chapters in total): Introduction, Origin and Migration, Habitat (source rock, and petroleum in the reservoir), and Applications. It has a useful Glossary, and an extensive list of references with an unusually high proportion from the eastern world.

Hunt's stated objective is to explain the basic principles of petroleum geochemistry in a way that geologists as well as chemists will understand, in a book intended for use as a reference as well as a text. In these aims, Hunt very largely succeeds. It was a relief to the reviewer to find that Hunt is more cautious in his claims for petroleum geochemistry than many of his colleagues because some important petroleum reserves would perhaps not have been found if recent dogma had been applied to the early boreholes.

It is a pity that *Geology* was included in the title, because the book contains no more geology than is implied in *geo*chemistry — and here we come to the nub of the matter. Hunt correctly states (p. 516): 'Geologists and geophysicists frequently have an interest but have limited knowledge of geochemistry, so they may misinterpret geochemical data'. The same is true, *mutatis mutandis,* of geochemists and geology. Some geologists fear that we are being led into error by premature acceptance of geochemical arguments. This book will not entirely allay those fears. The following questions seem to remain without a clear answer:

(1) Does 'good source rock' mean that is *has* generated significant quantities of petroleum, or that it *will* in the future?

(2) Do chemical reactions beyond the reach of cosmic radiation, but in the presence of other radiation, follow laboratory laws? For example, could some of the changes be caused by gamma radiation from clay minerals?

(3) Biodegradation is explained using reservoir examples, yet the same characters have been found in extracts from samples taken from deep within a shale, tens of metres from the nearest permeable bed. How do bacteria penetrate the shale, or do they live for millions of years? Are bacteria primary source material? Or, have we misunderstood this?

(4) The depth of the threshold of intense oil generation is commonly taken as about 1500 m. Why was the most productive depth of 236 fields, each with more than 100 X 10^6 bbl of oil, containing more than 80% of the western world's 1956 known reserves, only 1067 m? (p. 355).

(5) Why does catalysis receive such scant attention compared to temperature when there are so many known petroleum catalysts in natural shales?

(6) Is the well-documented decrease of oil density in successive reservoirs with depth really just a function of temperature and time, or is it (also) a function of the sedimentary facies of the stratigraphic sequence?

Clues to the answers to some of these questions (and others not asked) may lie in petroleum geology rather than geochemistry. For example, there is a strong association between fields with multiple reservoirs and sedimentary sequences that are regressive, so there is stratigraphic bias in data from this association. And in Indonesia, crude oils in transgressive sequences tend to be heavier than those in regressive sequences. The reviewer finds it hard to believe that stratigraphy has no effect on petroleum character, and that all reversals of the density/depth trend (and there are many) are to be attributed to biodegradation.

The book is very well produced, with remarkably few typographical/spelling errors. There are a few minor errors of geological terminology. The figures are clear and pertinent.

Hunt has done us all a great service by writing this book. May geologists now make good use of it so that we shall see at least some of our doubts removed in the next decade. This book is strongly recommended to all geologists with interests in petroleum, and to post-graduate students pursuing topics that include the organic content and diagenesis of sediments.

R.E. Chapman, Brisbane, Qld.

W.S. Fyfe, N.J. Price and A.B. Thompson, 1978. *Fluids in the Earth's Crust. Their Significance in Metamorphic, Tectonic and Chemical Transport Processes.* Developments in Geochemistry, 1. Elsevier, Amsterdam, 383 pp., U.S. $ 49.75, Dfl. 125.00.

This modern book stimulates the development of geochemistry in the earth sciences. The authors have largely put together separately written text on geochemistry, metamorphic petrology and structural geology. Their 'little attempt to unify' texts on the mentioned subjects has only been successful in the last three chapters, in which some integration of thoughts of the individual authors took place. These fascinating chapters answer to all purposes which the authors wrote down in the preface to this book.

Chapter 1 (pp. 1–18), in which 'the problem: fluid motion, geochemical and tectonic processes' is brought, is a somewhat sloppy introduction. The presence of fluids in the earth's crust is discussed in an obvious way: as water plays an important role during erosion and normal sedimentation. The note, for example, that overthrusting may be indicated if a dry high-grade rock is pervasively rehydrated only distracts the reader's attention from the discussion on the evidence of fluid motion during uplift (p. 14).

Chapter 2 (pp. 19–45) deals with the 'chemistry of natural fluids'. It is an elaborated chapter with excellent tables on chemical compositions of various types of fluids from deep in the lithosphere to the hydrosphere.

Chapter 3 (pp. 47–54) is extremely short and gives some conclusions on 'volatile species in minerals', whereas Chapter 4 (pp. 55–88) is an extensive chapter with a lot of information on 'solubility of minerals and physical chemistry of their solutions'. Numerous experimental geochemical studies are very concisely discussed; therefore this chapter will be difficult to understand for 'pure geologists' without any background in geochemistry and thermodynamics.

Chapter 5 (pp. 89–128) on 'rates of metamorphic reactions' stands in fact on its own. It contains a good discussion on rates of mineral dissolution, on nucleation and growth and on rates of volume diffusion in aqueous solution, through intergranular films and through mineral lattices.

Chapters 6 (pp. 129–162) and 7 (pp. 163–184) are scoped on modern petrology with typical geochemical approaches. The chapters are called 'the release of fluids from rocks during metamorphism' and 'controls of fluid composition: buffer systems and melting', respectively. They are carefully written and refer to mainly recent and excellent petrological research studies. Special attention should be given to the paragraph on 'the behaviour of fluids during partial fusion', in which a clear exposé is given on the role of fluids on several melt reactions in the granitic system.

In Chapters 8 (pp. 185–224), 9 (pp. 225–251) and 10 (pp. 253–273), a synopsis of the modern structural geology is given. The influence of temperature and of the presence of pore fluids on rock mechanics are considered in Chapter 8 on 'experimental rock deformation: the strength of rocks under geological conditions'.

Chapter 9 gives 'the quantification of crustal conditions ($P, T, \sigma_1 - \sigma_2, \lambda, \epsilon$) from geological evidence'. It is interesting to see how structural geologists squeeze values of differential stress and strain rates out of geological data.

In Chapter 10 'permeability, hydraulic fracture and elasticity' are treated.

Chapter 11 (pp. 275–316) is concerned with the 'dewatering of the crust'. It starts with a model in which systems of escape channels are formed by fracturing in a sediment sequence. Along such an initial vein system hydrothermal solutions may migrate upwards. Impervious barriers play an important role in the formation of fluid sills and often cause the local formation of mineral flats. Especially interesting is the treatment of the tectonic pumping mechanism.

In Chapter 12 (pp. 317–341), 'diapirs and diapirism' are discussed. The authors make clear that in igneous and salt diapirism the physical action of water in the surrounding rocks has great significance. The initial flow of the diapirism is mostly caused by tectonics (trigger mechanism). The flow properties of any kind of intrusion are a function of temperature, total pressure and especially fluid regime.

Chapter 13 (pp. 343–365) on 'fluids, tectonics and chemical transport' is a kind of happy ending synthesis. The large-scale transport of rock volumes at ocean ridges and in subduction zones are good evidence that people have only little idea (and not

any influence) on the imperturbable recycling of the earth.

This book is provided with many figures, it is well printed and the printing errors are scarce. However, a few diagrams (e.g. 11.2) have three-double labeled axes and some figures (e.g. 8.18 and 8.19) with different legends are exactly the same.

The reviewer concludes that this book contains numerous modern concepts in the field of geochemistry, metamorphic petrology and structural geology. The book is recommended to experts in one of these subjects wishing to learn more about the other subjects and their interrelations. Not being a textbook, it seems to be too expensive for students, but it should be present in any earth science library.

J. Ben H. Jansen, Utrecht

J. Jäger and J.C. Hunziker, 1979. *Lectures in Isotope Geology.* Springer, Berlin, 329 pp., D.M. 49.00, U.S. $ 27.00.

This is a collection of 24 papers based on an isotope geology course given by seventeen invited speakers at Berne University in 1977. There are a few interesting and substantial review articles, such as 'A new approach to Rb–Sr dating of sedimentary rocks' by N. Clauer, '$^{40}Ar/^{39}Ar$ dating: principles, techniques and applications in orogenic terranes' by R.D. Dallmeyer, 'Fisson-track dating and geologic annealing of fission tracks' by C.W. Naeser, 'Stable isotope geochemistry of rocks and minerals' by J.R. O'Neil, 'Sulfur isotopes' by H. Nielsen. Useful shorter contributions include 'Archaeometric dating' by G.A. Wagner, 'Theory of cooling ages' by M.H. Dodson, as well as a number of introductions to the methodology of the principal age techniques, including 'The Rb–Sr method' by E. Jäger, 'Potassium–Argon dating' by J.C. Hunziker, 'U–Th–Pb dating of minerals' by D. Gebauer and M. Grünenfelder, 'Isotope geochemistry of lead' by V. Köppel and M. Grünenfelder. The latter papers are competent enough, but at times not sufficiently comprehensive, even taking into account limitations of space. For example, the chapter by E. Jäger neither deals with the principles underlying the important Rb–Sr total rock method, nor with the application of strontium isotope geology to petrogenetic problems or crust/mantle evolution. The chapter by Köppel and Grünenfelder describes the basic principles of lead isotope variations, but the section on geological applications, particularly using rock leads, is not really very informative. All this has been much more thoroughly discussed elsewhere.

My main criticism of the book, however, concerns the large number of papers with promising titles like 'Rb–Sr dating of thin slabs: an important method to determine the age of metamorphism', 'Diffusion experiments in geology'. 'Isotope and trace element geochemistry of the earth's mantle', 'Archaean geochronology', 'Evolution of the European continent', 'Thermal models of the Central Alps', 'Geochronology of ophiolites', etc., which are all nothing more than extended abstracts, each occupying only a very few printed pages. It seems that quite a number of contributors did not submit complete articles. The value of these short items is very limited.

This volume is no substitute for a good text-book, or for a collection of comprehensive review or research articles. Except for the few substantial papers already referred to, it does not provide a satisfying, moderately complete summary of the current state of modern geochronology and isotope geology. Thus I found the volume somewhat disappointing on the whole, although selected portions will undoubtedly prove instructive for a fairly wide readership to 'dip into'. The book is well produced and efficiently illustrated.

S. Moorbath, Oxford

L.H. Ahrens (Editor), 1979. *Origin and Distribution of the Elements. Proceedings of the 2nd Symposium, Paris, May 1977.* Physics and Chemistry of the Earth, II. Pergamon Press, Oxford, 909 pp, U.S. $ 80.00.

In May 1967, an international symposium entitled 'Origin and the Distribution of the Elements' was held at the Paris UNESCO Headquarters. The proceedings of that conference were published in the International Series in Earth Sciences, Vol. 30. This volume, edited by L.H. Ahrens, has