

substantiated optical data in the range An_{90-100} and today few universities give instruction in the Universal Stage.

The Burri data were not presented in the most convenient form for direct application to the microscope so Professor Tsuboi and his colleagues have used computer methods to transform them into five groups of diagrams with this in mind. Unfortunately the steps in the procedure are not spelt out and one's initial reaction to the sheer mass of charts with their twin commentaries in Japanese and in English could well be one of disbelief and then of panic, with immediate recourse to the electron probe or perhaps to the whisky bottle.

However, upon more careful examination the procedure to be followed becomes a little clearer. First Tsuboi's Dispersion method (1925) is applied to find α' on a cleavage flake; this fixes the composition irrespective of structural state or orientation, and with care can be used on zoned material. Then one of the Group 2 diagrams (extinction angles in special orientations) is used to determine the structural state and check the composition. Group 3 presents extinction angles for all general orientations and so can be used with the Universal stage on unfavourably oriented material. As orientations are listed as Becke coordinates, these can be set directly on A_2 and A_4 . Group 4 does the same for the two sets of sub-individuals of an albite twin, and Group 5 is the analogue of Group 3 but shows partial birefringences—of little value in the writer's opinion. By interpolation, and using different orientations, transitional structural states can be deduced though this is not stated. The work is well produced, the English is satisfactory, the charts are clear and there is a short bibliography.

Optical studies have still an important role to play in the study of such complex minerals as the feldspars where details of the thermal history can be deciphered; unfortunately this would not be obvious from a first reading of this text. I am afraid the work, though of very considerable merit, will only appeal to those who already know the value of optical studies on the feldspars and who can use the Universal Stage.

I. D. MUIR

Powell (Roger). *Equilibrium Thermodynamics in Petrology*. London (Harper and Row), 1978. xii + 284 pp., 111 figs. Price £8.95 (cloth), £4.95 (paperback).

The applications of thermodynamics to problems in mineralogy, petrology, and geochemistry have been explored in a number of recent books, and one looks for a new approach to justify further offerings. The new features in this book are a marked

simplification of the mathematics and of the ideas, and the provision of numerous worked examples. Taken together, these should enable the average undergraduate in the earth sciences to follow the work. The price of simplification is necessarily a rather superficial approach to a subject rich in mathematical and philosophical pitfalls, which are normally thought to require a more cautious and rigorous approach.

The first two chapters introduce the idea of equilibrium, and the assumptions that at equilibrium the Gibbs free energy (G) of the system is minimized, and that the chemical potentials $\mu_i \equiv (\delta G/\delta n_i)_{P,T}$ of the components are equalized between the phases. This is followed by a discussion of $G-x$ and $T-x$ diagrams. The next four chapters (3-6) deal with activities and standard states, thermodynamics of solids, thermodynamics of fluids, and equilibrium thermodynamic calculations.

Although time has no place in equilibrium thermodynamics, since at equilibrium $(\delta G/\delta t)_{P,T,x} \equiv 0$, the next two chapters are mainly concerned with (irreversible) rate processes. Chapter 7 deals with nucleation and growth, mass transfer, and the $T-t$ dependence of rate processes, the discussion being largely qualitative. Chapter 8 covers buffering, fractionation, and metasomatism, and is more quantitative.

Chapter 9 contains worked examples of petrological calculations, and it is followed by appendices, in the first of which is found the only serious mention of entropy, enthalpy, heat capacity, thermal expansion, and compressibility. This peculiarity may evoke a hostile reaction from readers used to more rigorous texts, although it will be greeted with relief by students suffering from a surfeit of Maxwell's relations.

Perhaps it is best to view this as a thermodynamic cook book: just as a cook ignorant of the chemistry and physics of food can produce an edible product by following a recipe, so can our budding petrologist calculate his phase diagrams using the methods outlined here. Whether he will reach a better understanding of either thermodynamics or petrology in the process is open to doubt. A book on equilibrium thermodynamics in which equilibrium is as loosely defined as it is on pp. 1-3, in which molar volumes have units of kilojoules per kilobar, and in which entropy and enthalpy are relegated to an appendix, is perhaps not calculated to produce perfect enlightenment. In this respect the book compares poorly with the recent Mineralogical Association of Canada publication (*Application of Thermodynamics to Petrology and Ore Deposits*, ed. H. J. Greenwood (M.A.C. 1977), \$5.00), reviewed in M.M. 42-164,

which covers much of the same ground. Nonetheless, it represents an interesting approach to the problems of teaching thermodynamics to petrologists, and it deserves serious consideration by those involved in such teaching.

R. G. J. STRENS

Mason (R.). *Petrology of the Metamorphic Rocks*. London (George Allen and Unwin), 1978. xvi + 254 pp., 122 figs. Price £10.95 (boards), £5.95 (paperback).

This is the metamorphic counterpart of the well-known text *Petrology of the Igneous Rocks* by Hatch, Wells, and Wells; it aims to be comprehensible to geology students who are not necessarily petrology specialists. General principles are illustrated by selected suites of metamorphic rocks, the underlying theme being the recognition of equilibrium assemblages in metamorphism. The three parts of the book deal with metamorphic rocks in the field, under the microscope, and in the laboratory—the latter including useful chapters on the study of metamorphic reactions, isotope geology, and electron-probe microanalysis.

The part on metamorphic rocks under the microscope takes up more than half of the book and will be the section of most general use. It is illustrated by thin-section drawings keyed to the text and generally of rocks from Britain or Europe. This section deals with considerably more than petrography, ranging as it does from consideration of the phase rule and AFM and ACF diagrams to the conditions of formation of blueschists. Contact rocks, however, are dealt with rather summarily (Skiddaw, Comrie, Skye) and with virtually no descriptions of skarns or of the problems of metasomatism. For dynamic metamorphism we are taken to Turkey and to the Lochseiten mylonite, Switzerland, but also included are descriptions of progressive shock metamorphism at the Ries crater, Germany, and of metamorphism in Moon rocks.

Regional metamorphism is split into a consideration of metamorphic rocks of Precambrian shield areas, Palaeozoic orogenic belts, Cainozoic orogenic belts, the ocean floor, and the upper mantle. After consideration of the pyroxene gneisses of the Scourie area and Lewisian migmatites, progressive Barrovian regional metamorphism of pelitic and basic igneous rocks in orogenic belts is exemplified not by the Scottish Dalradian area but by the Furulund schist and Sulitjelma amphibolites of Norway. For this interesting departure the author is to be congratulated: in this area the two respective stratigraphical units can be traced continuously from low- to high-grade assemblages; the progressive changes are sketched in AFM diagrams

and the textural developments are integrated. A different type of regional metamorphic sequence is described from the Dalradian schists of Connemara, the later phases of which represent a Buchan-type assemblage, thus leading to consideration of variations in the conditions of metamorphism in space and time. A description of the Alpine orogenic belt includes descriptions of the progressive regional metamorphism of pelitic rocks above the Aar massif and of basic igneous rocks in the Pennide nappe, going on to a consideration of retrograde metamorphism. The Troodos basic-ultrabasic complex of Cyprus illustrates metamorphic rocks of the ocean floor, and the upper mantle is represented by the xenoliths of eclogite in the South African kimberlites. Throughout this section some of the pitfalls of nomenclature are carefully avoided; pelite and psammite are eschewed though their adjectival forms are used.

The chapter on metamorphic reactions comes in part III, though its contents need to be studied in conjunction with the rock descriptions of part II. The introduction of the concept of metamorphic facies at this stage is, however, well justified: as the author states, the assignment of a suite of metamorphic rocks should come at the end of an extensive programme of field and microscopic rocks not at the beginning. The uses of both unstable (radioactive) and stable isotopes are described, including the application of oxygen isotope geothermometry to progressive regional metamorphic sequences. The final chapter deals with metamorphic rocks and the evolution of the earth, with mention of paired metamorphic belts and introducing a model of the crust and upper mantle beneath an island arc.

Terms in the eight-page glossary are indicated in bold type when first introduced in the text. The printing and diagrams are clear and such oddities as Beinn an Duhaich being shorn of its final 'h' throughout the book will no doubt be rectified in succeeding editions which will assuredly be necessary. A book to be digested thoroughly by students before entering their final Honours petrology course.

R. A. HOWIE

Rösslin (Eucharius) d. 1526. *Eucharius Rösslin The Younger on Minerals and Mineral Products. Chapters on Minerals from his 'Kreuterebuch'* (Critical text, English translation, and commentary by J. S. Belkin and E. R. Caley). Berlin and New York (Walter de Gruyter & Co.), 1978. xxxviii + 415 pp., 3 figs. Price DM 240.

The mineralogist interested in the curious lore of the late Middle Ages that surrounded minerals, especially in connection with the use of such