

# PITTODRIE

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## Highlights

At Pittodrie, a small pit shows an exposure of decomposed granite bedrock which has undergone relatively advanced chemical weathering during pre-glacial times. It provides valuable information for interpreting the longer-term geomorphological evolution of north-east Scotland and shows the limited effects of glacial erosion in this area.

## Introduction

The site at Pittodrie (NJ 693245), 30 km north-west of Aberdeen, is a small exposure at c. 180 m OD at the foot of Bennachie, a granite hill with good examples of tors at its summit (518 m O.D). It shows kaolinized granite containing a hematite/layer-silicate clay mineral, macaulayite, known only from this locality (Wilson *et al.*, 1981, 1984). The weathering of the granite probably occurred during the late Tertiary (Hall, 1985; Hall *et al.*, 1989a). Additional interest in the site is provided by the excellent examples of downslope flaring of bedrock structures as a result of mass movement under former periglacial conditions.

## Description

The section is up to 4 m high and shows 3–4 m of friable weathered granite overlain by 1–2 m of stoney and sandy solifluction deposits, on which a podsollic soil profile has developed (Figure 8.3).



Figure 8.3: Weathered granite at Pittodrie overlain by soliflucted deposits. (Photo: J. E. Gordon.)

The parent rock at the site is a leucogranite consisting of quartz, K-feldspar and subsidiary mica. The rock has generally weathered to a friable, clayey, silty sand in which bedrock structures, such as joints and quartz veins, are still clearly visible. The weathered granite is usually white to light brown, but also shows striking zones of bright red mottling. Kaolinite and illite are the dominant clay minerals and the rock is strongly depleted of more soluble bases but

retains approximately 3.0% K<sub>2</sub>O owing to the survival of partially altered grains of K-feldspar. Occasional patches of harder rock coincide with zones of relatively quartz-rich granite.

In situ weathered rock is overlain by about 0.5 m of banded growan (cf. Brunsden, 1964) in which vertical bands of white, pink and red weathered granite have been bent or flared downslope in response to former solifluction. This layer is overlain by up to 1.5 m of dark-brown, soliflucted till. The soliflucted till has a high content of basic igneous clasts, indicating original deposition by ice impinging on the hill from the west.

## Interpretation

The Pittodrie site was mentioned as an example of weathered rock of pre-glacial age by FitzPatrick (1963) and Glentworth and Muir (1963). However, the only detailed descriptions of the exposure are those by Wilson *et al.* (1981) and Hall (1983).

Wilson *et al.* (1981, 1984) demonstrated the existence of a previously undescribed swelling hematite/layer-silicate complex, now formally named as macaulayite, in rubefied zones in the weathered granite. They suggested that the mineral formed in pre-glacial or interglacial times, when iron was complexed at higher, subsequently eroded, levels in the weathering profile and passed down joint planes to be oxidized at depth.

Hall (1983) and Hall *et al.* (1989a) described the site in more general terms and gave data on granulometry, geochemistry and clay mineralogy. Hall allocated the Pittodrie site to his 'clayey grus weathering type', a type of intense kaolinitic weathering found at only a few sites in north-east Scotland. Comparisons with the mineralogy of North Sea drill holes (Karlsson *et al.*, 1979) suggests that the clayey gruses are of Miocene to middle Pliocene age (Hall, 1985; Hall *et al.*, 1989a).

The possibility that the observed weathering features are a result of hydrothermal alteration has still to be fully considered. This origin is suggested by the brief reference of Wilson and Hinxman (1890) to a 'segregation vein' in the granite in the vicinity of Pittodrie.

The intensity of weathering at Pittodrie is far in excess of that usually found in weathered granites in north-east Scotland. Comparable kaolinitic alteration is currently exposed at only a small number of other sites in Buchan, where it is generally confined to quartz schist parent rocks (Hall, 1983; Hall *et al.*, 1989a).

Deep weathering of granite and other rocks is widespread in north-east Scotland (Pemberton and Simpson, 1949; FitzPatrick, 1963; Hall, 1985, 1986, 1987; Auton and Crofts, 1986; Munro, 1986; Hall *et al.*, 1989a) and is generally ascribed to a pre-glacial or interglacial period. The degree of preservation of deep weathering despite multiple glaciation is remarkable and is matched in only a few other formerly glaciated areas around the North Atlantic (Hall, 1984b, 1985). The weathering has considerable geomorphological significance:

1. The survival of weathered rock has been used as evidence of minimal glacial erosion in north-east Scotland (Clayton, 1974) and to identify local variations in the intensity of such erosion (Hall, 1983, 1985; Hall and Sugden, 1987; Sugden, 1989). Such studies have significant potential for elaborating the basal processes and dynamics of former mid-latitude ice-sheets (Sugden, 1989).
2. Analysis of the mineralogy of the weathered rock has provided important information on former weathering environments (Basham, 1974; Wilson and Tait, 1977; Hall, 1983; Hall *et al.*, 1989a).
3. The characteristics and distribution of the weathering have been used to investigate long-term landscape evolution in the region (Hall, 1983, 1986, 1987, 1991).

North-east Scotland, particularly the Buchan district, has therefore become an important area for the study of weathering and landform development in formerly glaciated regions (see Hill of Longhaven Quarry). Pittodrie provides a rare example of rubefied and kaolinitic weathered granite and it has supplied important information on pre-glacial or interglacial weathering environments. Pittodrie is also the only known locality for the clay mineral macaulayite.

## Conclusions

Pittodrie is a reference site for deeply weathered bedrock, one of the characteristic features of the geomorphology of north-east Scotland. It shows a relatively intense type of weathering in granite represented at only a few sites in the area, and it is the only known location for a particular type of clay mineral. The decomposed bedrock, considered to be the product of pre-glacial weathering, is important for interpreting geomorphological processes during the landscape evolution of north-east Scotland. Its preservation is also significant in demonstrating a relatively low degree of glacial erosion in this area during the Quaternary ice ages.

## Reference list

- Auton, C.A. and Crofts, R.G. (1986) The sand and gravel resources of the country around Aberdeen, Grampian Region. Description of 1:25,000 resource sheets NJ71, 80, 81 and 91 with parts of NJ61, 90 and 92 and with parts of NO89 and 99. *Mineral Assessment Report of the British Geological Survey*, No. 146, 46pp + appendices.
- Basham, J.R. (1974) Mineralogical changes associated with deep weathering of gabbro in Aberdeenshire. *Clay Minerals*, **10**, 189–202.
- Brunsdon, D. (1964) The origin of decomposed granite on Dartmoor. In *Dartmoor Essays* (ed. I.G. Simmons). Torquay, the Devonshire Association for the Advancement of Science, Literature and Art, 97–116.
- Clayton, K.M. (1974) Zones of glacial erosion. *Institute of British Geographers Special Publication*, **7**, 163–176.
- FitzPatrick, E.A. (1963) Deeply weathered rock in Scotland, its occurrence, age and contribution to the soils. *Journal of Soil Science*, **14**, 33–43.
- Glentworth, R. and Muir, J.W. (1963) The soils of the country round, Aberdeen, Inverurie and Fraserburgh. (Sheets 77, 76 and 87/97). *Memoirs of the Soil Survey of Great Britain*. Edinburgh, HMSO, 371pp.
- Hall, A.M. (1983) Deep weathering and landform evolution in north-east Scotland. Unpublished PhD thesis, University of St Andrews.
- Hall, A.M. (1984b) Introduction. In *Buchan Field Guide* (ed. A.M. Hall). Cambridge, Quaternary Research Association, 1–26.
- Hall, A.M. (1985) Cenozoic weathering covers in Buchan, Scotland and their significance. *Nature*, **315**, 392–5.
- Hall, A.M. (1986) Deep weathering patterns in north-east Scotland and their geomorphological significance. *Zeitschrift für Geomorphologie*, NF, **30**, 407–22.
- Hall, A.M. (1987) Weathering and relief development in Buchan, Scotland. In *International Geomorphology 1986*. Part II. (ed. V. Gardiner). Chichester, John Wiley and Sons Ltd, 991–1005.
- Hall, A.M. (1991) Pre-Quaternary landscape evolution in the Scottish Highlands. *Transactions of the Royal Society of Edinburgh. Earth Sciences*, **82**, 1–26.
- Hall, A.M. and Sugden, D.E. (1987) Limited modification of mid-latitude landscapes by ice sheets. *Earth Surface Processes and Landforms*, **12**, 531–42.
- Hall, A.M., Mellor, A.M. and Wilson, M.J. (1989a) The clay mineralogy and age of deeply weathered rocks in north-east Scotland. *Zeitschrift für Geomorphologie*, NF, Supplementband, **72**, 97–108.
- Karlsson, W., Vollsett, J., Bjørlykke, K. and Jørgensen, P. (1979) Changes in mineralogical composition of Tertiary sediments from North Sea wells. *Proceedings of the VIth International Clay Conference*, **27**, 281–9.
- Munro, M. (1986) Geology of the country around Aberdeen. *Memoir of the British Geological Survey*, 1:50,000 Sheet 77 (Scotland). London, HMSO, 124pp.
- Phemister, T.C. and Simpson, S. (1949) Pleistocene deep-weathering in north-east Scotland. *Nature*, **164**, 318–9.
- Sugden, D.E. (1989) Modification of old land surfaces by ice sheets. *Zeitschrift für Geomorphologie*, NF, Supplementband **72**, 163–72.
- Wilson, J.S.G. and Hinxman, L.W. (1890) Explanation of Sheet 76. Central Aberdeenshire. *Memoirs of the Geological Survey of Scotland*. Edinburgh, HMSO, 43pp.
- Wilson, M.J. and Tait, J.M. (1977) Halloysite in some soils from north-east Scotland. *Clay*

*Minerals*, **12**, 59–66.

Wilson, M.J., Russell, J.D., Tait, J.M., Clark, D.R., Fraser, A.R. and Stephen, I. (1981) A swelling haematite/layer-silicate complex in weathered granite. *Clay Minerals*, **16**, 261–78.

Wilson, M.J., Russell, J.D., Tait, J.M., Clark, D.R. and Fraser, A.R. (1984) Macaulayite, a new mineral from north-east Scotland. *Mineralogical Magazine*, **48**, 127–9.