British Tertiary Volcanic Province

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References

Agrell, S.O. (1965) Polythermal metamorphism of limestones at Kilchoan, Ardnamurchan. *Mineralogical Magazine*, **34** (Tilley Volume), 1–15.

Allwright, A.E. (1980) The structure and petrology of the Tertiary volcanic rocks of Eigg, Muck and Canna, N.W. Scotland. Unpublished M.Sc. thesis, University of Durham.

Allwright, A.E. and Hudson, J.D. (1982) The Sgùrr of Eigg. *Journal of the Geological Society of London*, **139**, p. 215 (abstract).

Almond, D.C. (1960) The Tertiary igneous geology of Strathaird, Skye. Unpublished Ph.D. Thesis, University of Durham.

Almond, D.C. (1964) Metamorphism of Tertiary lavas in Strathaird, Skye. *Transactions of the Royal Society of Edinburgh*, **65**, 413–34.

Anderson, E.M. (1936) Dynamics of formation of cone-sheets, ring-dykes and cauldron-subsidences. *Proceedings of the Royal Society of Edinburgh*, **61**, 128–57.

Anderson, F.W. and Dunham, K.C. (1966) *The Geology of Northern Skye*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Anderson, J.G.C. (1945) The Dalradian rocks of Arran. *Transactions of the Geological Society of Glasgow*, **20**, 264–86.

Argyll, Duke of (1851) On Tertiary leaf-beds in the Isle of Mull. With a note on the vegetable remains from Ardtun Head by Prof. E. Forbes. *Quarterly Journal of the Geological Society of London*, **7**, 89–103.

Bailey, E.B. (1914) The Sgùrr of Eigg. *Geological Magazine (Decade 6)*, **1**, 296–305.

Bailey, E.B. (1926) Domes in Scotland and South Africa: Arran and Vredefort. *Geological Magazine*, **63**, 481–95.

Bailey, E.B. (1945) Tertiary igneous tectonics of Rhum (Inner Hebrides). *Quarterly Journal of the Geological Society of London*, **100** (for 1944), 165–91.

Bailey, E.B. (1954) Relations of Torridonian to Durness Limestone in the Broadford–Strollamus district of Skye. *Geological Magazine*, **91**, 73–8.

Bailey, E.B. (1956) Hebridean notes: Rhum and Skye. *Liverpool and Manchester Geological Journal*, **1**, 420–6.

Bailey, E.B. and Anderson, E.M. (1925) *The Geology of Staffa, Iona and western Mull*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Bailey, E.B., Clough, C.T., Wright, W.B. *et al.* (1924) *Tertiary and Post-Tertiary Geology of Mull, Loch Aline and Oban*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Barrow, G. (1888) *The Geology of North Cleveland*. Memoir of the Geological Survey of Great Britain, HMSO, London.

Beckinsale, R.D. (1974) Rb–Sr and K–Ar age determinations and oxygen isotope data for the Glen Cannel granophyre, Isle of Mull, Argyllshire, Scotland. *Earth and Planetary Science Letters*, **22**, 267–74.

Beckinsale, R.D., Pankhurst, R.J., Skelhorn, R.R. *et al.* (1978) Geochemistry and petrogenesis of the early Tertiary lava pile of the Isle of Mull, Scotland. *Contributions to Mineralogy and Petrology*, **66**, 415–27.

Bédard, J.H., Sparks, R.S.J., Renner, R. *et al.* (1988) Peridotite sills and metasomatic gabbros in the Eastern Layered Series of the

Rhum complex. *Journal of the Geological Society of London*, **145**, 207–24.

Bell, B.R. (1982) The evolution of the Eastern Red Hills Tertiary igneous centre, Skye, Scotland. Unpublished Ph.D. Thesis, University of London.

Bell, B.R. (1983) Significance of ferrodioritic liquids in magma mixing processes. *Nature*, **306**, 323–7.

Bell, B.R. (1984a) The basic lavas of the Eastern Red Hills district, Isle of Skye. *Scottish Journal of Geology*, **20**, 73–86.

Bell, B.R. (1984b) The geochemistry of Lower Tertiary basic dykes in the Eastern Red Hills district, Isle of Skye, and their significance for the proposed magmatic evolution of the Skye Centre. *Mineralogical Magazine*, **48**, 365–72.

Bell, B.R. (1985) The pyroclastic rocks and rhyolitic lavas of the Eastern Red Hills district, Isle of Skye. *Scottish Journal of Geology*, **21**, 57–70.

Bell, B.R. and Emeleus, C.H. (1988) A review of the silicic pyroclastic rocks in the British Tertiary Volcanic Province. In *Early Tertiary Volcanism and the Opening of the NE Atlantic*, (eds A.C. Morton and L.M. Parson), Geological Society Special Publication, No. 39, pp. 365–80.

Bell, B.R. and Harris, J.W. (1986) *An Excursion Guide to the Geology of the Isle of Skye*. Geological Society of Glasgow, 317 pp.

Bell, J.D. (1966) Granites and associated rocks of the eastern part of the Western Red Hills Complex, Isle of Skye. *Transactions of the Royal Society of Edinburgh*, **66**, 307–43.

Bell, J.D. (1976) The Tertiary intrusive complex on the Isle of Skye. *Proceedings of the Geologists' Association*, **87**, 247–71.

Berggren, W.A., Kent, D.V. and Flynn, J.J. (1985) Jurassic to Palaeogene: Part 2 Palaeogene geochronology and chronostratigraphy. In *The geochronology of the geological record*, (ed. N.J. Snelling). Memoir of the Geological Society of London, **10**, 141–95.

Bhattacharji, S. and Smith, C.H. (1964) Flowage differentiation. *Science*, **145**, 150–3.

Binns, P.E., McQuillin, R. and Kenolty, N. (1974) *The Geology of the Sea of the Hebrides*. Report of the Institute of Geological Sciences, No. 73/14, 43 pp.

Black, G.P. (1952a) The age relationship of the granophyre and basalt of Orval, Isle of Rhum. *Geological Magazine*, **89**, 106–12.

Black, G.P. (1952b) The Tertiary volcanic succession of the Isle of Rhum, Inverness-shire. *Transactions of the Edinburgh Geological Society*, **15**, 39–51.

Black, G.P. (1954) The acid rocks of western Rhum. *Geological Magazine*, **91**, 257–72.

Black, G.P. (1955) The junction between Jurassic sandstones and Tertiary granophyre near Dunan, Isle of Skye: a re-interpretation. *Transactions of the Edinburgh Geological Society*, **16**, 217–22.

Black, G.P. (1974) Appendix 4: The geology of Rhum. In *Isle of Rhum Nature Reserve: the Reserve Handbook*. Nature Conservancy Council, Scotland.

Black, G.P. and Welsh, W. (1961) The Torridonian succession of the Isle of Rhum. *Geological Magazine*, **98**, 265–76.

Blake, D.H., Elwell, R.W.D., Gibson, I.L. *et al.* (1965) Some relationships resulting from the intimate association of acid and basic magmas. *Quarterly Journal of the Geological Society of London*, **121**, 31–49.

Bott, M.H.P. and Tantrigoda, D.A. (1987) Interpretation of the gravity and magnetic anomalies over the Mull Tertiary intrusive complex, NW Scotland. *Journal of the Geological Society of London*, **144**, 17–28.

Bott, M.H.P. and Tuson, J. (1973) Deep structure beneath the Tertiary volcanic regions of Skye, Mull and Ardnamurchan, north-west Scotland. *Nature, Physical Sciences*, **242**, 114–16.

Boué, Ami (1820) Short comparison of the volcanic rocks of France with those of a similar nature found in Scotland. *Edinburgh Philosophical Journal*, **2**, p. 326.

Bowen, N.L. (1928) *The Evolution of the Igneous Rocks*. Princeton University Press, Princeton, New Jersey, 334 pp.

Boyd, W.W. (1974) A geochemical investigation of composite bodies involving intermediate members of the alkali—basalt—trachyte suite. Unpublished Ph.D. Thesis, University of Edinburgh.

Bradshaw, N. (1961) The mineralogy and petrology of the eucrites of the Centre 3 igneous complex, Ardnamurchan, Scotland. Unpublished Ph.D. Thesis, University of Manchester.

Brown, G.C. and Mussett, A.E. (1976) Evidence for two discrete centres in Skye. *Nature, London*, **261**, 218–20.

Brown, G.M. (1954) A suggested igneous origin for the banded granular hornfelses within the hypersthene-gabbro of Ardnamurchan, Argyllshire. *Mineralogical Magazine*, **30**, 529–33.

References

Brown, G.M. (1956) The layered ultrabasic rocks of Rhum, Inner Hebrides. *Philosophical Transactions of the Royal Society*, **B240**, 1–53.

Brown, G.M. (1963) Melting relations of Tertiary granitic rocks in Skye and Rhum. *Mineralogical Magazine*, **33**, 533–62.

Brown, G.M. (1969) *The Tertiary Igneous Geology of the Isle of Skye*. Geologists' Association Guide, **13**, 37 pp.

Buist, D.S. (1959) The composite sill of Rudh' an Eireannaich, Skye. *Geological Magazine*, **96**, 247–52.

Butcher, A.R. (1985) Channelled metasomatism in Rhum layered cumulates – evidence from late-stage veins. *Geological Magazine*, **122**, 503–18.

Butcher, A.R., Young, I.M. and Faithfull, J.W. (1985) Finger structures in the Rhum Complex. *Geological Magazine*, **122**, 491–502.

Butchins, C.S. (1973) An extension of the granophyric quartz-dolerite intrusion of Centre 2, Ardnamurchan, Argyllshire. *Geological Magazine*, **110**, 473–5.

Cann, J.R. (1965) The metamorphism of amygdales at 'S Airde Beinn, northern Mull. *Mineralogical Magazine*, **34**, 92–106.

Carmichael, I.S.E. (1960a) The feldspar phenocrysts of some Tertiary acid glasses. *Mineralogical Magazine*, **32**, 587–608.

Carmichael, I.S.E. (1960b) The pyroxenes and olivines from some Tertiary acid glasses. *Journal of Petrology*, **1**, 309–36.

Carmichael, I.S.E. (1962) A note on the composition of some natural acid glasses. *Geological Magazine*, **99**, 253–64.

Carmichael, I.S.E. (1963) The crystallization of feldspar in volcanic acid liquids. *Quarterly Journal of the Geological Society of London*, **119**, 95–131.

Carmichael, I.S.E. (1964) The petrology of Thingmuli, a Tertiary volcano in eastern Iceland. *Journal of Petrology*, **5**, 435–60.

Carmichael, I.S.E. and McDonald, A. (1961) The geochemistry of some natural acid glasses from the North Atlantic Tertiary Volcanic Province. *Geochimica et Cosmochimica Acta*, **25**, 189–222.

Carr, J.M. (1952) An investigation of the Sgùrr na Stri–Druim Hain sector of the basic igneous complex of the Cuillin Hills, Isle of Skye. Unpublished D. Phil. Thesis, University of Oxford.

Cheeney, R.F. (1962) Early Tertiary fold movements in Mull. *Geological Magazine*, **99**, 227–32.

Chesher, J.A., Smythe, D.K. and Bishop, P. (1983) *The geology of the Minches, Inner Sound and Sound of Raasay*. Report of the Institute of Geological Sciences, No. 83/6, 29 pp.

Cockburn, A.M. (1935) The geology of St Kilda. *Transactions of the Royal Society of Edinburgh*, **58**, 511–47.

Cooper, J. (1979) Lower Tertiary fresh-water Mollusca from Mull, Argyllshire. *Tertiary Research*, **2**, 69–74.

Craig, G.Y. (ed.) (1965) *The Geology of Scotland*, 1st edn, Oliver and Boyd, Edinburgh, 556 pp.

Craig, G.Y. (ed.) (1983) *Geology of Scotland*. 2nd edn, Scottish Academic Press, Edinburgh, 472 pp.

Cressey, G. (1987) Skarn formation between metachalk and agglomerate in the Central Ring Complex, Isle of Arran, Scotland. *Mineralogical Magazine*, **51**, 231–46.

Dagley, P. (1969) Palaeomagnetic results from some British Tertiary dykes. *Earth and Planetary Science Letters*, **6**, 349–54.

Dagley, P. and Mussett, A.E. (1981) Palaeomagnetism of the British Tertiary Igneous Province: Rhum and Canna. *Geophysical Journal of the Royal Astronomical Society*, **65**, 475–91.

Dagley, P. and Mussett, A.E. (1986) Palaeomagnetism and radiometric dating of the British Tertiary Volcanic Province: Muck and Eigg. *Geophysical Journal of the Royal Astronomical Society*, **85**, 221–42.

Dagley, P., Mussett, A.E. and Skelhorn, R.R. (1987) Polarity, stratigraphy and duration of the Tertiary igneous activity of Mull, Scotland. *Journal of the Geological Society of London*, **144**, 985–96.

Dagley, P., Mussett, A.E., Wilson, R.L. *et al.* (1978) The British Tertiary igneous province: palaeomagnetism of the Arran dykes. *Geophysical Journal of the Royal Astronomical Society*, **54**, 75–91.

Day, S.J. (1989) The geology of the Hypersthene Gabbro of Ardnamurchan Point and implications for its evolution and as upper crustal basic magma chamber. Unpublished Ph.D. Thesis, University of Durham.

Deer, W.A. (1969) *Field Excursion Guide to the Tertiary Volcanic Rocks of Ardnamurchan*. International Association of Volcanology and Chemistry of the Earth's Interior. Symposium on volcanoes and their roots. Oxford, Eng-

land, 7–13 September 1969.

Dickin, A.P. (1981) Isotope geochemistry of Tertiary igneous rocks from the Isle of Skye, NW Scotland. *Journal of Petrology*, **22**, 155–89.

Dickin, A.P. and Exley, R.A. (1981) Isotopic and geochemical evidence for magma mixing in the petrogenesis of the Coire Uaigneich granophyre, Isle of Skye, N.W. Scotland. *Contributions to Mineralogy and Petrology*, **76**, 98–108.

Dickin, A.P. and Jones, N.W. (1983) Isotopic evidence for the age and origin of pitchstones and felsites, Isle of Eigg, N.W. Scotland. *Journal of the Geological Society of London*, **140**, 691–700.

Dickin, A.P., Moorbath, S. and Welke, H.J. (1981) Isotope, trace element and major element geochemistry of Tertiary igneous rocks, Isle of Arran, Scotland. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, **72**, 159–70.

Dickin, A.P., Brown, J.L., Thompson, R.N. *et al.* (1984) Crustal contamination and the granite problem in the British Tertiary Volcanic Province. *Philosophical Transactions of the Royal Society of London*, **A310**, 755–80.

Donaldson, C.H. (1974) Olivine crystal types in harrisitic rocks of the Rhum pluton and in Archaean spinifex rocks. *Bulletin of the Geological Society of America*, **85**, 1721–6.

Donaldson, C.H. (1975) Ultrabasic breccias in layered intrusions – the Rhum Complex. *Journal of Geology*, **83**, 33–45.

Donaldson, C.H. (1977a) Petrology of anorthite—bearing gabbroic anorthosite dykes in north-west Skye. *Journal of Petrology*, **18**, 595–620.

Donaldson, C.H. (1977b) Laboratory duplication of comb-layering in the Rhum pluton. *Mineralogical Magazine*, **41**, 323–36.

Donaldson, C.H. (1982) Origin of some of the Rhum harrisite by segregation of intercumulus liquid. *Mineralogical Magazine*, **45**, 201–9.

Donaldson, C.H., Drever, H.I. and Johnston, R. (1973) Crystallization of poikilo-macrospherulitic feldspar in a Rhum peridotite. *Nature, Physical Sciences*, **243**, 69–70.

Drever, H.I. (1953) A note on the field relations of the Shiant Isles picrite. *Geological Magazine*, **90**, 159–60.

Drever, H.I. (1957) A note on the occurrence of rhythmic layering in the Eilean Mhuire Sill, Shiant Isles. *Geological Magazine*, **94**, 277–80.

Drever, H.I. and Johnston, R. (1958) The petrology of picritic rocks in minor intrusions – a Hebridean group. *Transactions of the Royal Society of Edinburgh*, **63**, 459–99.

Drever, H.I. and Johnston, R. (1965) New petrographical data on the Shiant Isles picrite. *Mineralogical Magazine*, **34**, 194–203.

Drever, H.I. and Johnston, R. (1966) A natural high—lime silicate liquid more basic than basalt. *Journal of Petrology*, **7**, 414–20.

Dubey, S. and Holmes, A. (1929) Estimates of the ages of the Whin Sill and Cleveland Dyke by the helium method. *Nature*, **123**, 794–5.

Dunham, A.C. (1962) The petrology and structure of the northern edge of the Tertiary igneous complex of Rhum. Unpublished D.Phil. Thesis, University of Oxford.

Dunham, A.C. (1964) A petrographic and geochemical study of back-veining and hybridization at a gabbro–felsite contact in Coire Dubh, Rhum, Inverness-shire. *Mineralogical Magazine*, **33**, 887–902.

Dunham, A.C. (1965a) The nature and origin of the groundmass textures in felsites and granophyres from Rhum, Inverness-shire. *Geological Magazine*, **102**, 8–23.

Dunham, A.C. (1965b) A new type of banding in ultrabasic rocks from central Rhum, Inverness-shire. *American Mineralogist*, **50**, 1410–20.

Dunham, A.C. (1968) The felsites, granophyre, explosion breccias and tuffisites of the north-eastern margin of the Tertiary igneous complex of Rhum, Inverness-shire. *Quarterly Journal of the Geological Society of London*, **123** (for 1967), 327–52.

Dunham, A.C. and Emeleus, C.H. (1967) The Tertiary geology of Rhum, Inner Hebrides. *Proceedings of the Geologists' Association*, **78**, 391–418.

Dunham, A.C. and Wadsworth, W.J. (1978) Cryptic variation in the Rhum layered intrusion. *Mineralogical Magazine*, **42**, 347–56.

Durant, G.P., Dobson, M.R. and Kokelaar, B.P. *et al.* (1976) Preliminary report on the nature and age of the Blackstones Bank Igneous Centre, western Scotland. *Journal of the Geological Society of London*, **132**, 319–26.

Durant, G.P., Kokelaar, B.P. and Whittington, R.J. (1982) *The Blackstones Bank Igneous Centre, western Scotland.* Proceedings of the 6th Symposium of the Confederation Mondiale des Activites Subaquatique, Heriot-Watt University, September 1980. Natural Environment Research Council, London, 297–308.

References

Durrance, E.M. (1967) Photoelastic stress studies and their application to a mechanical analysis of the Tertiary ring-complex of Ardnamurchan, Argyllshire. *Proceedings of the Geologists' Association*, **78**, 289–318.

Emeleus, C.H. (1973) Granophyre pebbles in Tertiary conglomerate on the Isle of Canna, Inverness-shire. *Scottish Journal of Geology*, **9**, 157–9.

Emeleus, C.H. (1980) Rhum: Solid geology map, 1:20 000. Nature Conservancy Council, Scotland.

Emeleus, C.H. (1982) The central complexes. In *Igneous Rocks of the British Isles* (ed. D.S. Sutherland), Wiley, Chichester, pp. 369–414.

Emeleus, C.H. (1983) Tertiary igneous activity. In *Geology of Scotland* (ed. G.Y. Craig), 2nd edn, Scottish Academic Press, Edinburgh, pp. 357–98.

Emeleus, C.H. (1985) The Tertiary lavas and sediments of north-west Rhum, Inner Hebrides. *Geological Magazine*, **122**, 419–37.

Emeleus, C.H. (1987) The Rhum layered complex, Inner Hebrides, Scotland. In *Origins of igneous layering* (ed. I. Parsons), NATO ASI Series, Series C: Mathematical and Physical Sciences, **196**, 263–86, Reidel, Dordrecht.

Emeleus, C.H. (in preparation) *The geology of Rum and adjoining islands*. Memoir of the British Geological Survey.

Emeleus, C.H. and Forster, R.M. (1979) *Field guide to the Tertiary igneous rocks of Rhum*. Nature Conservancy Council, London, 44 pp.

Emeleus, C.H., Dunham, A.C. and Thompson, R.N. (1971) Iron-rich pigeonite from acid rocks in the Tertiary Igneous Province, Scotland. *American Mineralogist*, **56**, 940–51.

Emeleus, C.H., Wadsworth, W.J. and Smith, N.J. (1985) The early igneous and tectonic history of the Rhum Tertiary Volcanic Centre. *Geological Magazine*, **122**, 451–7.

England, R.W. (1988) The ascent and emplacement of granitic magmas: the Northern Arran Granite. Unpublished Ph.D. Thesis, University of Durham.

England, R.W. (1990) The identification of granite diapirs. *Journal of the Geological Society of London*, **147**, 931–4.

Esson, J., Dunham, A.C. and Thompson, R.N. (1975) Low alkali, high calcium olivine-tholeiite lavas from the Isle of Skye, Scotland. *Journal of Petrology*, **16**, 488–97.

Evans, A.L. (1969) On dating the British Tertiary Igneous Province. Unpublished Ph.D. Thesis, University of Cambridge.

Evans, A.L., Fitch, F.J. and Miller, J.A. (1973) Potassium–argon age determinations on some British Tertiary igneous rocks. *Journal of the Geological Society of London*, **129**, 419–43.

Faithfull, J.W. (1985) The Lower Eastern Layered Series of Rhum. *Geological Magazine*, **122**, 459–68.

Fenner, C.N. (1937) A view of magmatic differentiation. *Journal of Geology*, **45**, 158–68.

Flett, W.R. (1942) The contact between the granites of North Arran. *Transactions of the Geological Society of Glasgow*, **20**, 180–204.

Forester, R.W. and Taylor, H.P., Jun. (1976) ^{18}O-depleted igneous rocks from the Tertiary complex of the Isle of Mull, Scotland. *Earth and Planetary Science Letters*, **32**, 11–17.

Forester, R.W. and Taylor, H.P., Jun. (1977) $^{18}O/^{16}O$, D/H and $^{13}C/^{12}C$ studies of the Tertiary igneous complex of Skye, Scotland. *American Journal of Science*, **277**, 136–77.

Forster, R.M. (1980) A geochemical and petrological study of the Tertiary minor intrusions of Rhum, north-west Scotland. Unpublished Ph.D. Thesis, University of Durham.

Gardner, J.S. (1887) On the leaf-beds and gravels of Ardtun, Carsaig, etc. in Mull. *Quarterly Journal of the Geological Society of London*, **43**, 270–300.

Gass, I.G. and Thorpe, R.S. (1976) Igneous case study: the Tertiary igneous rocks of Skye, NW Scotland. In *Science: a third level course. Earth science topics and methods*, (ed. F. Aprahamian), Open University Press, Milton Keynes.

Geikie, A. (1888) The history of volcanic action during the Tertiary period in the British Isles. *Transactions of the Royal Society of Edinburgh*, **35**, 21–184.

Geikie, A. (1894) On the relations of the basic and acid rocks of the Tertiary volcanic series of the Inner Hebrides. *Quarterly Journal of the Geological Society of London*, **50**, 212–31.

Geikie, A. (1897) *The Ancient Volcanoes of Great Britain*. 2 vols, Macmillan, London.

Geikie, A. and Teall, J.J.H. (1894) On the banded structure of some Tertiary gabbros in the Isle of Skye. *Quarterly Journal of the Geological Society of London*, **50**, 645–60.

Gibb, F.G.F. (1973) The zoned clinopyroxenes of the Shiant Isles Sill, Scotland. *Journal of Petrology*, **14**, 203–30.

Gibb, F.G.F. (1976) Ultrabasic rocks of Rhum and

Skye: the nature of the parent magma. *Journal of the Geological Society of London*, **132**, 209–22.

Gibb, F.G.F. and Henderson, C.M.B. (1978a) The petrology of the Dippin Sill, Isle of Arran. *Scottish Journal of Geology*, **14**, 1–27.

Gibb, F.G.F. and Henderson, C.M.B. (1978b) Possible higher pressure relics within titaniferous augites in a basic sill. *Geological Magazine*, **115**, 55–62.

Gibb, F.G.F. and Henderson, C.M.B. (1984) The structure of the Shiant Isles Sill Complex, Outer Hebrides. *Scottish Journal of Geology*, **20**, 21–9.

Gibb, F.G.F. and Henderson, C.M.B. (1989) Discontinuities between picritic and crinanitic units in the Shiant Isles Sill: evidence of multiple intrusion. *Geological Magazine*, **126**, 127–37.

Gibson, S.A. (1988) The geochemistry, mineralogy and petrology of the Trotternish Sill Complex, northern Skye, Scotland. Unpublished Ph.D. Thesis, Kingston Polytechnic.

Gibson, S.A. (1990) The geochemistry of the Trotternish sills, Isle of Skye: crustal contamination in the British Tertiary Volcanic Province. *Journal of the Geological Society of London*, **147**, 1071–81.

Gibson, S.A. and Jones, A.P. (1990) Igneous stratigraphy and internal structure of the Little Minch Sill Complex, Trotternish Peninsula, northern Skye, Scotland. *Geological Magazine*, **128**, 51–66.

Green, J. and Wright, J.B. (1969) Ardnamurchan Centre 1 – does it need re-defining? *Geological Magazine*, **106**, 599–601.

Green, J. and Wright, J.B. (1974) Ardnamurchan, Centre 1 – new radiometric evidence. *Geological Magazine*, **111**, 163–4.

Greenwood, R.C. (1987) Geology and petrology of the margin of the Rhum ultrabasic intrusion, Inner Hebrides, Scotland. Unpublished Ph.D. Thesis, University of St Andrews.

Greenwood, R.C., Donaldson, C.H. and Emeleus, C.H. (1990) The contact zone of the Rhum ultrabasic intrusion: evidence of peridotite formation from magnesian magmas. *Journal of the Geological Society of London*, **147**, 209–12.

Gribble, C.D. (1974) The dolerites of Ardnamurchan. *Scottish Journal of Geology*, **10**, 71–89.

Gribble, C.D., Durrance, E.M. and Walsh, J.N. (1976) *Ardnamurchan: a Guide to Geological Excursions*. Edinburgh Geological Society, Edinburgh, 122 pp and map.

Gunn, W. (1900) On the old volcanic rocks of the Island of Arran. *Transactions of the Geological Society of Glasgow*, **11**, 174–91.

Gunn, W. (1903) *The Geology of North Arran, South Bute and the Cumbraes, with Parts of Ayrshire and Kintyre*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Halsall, T.J. (1978) The emplacement of the Tertiary dykes of the Kildonan shore, south Arran. *Journal of the Geological Society of London*, **135**, p. 462 (abstract).

Hampton, C.M. and Taylor, P.N. (1983) The age and nature of the basement of southern Britain: evidence from Sr and Pb isotopes in granites. *Journal of the Geological Society of London*, **140**, 499–509.

Harding, R.R. (1966) The Mullach Sgar Complex, St Kilda, Outer Hebrides. *Scottish Journal of Geology*, **2**, 165–78.

Harding, R.R. (1967) The major ultrabasic and basic intrusions of St Kilda, Outer Hebrides. *Transactions of the Royal Society of Edinburgh*, **66**, 419–44.

Harding, R.R., Merriman, R.J. and Nancarrow, P.H.A. (1984) *St Kilda: an illustrated account of the geology*. Report of the British Geological Survey, 16, 46 pp and 1:25 000 map.

Harker, A. (1904) *The Tertiary Igneous Rocks of Skye*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Harker, A. (1908) *The Geology of the Small Isles of Inverness-shire*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Harker, A. (1917) Some aspects of igneous action in Britain. *Proceedings of the Geological Society of London*, **73**, lxvii–xcvi.

Harland, W.B., Cox, A.V. and Llewellyn, P.G. *et al.* (1982) *A Geologic Time Scale*. Cambridge University Press, Cambridge, 131 pp.

Harris, J.P. and Hudson, J.D. (1980) Lithostratigraphy of the Great Estuarine Group (Middle Jurassic), Inner Hebrides. *Scottish Journal of Geology*, **16**, 231–50.

Harrison, R.K. (ed.) (1975) *Expeditions to Rockall 1971–1972*. Report of the Institute of Geological Sciences, No. 75/1, 72 pp.

Harrison, R.K. (1982) Mesozoic magmatism in the British Isles and adjacent areas. In *Igneous Rocks of the British Isles* (ed. D.S. Sutherland), Wiley, Chichester, pp. 333–41.

Harrison, R.K., Stone, P. and Cameron, I.B. *et al.* (1987) Geology, petrology and geochemistry of Ailsa Craig, Ayrshire. *Report of the British*

Geological Survey, **16/9**, 29 pp.

Heddle, M.F. (1884) On the geognosy and mineralogy of Scotland. *Mineralogical Magazine*, **5**, 41–71.

Henderson, C.M.B. and Gibb, F.G.F. (1977) Formation of analcime in the Dippin Sill, Isle of Arran. *Mineralogical Magazine*, **41**, 534–7.

Hodgson, B.D., Dagley, P. and Mussett, A.E. (1990) Magnetostratigraphy of the Tertiary igneous rocks of Arran. *Scottish Journal of Geology*, **26**, 99–118.

Hoersch, A.L. (1979) General structure of the Skye Tertiary igneous complex and detailed structure of the Beinn an Dubhaich Granite from magnetic evidence. *Scottish Journal of Geology*, **15**, 231–45.

Hoersch, A.L. (1981) Progressive metamorphism of the chert-bearing Durness Limestone in the Beinn an Dubhaich aureole, Isle of Skye, Scotland: a re-examination. *American Mineralogist*, **66**, 491–506.

Holland, J.G. and Brown, G.M. (1972) Hebridean tholeiitic magmas: a geochemical study of the Ardnamurchan cone sheets. *Contributions to Mineralogy and Petrology*, **37**, 139–60.

Holmes, A. (1936) The idea of contrasted differentiation. *Geological Magazine*, **73**, 228–38.

Holmes, A. and Harwood, H.F. (1929) The tholeiite dykes of the north of England. *Mineralogical Magazine*, **22**, 1–52.

Hornung, G., Al-Ani, A. and Stewart, R.M. (1966) The composition and emplacement of the Cleveland Dyke. *Transactions of the Leeds Geologists' Association*, **7**, 232–49.

Hughes, C.J. (1960a) The Southern Mountains Igneous Complex, Isle of Rhum. *Quarterly Journal of the Geological Society of London*, **116**, 111–38.

Hughes, C.J. (1960b) An occurrence of tilleyite-bearing limestones in the Isle of Rhum, Inner Hebrides. *Geological Magazine*, **97**, 384–8.

Hunter, R.H. (1987) Textural equilibrium in layered rocks. In *Origins of Igneous Layering*, (ed. I. Parsons), NATO ASI Series, Series C: Mathematical and Physical Sciences, **196**, 473–504, Reidel, Dordrecht.

Huppert, H.E. and Sparks, R.S.J. (1980) The fluid dynamics of a basaltic magma chamber replenished by influx of hot, dense, ultrabasic magma. *Contributions to Mineralogy and Petrology*, **75**, 279–89.

Hutchison, R. (1964) The Tertiary basic igneous rocks of the Western Cuillin, Isle of Skye. Unpublished Ph. D. Thesis, University of Glasgow.

Hutchison, R. (1966a) The age relationships between the Sgùrr Dubh ultrabasic laccolite and Cuillin gabbros. *Scottish Journal of Geology*, **2**, 227–8.

Hutchison, R. (1966b) Intrusive tholeiites of the western Cuillin, Isle of Skye. *Geological Magazine*, **103**, 352–63.

Hutchison, R. (1968) Origin of White Allivalite, western Cuillin, Isle of Skye. *Geological Magazine*, **105**, 338–47.

Hutchison, R. and Bevan, J.C. (1977) The Cuillin layered igneous complex – evidence for multiple intrusion and former presence of a picritic liquid. *Scottish Journal of Geology*, **13**, 197–209.

Hutton, J. (1795) *Theory of the Earth, with Proofs and Illustrations*. Edinburgh.

Irvine, T.N. (1987) Layering and related structures in the Duke Island and Skaergaard intrusions: similarities, differences and origins. In *Origins of Igneous Layering* (ed. I. Parsons), NATO ASI Series, Series C: Mathematical and Physical Sciences, **196**, 185–246, Reidel, Dordrecht.

Jassim, S.Z. and Gass, I.G. (1970) The Loch na Crèitheach volcanic vent, Isle of Skye. *Scottish Journal of Geology*, **6**, 285–94.

Johnston, R. (1953) The olivines of the Garbh Eilean Sill, Shiant Isles. *Geological Magazine*, **90**, 161–71.

Judd, J.W. (1874) The Secondary rocks of Scotland. Second Paper. On the ancient volcanoes of the Highlands and the relations of their products to the Mesozoic strata. *Quarterly Journal of the Geological Society of London*, **30**, 220–301.

Judd, J.W. (1878) The Secondary rocks of Scotland. Third Paper. The strata of the western coast and islands. *Quarterly Journal of the Geological Society of London*, **34**, 660–743.

Judd, J.W. (1885) On the Tertiary and older peridotites of Scotland. *Quarterly Journal of the Geological Society of London*, **41**, 354–418.

Judd, J.W. (1886) On the gabbros, dolerites and basalts of Tertiary age in Scotland and Ireland. *Quarterly Journal of the Geological Society of London*, **42**, 49–97.

Judd, J.W. (1889) The Tertiary volcanoes of the Western Isles of Scotland. *Quarterly Journal of the Geological Society of London*, **45**, 187–219.

References

Judd, J.W. (1890) The propylites of the Western Isles of Scotland, and their relation to the andesites and diorites of the district. *Quarterly Journal of the Geological Society of London*, **46**, 341–85.

Judd, J.W. (1893) On composite dykes in Arran. *Quarterly Journal of the Geological Society of London*, **49**, 536–65.

Judd, J.W. (1897) On the petrology of Rockall. *Transactions of the Royal Irish Academy*, **31**, 48–58.

Kanaris-Sotiriou, R. and Gibb, F.G.F. (1985) Hybridization and the petrogenesis of composite intrusions: the dyke at An Cumhann, Isle of Arran, Scotland. *Geological Magazine*, **122**, 361–72.

Kennedy, W.Q. (1931a) The parent magma of the British Tertiary Province. *Geological Survey of Great Britain, Summary of Progress* (for 1930), **II**, 61–73.

Kennedy, W.Q. (1931b) On composite lava flows. *Geological Magazine*, **68**, 166–81.

Kennedy, W.Q. (1933) Trends of differentiation in basaltic magmas. *American Journal of Science*, **25**, 239–56.

Kennedy, W.Q. and Anderson, E.M. (1938) Crustal layers and the origin of magmas. *Bulletin Volcanologique*, séries II, tome III, 23–82.

Kille, I.C., Thompson, R.N., Morrison, M.A. *et al.* (1986) Field evidence for turbulence during flow of basalt magma through conduits from south-west Mull. *Geological Magazine*, **123**, 693–7.

King, B.C. (1953) Structure and igneous activity in the Creag Strollamus area of Skye. *Transactions of the Royal Society of Edinburgh*, **62**, 357–402.

King, B.C. (1955) The Ard Bheinn area of the Central Igneous Complex of Arran. *Quarterly Journal of the Geological Society of London*, **110** (for 1954), 323–55.

King, B.C. (1960) The form of the Beinn an Dubhaich granite, Skye. *Geological Magazine*, **97**, 326–33.

King, P.M. (1977) The secondary minerals of the Tertiary lavas of northern and central Skye – zeolite zonation patterns, their origin and formation. Unpublished Ph.D. Thesis, University of Aberdeen.

Knapp, R.J. (1973) The form and structure of the Islay, Jura and Arran Tertiary basic dyke swarms. Unpublished Ph.D. Thesis, University of London.

Koomans, C. and Kuenen, Ph.H. (1938) On the differentiation of the Glen More ring-dyke, Mull. *Geological Magazine*, **75**, 145–60.

Kuenen, Ph.H. (1937) Intrusion of cone-sheets. *Geological Magazine*, **74**, 177–83.

Le Bas, M.J. (1959) The term eucrite. *Geological Magazine*, **96**, 497–502.

Le Bas, M.J. (1971) Cone-sheets as a mechanism of uplift. *Geological Magazine*, **108**, 373–6.

Lee, G.W. and Bailey, E.B. (1925) *The Pre-Tertiary Geology of Mull, Loch Aline and Oban*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Le Maitre, R.W. (1989) *A Classification of Igneous Rocks and Glossary of Terms*. Blackwell Scientific Publications, Oxford.

Lewis, J.D. (1968) Form and structure of the Loch Bà ring-dyke, Isle of Mull. *Proceedings of the Geological Society of London*, **1649**, 110–11.

Longman, C.D. and Coward, M.P. (1979) Deformation around the Beinn an Dubhaich granite, Skye. *Scottish Journal of Geology*, **15**, 301–11.

MacCulloch, J. (1819) *A Description of the Western Islands of Scotland, including the Isle of Man. Comprising an account of their Geological Structure; with Remarks on their Agriculture, Scenery, and Antiquities.* 3 vols, Hurst Robinson, London.

MacDonald, G.A. and Katsura, T. (1964) Chemical composition of Hawaiian lavas. *Journal of Petrology*, **5**, 82–133.

MacDonald, J.G. and Herriot, A. (1983) *Macgregor's excursion guide to the Geology of Arran*. 3rd edition (revised), Geological Society of Glasgow, Glasgow, 210 pp.

MacDonald, R., Wilson, L., Thorpe, R.S. and Martin, A. (1988) Emplacement of the Cleveland Dyke: evidence from geochemistry, mineralogy, and physical modelling. *Journal of Petrology*, **29**, 559–83.

MacGregor, A.G. (1931) Clouded feldspars and thermal metamorphism. *Mineralogical Magazine*, **22**, 524–38.

Macgregor, M. (1965) *Excursion Guide to the Geology of Arran*. Geological Society of Glasgow, Glasgow, 192 pp.

Macintyre, R.M. (1973) Lower Tertiary geochronology of the North Atlantic continental margins. In *Geochronology and Isotope Geology of Scotland*. Field guide and reference.

Marshall, L.A. and Sparks, R.S.J. (1984) Origins of some mixed-magma and net-veined ring intrusions. *Journal of the Geological Society of London*, **141**, 171–82.

Martin, J.H. (1969) A petrographic study of the allivalite dykes of north Skye. Unpublished Ph.D. Thesis, University of St Andrews.

Mattey, D.P., Gibson, I.L., Marriner, G.F. *et al.* (1977) The diagnostic geochemistry, relative abundance, and spatial distribution of high-calcium, low-alkali olivine tholeiite dykes in the Lower Tertiary regional swarm of the Isle of Skye, N.W. Scotland. *Mineralogical Magazine*, **41**, 273–85.

McBirney, A.R. (1975) Differentiation of the Skaergaard intrusion. *Nature*, **253**, 691–4.

McBirney, A.R. and Noyes, R.M. (1979) Crystallization and layering of the Skaergaard intrusion. *Journal of Petrology*, **20**, 487–554.

McClurg, J.E. (1982) Geology and structure of the northern part of the Rhum ultrabasic complex. Unpublished Ph.D. Thesis, University of Edinburgh.

McKerrow, W.S. and Atkins, F.B. (1985) *Isle of Arran: a Field Guide for Students of Geology*. Geologists' Association guide, 96 pp.

McQuillin, J. and Tuson, J. (1963) Gravity measurements over the Rhum Tertiary plutonic complex. *Nature*, **199**, 1276–7.

McQuillin, R., Bacon, M. and Binns, P.E. (1975) The Blackstones Tertiary igneous complex. *Scottish Journal of Geology*, **11**, 179–92.

Meighan, I.G., Hutchison, R. and Williamson, I.T. (1981) Geological evidence for the different relative ages of the Rhum and Skye Tertiary central complexes. *Geological Society of London Newsletter*, **10**, p. 12 (Abstract).

Meighan, I.G., McCormick, A.G., Gibson, D. *et al.* (1988) Rb–Sr isotopic determinations and the timing of Tertiary central complex magmatism in NE Ireland. In *Early Tertiary Volcanism and the Opening of the NE Atlantic*, (eds A.C. Morton and L.M. Parson), Geological Society Special Publication, No. 39, pp. 349–60.

Miller, J.A. and Brown, P.E. (1965) Potassium–argon age studies in Scotland. *Geological Magazine*, **102**, 106–34.

Mitchell, J.G. and Reen, K.P. (1973) Potassium–argon ages from the Tertiary ring complexes of the Ardnamurchan Peninsula, western Scotland. *Geological Magazine*, **110**, 331–40.

Moorbath, S. and Bell, J.D. (1965) Strontium isotope abundance studies and rubidium–strontium age determinations on Tertiary igneous rocks from the Isle of Skye, northwest Scotland. *Journal of Petrology*, **6**, 37–66.

Moorbath, S. and Thompson, R.N. (1980) Strontium isotope geochemistry and petrogenesis of the Early Tertiary lava pile of the Isle of Skye, Scotland, and other basic rocks of the British Tertiary Province: an example of magma–crust interaction. *Journal of Petrology*, **21**, 295–321.

Moorbath, S. and Welke, H. (1969) Lead isotope studies on igneous rocks from the Isle of Skye, north-west Scotland. *Earth and Planetary Science Letters*, **5**, 217–30.

Morrison, M.A. (1978) The use of 'immobile' trace elements to distinguish palaeotectonic affinities of metabasalts: applications to the Palaeocene basalts of Mull and Skye, NW Scotland. *Earth and Planetary Science Letters*, **39**, 407–16.

Morrison, M.A. (1979) Igneous and metamorphic geochemistry of Mull lavas. Unpublished Ph.D. Thesis, University of London.

Morrison, M.A., Thompson, R.N. and Dickin, A.P. (1985) Geochemical evidence for complex magmatic plumbing during development of a continental volcanic centre. *Geology*, **13**, 581–4.

Muir, I.D. and Tilley, C.E. (1961) Mugearites and their place in alkali igneous rock series. *Journal of Geology*, **69**, 186–203.

Murray, R.J. (1954) The clinopyroxenes of the Garbh Eilean Sill, Shiant Isles. *Geological Magazine*, **91**, 17–31.

Mussett, A.E. (1984) Time and duration of Tertiary igneous activity of Rhum and adjacent areas. *Scottish Journal of Geology*, **20**, 273–9.

Mussett, A.E. (1986) ^{40}Ar-^{39}Ar step-heating ages of the Tertiary igneous rocks of Mull, Scotland. *Journal of the Geological Society of London*, **143**, 887–96.

Mussett, A.E., Brown, G.C., Eckford, M. *et al.* (1973) The British Tertiary Igneous Province: K–Ar ages of some dykes and lavas from Mull, Scotland. *Geophysical Journal of the Royal Astronomical Society*, **30**, 405–14.

Mussett, A.E., Dagley, P. and Skelhorn, R.R. (1980) Magnetostratigraphy of the Tertiary igneous succession of Mull, Scotland. *Journal of the Geological Society of London*, **137**, 349–57.

Mussett, A.E., Dagley, P. and Skelhorn, R.R. (1988) Time and duration of activity in the British Tertiary Igneous Province. In *Early Tertiary Volcanism and the opening of the NE Atlantic*, (eds A.C. Morton and L.M.

Parson), Geological Society of London Special Publication, No. 39, 337–48.

Necker de Saussure, L.A. (1840) Documents sur les Dykes de Trap d'une Partie de l'île d'Arran. *Transactions of the Royal Society of Edinburgh*, **14**, 677–98.

Nicholson, R. (1970) A note on deformed igneous sheets in the Durness Limestone of the Strath district of Skye. *Geological Magazine*, **107**, 229–33.

Nicholson, R. (1985) The intrusion and deformation of Tertiary minor sheet intrusions, west Suardal, Isle of Skye, Scotland. *Geological Journal*, **20**, 53–72.

Nielsen, T.F.D. (1987) Tertiary alkaline magmatism in East Greenland: a review. In *Alkaline Igneous Rocks* (eds J.G. Fitton and B.G.J. Upton), Geological Society Special Publication, No. 30, 489–516.

Nockolds, S.R. and Allen, R. (1954) The geochemistry of some igneous rock series, Part II. *Geochimica et Cosmochimica Acta*, **5**, 245–85.

Paithankar, M.G. (1968) Petrological study and intrusion history of the granophyre of Grigadale and associated gabbros, Ardnamurchan, Argyllshire, Scotland. *Neues Jahrbuch für Mineralogie*, **110**, 1–23.

Palacz, Z.A. and Tait, S.R. (1985) Isotopic and geochemical investigation of unit 10 from the Eastern Layered Series of the Rhum intrusion, north-west Scotland. *Geological Magazine*, **122**, 485–90.

Pankhurst, R.J., Walsh, J.N., Beckinsale, R.D. *et al.* (1978) Isotopic and other geochemical evidence for the origin of the Loch Uisg granophyre, Isle of Mull, Scotland. *Earth and Planetary Science Letters*, **38**, 355–63.

Parsons, I. (ed.) (1987) *Origins of Igneous Layering*. NATO ASI Series, Series C: Mathematical and Physical Sciences, **196**, Reidel, Dordrecht.

Peach, B.N., Gunn, W. and Newton, E.T. (1901) On a remarkable volcanic vent of Tertiary age in the Island of Arran, enclosing Mesozoic fossiliferous rocks. *Quarterly Journal of the Geological Society of London*, **62**, 226–43.

Peach, B.N., Horne, J., Woodward, H.B. *et al.* (1910) *The Geology of Glenelg, Lochalsh and South-East Part of Skye*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Pennant, T. (1774) *A Tour in Scotland and Voyage to the Hebrides, 1772*. Chester (Arran, volume 1, pp. 168–89).

Phillips, W.J. (1974) The dynamic emplacement of cone-sheets. *Tectonophysics*, **24**, 69–84.

Preston, J. (1963) The dolerite plug at Slemish, Co. Antrim, Ireland. *Liverpool and Manchester Geological Journal*, **3**, 301–14.

Ramsay, A.C. (1841) *The Geology of the Island of Arran from Original Survey*. Glasgow, 78 pp.

Rao, M.S. (1958) Composite and multiple intrusions of Lamlash–Whiting Bay region, Arran. *Geological Magazine*, **95**, 265–80.

Rao, M.S. (1959) Minor acid intrusions and dykes of the Lamlash–Whiting Bay region, Arran. *Geological Magazine*, **96**, 237–46.

Rast, D.E. (1968) Age relationships and geometry of the Knock and Beinn a Ghraig granophyres, Isle of Mull. *Proceedings of the Geological Society of London*, **1649**, 114–15.

Rast, N., Diggens, J.N. and Rast, D.E. (1968) Triassic rocks of the Isle of Mull: their sedimentation, facies, structure, and relationship to the Great Glen Fault and the Mull caldera. *Proceedings of the Geological Society of London*, **1645**, 299–304.

Ray, P.S. (1960) Ignimbrite in the Kilchrist vent, Skye. *Geological Magazine*, **97**, 229–38.

Ray, P.S. (1962) A note on some acid breccias in the Kilchrist vent, Skye. *Geological Magazine*, **99**, 420–6.

Ray, P.S. (1964) On the association of an indurated basic tuff and a felsite intrusion in the Kilchrist vent, Skye. *Geological Magazine*, **101**, 289–301.

Ray, P.S. (1966) An association of rhyolite and ignimbrite in the Kilchrist vent, Skye. *Geological Magazine*, **103**, 8–18.

Ray, P.S. (1972) A rhyolitic injection-breccia in tuff near Allt Slapin, Strath, Skye. *Geological Magazine*, **109**, 427–34.

Raybould, J.G. (1973) The form of the Beinn an Dubhaich Granite, Skye, Scotland. *Geological Magazine*, **110**, 341–50.

Renner, R. and Palacz, Z. (1987) Basaltic replenishment of the Rhum magma chamber: evidence from unit 14. *Journal of the Geological Society of London*, **144**, 961–70.

Reynolds, D.L. (1951) The geology of Slieve Gullion, Foughill and Carrickcarnan: an actualistic interpretation of a Tertiary gabbro–granophyre complex. *Transactions of the Royal Society of Edinburgh*, **62**, 85–143.

Reynolds, D.L. (1954) Fluidization as a geological process, and its bearing on the problem of intrusive granites. *American Journal of Sci-*

ence, **252**, 577–613.

Richey, J.E. (1928) The structural relations of the Mourne granites (Northern Ireland). *Quarterly Journal of the Geological Society of London*, **83** (for 1927), 653–88.

Richey, J.E. (1932) Tertiary ring structures in Britain. *Transactions of the Geological Society of Glasgow*, **19**, 42–140.

Richey, J.E. (1933) Summary of the geology of Ardnamurchan. *Proceedings of the Geologists' Association*, **44**, 1–56.

Richey, J.E. (1937) Some features of Tertiary volcanicity in Scotland and Ireland. *Bulletin Volcanologique*, séries II, tome **I**, 13–34.

Richey, J.E. (1938) The rhythmic eruptions of Ben Hiant, Ardnamurchan, a Tertiary volcano. *Bulletin Volcanologique*, séries II, tome **III**, 2–21.

Richey, J.E. (1940) Association of explosive brecciation and plutonic intrusion in the British Tertiary Igneous Province. *Bulletin Volcanologique*, séries II, tome **VI**, 157–75.

Richey, J.E. and Thomas, H.H. (1930) *The Geology of Ardnamurchan, North-west Mull and Coll.* Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Richey, J.E., Stewart, F.H. and Wager, L.R. (1946) Age relations of certain granites and marscoite in Skye. *Geological Magazine*, **83**, p. 293.

Richey, J.E. (1961) *British Regional Geology, Scotland: the Tertiary Volcanic Districts.* 3rd edn, revised by A.G. MacGregor and F.W. Anderson, HMSO, Edinburgh, 120 pp.

Ridley, W.I. (1971) The petrology of some volcanic rocks from the British Tertiary Province: the islands of Rhum, Eigg, Canna and Muck. *Contributions to Mineralogy and Petrology*, **32**, 251–66.

Ridley, W.I. (1973) *The Petrology of Volcanic Rocks from the Small Isles of Inverness-shire.* Report of the Institute of Geological Sciences, No. 73/10, 55 pp.

Roberts, D.G., Ardus, D.A. and Dearnley, R. (1973) Precambrian rocks drilled on the Rockall Bank. *Nature, Physical Sciences*, **244**, 21–3.

Roberts, D.G., Matthews, D.H. and Eden, R.A. (1972) Metamorphic rocks from the southern end of the Rockall Bank. *Journal of the Geological Society of London*, **128**, 501–6.

Roberts, D.G., Flemming, N.C. and Harrison, R.K. *et al.* (1974) Helen's Reef: a microgabbroic intrusion in the Rockall Intrusive Centre, Rockall Bank. *Marine Geology*, **16**, M21–M30.

Rogers, N.W. and Gibson, I.L. (1977) The petrology and geochemistry of the Creag Dubh composite sill, Whiting Bay, Arran, Scotland. *Geological Magazine*, **114**, 1–8.

Ross, A. (1884) A visit to St Kilda. *Transactions of the Inverness Scientific Society*, **3**, 72–91.

Sabine, P.A. (1960) The geology of Rockall, North Atlantic. *Bulletin of the Geological Survey of Great Britain*, **16**, 156–78.

Simpson, J.B. (1961) The Tertiary pollen-flora of Mull and Ardnamurchan. *Transactions of the Royal Society of Edinburgh*, **64**, 421–68.

Simkin, T.E. (1965) The picritic sills of north Skye, Scotland. Unpublished Ph.D. Thesis, University of Princeton.

Simkin, T.E. (1967) Flow differentiation in the picritic sills of north Skye. In *Ultramafic and Related rocks.* (ed. P.J. Wyllie), Wiley, New York, pp. 64–9.

Skelhorn, R.R. (1969) *The Tertiary Igneous Geology of the Isle of Mull.* Geologists' Association Guide, No. 20.

Skelhorn, R.R. and Elwell, R.W.D. (1966) The structure and form of the granophyric quartz-dolerite intrusion, Centre II, Ardnamurchan, Argyllshire. *Transactions of the Royal Society of Edinburgh*, **66**, 285–306.

Skelhorn, R.R. and Elwell, R.W.D. (1971) Central subsidence in the layered hypersthene-gabbro of Centre II, Ardnamurchan, Argyllshire. *Journal of the Geological Society of London*, **127**, 535–51.

Smith, D.I. (1957) The structure and petrology of the third ring-dyke complex, Ardnamurchan. Unpublished Ph.D. Thesis, University of Edinburgh.

Smith, J. (1896) A new view of the Arran granite mountains. *Transactions of the Geological Society of Glasgow*, **10**, 216–56.

Smith, N.J. (1985) The age and structural setting of limestones and basalts on the Main Ring Fault in south-east Rhum. *Geological Magazine*, **122**, 439–45.

Smith, N.J. (1987) The age and structure of limestone and basalt on the Main Ring Fault of south-east Rhum, Inner Hebrides, Scotland. Unpublished M.Sc. Thesis, University of Durham.

Sparks, R.S.J. (1988) Petrology and geochemistry of the Loch Bà ring-dyke, Mull (NW Scotland): an example of the extreme differentiation of tholeiitic magmas. *Contributions to Mineralogy and Petrology*, **100**, 446–61.

Sparks, R.S.J., Huppert, H.E. and Turner, J.S.

(1984) The fluid dynamics of evolving magma chambers. *Philosophical Transactions of the Royal Society of London*, **A310**, 511–31.

Sparks, R.S.J., Huppert, H.E., Kerr, R.C. *et al.* (1985) Postcumulus processes in layered intrusions. *Geological Magazine*, **122**, 555–68.

Speight, J.M., Skelhorn, R.R., Sloan, T., *et al.* (1982) The dyke swarms of Scotland. In *Igneous Rocks of the British Isles*. (ed. D.S. Sutherland), Wiley, Chichester, pp. 449–59.

Stewart, F.H. (1965) Tertiary igneous activity. In *The Geology of Scotland*. (ed. G.Y. Craig), 1st edn, Oliver and Boyd, Edinburgh, pp. 417–65.

Streckeisen, A. (1978) IUGS Subcommission on the systematics of igneous rocks. Classification and nomenclature of volcanic rocks, lamprophyres, carbonatites and melilite rocks. Recommendations and suggestions. *Neues Jahrbuch für Mineralogie*, Stuttgart, Abhandlung, **143**, 1–14.

Sutherland, D.S. (ed.) (1982) *Igneous Rocks of the British Isles*. Wiley, Chichester, 645 pp.

Tait, S.R. (1985) Fluid dynamic and geochemical evolution of cyclic unit 10, Rhum, Eastern Layered Series. *Geological Magazine*, **122**, 469–84.

Tate, R. and Blake, J.F. (1876) *The Yorkshire Lias*. John van Voorst, London.

Taylor, H.P. Jun. and Forester, R.W. (1971) Low-^{18}O igneous rocks from the intrusive complexes of Skye, Mull and Ardnamurchan, western Scotland. *Journal of Petrology*, **12**, 465–97.

Teall, J.J.H. (1884) Petrological notes on some north-of-England dykes. *Quarterly Journal of the Geological Society of London*, **40**, 209–47.

Teall, J.J.H. (1888) *British Petrography*. Dulau, London, 469 pp.

Thirlwall, M.F. and Jones, N.W. (1983) Isotope geochemistry and contamination mechanics of Tertiary lavas from Skye, north-west Scotland. In *Continental Basalts and Mantle Xenoliths* (eds C.J. Hawkesworth and M.J. Norry), Shiva, Nantwich, 186–208.

Thomas, H.H. (1922) Xenolithic Tertiary minor intrusions in the Island of Mull. *Quarterly Journal of the Geological Society of London*, **78**, 229–60.

Thompson, R.N. (1969) Tertiary granites and associated rocks of the Marsco area, Isle of Skye. *Quarterly Journal of the Geological Society of London*, **124**, 349–85.

Thompson, R.N. (1982) Magmatism of the British Tertiary Volcanic Province. *Scottish Journal of Geology*, **18**, 49–107.

Thompson, R.N. and Morrison, M.A. (1988) Asthenospheric and lower lithospheric contributions to continental extensional magmatism: an example from the British Tertiary Province. *Journal of Geophysical Research*, **91**, 5985–97.

Thompson, R.N., Esson, J. and Dunham, A.C. (1972) Major element chemical variation in the Eocene lavas of the Isle of Skye, Scotland. *Journal of Petrology*, **13**, 219–53.

Thompson, R.N., Gibson, I.L., Marriner, G.F. *et al.* (1980) Trace-element evidence of multistage mantle fusion and polybaric fractional crystallization in the Palaeocene lavas of Skye, NW Scotland. *Journal of Petrology*, **21**, 265–93.

Thompson, R.N., Dickin, A.P. and Gibson, I.L. (1982) Elemental fingerprints of isotopic contamination of Hebridean Palaeocene mantle-derived magmas by Archaean sial. *Contributions to Mineralogy and Petrology*, **79**, 159–68.

Thompson, R.N., Morrison, M.A., Dickin, A.P. *et al.* (1986) Two contrasting styles of interaction between basic magmas and continental crust in the British Tertiary Volcanic Province. *Journal of Geophysical Research*, **91**, B6, 5985–97.

Tilley, C.E. (1947) The gabbro–limestone contact zone of Camas Mor, Muck, Inverness-shire. *Comptes Rendus de la Société geologique de Finlande*, No. **140**, 97–105.

Tilley, C.E. (1949) An alkali facies of granite at granite–dolomite contacts in Skye. *Geological Magazine*, **86**, 81–93.

Tilley, C.E. (1951) The zoned contact-skarns of the Broadford area, Skye: a study of boron–fluorine metasomatism in dolomites. *Mineralogical Magazine*, **29**, 621–66.

Tilley, C.E. (1952) Some trends of basaltic magma in limestone syntexis. *American Journal of Science* (Bowen Volume), 529–45.

Tilley, C.E. and Harwood, H.F. (1931) The dolerite–chalk contact of Scawt Hill, Co. Antrim. The production of basic alkali-rocks by the assimilation of limestone by basaltic magma. *Mineralogical Magazine*, **22**, 439–68.

Tilley, C.E. and Muir, I.D. (1962) The Hebridean plateau magma type. *Transactions of the Edinburgh Geological Society*, **19**, 208–15.

Tilley, C.E. and Muir, I.D. (1967) Tholeiite and tholeiitic series. *Geological Magazine*, **104**, 337–43.

Tomkeieff, S.I. (1942) The Tertiary lavas of Rum. *Geological Magazine*, **79**, 1–13.

Tomkeieff, S.I. (1961) *Isle of Arran*. Excursion Guide, No. 32, Geologists' Association.

Tomkeieff, S.I. (1969) *Isle of Arran*. Excursion Guide, No. 32 (revised edition), Geologists' Association, 35 pp.

Tuson, J. (1959) A geophysical investigation of the Tertiary volcanic districts of western Scotland. Unpublished Ph.D. Thesis, University of Durham.

Tuttle, O.F. and Bowen, N.L. (1958) Origin of granite in the light of experimental studies in the system $NaAlSi_3O_8$–$KAlSi_3O_8$–SiO_2–H_2O. *Geological Society of America Memoir*, **74**.

Tuttle, O.F. and Keith, M.L. (1954) The granite problem: evidence from the quartz and feldspar of a Tertiary granite. *Geological Magazine*, **91**, 61–72.

Tyrrell, G.W. (1928) *The Geology of Arran*. Memoir of the Geological Survey of Great Britain, HMSO, Edinburgh.

Upton, B.G.J. (1988) History of Tertiary igneous activity in the N. Atlantic borderlands. In *Early Tertiary Volcanism and the Opening of the NE Atlantic* (eds A.C. Morton and L.M. Parson), Geological Society Special Publication, No. 39, pp. 3–14.

Vann, I.R. (1978) The siting of Tertiary vulcanicity. In *Crustal Evolution in Northwestern Britain and Adjacent Regions* (eds D.R. Bowes and B.E. Leake), Geological Journal Special Issue, No. 10, 393–414.

Vogel, T.A. (1982) Magma mixing in the acidic–basic complex of Ardnamurchan: implications on the evolution of shallow magma chambers. *Contributions to Mineralogy and Petrology*, **79**, 411–23.

Vogel, T.A., Younker, L.W., Wilband, J.T. *et al.* (1984) Magma mixing: the Marsco Suite, Isle of Skye, Scotland. *Contributions to Mineralogy and Petrology*, **87**, 231–41.

Volker, J.A. (1983) The geology of the Trallval area, Rhum, Inner Hebrides. Unpublished Ph.D. Thesis, University of Edinburgh.

Volker, J.A. and Upton, B.G.J. (1990) The structure and petrogenesis of the Trallval and Ruinsival areas of the Rhum Ultrabasic Complex. *Transactions of the Royal Society of Edinburgh: Earth Sciences*, **81**, 69–88.

Wadsworth, W.J. (1961) The layered ultrabasic rocks of south-west Rhum, Inner Hebrides. *Philosophical Transactions of the Royal Society*, **B244**, 21–64.

Wadsworth, W.J. (1982) The major basic intrusions. In *Igneous rocks of the British Isles*. (ed. D.S. Sutherland), Wiley, Chichester, pp. 415–25.

Wager, L.R. (1956) A chemical definition of fractionation stages as a basis for comparison of Hawaiian, Hebridean and other basic lavas. *Geochimica et Cosmochimica Acta*, **9**, 217–48.

Wager, L.R. and Bailey, E.B. (1953) Basic magma chilled against acid magma. *Nature, London,* **172**, 68–9.

Wager, L.R. and Brown, G.M. (1951) A note on rhythmic layering in the ultrabasic rocks of Rhum. *Geological Magazine*, **88**, 166–8.

Wager, L.R. and Brown, G.M. (1968) *Layered Igneous Rocks*. Oliver and Boyd, Edinburgh, 588 pp.

Wager, L.R. and Deer, W.A. (1939) Geological investigations in East Greenland, Part III – The petrology of the Skaergaard intrusion, Kangerdlugssuaq, East Greenland. *Meddelelser om Grønland*, **105**, 1–352.

Wager, L.R. and Vincent, E.A. (1962) Ferrodiorite from the Isle of Skye. *Mineralogical Magazine*, **33**, 26–36.

Wager, L.R., Brown, G.M. and Wadsworth, W.J. (1960) Types of igneous cumulates. *Journal of Petrology*, **1**, 73–85.

Wager, L.R., Vincent, E.A., Brown, G.M. *et al.* (1965) Marscoite and related rocks from the Western Red Hills complex, Isle of Skye. *Philosophical Transactions of the Royal Society*, **A257**, 273–307.

Wager, L.R., Weedon, D.S. and Vincent, E.A. (1953) A granophyre from Coire Uaigneich, Isle of Skye, containing quartz paramorphs after tridymite. *Mineralogical Magazine*, **30**, 263–76.

Walker, F. (1930) The geology of the Shiant Isles (Hebrides). *Quarterly Journal of the Geological Society of London*, **86**, 355–98.

Walker, F. (1932) Differentiation in the sills of northern Trotternish (Skye). *Transactions of the Royal Society of Edinburgh*, **57**, 241–57.

Walker, G.P.L. (1959) Some observations on the Antrim basalts and associated dolerite intrusions. *Proceedings of the Geologists' Association*, **70**, 179–205.

Walker, G.P.L. (1960) Zeolite zones and dike distribution in relation to the structure of the basalts of eastern Iceland. *Journal of Geology*, **68**, 515–28.

Walker, G.P.L. (1971) The distribution of amygdale minerals in Mull and Morvern (western

Scotland). In *Studies in Earth Sciences, W.D. West Commemorative Volume*. (eds T.V.V.G.R.K. Murty and S.S. Rao), pp. 181–94.

Walker, G.P.L. (1975) A new concept of the evolution of the British Tertiary intrusive centres. *Journal of the Geological Society of London*, **131**, 121–41.

Walsh, J.N. (1971) The geochemistry and mineralogy of the Centre 3 igneous complex, Ardnamurchan. Unpublished Ph.D. Thesis, University of London.

Walsh, J.N. (1975) Clinopyroxenes and biotites from the Centre 3 igneous complex, Ardnamurchan, Argyllshire. *Mineralogical Magazine*, **40**, 335–45.

Walsh, J.N. and Henderson, P. (1977) Rare earth element patterns of rocks from the Centre 3 igneous complex, Ardnamurchan, Argyllshire. *Contributions to Mineralogy and Petrology*, **60**, 31–8.

Walsh, J.N., Beckinsale, R.D., Skelhorn, R.R. *et al.* (1979) Geochemistry and petrogenesis of Tertiary granitic rocks from the Island of Mull, north-west Scotland. *Contributions to Mineralogy and Petrology*, **71**, 99–116.

Washington, H.S. (1914) The composition of rockallite. *Quarterly Journal of the Geological Society of London*, **70**, 294–302.

Weedon, D.S. (1960) The Gars-bheinn ultrabasic sill, Isle of Skye. *Quarterly Journal of the Geological Society of London*, **116**, 37–54.

Weedon, D.S. (1961) Basic igneous rocks of the Southern Cuillin, Isle of Skye. *Transactions of the Geological Society of Glasgow*, **24**, 190–212.

Weedon, D.S. (1965) The layered ultrabasic rocks of Sgùrr Dubh, Isle of Skye. *Scottish Journal of Geology*, **1**, 41–68.

Wells, M.K. (1951) Sedimentary inclusions in the hypersthene-gabbro, Ardnamurchan, Argyllshire. *Mineralogical Magazine*, **29**, 715–36.

Wells, M.K. (1954a) The structure and petrology of the hypersthene–gabbro intrusion, Ardnamurchan, Argyllshire. *Quarterly Journal of the Geological Society of London*, **109** (for 1953), 367–97.

Wells, M.K. (1954b) The structure of the granophyric quartz–dolerite intrusion of Centre 2, Ardnamurchan, and the problem of net-veining. *Geological Magazine*, **91**, 293–307.

Wells, M.K. and McRae, D.G. (1969) Palaeomagnetism of the hypersthene–gabbro intrusion, Ardnamurchan. *Nature*, **223**, 608–9.

Whetton, J.T. and Myers, J.O. (1949) Geophysical survey of magnetite deposits in Strath, Isle of Skye. *Transactions of the Geological Society of Glasgow*, **21**, 263–77.

White, R.S. (1988) A hot-spot model for early Tertiary volcanism in the N. Atlantic. In *Early Tertiary Volcanism and the Opening of the NE Atlantic* (eds A.C. Morton and L.M. Parson), Geological Society Special Publication, No. 39, pp. 3–14.

Whitten, E.H.T. (1961) Modal variation and the form of the Beinn an Dubhaich Granite, Skye. *Geological Magazine*, **98**, 467–72.

Williams, P.J. (1985) Pyroclastic rocks in the Cnapan Breaca felsite, Rhum. *Geological Magazine*, **122**, 447–50.

Williamson, I.T. (1979) The petrology and structure of the Tertiary volcanic rocks of west-central Skye, N.W. Scotland. Unpublished Ph.D. Thesis, University of Durham.

Wills, K.J.A. (1970) The inner complex of Centre 3, Ardnamurchan. Unpublished B.Sc. Thesis, University of London (Royal School of Mines).

Wilson, G.V. (1937) In *Geological Survey of Great Britain, Summary of Progress* (for 1936), 77–9.

Woodcock, N.H. and Underhill, J.R. (1987) Emplacement-related fault patterns around the Northern Granite, Arran, Scotland. *Geological Society of America Bulletin*, 515–27.

Wyatt, M. (1952) The Camasunary (Skye) gabbro–limestone contact. Unpublished Ph.D. Thesis, University of Cambridge.

Wyllie, P.J. and Drever, H.I. (1963) The petrology of picritic rocks in minor intrusions – a picritic sill on the Island of Soay (Hebrides). *Transactions of the Royal Society of Edinburgh*, **65**, 155–77.

Young, I.M., Greenwood, R.C. and Donaldson, C.H. (1988) Formation of the Eastern Layered Series of the Rhum Complex, north-west Scotland. *Canadian Mineralogist*, **26**, 225–33.

Zinovieff, P. (1958) The basic layered intrusion and the associated igneous rocks of the central and eastern Cuillin Hills, Isle of Skye. Unpublished D.Phil. Thesis, University of Oxford.

Zirkel, F. (1871) Geologische Skizzen von der Westküste Schottlands. *Zeitskrifte Deutsches Geologisches Gesellschaft*, **23**, 1–124.

Glossary

This glossary contains simple explanations of a selection of the more important technical terms used in Chapter 1 and in the Introduction, Highlights and Conclusions sections of Chapters 2 to 7. These explanations do not pretend to be scientific definitions. Rock groups are usually explained in terms of their chemistry rather than by reference to their precise mineral content. Only major mineral groups are included. Stratigraphical terms are omitted as they are related to their contexts within the tables and figures. Bold face indicates a further glossary entry.

Throughout the glossary and the volume as a whole the following grain (i.e. crystal) sizes are assumed for the igneous rocks:

coarse-grained – grains over 3mm on average
medium-grained – grains between 1 and 3mm on average
fine-grained – grains under 1mm on average (including non-crystalline glass)

Acid: coarse- to fine-grained **igneous rocks** relatively enriched in silica (SiO_2 nominally over 66%) which was originally thought to reflect the proportion of 'silicic acid'. An alternative term is 'silicic'.

Agglomerate: a **volcaniclastic rock** composed of large, often angular rock and mineral fragments (**clasts**).

Alkali-feldspar: see **feldspar**.

Allivalite: a coarse-grained **ultrabasic igneous rock** composed largely of the minerals plagioclase **feldspar** and **olivine**.

Amygdale: a **vesicle** infilled by minerals.

Aphyric: **igneous rocks**, especially those which are generally fine-grained, which contain no particularly large crystals; = non-**porphyritic**.

Arkose: sandstone containing abundant fragmental grains (**clasts**) of alkali-**feldspar**.

Aureole: the **metamorphic rocks** adjacent to an **igneous** intrusion.

Basalt: a fine-grained, **basic igneous rock** consisting largely of the minerals plagioclase **feldspar**, **pyroxene(s)** +/− **Olivine**. Usually a lava or a **dyke**.

Basic: coarse- to fine-grained **igneous rocks** relatively enriched in the 'bases' of early chemistry i.e. MgO, FeO, FeO_2, FeO_3CaO etc; silica (SiO_2) relatively low (nominally 45–53%.

Benmoreite: a fine-grained **igneous rock**, usually a lava, consisting essentially of soda-rich alkali-**feldspar**; see also **hawaiite**.

Bole: the iron-rich (sub-)soil produced by the surface weathering of **basalts**.

Breccia: a **volcaniclastic**, sedimentary, or fault-related rock composed of very large, usually angular rock fragments (**clasts**).

Caldera: a very large, approximately circular, fault-bounded basin formed by the collapse of a volcano.

Clast: a fragment.

Cone-sheet: a cone-like **igneous** intrusion which dips towards its centre, i.e. which closes downwards on projection. (cf. **ring-dyke**).

Crinanite: an alkali-(especially soda-)rich **dolerite** (or **gabbro**).

Diapir: a body, e.g. of **igneous rock/magma** which has risen through other rocks in consequence of its lower density and/or greater plasticity.

Diorite: a coarse-grained, lime-rich **intermediate igneous rock** containing plagioclase **feldspar** and various ferromagnesian silicate minerals.

Dolerite: a medium-grained, **basic igneous rock** containing plagioclase **feldspar** and **pyroxene(s)**; usually a **dyke** or **sill**.

Dyke: a sheet-like body of **igneous rock** which cross-cuts the structure of the rocks it intrudes; often steeply inclined and composed of **dolerite** or **basalt** (cf. **sill**).

Eucrite: a coarse-grained, **ultrabasic igneous rock** containing plagioclase **feldspar**, **pyroxene(s)** and **olivine**.

Eutaxitic: the 'streaky' fabric (i.e. gross texture) exhibited by an **ignimbrite**.

Feldspars: a series of alumino-silicate minerals between lime-soda-rich (plagioclase) and potash-soda-rich (alkali-feldspar) end-members; the most abundant minerals in the earth's crust.

Felsite: medium- to fine-grained, equigranular, **acid igneous rock** consisting largely of alkali-**feldspar** and **quartz**; often a **dyke** or **sill**.

Gabbro: a coarse-grained, **basic igneous rock** consisting largely of plagioclase **feldspar**, **pyroxene(s)** +/− **olivine**; usually in large intrusions.

Gneiss: a coarse-grained, often banded **metamorphic rock**.

Granite: a coarse-grained, **acid igneous rock** consisting largely of alkali-**feldspar** and **quartz**; usually in large intrusions.

Granophyre: a medium- to coarse-grained **acid igneous rock** which often displays a complicated, angular ('graphic') intergrowth between **quartz** and alkali-**feldspar**; usually in large intrusions.

Granulite: an even-grained granular **metamorphic rock**.

Harrisite: a coarse-grained, **ultrabasic igneous rock** which displays branching crystals of **olivine**.

Hawaiite: a variety of **trachybasalt** rich in soda. Hawaiite, **mugearite** and **benmoreite** form a compositional series between alkali-**basalt** and **trachyte**; all usually occur as lava flows.

Hornfels: a well-baked, hard **metamorphic rock**.

Hyaloclastite: **volcaniclastic rock** composed of quenched, glassy fragments (**clasts**) formed when magma cools and shatters on coming into contact with water.

Hydrothermal: to do with hot water.

Igneous Rocks: rocks which have solidified (usually crystallized) from molten rock (**magma**).

Ignimbrite: a lava-like sheet of **volcaniclastic rock** formed by the compaction and welding of an ash-flow (see also **tuff** and **eutaxitic**).

Intermediate: coarse- to fine-grained **igneous rocks** intermediate in compositions between **acid** and **basic**.

Laterite: a red (sub-)soil rich in iron and alumina.

Lherzolite: a **peridotite** consisting largely of **olivine** and **pyroxenes**; commonly exhibits a **metamorphic** texture indicating (re-) crystallization deep in the earth.

Mafic: see **basic**.

Magma: molten rock; referred to as lava when on the earth's surface.

Metamorphic Rocks: rocks whose texture and mineralogy have been changed in the solid, i.e. without melting, by heat and/or pressure.

Metasomatism: a group of processes by which rocks change their chemical composition in the solid, i.e. without melting.

Meteoric Water: water derived directly from the atmosphere.

Mullite: a very high-temperature alumino-silicate mineral.

Mugearite: see **hawaiite**.

Olivine: a silicate mineral enriched in magnesium (and/or iron).

Pegmatite: applied to very coarse-grained varieties of **igneous rocks**; however, 'pegmatite' normally implies very coarse-grained **granite**.

Peridotite: a coarse-grained, **ultrabasic igneous rock** consisting largely of **olivine** and **pyroxene(s)**.

Petrography: (the study of) the mineralogy and texture (fabric) of rocks.

Phyric: denotes the type(s) of the large crystals in a **porphyritic igneous rock** (usually a lava), e.g. **feldspar**-phyric.

Picrite: a lava of **ultrabasic** composition, particularly enriched in **olivine**.

Pitchstone: a **rhyolite** composed largely of volcanic glass.

Plagioclase: see **feldspar**.

Porphyrite: an **igneous rock**, often of **intermediate** composition and of medium grain-size, which displays **porphyritic** texture.

Porphyritic: the texture of those **igneous rocks**, often lavas, in which large crystals (megacrysts, phenocrysts) are surrounded

by a matrix of smaller crystals and/or glass.

Pyroclastic: see **volcaniclastic**.

Pyroxenes: the most abundant ferromagnesian silicate minerals in the earth's crust, e.g. augite and hypersthene.

Quartz: a mineral composed entirely of silica (SiO_2)

Rheomorphism: the processes by which a rock is (re-)melted.

Ring-Dyke: a near-cylindrical **igneous** intrusion which tends to close upwards on projection (cf. **cone-sheet**).

Skarn: a rock containing iron-rich and other minerals sometimes found at the contact between an **igneous** intrusion and its **aureole**, especially where this contains limestones; **metasomatism** is often invoked.

Sill: a sheet-like body of **igneous rock** which, in general, does not cross-cut the structure of the rocks which it intrudes; often gently inclined, medium-grained and composed of **dolerite** or **basalt** (cf. **dyke**).

Syenite: a coarse-grained, **intermediate igneous rock** consisting largely of alkali-**feldspar** and various ferromagnesian silicate minerals; usually in large intrusions.

Teschenite: an alkali-rich **gabbro**.

Tholeiite: **basalt** relatively enriched in silica $(SiO)_2$ and deficient in the alkalis (NaO_2 and K_2O).

Trachybasalt: **basalt** containing both plagioclase and alkali-**feldspar**.

Trachyte: a fine-grained, **intermediate igneous rock** consisting largely of alkali-**feldspar** and various ferromagnesian silicate minerals; usually a lava or **dyke**.

Transitional Basalt: **basalt** transitional between alkali-basalt and **tholeiite**.

Tridymite: a high-temperature equivalent (paramorph) of **quartz**.

Troctolite: a coarse-grained **basic igneous rock** consisting largely of **olivine** and plagioclase **feldspar**.

Tuff: consolidated volcanic ash (see also **volcaniclastic rocks**).

Tuffisite: a **Tuff**-like rock usually formed by the **hydrothermal** breakdown of volcanic rocks close to a rock fracture.

Ultrabasic Rocks: coarse- to fine-grained **igneous rocks** which are particularly enriched in 'bases' (see also **basic**) and relatively deficient in silica (SiO_2 nominally under 45%).

Vesicles: gas bubble cavities in consolidated lavas.

Volcaniclastic Rocks: rocks made up of volcanic fragments (**clasts**); also known as pyroclastic rocks.

Xenocrysts/-liths: (fragments of) crystals and rocks that are foreign to the **igneous rock** in which they are found.

Zeolites: a group of low-temperature, hydrous, elumino-silicate minerals.

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