels) and the diorites, with ghost-like features within the hybridized diorites, contrasts with those where wholly magmatic diorite is in sharp contact with country rock. It may be concluded that the diorites were emplaced partly by simple intrusion and assimilation, with radial fracturing of the surrounding rocks, and partly by metasomatic replacement of country rocks.

Reference list

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