Geoscience Canada

Kimberlites, Orangeites, and Related Rocks

Tony LeCheminant

Volume 25, Number 2, June 1998

URI: https://id.erudit.org/iderudit/geocan25_2br02

See table of contents

Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

Explore this journal

Cite this review

LeCheminant, T. (1998). Review of [Kimberlites, Orangeites, and Related Rocks]. *Geoscience Canada*, *25*(2), 93–94.

along and transmitted within tectonic plates are required for inversion." He provides numerous cross-sections, most based on reflection-seismic data, that display inversion in basins from around the world. Detachment faults have been reactivated as thrust faults, and normal faults have undergone reversal of dip-slip, or have become strike-slip faults, commonly displaying positive flower-structure configurations in cross-section. A detailed case study of inversion structures in the Gulf of Suez Basin follows, written by S.D. Knott and co-workers, and is offered as an analogue for the interpretation of similar structures in the North Sea Basin. The first section of the book concludes with a worldwide review and classification of petroleum deposits in inverted basins by D.S. MacGregor. Transpressional tectonism is accepted as the main cause of inversion, although thermal and isostatic uplift is also seen as a cause in some cases. MacGregor demonstrates that the timing of inversion and the accompanying development of structural traps, relative to the timing of petroleum generation and migration, is critical in the formation of many large oil and gas fields. Clay and sandbox models can be manipulated to simulate extension, followed by contraction and inversion, and the results can be compared to real-life examples with the use of reflection-seismic cross-sections. Three papers that describe such modeling experiments constitute the next section of the book.

The next section, consisting of three papers, is entitled "Recognition and measurement of basin inversion," and describes the principal methods used to estimate uplift and exhumation. These are threefold, consisting of: 1) apatite fission track analysis (AFTA), in which the indicated fission-track age indicates the date of cessation of track annealing that occurred because of uplift; 2) vitrinite reflectance, a technique for determining the maximum depth of burial; and 3) sediment density, as measured by interval-transit time on sonic logs, which is a reliable measure of depth-related compaction. These papers all make reference to detailed studies around Britain but, curiously, do not make direct reference to the study of regional uplift and exhumation by Brodie and White that forms the second paper in this book. This seems like an odd editorial oversight.

The 11 papers just described constitute about one-third of the total length of the book. The remaining papers are labelled as "case studies" and comprise a wide-ranging collection of papers, from detailed outcrop studies of fractures and small-scale faults to regional seismic analyses. Only one paper deals with Canadian geology, a study of the Jean d'Arc Basin off Newfoundland by J.K. Sinclair. Here it was the changing extensional-stress regime from a NW-SE axis to a NE-SW trend as sea-floor spreading extended from the central Atlantic Ocean into the Labrador Sea that served to reactivate some of the faults and resulted in uplift and trap formation. Altogether, this is an exhaustive collection of studies of basin inversion that serves well to illustrate the types of regional and more local structures generated by inversion, the types of tectonic setting in which it occurs, and the various methodologies and data bases used in petroleum studies to assess the timing of trap formation and petroleum maturation. As usual with Geological Society of London publications, editing and presentation are excellent.

Kimberlites, Orangeites, and Related Rocks

By Roger Howard Mitchell
Plenum Press, New York
1995, 410 p., US$89.50, hardcover

Reviewed by Tony LeCheminant
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

In this book, the final volume of an authoritative trilogy on the petrology of primary diamond-bearing rocks, Roger Mitchell presents new terminology and reviews advances in kimberlite studies since publication of his first synthesis in 1986. While petrologists argue over differences in textural, chemical and isotopic characteristics of kimberlites worldwide, few doubt that in South Africa there is a unique subset of phlogopite-rich rocks, generally termed micaceous or group II kimberlites, that are derived from different mantle sources than group I kimberlites. Mitchell proposes that differences between the two kimberlite groups are so great that group II rocks should have a new distinct name, "orangeite." Now, renaming some South African kimberlites might be considered primarily an academic exercise, related mainly to the experience and interests of the renamer, were it not for the fact that all dyke systems exploited for their diamond content in South Africa are orangeites.

Orangeites are an expression of lithospheric mantle-derived potassic magmatism interpreted by Mitchell to be restricted to the Kaapvaal craton in southern Africa. In April, 1998, delegates to the Seventh International Kimberlite Conference in Capetown had the opportunity to indulge first-hand in petrogenetic speculation about orangeites. All delegates were presented with high-quality maps produced by De Beers depicting time and space distribution of 1277 kimberlites and related rocks in southern Africa, including 778 group I kimberlites and 271 group II kimberlites (Ayres, *et al.*, 1998). In addition, there was the opportunity to visit several of the most productive dykes on the Small Mines Field Excursion (Gurney and Menzies, 1998). Zones within the "Main" dyke at the Helam Mine contained the highest diamond content in South African mines (5 carats per tonne). Extensive underground workings at two of the localities visited exposed unique three-dimensional views of the dyke systems.

In Chapter 1, Mitchell reviews major occurrences of orangeite in the Kaapvaal craton, discusses classification schemes for diamond-bearing igneous rocks and introduces a revised textural-genetic classification. The current profusion of classification schemes for these rocks makes comparision of rocks from different regions very difficult. Unfortunately, the revised textural-genetic classifications offer little solace; some terms contain as many as six tongue-twisting descriptors. There is no alternative to naming ("labelling") since it is the most important, perhaps the only, method available to us to attempt to understand and to communicate our interpretations. Development of a simplified scheme, which can aid understanding of these rocks, still remains an elusive goal.

Mineralogic, geochemical and tex-

tural overlap make some orangeites difficult to distinguish from group I kimberlites and lamproites. Chapter 2, the main focus of the volume, provides a complete and extensive synthesis of the primary mineralogy of orangeites, with detailed comparisons to group I kimberlites and lamproites. Chapter 3 features the geochemistry of orangeites, again with comparisons to group I kimberlites and lamproites, and summarizes radiogenic and stable isotope data. Orangeites have closer affinities to lamproites than kimberlites, as a consequence of their derivation from similar metasomatically enriched lithospheric mantle sources. Both are derived from ancient sources located in nonconvecting lithospheric mantle.

The final chapter provides detailed consideration of the petrogenesis of orangeites and kimberlites, beginning with a review of earlier hypotheses and progressing to new models. Mitchell states that orangeites do not occur outside the Kaapvaal craton, although he recognizes that they belong broadly to a family of magmas linked to metasomatic effects in the lithospheric mantle. He does not synthesize information from upper mantle xenoliths or xenocrysts, an omission that must be addressed to understand more clearly the processes involved in generation of diamond-bearing rocks beneath the Kaapvaal craton; in particular, the spatial and temporal evolution of source regions in the mantle. All dated orangeites are older than about 110 Ma, whereas most group I kimberlites were emplaced between 85-100 Ma (Gurney and Menzies, 1998). It seems that the composition and thermal structure of the Kaapvaal lithosphere was modified at about 90 Ma, a change associated with regional uplift and denudation of the craton prior to eruption of many group I kimberlites. Did this event eliminate the enriched source region for orangeites?

The paucity of data from most kimberlite provinces other than South Africa makes detailed consideration of Mitchell's regional hypothesis for the unique character of orangeites virtually impossible. Perhaps it is premature and somewhat extreme to imply that orangeites will not be found in other cratons. Why should specific processes form group I kimberlites and orangeites beneath southern Africa, but not occur beneath other cratons? With the exception of the xenolith data, Mitchell has brilliantly ordered and effectively presented a wide range of new information on kimberlites and orangeites to stand as an important sourcebook beside his previous volumes. New advances in synthesis and understanding of the source regions for diamond-bearing rocks will arise from studies heralded by this work.

REFERENCES

Ayres, N.P., Hatton, C.J., Quadling, K.E. and C.B. Smith, C.B., 1998, Update on the distribution in time and space of southern African kimberlites: 1: 5 million scale maps, 7th International Kimberlite Conference, University of Cape Town.

Gurney, J. and Menzies, A. 1998, Small mines field excursion: 7th International Kimberlite Conference, University of Cape Town, 40 p.

Jurassic Magmatism and Tectonics of the North American Cordillera

Edited by David M. Miller and Cathy Busby
Geological Society of America
Special Paper 299
1995, 432 p., US$95.00, paperback

Reviewed by Bob Anderson
Geological Survey of Canada
GSC Pacific
101-605 Robson Street
Vancouver, British Columbia V6B 5J3

In the Canadian Cordillera, Jurassic magmatism was an important part of the accretionary history and mountain-building consequence of terrane assembly; as well, Jurassic volcanic and plutonic rocks are disproportionately enriched in base and precious metals compared with any other Phanerozoic arc system. To the south, Jurassic magmatism marked the precursor to later events that so strongly shaped the present geology of the western United States.

Consequently, any volume that promises an orogen-wide integration of Jurassic magmatism and tectonics is awaited with some anticipation. A theme session at the 1991 San Diego Geological Society of America (GSA) Annual Meeting and a subsequent 1994 GSA Penrose Conference on Jurassic Magmatism and Tectonics of the North America Cordillera organized by Dave Miller, Cathy Busby and others underlie this volume. A compendium of 19 papers, derived in part from contributions to these meetings, is brought together by Miller and Busby in GSA Special Paper 299. It is an important milestone in the description and tectonic synthesis of Jurassic magmatic regimes and structural styles preserved in autochthonous and formerly allochthonous terranes extending from Yukon to southernmost United States along the present margin of the North American plate. In the course of 192 figures, 50 tables, and almost 2000 references encompassed within the 19 papers, the volume succeeds in providing a significant overview geographically, temporally and conceptually of Jurassic geological history along North America's western margin. In addition to the preface, a frontispiece photograph of R.L. (Dick) Armstrong and a subject index at the back round out the contents; the table of contents is helpfully reproduced on the back cover of the book.

Special Paper 299 serves a secondary, although no less important purpose as a memorial to the late Dick Armstrong (University of British Columbia), whose data, syntheses and ideas implicitly or explicitly form points of departure for many of the new contributions. One is continually reminded of his integrative style of tectonic synthesis, a theme present throughout the volume.

In their preface, editors Miller and Busby see the volume as providing a multidisciplinary view of mainly Jurassic (but also including Triassic and Cretaceous) volcanism, plutonism, metamorphism, structural development, geochemical and isotopic evolution, metallogeny, and sedimentology of Jurassic tectono-magmatic events. New structural and stratigraphic field data and syntheses obviously predominate in this volume, and are shown to be critical to understanding processes as diverse as terrane assembly and the inter-relationships between deformation style(s) and magmatism (exemplified in papers by Murphy *et al.*, Elison, Wadsworth *et al.*, and Miller and Hoisch). The value of unraveling the stratigraphic and sedimentological record of magmatism