BOOK REVIEWS

Regional Geochemistry of Parts of North-West England and North Wales. Keyworth, Nottingham (British Geological Survey), 1997. vii + 128 pp (with maps and an overlay in pocket). Price, £75.00. ISBN 0-85272-307-5.

This, the twelfth volume in the series, presents baseline geochemical data over an area ranging from the Forest of Bowland and the western Pennines, the drift-covered plains of Lancashire and Cheshire (including the urban and industrial belt of Manchester and Liverpool), and northern Wales, including the Denbigh Moors, Snowdonia, Anglesey and the Lleyn Peninsula. After an introductory section detailing the methods of sample collection and preparation, chemical analysis, statistical information and data intepretation, there is a useful summary of the geology of the area accompanied by a simplified geological map. This is followed by a brief but important description of the mineralization and mining (ranging from coal, slate and rock salt to volcanic massive sulphide base-metal deposits, red-bed Cu-Ba mineralization in Triassic sandstones, and stratiform volcanogenic manganese deposits on the Lleyn Peninsula); this is usefully accompanied by a map showing the locations of the various mineral deposits and brief details of the elements or commodities mined.

The collection of multicoloured maps opens by illustrating the geochemistry of stream water, with individual maps for acidity, conductivity, and the levels of bicarbonate, fluoride and uranium. These are followed by a series of maps displaying the geochemistry of 31 individual elements in stream sediments, and by a further batch of maps of the individual elements in soil samples (all on a scale of 1:500 000). These are succeeded by 14 maps showing multi-element geochemistry, ranging from Mg:Ga and La:Y ratios in stream sediments to five sophisticated three-component colour composite maps of, for example, Fe-Mn-Co in stream sediment, followed by a series of smaller scale maps demonstrating the geochemical signatures of black shales in the Craven Basin contrasted with those of the Llanrwst mining area and the Vale of Conwy (single element maps for Cu and Ag together with a Mo-U-V three-component map); the distribution of Be, Cd, Ni and three-component Ni-Cd-Zn in the S part of the Denbigh Moors; an Y anomaly associated with igneous rocks at Pen-y-Bedw, S of Betwys-y-Coed; Cu and Pb with three three-component maps for Snowdonia; and maps of the distribution of Cu and of the three components Cd-Ag-Zn and Sb-As-Bi for the Parys Mountain area of Anglesey.

The final double-page spread contains a map for Cu and six three-component maps for various heavy metals in the contaminated soils of Lancashire, chiefly to the west of Manchester. Here the low-lying land mainly in the floodplain of the River Mersey, and underlain by glacial and fluvial sand and gravels, was formerly occupied by fens (locally known as 'mosses') in which peat deposits developed after the last glaciation. Drainage reclaimed most of this land for agricultural and industrial use (including the Liverpool and Manchester railway), and the town of Irlam had iron and steel works, a large coal-fired power station, major gas and sewage works and a large chemical factory. The very high levels of several heavy metals found in the soils of Chat Moss and Carrington Moss (and also Halsall Moss NW of Ormskirk) reflect the historical use of these mosses for the disposal of Manchester's 'street waste', transported down the Ship Canal in barges, distributed over the area of the mosses and ploughed in. This combination of peaty soil and organic and mineral waste produced a rich fertile soil which was used for growing vegetables until the 1950s. There is some indication from the metal levels that furnace slag and power-station ash was also disposed of in this fashion.

A feature in this volume is the enclosure, at the back, of 1:250 000 maps of not only outdoor gamma-ray radiation based on solid geology but also of radon potential based on solid and drift geology, both for 'Liverpool Bay', which in fact includes most of the area covered by the rest of the volume apart from Anglesey, the Lleyn Peninsula and parts of Snowdonia. The radon potential was calculated by log-normal modelling, based on the interpretation of radon measurements in dwellings and soil-gas radon measurements, supplemented where data were sparse by assessment of rock and geochemical evidence. The rocks with the highest radon potential in this

map area are the Carboniferous Limestone in North Wales and around Clitheroe, and the Namurian and certain acid intrusive rocks in North Wales. The Permo-Triassic rocks underlying much of the Manchester and Liverpool areas have uniformly low radon potential. Surprisingly, perhaps, there is no mention of selenium in soils of the agricultural areas covered.

Altogether this volume is extremely informative, dealing as it does with an area where the geological map alone can only give part of the story, because of the extensive spread of mining and industrial debris and contamination. The map of radon potential will be of considerable interest, and the degree of heavy-metal contamination in the soils to the west of Manchester should serve as a warning to future generations. The areas covered by published atlases in this series are creeping steadily south; it will be useful to have coverage of the whole of Great Britain on this scale.

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Treloar, P.J. and O'Brien, P.J. (Eds). *What Drives Metamorphism and Metamorphic Reactions?* London (The Geological Society, Special Publication No. 138), 1998. vi + 287 pp. Price £69.00. ISBN 1-86239-009-6.

Understanding the causes of metamorphism has been one of the major objectives for metamorphic petrologists throughout the 20th century. Progress has been remarkable despite a few wrong turnings, from the invention of geothermometry by Goldschmidt in the early years of the century, through Eskola's facies principle to the recognition by Miyashiro, first that different patterns of metamorphic facies corresponded with different thermal gradients in the crust, and subsequently that these could be identified with different plate tectonic settings. Contrary to the impression given by the editors of this volume in their introduction, the developments of the last 20 years have largely been in the detail, but this work is gradually bringing us to a much more complete and dynamic view of orogenesis, tracking tectonics and structure, heat and burial, through time. Despite the breadth of its main subject, this book also finds room to include papers that deal with metamorphic processes and reaction mechanisms, and one that does not seem to have much to do with either theme.

Inevitably, with just 14 chapters to review most of what has interested most of today's metamorphic petrologists for their entire careers, the coverage is patchy. Nevertheless, there are some excellent chapters here which present the results from some of the most exciting work going on in the field. While readers of a philosophical bent will like Hodges' Gaia-like view of the Himalayas as a self organising system, I particularly enjoyed the modelling study of Barrovian metamorphism by Jamieson and her colleagues. This coupled thermal and mechanical model is presented with an honest account of its limitations, but nicely demonstrates the importance of the balance between subduction and radiogenic heating in the thermal development of an orogen.

Another paper that I found very valuable is that by Sandiford & Hand on the high-*T*, low-*P* metamorphism of the Australian Proterozoic. Most examples of such metamorphism are clearly associated with contemporaneous magmatism, and lead to the old debate about the distinction between regional and contact metamorphism in situations where volcanism means that the magmatic heat input to the upper crust was much greater than that contributed by the plutonic rocks remaining today. However there are a few areas, and this is the best known, where geochronology stubbornly refuses to support such a simple association, and these authors have produced a conductive heating model, based on the presence of anomalously radiogenic material in the crust. The more normal association of high-*T*, low-*P* metamorphism is discussed by Brown in the context of the classic Ryoke and Abukuma belts of Japan. These have been interpreted as having formed in the roots of an arc for many years, but Brown argues that it is actually ridge-trench interactions which cause such metamorphism, through the more voluminous basic volcanism that results. It is certainly an important point to recognize that on a spherical earth, triple junctions may migrate through any one point during the evolution of an individual belt, but the specific evidence for ridge involvement seems to remain elusive. Certainly in the example with which I am most familiar, that of Connemara in the Irish Caledonides, the arc was recognized in the first place in the early 1980s precisely because the mineralogy and chemistry of the basic intrusions had unequivocal arc characteristics. Back then we would have been much less certain if there had been a MORB signature to confuse the issue!

A final paper of note in this part of the volume, which also includes several meticulous case