

an interesting discussion of the possibility that the seas of the past 600 Ma were stratified and thus not amenable to the Principle of Uniformity. J. Pereira, though hindered by the limitations of the literature, attempts an assessment of the ore resources of China in relation to plate tectonics. A new potash evaporite field, at Sergipe (Brazil) makes its first impact at the capable hands of H. Borchert, while G. K. Strauss, J. Madel, and F. Fdez Alonzo, describing the latest position in the Spanish-Portuguese pyrite belt, produce the interesting fact that of 500 m tonnes of new ore reserves, 50 m can be credited to geological reasoning, 130 m to geophysics, and the rest to systematic driving and boring.

The catholic outlook of the *Festschrift* is even clearer in the particular description of ore problems, grouped under Pre-Cambrian, Palaeozoic, and Mesozoic for discussions of fields, with concluding sections on strata-bound intrusive deposits (an elaborate way of describing chromite layers!) and on geochemical problems, especially those of S, C, and O-isotopes. A remarkable discovery in the past few years in which Professor Maucher played an important part has been that of stratified scheelite deposits in metamorphic contexts in such widely separated areas as the Eastern Alps, Tasmania, and South Korea. This volume adds another case, this time in Argentina, described by M. K. and A. de Brodtkorb. R. Höll contributes on the Alpine Sb-W-Hg deposits and U. Burchard on King Island. G. C. Amstutz who always attempts to find the origin of ores in the enclosing strata runs true to form and deals with the Michigan copper deposits, invoking statistical procedures, which, to me, fail to give objective conviction. The strata-bound magnesite deposits of the Spanish Pyrenees appear to W. Petrascheck and his collaborators as showing many metasomatic features, yet the unravelling of the structure convinces them of a sedimentary origin; while O. Schultz and F. Vartar find sedimentary fabrics in the well-known Alpine magnesites.

Finally the notion of time in ore-genesis could hardly be better illustrated than in H. J. Schneider and B. Lehmann's new conception of the Bolivian tin province, where they identify Pre-Cambrian stanniferous granites, Silurian metasedimentary tin mantos, and two cycles of magmatic regeneration respectively in Early Mesozoic and Cainozoic times.

Except for one excellent article by Paul Ramdohr in German (on titanomagnetite) the papers are all in English. Proof reading has not been perfect, but the volume is well-produced and illustrated.

KINGSLEY DUNHAM

Waters (K. H.). *Reflection seismology*. New York and Chichester (Wiley-Interscience: John Wiley & Sons), 1978. xvi + 377 pp., 211 figs., 2 colour pls. Price \$35.60 (£19.75).

The sub-title of this book is *A Tool for Energy Resource Exploration* and it deals almost wholly with the exploration for petroleum with only passing reference to the investigation of the structure of coal seams. Possible uses of reflection seismology to map bedded ores or in hydrogeology are not specifically dealt with although both the general principles and specific techniques described have applications in these fields.

After dealing with general principles there are chapters on sources and receivers, data gathering, and data processing. In the second half of the book the author deals with more detailed investigations, and includes separate chapters on migration, near surface corrections, and interpretation. He concludes with an account of new techniques now in development. Appendices deal more fully with special subjects following the general accounts in some chapters.

The book is well illustrated throughout and includes many illustrations from unpublished industrial sources. Although the author disclaims the level of the mathematical background he provides it should prove more than adequate for honours students in geology and geophysics and to most practising exploration personnel. However geologists can use this work advantageously without following all the mathematical arguments.

H. C. POTTER

Tsuboi (S.), Mizutani (S.), Suwa (K.), and Tsuzuki (Y.). *Charts of Plagioclase Optics*. Tokyo (Iwanami Shoten), 1977. ix + 137 charts. Price 7200 Yen.

Before the electron probe became widely available the Universal Stage was regarded as the most satisfactory instrument for investigating plagioclases in thin section. On good material it will give a reliable estimate of the composition ($\pm 2\%$), determine the twin laws present, and produce an assessment of the structural state if the mineral is less calcic than An₇₀. Unfortunately optical methods, though rapid, do not reveal the potassium content and are of restricted use on finely twinned or unfavourably oriented material. Until the appearance of *Die Orientierung der Plagioclase* by Burri *et al.* (1968), optical methods suffered from an inadequate number of reliably determined chemical compositions. Paradoxically the arrival of the electron probe coincided with a decline in optical studies: there is still an absence of good chemically

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,