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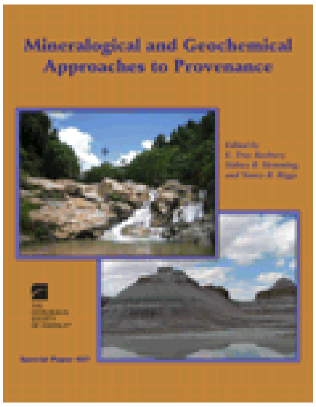

Mineralogical and geochemical approaches to provenance, edited by E. Troy Rasbury, Sidney R. Hemming & Nancy R. Riggs, 2012. GSA Special Paper 487. The Geological Society of America, 3300 Penrose Place, Boulder, Colorado, United States of America. Paperback, vi + 194 pages. Price US$ 75.00 (GSA member price US$ 55.00). ISBN 978-0-8137-2487-4.

The provenance of siliciclastic sedimentary rocks can be unraveled by tracing their source rocks. The correct recognition of source rocks and areas can add substantially to paleogeographic reconstructions, sediment-budget calculations, and basin analyses. No wonder therefore that, since the emergence of modern geology at the end of the 19th century, such studies have been undertaken frequently. With the advance of technology, new tools and methods have gradually been introduced in provenance studies, and the studies themselves have been moving from purely qualitative descriptions to more rigorous, quantitative analyses. Weltje & Von Eynatten (2004) detail this in a useful synopsis.

The 2009 Annual Meeting of the Geological Society of America in Portland devoted a session to sedimentary provenance studies. The book under review, published as GSA Special Paper 487, is a result of this session and consists of eleven independent contributions. The editors, E. Troy Rasbury of Stony Brook University, Sidney R. Hemming of the Lamont-Doherty Earth Observatory, and Nancy R. Riggs of Northern Arizona University, who thoroughly prepared the volume, were also the conveners of the 2009 session.

U-Pb geochronology of detrital zircons has become one of the most used and most robust techniques in provenance studies during the last decade. Zircon ubiquity in sedimentary rocks, coupled with the development and availability of SHRIMP (sensitive high-resolution ion microprobe) and LA-ICP mass spectrometry, resulted in a flood of publications that explored this new field. The age spectra of zircons have become almost standard in modern provenance studies. This is also reflected in the contents of this book, in which five contributions concern U-Pb ages of detrital zircons. Interestingly, some of them clearly show that in geologically complex settings, where different source rocks have similar ages, U-Pb zircon geochronology is of limited value only and must be supplemented with other methods. Morton *et al.* demonstrate that only with the use of a combination of methods it is possible to recognize the various provenances among Paleocene sands of the NE Atlantic. Each single technique, such as a conventional heavy-mineral analysis, geochemistry of detrital garnet and rutile, U-Pb dating of detrital zircon, and a palynofloral analysis, provides only a fragmental picture. Riggs *et al.* combine U-Pb zircon ages with Th/U ratios in zircon to detect two distinct sources for Late Triassic strata in south-western North America. The isotopic analyses of zircon grains alone are not sufficient to delineate the two sources. In turn, Clements *et al.* combine detrital-zircon U-Pb ages with zircon Hf-isotopes to unravel the complicated sediment provenance for SE Asia in the Paleogene. Despite the regional and methodological complexity, the authors present the results in an exceptionally interesting way, and the new data allow them to verify some tectonic models for this area. Rothfuss *et al.* use detrital-zircon geochronology to reveal regional unroofing of Late Cretaceous granitic plutons in SW Montana. The combination of zircon-age populations with traditional sedimentary facies analysis of Paleogene strata allows for the reconstruction of a complex intermontane basin system. Finally, Palmer *et al*. extracted zircon grains from nunatak moraines of East Antarctica in order to recognize the varied lithology of the ice-covered bedrock. They supplement the geochronological zircon study with the identification of the composition of pebbles and coarse sand by optical petrography, and the $^{40}Ar/^{39}Ar$ analyses of detrital mica and hornblend.

The remaining contributions deal with various siliciclastic rocks by means of a wide variety of methods. The only common aspect is that they tackle a provenance problem. Kundic *et al.* explore single-grain $^{40}Ar/^{39}Ar$ dating of detrital muscovite to characterize the provenance of Pleistocene loesses on Long Island. An earlier recognition of varied muscovite $^{40}Ar/^{39}Ar$ ages in potential source areas was a starting point of their study. Downing & Hemming measured Nd, Sr, and Pb isotopes in bulk marine sediments from the Labrador Sea. The obtained data are consistent with previously published results, $^{40}Ar/^{39}Ar$ hornblend ages among others, and altogether elucidate the late glacial and deglaciation history of ice rafting in the area and indicate the provenance of the sediments. The contribution by Resentini & Malusà addresses the problem of sediment budget in an orogenic setting. The authors examine two modern drainage systems in the Western Alps, and quantify the sediment generation and erosion rate of the source areas on the basis of detrital-apatite fission-track dating, supplemented with bulk petrography and geochemical analyses. To solve the problem, they had to evaluate the hydraulic sorting in the sediments. In contrast to this quantitative approach, Rodríguez *et al.* concentrate on the qualitative recognition of geological units subjected to erosion in the central Chilean fore-arc during the Cenozoic. Their study is an example of a conventional heavy-mineral analysis extended with a detailed study of the chemistry of detrital clinopyroxene, othopyroxene, amphibole and garnet. Heavy-mineral analysis is also the main method used in the contribution by Morton *et al.* They put forward an interesting hypothesis that apatite:tourmaline ratios in sedimentary rocks may be related to sea-level change because apatite easily weathers under subaerial conditions, whereas it is preserved in marine and burial environments. They test their hypothesis on Late Jurassic sandstones of the North Sea. The last contribution, by Allen *et al.,* differs from all other ones in that it presents the use of a quantitative electron microscope scanner (QEMScan) for the quantitative description of sandstone framework composition. Advantages and disadvantages of this method with regard to standard point-counting are discussed. It follows that the standard method will not be easily substituted in the nearest future.

Taken all together, this book is a snapshot of advanced provenance studies in the first decade of the 21st century. It is, however, not comprehensive. Many methods frequently used in provenance studies are only mentioned, and their possibilities are not fully described and presented.

Certainly this volume of the GSA Special Papers is not a regular textbook. I wish I could find a more extensive introduction or a chapter summarizing the state-of-the-art of modern provenance studies. A student who is interested in this discipline must start with other textbooks and classical articles published in technical journals. On the other hand, several contributions show a new perspective for future research, for example the successful combination of U-Pb zircon dating with zircon Hf-isotopes or zircon chemistry. Undoubtedly, the use of apatite abundance as an indicator of sea-level change is a challenging approach, but it needs further research and thorough discussion. The use of amphibole chemistry in provenance studies may also prove useful in future research. The book contains contributions covering an impressive diversity of geological settings, from East Antarctica covered by vast glaciers, through the Western Alps in Europe, to the tropical southern Sunda Shelf in SE Asia. I should emphasize that the regional geology is always presented in an extensive and intelligible way, although I would have preferred that some figures were published in color, in particular those showing geological settings.

In spite of some shortcomings, I highly recommend this book to libraries of all geological institutions. As for individual readers, they will probably not necessarily be interested in all of the contributions in this volume but most probably they will think at least some of the chapters useful.

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Reference

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