Tectonics and collisional architecture of the Grenville margins of Laurentia and Amazonia

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with Eric Essene, and Jay Busch, Michael Cosca, James Cureton, Katherine Carlson, Jerry Magloughlin, Klaus Mezger, Mark Rathmell, Margaret Streepey, Mary Ellen Tuccillo.

08GSA, James McLelland Symposium
Penetrative Deformation (Transposition)
Architecture and Orogenic Evolution through Chronology: Fault Dating and Temperature-Time Paths

van der Pluijm et al., Geology 1994

Mezger et al., CMP 1993
Parry Sound Shear Zone (reverse faulting) ~1120 Ma
Metasedimentary Belt Boundary Zone (reverse faulting) 1080-1040 Ma
Bancroft Shear Zone
(normal faulting)
~1040Ma

van der Pluijm and Carlson, Geology 1989; Carlson et al., GSAB 1990; Mezger et al. Science, 1991
Grenville Syn-Oroge nic Extension – Himalayan Analog

van der Pluijm and Carlson, Geology 1989
Carthage-Colton Shear Zone
(normal and strike-slip faulting)
Carthage-Colton Shear Zone: T-t paths

Mezger et al., J Geol 1992
Streepey et al., GSAB 2000
Streepey et al., GSA Mem 2004
Eastern Segment of North American Grenville: Transpression and Extension

Left-lateral displacement and contraction around 1040Ma

Extension and differential uplift at integrated cooling rate of 2°C/my and 30 km uplift over 300 my (using continuous uplift during entire period)

Streepey et al., JGR 2002
The geodynamic map of Rodinia

The Earth 900 million years ago

1:20,000,000

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Li et al., Precam Res, 2008
Paleoreconstruction Nova Floresta Basalt (~1200 Ma)

Dalziel, 1991

Hoffman, 1991

Tohver et al., 2002

Tohver et al., EPSL 2002
Ji Parana Shear Zone
(left-lateral strike-slip faulting)
~1150 Ma

Tohver et al., Tectonics, 2004
Paleoreconstruction
Fortuna Fm, Aguapei Gp
~1150 Ma
Laurentia-Amazonia Interactions

Time of final contraction

Labrador: ~990 Ma (Krogh, 1994)

Ont/NY: 1120-1010 Ma (Mezger et al. 1993)

Llano: 1240-1120 Ma (Mosher, 1996)

Sequence:

Rondonia-Texas first collision: ~1200 Ma
Left-lateral shear: through ~1100 Ma
North and South American Grenville Thermochronology

Tohver et al., Geology 2006
Deep-orogenic Architecture
(Paleodepths at ~1 Ga)

Exhumed levels:
Deep
Shallow
Deep (suture zone)
Shallow

Recalculated cooling and growth ages with 30°C/km geotherm

Tohver et al., Geology 2006
Grenville Architecture and Orogenic Style

Transpressive, protracted collision:
- Reverse faulting in “W” (ductile)
- Strike-slip faulting in “E” (ductile)
- Late to post-orogenic extension in overthickened “W”
- Normal faulting (ductile to brittle)
- Terrane accretion

Asymmetric orogenic architecture:
- Minor reverse faulting progressively replaced by strike-slip faulting

So, Grenville is an exhumed hybrid Himalayan-Cordilleran orogen
Abstract

Tectonics and collisional architecture of the Grenville margins of Laurentia and Amazonia.
van der Pluijm and Tohver

The Grenville Orogen of Ontario, New York and SW Brazil documents the heterogeneous effects of late Mesoproterozoic oblique collision between the Laurentia and Amazonia cratons and subsequent exhumation. Rocks of the North American segment mostly preserve ages that range from 1.2 Ga to ~0.9 Ga, whereas basement rocks of the Amazon and adjacent Paragua cratons mostly preserve pre-Grenvillian ages (older than 1.3 Ga). Localized isotopic age resetting at 1.18–1.12 Ga is caused by Grenvillian activation of widespread, sinistral strike-slip shear zones in the Amazon basement, whereas widespread 1.0-0.9 Ga ages in the North American basement reflect late to post-collisional processes. Paleomagnetism of 1.20 and 1.15 Ga rocks in SW Amazonia records initial collision with SE Laurentia and 2000km of left-lateral displacement along the eastern margin of Laurentia. Regional growth and cooling ages from U/Pb and 40Ar/39Ar thermochronologic data that were collected over a period of two decades show characteristic exhumation patterns that match this history. Paleodepths calculated for 1.0 Ga along a restored 1300-km-wide section vary from uniformly deep levels (15–30 km) exposed in North America to shallower levels (5– 15 km) in southwest Amazonia. This pattern reflects variation in collisional style along a transpressional plate margin, with thrust-dominated deformation in Laurentia progressively giving way to strike-slip dominated deformation that dominates Amazonia, commensurate with variation in crustal thicknesses. The contrast in tectonic styles explains the widespread preservation of both pre-Grenvillian ages and collisional ages in the Amazon craton and the more homogeneous array of cooling ages from the North American Grenville. The asymmetric orogenic architecture that emerges for the reconstructed root of Grenville orogen is similar to cross sections of modern orogenic belts, indicating that collisional asymmetry is a fundamental feature that persists into the deep crust.