The Rock Record – January, 2015

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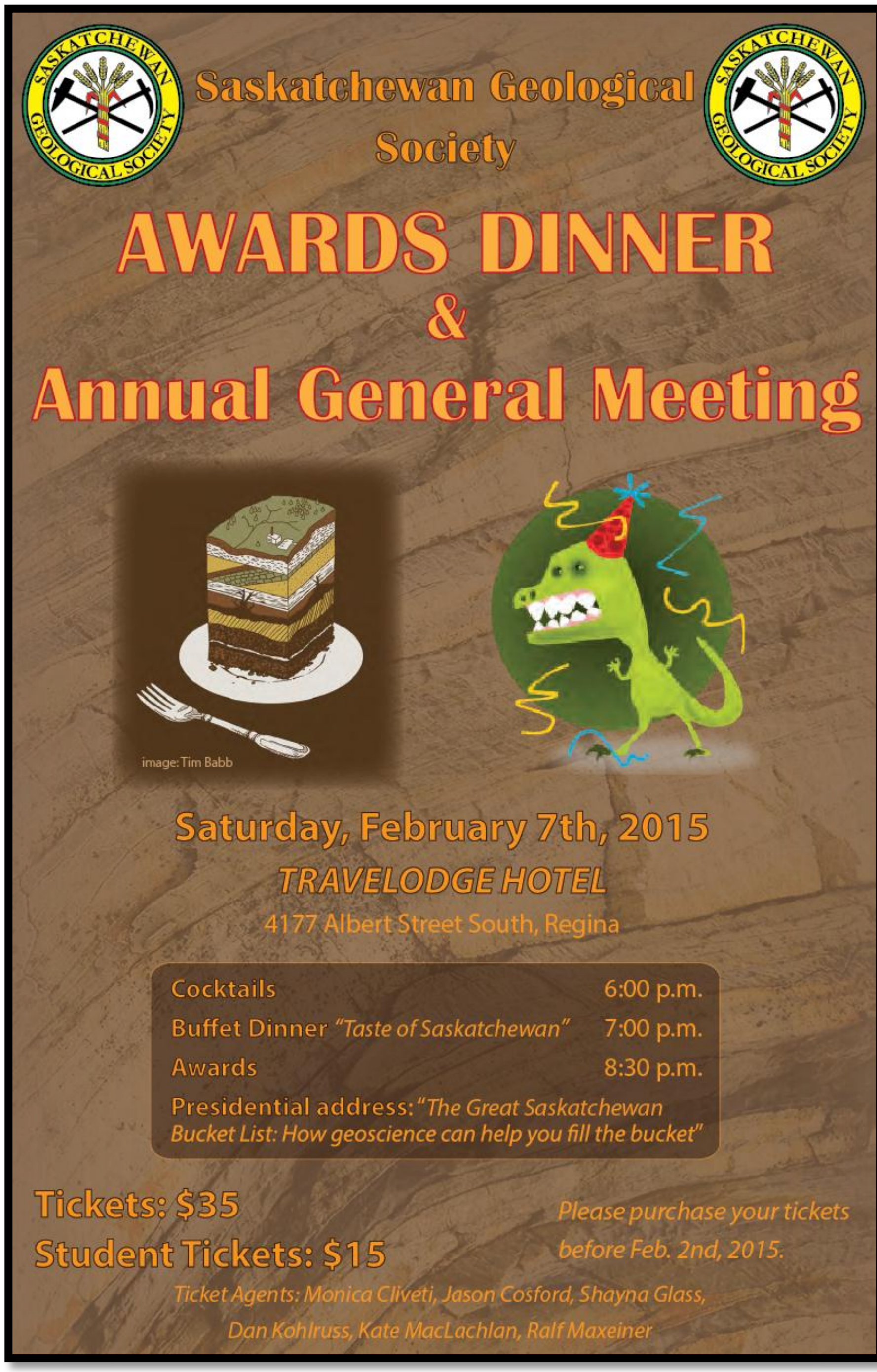

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The SGS Newsletter is produced by the SGS executive. Letters, announcements, notices, comments, photos, news and information about SGS members, etc. are always welcome. Call an executive member or write to us at:

Saskatchewan Geological Society
P.O. Box 234
Regina, SK S4P 2Z6

SGS e-mail address:
info@sgshome.ca

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www.sgshome.ca

All advertising inquiries should be directed to **Dan Kohlruss**

Saskatchewan Geological Society Luncheon Meetings: Winter 2015

Thursday, January 22nd

Dr. Jean Bédard; Geological Association of Canada, Howard Street Robinson Lecturer

Continental Drift on Subductionless Stagnant Lid Planets, the Archaean Earth and Venus

Ramada Hotel, 1818 Victoria Avenue, Regina
Canadian North Room, 2nd Floor

Lunch: 11:45 a.m.; Meeting talk: 12:15-1:00 p.m.
For lunch the cost is: Members: $15.00; Student Members: $5.00; Non-Members: $20.00
For those not having lunch the talk is free

Abstract: Continental drift on subductionless stagnant lid planets, the Archaean Earth and Venus
Modern subduction zones have lithofacies and geochemical signatures that differ from those of Archaean terrains. Linear volcano-plutonic island arcs and continental arcs develop above the locus of slab degassing/melting during subduction. Modern constructional arc strato-volcanos are surrounded by tuff-lahar aprons and commonly erupt abundant andesitic lavas. Yet andesitic lavas are among the least common component of Archaean greenstone belts and Archaean lahar deposits are almost unknown. Phanerozoic arc magmas also show characteristic trends on the Th/Yb vs Nb/Yb diagram of Pearce (2008, Precamb. Res. V.100 p.14-48) that are parallel to the OIB/MORB array. These trends are attributed to pre-melting metasomatism of the mantle wedge by fluids/melts released from the subducting slab. In contrast, most Archaean lavas define oblique arrays on this diagram, indicating assimilation-fractional crystallization processes, with the felsic mixing pole resembling typical Archaean felsic plutons and volcanics. Phase equilibrium data and trace element modelling imply that Archaean felsic melts can be generated by remelting local tholeiitic basalts at a variety of pressures. High P/T metamorphic rocks (blueschists) only occur in subduction zones but are absent from Archaean terrains, suggesting the absence of Archaean subduction. Ophiolites decorate the sutures of Phanerozoic orogens and most Thethyan type ophiolites are thought to form when an oceanic slab that was dragging down the continental plate detaches, allowing buoyant continental material to rebound and lift the upper plate oceanic lithosphere into place. This obduction mechanism should have operated if there was modern-style subduction in the Archaean. Considered in aggregate, the evidence implies that there was no modern-style subduction in the Archaean.

The komatiites and tholeiitic basalts that dominate Archaean greenstone belts are most plausibly generated above hot mantle upwellings or plumes. The high magmatic flux from the mantle, coupled with a higher radiogenic heat production pre-2.5 Ga, provide the heat needed to rework older rocks and generate the TTG to granite plutons that dominate the Archaean crust. Such a maturing oceanic plateau model involving basal anatexis and recycling is more consistent with the evidence noted above. This scenario also better explains the intimate and repetitive interbedding of mafic-ultramafic and felsic magmas and the commonly proximal volcanic facies than do arc+plume models. The ongoing magmatic flux from plumes would also contribute to softening of the lower crust, and create the archetypal Archaean granite-greenstone dome-and-keel architecture by triggering partial convective overturn.

Although evidence for subduction and seafloor-spreading in the Archaean is equivocal to absent, many Archaean terrains exhibit fabrics formed by bulk shortening and some cratons contain terranes with contrasting histories. Given the absence of evidence for Archaean subduction, what could be a plausible driving force for compression and terrane accretion? Bédard et al. (2012, Prec.
Res. v. 229, p.20-48) proposed that cratonic mobilism in response to mantle convection currents offers a solution to this paradox. Once a proto-craton develops a deep high-viscosity mantle keel it would become subject to pressure from mantle currents and could drift. Immature cratons or oceanic plateaux would not have a strong mantle keel and so would be static. So we propose that Archaean cratons were the active tectonic agents, accreting basaltic plateaux and other proto-cratons as they migrated across the planetary surface. Accreted terranes and structures indicating bulk shortening would be concentrated at the cratonic leading edge, with oblique and strike-slip shear zones at the sides, extension and possible

seafloor-spreading in the lee, and major oblique-slip shear zones in the interior. Overridden oceanic crust would be thrust (subcreted) deep enough to melt in the garnet field and generate syntectonic pulses of tonalite-trondhjemite-granodiorite (TTG), contributing to craton growth and stabilisation.

This continental drift model is not equivalent to modern plate tectonics, because of the absence of subduction. Similarities between Archaean and Phanerozoic magmas and tectonic styles result because modern continents also drift in response to mantle currents, not plate boundary forces as commonly assumed. Active advances of continental masses over unusually thick or buoyant oceanic crustal segments result in flat-slab subduction, and typically enhance uplift and deformation. Compressional thickening and anatexis of the base of the thickened upper plate crust in such regions leads to localized generation of high-Sr/Y high-La/Yb TTG-like magmas similar to Archaean ones.

Venus is presented as an analogue for a non-plate-tectonic Archaean Earth and structures similar to those observed in the Superior Craton are interpreted from radar images (Harris & Bédard, 2013). On Venus, anastomosing rifts link coronae interpreted to form above upwelling mantle plumes. Lakshmi Planum highland plateau in the western Ishtar Terra region of Venus lacks extensive, regional-scale internal deformation structures and resembles a continent on Earth. A fold-thrust belt produced mountains on its northern margin, rift zones are present along its southern margin, folds and sinistral strike-slip faults occur on its NW margin, and both regional dextral and sinistral strike slip belts occur in a zone of lateral escape to its NE. The scale and kinematics of structures in western Ishtar Terra closely resemble those of the Indian-Asia collision zone, despite the absence of evidence for subduction (trenches and volcanic arcs) or seafloor-spreading (volcanic ridges and transforms) on Venus. We propose that lateral displacement of 'craton-like' highlands on Venus result from mantle tractions at their base in a stagnant lid convection regime, a regime which preceded development of plate tectonics on Earth.

In the southern and western Superior Craton in Canada, the formation of granite-greenstone sequences in a plume-related volcanic plateau, and its subsequent deformation, can be generated through geodynamic processes similar to those on Venus without having to invoke modern-style plate tectonics. 3D S-wave seismic tomographic images of the Superior Province reveal a symmetrical rift in the sub-crustal lithospheric mantle (SCLM) beneath the Wawa-Abitibi Subprovince, with no evidence for 'fossil' subduction zones. We propose that the S and W Superior craton was partly disaggregated and extensively reworked as a result of the arrival of a major plume swarm at ca. 2750-2720 Ma, with more juvenile 'terranes' like the Abitibi-Wawa being new simatic crust formed as the end-result of extensive lithospheric necking and corrosion of the lithospheric mantle. Subsequently, a shift in mantle convection patterns (or the arrival of a different plume located to the N) caused the deep-keeled Hudson's Bay terrane to drift south and re-accrete the partly-dismembered fragments in N to S sequence. Early rift structures localized subsequent deformation and hydrothermal fluid flow during N-S shortening and lateral escape ahead of the southwardly moving indentor. The geometry of reverse and strike-slip shear zones in the Abitibi Subprovince of the SE Superior Province is similar to that of shear zones developed ahead of the western Ishtar Terra rigid indenter on Venus. Deformation in other Archaean cratons previously interpreted in terms of plate tectonics may also be the result of similar, mantle-driven processes.

Harris, L.B., Bédard, J.H., 2013. Crustal evolution and deformation in a non-plate-tectonic Archaean earth: Comparisons with Venus. In: Dilek, Y. & Furnes, H. (eds), Archean Earth and Early Life, Springer Verlag. In press.

Friday, January 23nd
Barry Katz, AAPG Distinguished Lecturer

Anatomy of a Petroleum Source Rock

Ramada Hotel, 1818 Victoria Avenue, Regina
Canadian North Room, 2nd Floor

Lunch: 11:45 a.m.; Meeting talk: 12:15-1:00 p.m.
For lunch the cost is: Members: $15.00; Student Members: $5.00; Non-Members: $20.00
For those not having lunch the talk is free

Abstract: Anatomy of a Petroleum Source Rock
With the growing global attention in shale gas and shale oil plays there has been a renewed interest in source rock geochemistry. This has resulted in a number of key questions concerning source characterization, including: 1) how much

internal variability might be anticipated; 2) what is the potential impact of the variability on resource assessment; and 3) how best may a source be sampled to "fully" understand its variability?

These questions were examined, in part, through the detailed sampling of the Kimmeridge Clay at the type locality. A representation of variability was obtained from basic source rock data collected on fresh outcrop samples. Total organic carbon contents, for this world-class source rock, varied between 0.88 and 21.35 wt.%, with a mean of 9.13 wt.%. Samples with greater than 1.0 wt.% TOC had total pyrolysis yields ranging between 6.31 and 126.65 mg HC/g rock, with a mean of 54.16 mg HC/g rock. Hydrogen index values ranged from 240 to 611 mg HC/g TOC, with a mean of 516 mg HC/g TOC.

Even these ranges do not fully capture the variability of the source, if data from elsewhere in the North Sea region is included. For example, TOC values exceeding 40 wt% have been measured. Although the hydrogen index values suggested similar liquid hydrocarbon products at Kimmeridge Bay across the outcrop the variability across the North Sea suggests that there are regions that are more gas-prone character. The differences in organic carbon content and hydrocarbon yields, which range by more than an order of magnitude, would have direct impact on estimates of both conventional and unconventional resources, if assessments were based on individual discrete samples.

Discrete sampling either from an outcrop or a core commonly results in bias. Historically, these biases have been skewed toward the more organically enriched samples. This can be overcome through an increase in the number of samples and the incorporation of lithologic information, so that weighted averages can be generated to obtain a better representation of the unit. The analysis of cuttings samples introduces a different suite of problems, associated with representativeness and positioning. Regional variation also needs to be incorporated through an examination of the depositional systems of the unit, ensuring that the key environments are sampled accounting for the impact of factors such as sedimentary dilution, influence of storms, and oxygen content of the water column.

Other Winter-Spring 2015 lectures

Deb Shewfelt – Northrim Consulting, confirmed for February, date TBD (Potash)

Ali Polat – GAC W.W. Hutchison Medal Lecturer; March 13th (Archean west Greenland)

Andrew Cohen –March 19th or 20th (African lake sediment coring)

Cathy Busby – AAPG speaker, April 1st (Oceanic arcs)

Taury Smith – AAPG speaker; April 17th (Petroleum)

Ryan McKellar – Royal Saskatchewan Museum confirmed. Will schedule for May (Amber paleontology)

Titles and Abstracts to follow.

2016 CALENDAR OF SASKATCHEWAN GEOLOGY

A committee to design a geological calendar for 2016 featuring geoscience in Saskatchewan is being formed. The calendar is to be ready for sale on December 1, 2015 . Anybody willing to help out with the design and production of the calendar, please get in touch with Ralf Maxeiner. Most critically, this calendar requires 12 amazing photographs of Saskatchewan geology. So please submit your photographs of geological landscapes, outcrop photographs, photomicrographs, fossils, close-ups of minerals, etc, etc.

ANNOUNCEMENTS AND EVENTS

2015 SGS field trip

The Society is holding this year’s meeting one month earlier than usual. John Lake will preside over the meeting at 7:00 pm Tuesday, January 13 at the Cathedral Freehouse, 2062 Albert Street, Regina. If you have field trip ideas please attend.

Luncheon Talk Speakers
If anyone has any ideas for luncheon speakers please contact Murray Rogers (murray.rogers@gov.sk.ca) or Jason Cosford (cosford@jdmollard.com).

SGS Merchandise
The SGS has a variety of reasonably-priced merchandise, mainly clothing, that is posted on the website: www.sgshome.ca for viewing. This includes seasonal items such as very nice golf shirts, t-shirts, and hats.

Membership
SGS membership is on a calendar year basis---Please renew your membership for 2015 if you have not already done so. Mail the form (with a cheque), bring it to the next luncheon meeting, or use the on-line form on the website at www.sgshome.ca.