BOOK REVIEWS

PITCHER (W. S.) and BERGER (A. R.). *The geology of Donegal: a study of granite emplacement and unroofing* (with a coloured 1:63 360 geol. map compiled by Margaret O. Spencer). New York and London (Wiley-Interscience), 1972. xii+435 pp., 150 figs., 2 maps (in back pocket). Price £17·00.

Although this book is ostensibly concerned with recent work on the granitic rocks of a relatively small part of the Caledonian orogenic belt it in fact mirrors the whole range of problems connected with the granite controversy. This detailed investigation of the Donegal granites was inspired and initiated by R. M. Shackleton and H. H. Read some twenty-five years ago and the memoir represents a synthesis of numerous studies on the rocks of north-west Ireland carried out by more than forty-five workers, mainly from Imperial College and King's College, London, and from the University of Liverpool. Not the least important part is the one-inch to one-mile coloured geological map of the solid geology of the whole of north-west and central Donegal.

After a useful outline of the geology of Donegal, the first part of the book deals with the Dalradian miogeosynclinal rocks and their deformation. The shales, limestones, turbidites, and tillite are grouped into two great divisions, the Creeslough succession and the structurally superimposed Kilmacrenan formation, and immediately after their deposition a large volume of tholeiitic magma was intruded as sills. These intrusions were followed by a series of tectonic and metamorphic events, reaching in places the kyanite grade of regional metamorphism. Several phases of metamorphism occurred, however, both prograde and retrograde, and it is not possible to draw simple isograds across Donegal.

The stage was thus set for the major episode of Caledonian granite emplacement (dated at just under 500 Myr), which produced relatively high-level plutons and accompanying suites of minor intrusions. Eight different granite units are distinguished, exhibiting a variety of mechanisms of emplacement and producing correspondingly different contact effects on their host rocks. Stoping is illustrated by the Thorr, Fanad, and Trawenagh plutons: with the Thorr pluton there is evidence of contemporaneous movement in the envelope and of reaction with the country rocks, and the authors refer to the process as active stoping, whereas with the Fanad pluton the movement was weaker, the reaction with the country rocks less severe, and the stoping was a passive process. Permissive emplacement is exemplified by the Rosses and Barnesmore plutons, both centred complexes in which a roughly concentric pattern of closely related granites resulted from repeated cauldron subsidence; the contact effects are slight or almost undetectable. The Ardara pluton is an example of forceful emplacement produced by successive pulses of magma causing a radial distension of the wall rocks; the Toories pluton, only exposed on off-shore islands, appears to be similar. The largest of the granitic masses, the Main Donegal granite, is difficult to fit into this scheme of emplacement mechanisms. Although earlier considered to be the result of forceful magmatic wedging accompanied by near horizontal flow of partly consolidated magma and the lateral distension of the country rocks, it is now clear that the

salient features of this granite are the result of its being strongly deformed at the present crustal level during the later stages of consolidation. It is shown that this deformation has for example affected xenoliths derived from the present envelope of the pluton and not brought up from depth and that marginal sheets and dykes cutting the granite and its envelope are deformed together; these relationships are taken to indicate that the deformation is a superimposed phenomenon, whatever its cause, and not due simply to strain accumulated during intrusion. A separate chapter is devoted to the envelope of this pluton and the detailed chronology of the tectonic events.

The coexistence of andalusite, sillimanite, and kyanite together with staurolite, garnet, biotite, chlorite, and more rarely chloritoid and cordierite in the aureole of the Main Donegal pluton makes this a situation with few counterparts. There is clear evidence of superposition of contact metamorphism on that of the regional crystallization in the country rocks. The authors feel that it seems especially significant that the magma in this case was forcibly emplaced: the creation of overpressures and the effect of deformation would be expected to influence not only the structural evolution of the contact rocks but the metamorphic reactions taking place within them. The late-stage overprinting of the early metamorphic assemblage by a metasomatic zone of fibrolite and muscovite may well be due to further accessions of heat resulting from a continued upward penetration of the intrusive. The structural considerations in this particular pluton are complex and one can but agree that the nature of the emplacement mechanism does influence the chemical controls of metamorphism. The fabric of the granitic rocks themselves is also discussed, with comments on granite tectonics, on the interpretations of textures, and on ghost stratigraphy; it is concluded that although ghost patterns have an important bearing on the mode of emplacement of the rocks, they do not provide prima facie evidence of replacement.

Certain of the Donegal granites are connected in time and space with a highly characteristic assemblage of basic minor intrusions with a typical coarse-grained association of hornblende, plagioclase, and sometimes quartz, and with biotite and pyroxene as alternative mafic minerals. This appinite suite is considered to be the result of crystallization under high vapour pressures of magma released from the mantle, such mobilization being related to or facilitated by the addition of volatiles from granitic crustal material. The final model proposed is one in which granitic and appinitic or dioritic magmas were produced by melting processes in the crust and mantle, respectively, during the Caledonian orogeny. The granites were not simply produced at the peak of metamorphism and left to migrate slowly into the upper crust but were generated during each of the main episodes of deformation when, in response to a slight increase in heat flow and followed by a progressive drop in pressures, a series of magma pulses of changing composition were formed.

As the authors remark in their preface, the granite controversy has been bedevilled by overgeneralization; the need is now for very detailed studies of particular plutons in different geological settings. Certainly in Donegal such a variety of modes of emplacement is displayed, with a considerable range of contact effects at the one level in the crust, that it seems evident that the character of a granitic pluton, and its

relationship with its present envelope, need bear little relation to position in the crust. Here in this memoir we have a synthesis of the now abundant factual record of the unusually well exposed Donegal granites and their envelopes—with one exception: surprisingly little is said about the geochemistry of the rocks (one table of major oxide averages for the plutons) and there is little attempt to link or relate results with those of modern experimental work other than that dealing with anatexis. Mineralogical details are also somewhat thin. But such criticism is perhaps ungracious. The authors have aimed to cover mainly such topics as varying modes of emplacement, internal structures in plutons, and the relationships between granitic plutons and the structures and metamorphism of the country rocks and in this they have succeeded brilliantly.

The book is beautifully produced and well illustrated, but with British geologists as a major market (despite its having been translated, in places, into American) it is highly priced and presumably aimed at libraries—for whom it is essential.

R. A. HOWIE

McCALL (G. J. C.). *Meteorites and their Origins*. Newton Abbot (David and Charles), 1973. 352 pp., 80 figs. Price £4·95.

The author has set himself the well-nigh impossible task of condensing meteoritics into 'a single readable volume . . . suitable for use as a general text for amateur scientists, university students, and professional scientists'. On the credit side, he has compressed a great deal of information into an inexpensive volume and appended a useful selection of references, but both the amateur and the professional will find much lacking.

As the author remarks, 'meteoritics . . . is bedevilled with strange names', many of which can hardly be avoided; the author carefully explains some (e.g. isomorphous series, on p. 87), but the amateur will find many descend on him out of the blue (e.g. 'twinning on the trapezohedron face', p. 98)—a glossary would have been a better solution of the problem. The professional scientist, on the other hand, will find the select bibliography a poor substitute for detailed references when he seeks for further information on any point; and the selection of references for inclusion is peculiar—for example, two short accounts of the Barwell fall are included, but the definitive paper by Jobbins *et al.* (*Min. Mag.* **35** 881) is not. And in the absence of a date of finalization of the text (there are only a few 1971 references) it is uncertain where updating should start (the discussion of Ga-Ge grouping of irons is already seriously outdated).

The segregation of metamorphism into Ch. 16 and of the chemistry of meteorites into Ch. 12 has resulted in a very inadequate discussion of the common chrondrites (pp. 129–32). The Fa_{21} boundary between bronzite and hypersthene chondrites is shown in fig. 16, but omitted from the text, as is the sharp distinction in total iron content (mentioned later, p. 157). Incidentally, the author uses Poldervaart's redefinition of bronzite and hypersthene, rejected with good reason by most meteoriticists, and the whole discussion of meteoritic pyroxenes is seriously incomplete.