PROTEROZOIC GEOLOGY OF WESTERN NORTH AMERICA AND SIBERIA

Edited by
Paul K. Link and Reed S. Lewis

SEPM (Society for Sedimentary Geology)
Special Publication No. 86
PROTEROZOIC GEOLOGY OF WESTERN NORTH AMERICA AND SIBERIA
SEPM and the authors are grateful to the following for their generous contribution to the cost of publishing

*Proterozoic Geology of Western North America and Siberia*

**U.S. Geological Survey**

**Eastern Washington University**

**Utah State University Department of Geology and College of Science**

Contributions were applied to the cost of production, which reduced the purchase price, making the volume available to a wide audience.

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ISBN 978-1-56576-126-1

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SEPM (Society for Sedimentary Geology)

6128 E. 38th Street, Suite 308

Tulsa, Oklahoma 74135-5814, U.S.A.

Printed in the United States of America
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Preface
This volume is the fourth decadal compendium of research on the Belt Supergroup. It is an outgrowth of Belt Symposium IV, held in Salmon, Idaho, in July, 2003, in conjunction with the Tobacco Root Geological Society annual field conference. A full abstract and field-trip volume for that meeting is Lageson and Christner (2003). In keeping with previous Belt Symposia, the scope of the meeting and subsequent papers was broad and included Neoproterozoic strata of the western U.S. and Siberia.

In the preface to the first Belt Symposium Savage (1973) acknowledges A.C. Peale as “Founder” of Belt Geology and C.P. Ross as “Father” of Belt Geology. These men, and C.D. Walcott, who was first to sub-divide the Belt, were strong-willed field geologists who spent decades mapping this thick pile of thrust-faulted quartzite, siltite, and argillite. Because of the geographic extent and great thickness of the Belt Supergroup, years of work have been required before one’s conclusions are “bona fide”, and only a few have been able to pay their dues. A core of these geologists composes the non-profit Belt Association, founded in 1984 by officers Jack Harrison, Greg McKelvey, Jon Thorson, and Jim Whipple, and board members Dick Berg, Ian Lange, Chet Wallace, and Don Winston. Subsequent board members John Balla, Earl Bennett, Lisa Hardy, Nancy Joseph, David Kidder, David Lidke, and Brian White kept the Belt Association active through the 1980s and 1990s. Present board members Larry Appelgate, Art Bookstrom, Jim Browne, Reed Lewis, Paul Link, Jeff Lonn, Karen Lund, Mark McFadden, and Don Winston continue to foster research and communication regarding the enigmatic Belt Supergroup.

LONG-STANDING ISSUES

The Mesoproterozoic Belt Supergroup of western Montana and adjacent areas is geologically and economically important, but it has been frustratingly hard to understand. The previous Belt Symposium volumes (Savage, 1973; Hobbs, ed., 1984; Roberts, ed., 1986; and Berg, ed., 1998) offer an historical view of the progress of the science of geology in the western United States.

Geochronology

In 1973, Savage stressed geochronology as an issue which exemplified the difficulty of doing geology in the Belt Supergroup. Available Rb-Sr and U-Pb ages suggested that Belt deposition may have spanned 400 million years, from 1300 to 900 Ma (Obradovich and Peterman, 1973). Elston (1984) used magnetostratigraphy to narrow the range to about 250 Myr (1500 to 1250 Ma). In a summary of progress and prospects after Belt Symposium II, in Missoula in 1983, Thorson and McKelvey (1984) labeled better geochronology as the most critical need for Belt research. This has been partly accomplished, and now the Belt is restricted in time to a much shorter interval than some participants in Belt Symposium I dreamed of. Thanks to zircon U-Pb geochronology, today we know that Belt deposition lasted about 70 Myr, from about 1470 to about 1400 Ma (Evans et al., 2000).

The advent of U-Pb geochronology, especially using the ion microprobe (SHRIMP) and laser-ablation ICPMS, has injected geochronometric reality into long-standing arguments about Belt stratigraphy. Several papers in this volume utilize these new tools to provide constraints on age and correlation of Belt strata (Chamberlain et al., Lewis et al., Link et al., and Doherty et al.).

Correlation

In 1973, disagreement flourished over correlation of Belt sedimentary units, and Savage cautioned against almost all correlation beyond continuous local map areas. An excellent review of long-term correlation problems was presented by Winston (1986). The production of 1:250,000-scale and 1:100,000-scale geologic maps of much of the Belt Supergroup has settled many of these issues (see listing in Link, 1998), and subsequent maps by Berg and Lonn, 1999; Evans and Green, 2003; Lewis, 1998a, 1998b; Lewis and Derkey, 1999; Lewis et al., 1999; Lewis et al., 2000; Lewis et al., 2002; Lewis et al., 2005; Lewis and Stanford, 2002a, 2002b; Lonn and Berg, 1999; Lonn and Derkey, 1999; Lonn and McFadden, 1999; Lonn et al., 2003; Lund, 2004). Arguments still flourish over correlation of Belt units, and confusion especially exists as to which metamorphosed packages in central Idaho are meta-Belt versus younger strata. One amusing irony is that complex gneissic rocks northeast of Lowell, Idaho, correlated with the Belt Supergroup with great care and authority by Reid et al. (1973) (in the longest research paper in Belt Symposium I), have recently been shown to be a window of underthrust Mesozoic rocks of accreted terranes (Lund et al., 2005). Additional points of contention include the interval of the Snowslip and Shepard formations as it fines to the southwest into Idaho and has been called the upper member of the Wallace Formation, and the correlation of the Lemhi Group near Salmon, Idaho, with Belt strata to the northeast in Montana. In an important summary and redefinition by Winston in this volume, the name Piegan Group is revised. The revised Group replaces “Middle Belt carbonate” and consists of the Helena overlain by the Wallace Formation. These two formations are no longer thought to represent coeval eastern and western facies, but rather two stratigraphic packages separated by a locally erosional sequence boundary.

Another important paper is that of Lund et al., who propose a complex structural history for the Blackbird Mining District. This is a totally new structural interpretation of a well-known

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mineralized area in eastern Idaho, where the rocks were formerly included in the “Yellowjacket Formation”.

Crittenden and Wallace (1973) mentioned the attractive “Ud- der hypothesis”, which correlated the Belt Supergroup, the Uinta Mountain Group, and the Grand Canyon Supergroup as continental embayments to the Neoproterozoic Cordilleran miogeocline. In fact U-Pb geochronology, producing largely Neoproterozoic ages, has recently constrained their lack of correlation with the Belt. In this volume Rob Hargraves et al., in a posthumous paper put together by Ed Ruppel, discuss Neoproterozoic rocks south of Challis, Idaho, that may be related to the ca. 900 Ma Beaverhead impact structure on the Montana–Idaho border to the east. Burtis et al. describe dating of a 700 Ma dike swarm in eastern Montana that may presage rifting of Laurentia. Dehler et al. and Corsetti et al. deal with new biostrati- graphic and chronostratigraphic work on Neoproterozoic (800 to 600 Ma) rocks of the Uinta Mountain Group in Utah and the Blackrock Canyon Limestone in Idaho.

**Depositional Setting**

Don Winston, the latest in a series of tough “Grand Old Men” of Belt geology, has been passionate about these rocks for over 40 years. One issue, which has been settled by Winston’s refusal to change his mind, and by the fact that he was mainly right, is that the Belt Basin was intracratonic and largely lacustrine (Winston, this volume). It was fed by sand coming from the west, south, and locally the east (Ross et al., 1992; Ross and Villeneuve, 2003; Link et al., this volume). Winston interprets the Piegan Group as deposited largely in large, generally shallow, lakes, which display pervasive cyclic sedimentation. At times this basin was connected geochromically to the world ocean (Frank et al., 1997; Lyons et al., 1998), but primarily the Belt basin acted sedimentologically as an underfilled fluvial and lake system (sensu Bohacs et al., 2000).

**INTERNATIONAL COMPONENT**

Belt Symposia have always had an international component. In the first Belt Symposium Rowlands (1973) summarized the permissively correlative Adelaide Geosyncline in South Austra- lia. The Adelaidean Period is now known to be totally Neo- proterozoic and thus younger than the time of deposition of the Belt Supergroup (Preiss, 1993). Proterozoic successions world- wide have been compared with the Belt. The “outrageous” pro- posed Siberian connection, as an alternative to the SWEAT hy- pothesis (Moores, 1991; Sears and Price, 2000, 2003), and as now modified to the “Troika” paleocontinental reconstruction, has fuelled international geologic research. Jim Sears of the Univer- sity of Montana and Russian colleagues have researched possible connections to a Siberian continent to the west of the Belt Basin. Three papers in this volume address that issue (Sears; Khudoley et al.; and Podkorytov et al.). By 2013, the date of a hypothetical hypothesis (Moores, 1991; Sears and Price, 2000, 2003), and as now modified to the “Troika” paleocontinental reconstruction, has fuelled international geologic research. Jim Sears of the Univer- sity of Montana and Russian colleagues have researched possible connections to a Siberian continent to the west of the Belt Basin. Three papers in this volume address that issue (Sears; Khudoley et al.; and Podkorytov et al.). By 2013, the date of a hypothetical

**REFERENCES**


Lewis, R.S., 1998b, Geologic Map of the Montana Part of the Missoula West 30° x 60’ Quadrangle: Montana Bureau of Mines and Geology, Open-File Report 373, scale 1:100,000.


Lewis, R.S., and Stanford, 2002b, Geologic map Compilation of the Missoula West 30 x 60 Minute Quadrangle, Idaho: Idaho Geological Survey, Geologic Map 34, scale 1:100,000.


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March, 2007
Paleoproterozoic Basement and Mesoproterozoic Strata of the Northwestern United States