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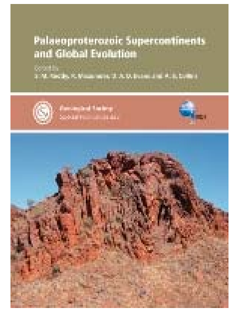

Palaeoproterozoic Supercontinents and Global Evolution, edited by S.M. Reddy, R. Mazumder, D.A.D. Evans, and A.S. Collins, 2009. Geological Society (London) Special Publication 323. The Geological Society of London, Publishing House, Unit 7, Brassmill Enterprise Centre, Brassmill Lane, Bath, BA1 3JN, United Kingdom. Hardback, 362 pages. Price GBP 100.00 (fellows GBP 50.00; corporate affiliates GBP 80.00; other societies GBP 60.00). ISBN 978-1-86239-283-0.

Sedimentologial research originally focused, understandably, on rocks in which the sedimntary characteristics could be easily determined. This implied a focus on Phanerozoic rocks. Now that most Phanerozoic rocks have been studied, sedimentological interest shifts towards the Precambrian, and it turns out that interesting sedimentological features can befound in these rocks, which partly differ from Phanerozoic features because of different environmental conditions (for instance, hardly any biogenic influence). Therefore this book on the Paleoproterozoic is of interest for sedimentologists,although emphasis is on stratigraphy, geodynamics and continental drift.

The rocks dating from the Paleoproterozoic (2.5-1.6 Ga according to a quote in the volume under review) nowadays form disparate segments in space, but these segments show a comparable tectonothermal history, isotopic characters, and paleomagnetic signatures. This promoted the concept of a large landmass, comprising these fragments: the supercontinent Columbia, that existed during the Paleoproterozoic. The challenge of reconstructing the supercontinent and placing it back to its original position has led to collaborative efforts among geoscientists from different disciplines. The volume under review is a testimony to such an effort, with detailed analyses of new and already existing data. It is most fortunate (because many problems regarding Paleoproterozoic rocks can be solved only by mulidisciplinary approaches) that almost all the contributions are coauthored (15 out of 16). As could be expected, the authors of the various chapters pay much attention to geochronology and isotope geochemistry. But field relations, structural geology, paleomagnetism, and sedimentology are also dealt with, sometimes in detail. The drawings are, apart from only a few, of excellent quality, regarding both presentation and information. The texts are well readable, which shows the efforts of the authors and editors.

The sixteen chapters focus on eight major topics: (1) an overview, with two contributions: (1a) Earth evolution in the Paleoproterozoic, and (1b) a database of Paleoproterozoic data; (2) the North China Craton (with three contributions); (3) South Siberia (two contributions); (4) the Baltic (also two contributions); (5) Africa (2 contributions); (6) Brazil (2 contributions); (7) India (2 contributions); and a single contribution on (8) Australia-Antarctica. All these contributions are interesting, and therefore deserve some attention here.

(1a). The introductory paper by S.M. Reddy & D.A.D. Evans (Palaeoproterozoic supercontinents and global evolution: correlations from core to atmosphere) is very wide in scope. It is a well readable overview of the Earth's evolution during the early Proterozoic, even for the uninitiated, and it shows in how far the Proterozoic differs from the other eras of Earth's history, using excellent tell-tale diagrams and tables. This chapter is aimed at a much larger readership than just the group of Paleoproterozoic experts.

(1b). The second chapter (The IGCP 509 database system: design and application of a tool to capture and illustrate litho- and chrono-stratigraphic information for Palaeoproterozoic tectonic domains, large igneous provinces and ore deposits; with examples from southern Africa), authored by Bruce M. Eglington, Steven M. Reddy & David A.D. Evans, is a report on the outcome of the efforts by at least twenty regional experts "to establish a database system to facilitate data capture, sharing and standardization and to provide standardized software for producing time-space correlation charts derived from information in the database. An added advantage of this approach is that all information captured will remain available in a digital format for future researchers." It must have been a painstaking effort to globalize data by making them available in a desired format at the touch of a button. This database and the retrieval system may well become a separate tool by themselves, as is indicated in this chapter itself while analyzing data from different areas in southern Africa. This chapter explains, using box-models and flow-charts, in a simple way how the database works that includes numerous complexly interrelated smaller databases. Highly commendable also is the effort to standardize the legend.

(2a). The contribution "The Columbia connection in North China" by T.M. Kusky & M. Santosh paints the picture of the supercontinent Columbia and its North China representative, the North China Craton, during the Paleoproterozoic, using a wide array of isotopic, geochronologic, and metamorphic (especially ultra-high temperature - UHT) data from previously published works. It is an intelligible analysis of a rather complicated mass of information from various geosciences that goes to prove that the North China Craton has experienced a similar tectonothermal history as the Baltic shield, the Amazonian craton and the Sao Francisco craton. All these segments might thus have belonged to a single supercontinent during 1.8-1.7 Ga. These segments experienced extensional tectonics, while the coeval Laurentia and North Atlantic cratons underwent collision tectonics. Hence the North China Craton was separate from Laurentia and Greenland.

(2b). SHRIMP datings of metamorphic rocks are presented by Yusheng Wan, Dunyi Liu, Chunyan Dong, Zhongyuan Xu, Zhejiu Wang, Simon A. Wilde, Yueheng Yang, Zhenghong Liu & Hongying Zhou in their chapter "The Precambrian Khondalite Belt in the Daqingshan area, North China Craton: evidence for multiple metamorphic events in the Palaeoproterozoic era". The new datings lead to a substantive revision of the Neoarchean-Paleoproterozic stratigraphy. The Hf-zircon data suggest three phases of addition of juvenile material from the mantle. However, the major contribution to the building up of this segment of Columbia came from recycling of Neoarchean crustal material.

(2c). A detailed structural analysis is presented by P. Trap, M. Faure, W. Lin & S. Meffre in their chapter "The Lüliang Massif: a key area for the understanding of the Palaeoproterozoic Trans-North China Belt, North China Craton". It documents the collisional orogeny during the final phase of assembly of the North China Craton. The authors also used field relations in addition to U-Pb geochronology. The asymmetry of folds and other vergence data are used to establish the polarity of subduction.

(3a). Nd isotopic data from southern Siberia suggesting mixing of juvenile and older crusts are presented by Dmitry P. Gladkochub, Tatiana V. Donskaya, Steven M. Reddy, Ulrike Poller, Tamara B. Bayanova, Anatoliy M. Mazukabzov, Sergei Dril, Wolfgang Todt & Sergei A. Pisarevsky (Palaeoproterozoic to Eoarchaean crustal growth in southern Siberia: a Nd-isotope synthesis). A long history of continent development culminated in Late Paleoproterozoic granite activity and supercontinent building at 1.9 Ga. Nd systematics in a wide range of rock types (gneisses, granulites, metasediments, and mafic dykes) is used to prove large-scale recycling of Archean material as old as 3.9 Ga, including accretion of older crustal fragments, during the Paleoproterozoic. Nd data indicate a significant heterogeneity in the protoliths from the Paleoarchean crust. The authors use a terrane amalgamation diagram that shows the match with the episodes of global supercontinent building elsewhere. As in the case of the North China Craton (see 2b above), recycled crust is the dominant contributor to the building of the Paleoproterozoic continent.

(3b). Paleomagnetic data from sandstones, conglomerates, and volcano-sedimentary rocks, in addition to geochronology, from the same Akitkan Group as in (3a) are used by Alexei

N. Didenko, Vladimir Y. Vodovozov, Sergei A. Pisarevsky, Dmitry P. Gladkochub, Tatyana V. Donskaya, Anatoly M. Mazukabzov, Arkady M. Stanevich, Elena V. Bibikova & Tatyana I. Kirnozova in their contribution "Palaeomagnetism and U-Pb dates of the Palaeoproterozoic Akitkan Group (South Siberia) and implications for pre-Neoproterozoic tectonics" to propose, with some limitations, a post-Paleoproterozoic relative movement between Siberia and the Superior cratons.

(4a). U-Pb (TIMS), and Sm-Nd datings of N-i, Cu-, Cr-, Ti-and PGE-bearing layered complexes in the Kola peninsula (Baltic Shield) in Russia are used by T. Bayanova, J. Ludden & F. Mitrofanov to support a large long-lived mantle diapir or a multiple mantle plume as the source of one of the earliest intraplate LIP and associated metallogeny. Their contribution "Timing and duration of Palaeoproterozoic events producing ore-bearing layered intrusions of the Baltic Shield: metallogenic, petrological and geodynamic implications" describes the field relations and presents discordant plots on the Concordia diagram, including two plots with datings above the Concordia curve: zircon in Figure 7b ("uranium loss") and baddeleyite in Figure 9a (attributed to "lead removal"). Helium-isotope data from Kola belt intrusions suggest an upper-mantle derivation of magmas and a very low contamination by the crust. As opposed to the North China Craton and South Siberia (2b and 3a), the juvenile crust is here the dominant contributor to the growth of the Paleoproterozoic continent.

(4 (b). A rigorous presentation of paleomagnetic data of the 1.12 Ga Sally Diabase dyke of Finland is made by J. Salminen, L.J. Pesonen, S. Mertanen, J. Vuollo & M.-l. Airo in the chapter "Palaeomagnetism of the Salla Diabase Dyke, northeastern Finland, and its implication for the Baltica-Laurentia entity during the Mesoproterozoic". The authors propose a long-lived Mesoproterozoic connection between the Baltic and Laurentia, but are also, justifiably, aware of the uncertainty introduced by secular variation, because only one out of thirteen sites yielded the relevant result.

(5a). The importance of Nd-systematics in Precambrian crustal-evolution studies is again (see also 3a) demonstrated by Åsa Pettersson, David H. Cornell, Masaki Yuhara & Yuka Hirahara in "Sm-Nd data for granitoids across the Namaqua sector of the Namaqua-Natal Province, South Africa". The work highlights the complexity of crust-building processes in the Archean, Paleoproterozoic, and also Mesoproterozoic in the various terranes. Some terrane boundaries are well identified by the isotope data, whereas others show no major change. Contrary to the older datings, the Namaqua belt is dominated by juvenile crust of 1.4 to 1.0 Ga, suggesting that, like in the Paleoproterozoic, strong crustal extraction from the mantle did occur in the Mesoproterozoic. The evolution of continents to form Rodinia after disintegration of Columbia seems no less complex than the assembly and growth of Columbia.

(5b). M. Lompo presents a model for the development of the Man-Leo shield of western Africa, by synthesizing various major element and REE data in his contribution "Geodynamic evolution of the 2.25-2.0 Ga Palaeoproterozoic magmatic rocks in the Man-Leo Shield of the West African craton". It is a model of subsidence of an oceanic plateau. Lompo explains the three-stage evolution of the Paleoproterozoic (Birimian), beginning with a mantle-plume-related extension producing a tholeiitic greenstone belt − oceanic rock − followed by compressional granitic activity and vertical tectonics.

(6a). Maria E.S.D. Giustina, Claudinei G. de Oliveira, Márcio M. Pimentel, Luciana V. de Melo, Reinhardt A. Fuck, Elton L. Dantas & Bernhard Buhn highlight in their contribution "U-Pb and Sm-Nd constraints on the nature of the Campinorte sequence and related Palaeoproterozoic juvenile orthogneisses, Tocantins Province, central Brazil" the growth of the Paleoproterozoic continent by accretion of magmatic arcs, where the magmatic activity is dominated by juvenile magma. However, the neighbouring Sao Francisco craton is dominated by recycled crustal material of comparable age. Thus the Campinorte sequence is allochthonous with a thrust boundary. The Campinorte sequence has a lithostratigraphy similar to the Birimian Belt greenstone, except for the absence of mafic and intermediate volcanism in the former. The correlation with the western African Birimian Belt supports the reconstruction of Columbia.

(6b). Using U-Pb zircon and Sm-Nd whole-rock studies of tonalite-trondhjemite-granodiorite basement gneisses, evidence for 2.35-2.30 Ga juvenile crustal growth in the northwest Borborema Province, NE Brazil is provided by Ticiano J.S. Dos Santos, Allen H. Fetter, W. Randall van Schmus & Peter C. Hackspacher. This suggests growth of continental crust in an island-arc setting during a part of the Earth's history that was marked by general tectonic quiescence. The study reveals that not all tectonic lineaments are terrane boundaries, as quite a few such lineaments cut across terranes. A correlation is made with the western African sequences, mentioning earlier rifting episodes separating the Brazilian sequences.

(7a). Nine U-Pb SHRIMP datings are the most significant contribution to Himalayan geology made by Sandeep Singh, A.K. Jain & Mark E. Barley in their chapter "SHRIMP U-Pb c. 1860 Ma anorogenic magmatic signatures from the NW Himalaya: implications for Palaeoproterozoic assembly of the Columbia supercontinent". This work devotes significant space to a review of the Himalayan geology and tectonism, much of which is Cenozoic in age. Suggestions are made for Paleoproterozoic plume-related rifting and basic volcanism in that portion of Columbia where the present-day Himalaya is located. The authors also report the occurrence of a zircon with a core of 3 Ga − another novum in Himalayan geology.

(7b). "Palaeoproterozoic seismites (fine-grained facies of the Chaibasa Formation, east India) and their soft-sediment deformation structures" by R. Mazumder, J.P. Rodríguez-López, M. Arima & A.J. van Loon is the only contribution in this volume that is not based on geochronology and geochemistry, and as such has no bearing on the reconstruction and/or identification of Columbia or fragments of Columbia. It describes in vivid details the geometry of certain enigmatic sedimentary structures found in the generally low-grade metamorphosed, but locally intensely deformed Chaibasa Formation, which was originally sedimentary in nature. The authors prefer to use sedimentary rock names for the various lithological units. The sedimentary structures described come from the fine-grained part of the formation and they are, except for local penetrative foliation, free from outcrop-scale tectonic structures. The structures are described and analyzed in commendable details, though the numerical measurements quoted might deviate from premetamorphic values because of tectonic deformation. The authors show a reasonable openness in attributing seismogenic status to these structures after evaluating the combination of features, and an assortment of structures. In a field-observation-based work like this, which contains a wealth of descriptions of geometry, the quality of some illustrations leaves much to be desired, but their Figure 16 puts the story in a nutshell, adding much value to this contribution.

(8). "The Mawson Continent comprises the Gawler Craton, South Australia, and the correlative coastal outcrops (e.g. Cape Hunter and Cape Denison) of Terre Adélie and George V Land in Antarctica and various other terrains of East Antarctica .... . Perhaps the most notable feature of the Mawson Continent is its lack of exposure." With these lines, Justin L. Payne, Martin Hand, Karin M. Barovich, Anthony Reid & David A.D. Evans introduce the reader to their contribution "Correlations and reconstruction models for the 2500-1500 Ma evolution of the Mawson Continent." The Gawler-Adélie craton and the North Australian craton formed a contiguous continental terrain throughout the Paleoproterozoic. The authors present an in-depth review of the wealth of data, including geochronology, UHT metamorphism, paleomagnetism and sedimentology, concerning this hardly exposed Neoarchean-Mesoproterozoic landmass. The refinement of the paleomagnetic datings suggests that Australia and Laurentia may have been contiguous from approx. 1730 to1595 Ma. The authors' comment "Due to the large degrees of freedom in reconstruction models for the Palaeoproterozoic, an exact geometry of the continental blocks is commonly not required and typically not possible" greatly reduces the uncertainty regarding the fit of the continental blocks. The charts and tables (their Figures 3, 7 and 9) correlating the events within the Mawson continent and Australia with the rest of the world will be very useful for students and researchers alike.

A quick survey of this volume brings out the following regarding the Paleoproterozoic:

(a) during the Paleoproterozoic, the growth of continents involved both recycling of older crust (North China craton, South Siberia), and also the extraction of juvenile crust from the mantle (Baltic, Brazil); in some areas (like southern Africa) both processes took place;

(b) a distinct island-arc/volcanic-arc affinity can be noticed for Brazil and southern Australia;
(c) except for the western African Birimian Belt, and to some extent for its Brazilian counterpart, the general lack of greenstone belts from the Paleoproterozoic may reflect a paucity in the development of greenstone belts at the time;
(d) plume-related magmatism is reported from only three areas: the Kola peninsula in the Baltic, the Birimian Belt in western Africa, and (with some uncertainty) northern India (now within the Himalayas);
(e) extracting and interpreting paleomagnetic data from the Paleoproterozoic is highly complex: datings from nearly unmetamorphosed dykes from Finland suffer from a high uncertainty due to secular variation, whereas sediments from South Siberia yield better constrained data on the paleopoles.

Taking all the above into account, it must be conluded that he book is certainly valuable for all advanced undergraduate and graduate students of Precambrian geology, but not less for specialist researchers of the Proterozoic. University and college libraries will find the volume also useful to demonstrate how an integrated approach from different geoscience disciplines can be fruitful.

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