BOOK REVIEWS

Basin Inversion

Edited by J.G. Buchanan and P.G. Buchanan
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Basin inversion is defined as the uplift by compression or transpression of a basin along its controlling fault system, resulting in uplift and partial exhumation of the basin fill. Typically, only a few of the faults present in the basin may be reactivated, and the deeper parts of the basin may be left largely undisturbed. Basin inversion may be a precursor to orogenic deformation. Inversion is of considerable importance to the petroleum industry, because it commonly generates new hydrocarbon traps, and because of the effects the contractional movements have on fluid pressures and fluid transmission along fractures and faults.

This is the second volume published by the Geological Society of London that is devoted to the topic of basin inversion. The first was Special Publication 44, edited by Cooper and Williams and published in 1989. The present volume was prepared following a conference on the topic held at Oxford in 1993 that was sponsored by British Gas Exploration and Production Limited. The book consists of 27 papers and one extended abstract. There is an introduction to the contents of the book by the editors, but no synthesis or overview paper that pulls together all of the contents. This is a common failing of the GSL special publications that has been commented on by this reviewer before. This book, more than some of the other special publications by the Society, does, however, seem to consist of a reasonably complete treatment of its topic, although the order of presentation sometimes seems odd. This review will not attempt to summarize the results from all the papers, but focuses on some of the main points of the book.

The first five papers constitute a section called "Mechanics, dynamics and geometry of basin inversion." The non-specialist reader would be well served just by reading this section, which covers a wide range of topics and manages to convey a good impression of the range of scales of inverted basins and their controls, and the kinds of questions being asked about them by petroleum geologists. The first paper, by R. H. Sibson, discusses the mechanics of fault reactivation, including the puzzling question of why some faults are reactivated by compression and others having very similar geometries are not. The author describes the process known as fault-valve release, whereby faults oriented at high angles to the contractional stresses may move suddenly, resulting in temporary dilation and the release of large volumes of overpressured fluids. Such events can commonly be reconstructed by the careful study of extensional vein systems and their calcite or quartz infills. The second paper by J. Brodie and N. White answers a question that I, as an ex-Brit, am ashamed to admit I had never even thought to ask, and that is "why are the British Isles there in the first place?" Given the history of Mesozoic extension of the northwest European margins, and the distance of this region from the Cenozoic Alpine orogen, it might have been expected that the area occupied by Britain would consist of flat-lying Mesozoic-Cenozoic strata covered by the seas of a broad continental shelf. The islands owe their existence to widespread uplift by igneous underplating during the development of the Tertiary Igneous Province. Geological evidence for this consists of the lack of thick rift-fill sediments of Permo-Triassic age (the numerous Permo-Triassic basins in and around the British landmass are all too shallow, based on the criteria of the standard extensional-basin models), high maturation levels in the Pre-Tertiary section, and the offlapping pattern of the Jurassic-Cretaceous section in southern and eastern Britain (and offshore in Moray Firth), indicating broad uplift to the north and west, and removal of some 2-3 km of the cover succession from northern England and Scotland. This uplift took place in the Paleocene, and the resulting detritus (including much reworked Chalk), was transported into deep basins, such as the Viking Graben, where it now forms some of the best hydrocarbon reservoir units in the northern North Sea Basin. This form of large-scale inversion is not, however, the main topic of this book, although several papers in the book come back to the case of the northwest European continental margin, discussing thermal evidence for Tertiary uplift, and so on.

The third paper, by J.D. Lowell, discusses the more typical form of inversion, which affects individual basins on scales of a few tens to hundreds of kilometres. Most inverted basins achieve this configuration by contractional movements oblique to the orientation of the original extensional tectonism. Lowell states that "it seems inescapable that external horizontal or far-field forces

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

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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-