abstracts given at the commencement of each paper are concise and indicate very clearly the scope of the paper and the conclusions reached. The standard of presentation and publishing is excellent and the book is provided with a brief but adequate index. In the papers generally, there is more reference to work done outside America than has often been the case in previous volumes. The editor and printers are to be congratulated on the high standard attained and on providing a volume which will not only be essential to clay mineralogists but also to those interested in rheological and geological problems and to several branches of industry.

R. C. MACKENZIE

RUSSELL (R. D.) and FARQUHAR (R. M.). *Lead isotopes in geology.* New York and London (Interscience Publishers), 1960, 243 pp. Price $9.00 or 65*s*.

This monograph deals principally with the use of common lead in geochronology. As it includes a series of tables for deriving ages it is necessary to examine with some care the parameters selected for the basic equations.

Mathematical models for dating ordinary lead are of two kinds, depending on whether they postulate a uniform distribution of lead, uranium, and thorium in the source material or allow variation from place to place. In both cases the lead has grown from primeval lead by the addition of radiogenic isotopes from uranium and thorium. According to the first hypothesis, leads formed at the same time have the same isotopic composition. On the second, the composition depends on the proportions of primeval lead, uranium, and thorium in the source material as well as on age, but since ^{206}Pb and ^{207}Pb are decay products of a single element, there is a constant relationship between the ratios 206/204 and 207/204 in all leads of the same age; this is the basis of the Holmes–Houtermans method of dating. The age equations on both hypotheses incorporate the decay constants and the present-day $^{238}U/^{235}U$ ratio, all of which are tolerably well known, and make specific assumptions for the compositions of primeval and modern lead. Put in another way, the compositions of primeval lead (known from uranium- and thorium-free meteorites) and of a single ordinary lead of known age are sufficient to establish the equations for either type of model and, incidentally, to give the age of the earth.

The particular Holmes–Houtermans model in this book uses values

for the constants and for primeval lead differing slightly from those in Houtermans' original equation, but the parameters have been adjusted to give closely agreeing ages. Houtermans specified his modern lead so that a number of Post-Cambrian leads had ages in keeping with their geological relationships. No doubt this empirical approach is the right one, but the actual values adopted for modern lead should be reviewed periodically in the light of refinements to the time scale and of new lead analyses.

For the homogeneous-source hypothesis, which is open to criticism on general grounds as being at variance with the well-established concept of geochemical provinces, the reader is offered a choice of two models. The first one, designated the Russell–Farquhar–Cumming method, can be discarded at once as being inconsistent with the meteoritic ratios for primeval lead. It is claimed that the second, designated the Russell–Stanton–Farquhar method, gives the age of lead in stratigraphically conformable deposits rather accurately, if Stanton's theory that such lead is derived directly from the upper mantle is accepted. Two ages are obtained from the ratios 206/207 and 208/204 respectively. The growth curve for the first is defined as starting at the meteoritic ratios for primeval lead, passing through the measured ratios of lead from a particular conformable deposit, and finishing on a zero isochron derived from Patterson's analyses of the total-leads in three uraniferous meteorites. This zero isochron differs considerably from that adopted for the Holmes–Houtermans model—a lead sample of zero age on the Russell–Stanton–Farquhar model has a Holmes–Houtermans age of 204 million years. Being based on lead ratios for which Patterson claimed only 2% accuracy, the R-S-F zero isochron is likely to be much the less accurate. Its unreliability for this purpose is indicated by the spread of the Holmes–Houtermans ages calculated for the total-leads from the three meteorites: +301, −32 and −454 m.y. The other R-S-F growth curve, that of the 208/204 ratio, has been defined so as to give the best fit for galenas from eight conformable deposits, but it is inconsistent with the 208/204 ratio for primeval lead and with the age of the earth implied by the 206/207 equation.

Leads that have been enriched in radiogenic isotopes during migration of the ore fluids through crustal rocks are 'anomalous' in that the simple models discussed above are inapplicable. Such leads, however, can provide valuable information on the history of the ore deposits in which they occur, as is well brought out in case studies of Sudbury and of Thunder Bay, Ontario, and of Broken Hill, N.S.W. A potential

hazard in dating common leads is that anomalous samples may not be recognized as such if the added component is small, with the result that erroneous ages are derived. The danger is greatest when reliance is placed on single specimens, a practice the authors rightly condemn. A representative suite should be collected and the isotopic analyses considered in the light of the known geological environment of the samples.

Recent developments in dating uranium and thorium minerals are discussed in outline only, as the authors consider this aspect of their subject has been adequately covered elsewhere. This is unfortunate, since the validity of ages that 'provide the standards against which all other methods of age determination are compared' is important enough to warrant detailed treatment in any book on lead isotopes in geology.

A series of appendices, filling 121 pages or half the book, lists several hundred isotopic analyses of common lead. About half these are Toronto analyses, both published and unpublished; the remainder are published analyses from other laboratories. The analyses are grouped geographically, but geological associations are seldom given owing to lack of data.

Attention should be drawn to misprints that might mislead the reader: p. 50, l. 2, V should be '0.0800', not '11.0(2)'; p. 65, eq. (5.4), the exponential term should be in the denominator; p. 74, l. 11, '0.128' should read '1.28'; p. 85, l. 11, 'grain' should read 'gramme'; pp. 158, 159, the geographical heading is incorrect. Errors have been noted as follows in the tables for deriving ages from the proposed equations: Table 4.1 −372 (should be −327), 1(61), 3701(3710); Table 4.2 230(232); Table 4.5 3081(3181); Table 4.6 2370(2367), 386(406), 329(349); Table 8.1 890(887).

The book is in the nature of an interim report on a rapidly developing subject. It was perhaps too hurriedly put together and was certainly inadequately revised, but it offers a stimulating discussion of much scattered literature and no one interested in geochronology or in lead ores would wish to be without it.

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