

4. Study the solubility and precipitation mechanisms of gold at amphibolite to granulite grade conditions.

5. Document the post-depositional history of these deposits and explore the possible isotopic (stable and radiogenic) re-equilibration of hydrothermal minerals.

One of the most important overall agreements reached at this meeting is that greenstone gold deposits are the product of large, crustal-scale fluid systems and represent one of several concurrent processes characterizing the last stages of collisional orogenies. It is clear that future research will also have to place greenstone gold deposits more accurately within the geologic and tectonic evolution of their host environment. This will require multi-disciplinary efforts and the active involvement of experts in several fields of geology.

More information on the content of the conference can be found in the NUNA Conference Volume on *Greenstone Gold and Crustal Evolution*, edited by F. Robert, P.A. Sheahan and S.B. Green and published by the Geological Association of Canada/Mineral Deposits Division. This volume contains six invited papers, written reports by the chairmen of the working groups, transcripts of the plenary discussions, and abstracts submitted by the participants. It can be obtained through the headquarters of the Geological Association of Canada.

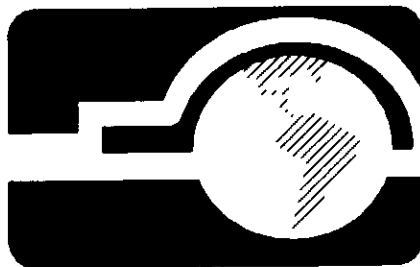
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GAC NUNA Research Conference: Late Proterozoic Glaciation, Rifting and Eustasy: Windermere Supergroup

F.J. Hein and P.S. Simony
*Department of Geology and Geophysics
University of Calgary
Calgary, Alberta T2N 1N4*

During the week 8-16 September 1990, 35 stratigraphers, structural geologists, sedimentologists, climatologists, paleontologists and all-round general geologists gathered for a NUNA Research Conference, the second sponsored by the Geological Association of Canada, on the theme "Late Proterozoic Glaciation, Rifting and Eustasy, as illustrated by the Windermere Supergroup". NUNA is the Inuktituk word for Earth, and the meeting was a field research conference to explore the problems of Late Proterozoic geology and their possible solutions. The meeting combined formal technical presentations with presentations and discussions in local field trips during the conference and formal pre-and post-conference field trips. To facilitate the field components, the conference began near Invermere, and then moved northward more than 300 km to Valemount. Both sites are in eastern British Columbia in the outcrop belt of the Late Proterozoic Windermere Supergroup.

Talks and poster sessions were held at approximately one to one and a half day intervals, punctuated by local field trips. Oral presentations were given as longer overviews or as shorter talks on specific topics. Posters were grouped according to topic. Technical presentations ran the gamut from causes of glaciation (climatic and plate tectonic controls), to sedimentology, and to the major stratigraphic and correlation problems in the Western Cordillera of North America and in Australia. The local field trips were led by individuals and teams of geologists who, along with Jim Aitken (conference co-ordinator), successfully choreographed what had the potential to become a logistical nightmare. Pre- and post-meeting field excursions,

including helicopter transport to more inaccessible sections, also provided a wealth of opportunity for participants to see the superb Late Proterozoic outcrops in the Canadian Rockies and in the ranges west of the Rocky Mountain Trench. Ample time was set aside for dialogue (and argument) among the participants, who were largely from universities and government surveys, with a sprinkling from industry. Registrants were largely from Canada and the United States, but included significant and very active contributors from Australia and Germany.

The first half of the meeting was held at Panorama Ski Resort near Invermere, during beautiful Indian summer days. Panorama is nestled in the valley of Toby Creek, along the sides of which occur massive cliff sections of the Toby diamicton — a Late Proterozoic unit of possible glacial and debris flow origin. Huge blocks occur as dropstones within the Toby diamicton, and a spectacular variety of lithologies occurs in both the diamicton and the older Mount Nelson Formation, providing interest for those with a more petrographic bent.

The meeting started Monday on glaciogenic sedimentation with the lead-off paper presented by John Crowell on the factors responsible for Late Proterozoic glaciation. In the afternoon, we examined Toby conglomerate (diamictite) on Toby Creek and at least some participants agreed that some parts of the Toby are glaciogenic while others are not. The next day, we continued with rift tectonics and Geri Eisbacher led us through the different kinds of rifts we might contemplate for the Windermere. That afternoon, we remained inside and learned about Proterozoic basins in Spitzbergen, the Adelaide Geosyncline of South Australia, and Proterozoic rocks in Idaho and the Yukon. Andy Knoll also encouraged us with his successes in combining microfossils with carbon and strontium isotope systematics in carbonates as a powerful correlation tool for Late Proterozoic strata in Spitzbergen.

On Wednesday, we packed ourselves into the vans and spent the day travelling northward through Lake Louise and Jasper to Valemount. *En route*, everyone had an opportunity to see key localities in the Late Proterozoic Miette Group of the Rocky Mountains.

Thursday morning was devoted to eustasy. Jim Gehling introduced the topic with a discussion of the depositional sequences in the Late Proterozoic to Early Cambrian of the Adelaide Geosyncline. This was followed by papers dealing with a widespread marker in the Windermere succession of the southern Cordillera that probably represents an important eustatic event. Its occurrence in the middle of a 3 km thick sequence of stacked turbidites over an area of more than 200,000 km² has many implications and led to lively discussions. In the afternoon, we had an opportunity to visit key localities of Winder-

mere stratigraphy between Valemount and Jasper, including localities of the famous Old Fort Point marker west of Jasper.

Biological and chemical interaction was the theme for Friday morning. Guy Narbonne provided us with an excellent and encourag-

ing overview of what megafossil biostratigraphy, including Ediacaran fossils, could do for understanding Late Proterozoic stage-level stratigraphy within the Cordillera and across the globe. Thomas Worsley then introduced us to icehouse-greenhouse cycles and the effects of silicate weathering and continent emergence and dispersal on atmosphere CO₂. In the afternoon, the technical sessions were rounded off with a global tectonic outlook and Brendan Murphy reviewed evidence, particularly from eastern North America and western Africa, for a Late Proterozoic supercontinent. That evening, a mildly organized, but very lively, general discussion ensued over an ample supply of beer.

The three Australian participants, W. Preiss, J. Gehling and R. Jenkins, provided us with an exciting picture of some of the challenging problems in, and the growing understanding of, the Late Proterozoic to Cambrian succession of the Adelaide Geosyncline in South Australia. There was lively discussion at the talks and in the field of comparisons and possible correlations between the Windermere and the Adelaide belts. It was somewhat unsettling to find that correlations are actually more easily done between the Mackenzie mountains of north-western Canada and the Wernecke mountains of Australia than between the Wernecke and Mackenzie mountains and the southern Canadian Cordillera — let alone the correlations within the Toby Creek drainage basin!!

The major theme to come out of this meeting was the inherent difficulty in correlation within basins and between basins in what appears to be a rifted continental margin succession. The nature of this margin is controversial — is it really a rift succession, or is it a pre-rift succession, with true continental breakup occurring much later in the Cambrian? How can our correlations be done more accurately? The new discoveries of Ediacarian trace fossils provide a useful database that may help in solving the correlation dilemma. The other approach that seems promising, with regard to possible margin-wide eustatic and tectonic cycles, is the application of sequence stratigraphy or event stratigraphy. The possibility of matching events in Canada and the northwestern United States with those in Australia and/or China is intriguing and very exciting.

The field trips formed an integral part of the conference, and their success greatly contributed to the success of the conference because the field trips not only focussed on elements of Windermere geology, but also on the more general problems of Late Proterozoic rifting, glaciation and eustasy. Because helicopter bases happen to be near Invermere and Valemount, it was possible, at relatively low cost, to ferry participants to good, continuous exposures above timberline. The field trips enabled participants to see sub-

Wolfgang Preiss has eloquently summarized our NUNA conference in the following poem:

Ode to a Broken Plate

Dear friends, Canadians, and dare I say
Countrymen, if the game we play
Is Proterozoic plate tectonic
And our relationship is more than platonic

Could it be that we've found each other at last?
Is it true that we share a common past?
At NUNA, perhaps, we have made a start
To reunite friends long drifted apart.

But let us consider, what's half a gigayear
Of Adelaidean separation from Windermere?
If our continents had remained tied with a tether
We would today all still be together.

So we three have travelled across the wide ocean
To reverse the effects of ancient plate motion;
We have come here to learn and see with our own eyes
Your wonderful mountains of incredible size

But despite the splendor, it soon became clear
That the facies are different in your Windermere.
Your deep-water grits, shed from rift shoulders,
Are packed full of feldspar and carbonate boulders.

The Toby is great, but lacks iron formation
So we must look northward in this vast nation
To the Mackenzie Mountains and their legendary strata
To find better matches with South Aussie data.

If the Toby be Sturt, if the Tapleys be Twitya,
Then other counterparts soon start to hit ya.
The Brighton Limestone has kinda the right feel
To be complementary to an easterly Keele.

And what may you ask, of our Marinoan glaciation?
Jim Aitken can answer - the Ice Brook Formation.
What better name for a melt-water deposit,
So aptly applied, all the more so because it
Honours in literal translation the name
Of an Austrian Windermereologist so game.

Now the time has come to express our thanks
To the organizers of these mobile think-tanks.
The NUNA Conference has been a success,
And we come away feeling no less
Than our terranes may be related,
Even though they cannot be precisely dated.

So we thank you, Jim Aitken and your every colleague,
For your splendid work, with no sign of fatigue
To bring us to see your spectacular sections
And to re-establish our long-lost connections.

W.V. Preiss, September 1990

stantial channels in the turbidite succession, Proterozoic growth faults, glacial(?) diamictites, carbonate platforms and widespread markers that imply eustasy. The trips led to a lot of constructive interaction among the participants.

On the last day of the technical conference, Jim Aitken proclaimed that the conference was a success — and we wholeheartedly agree. Assembling geologists from different specialties to tackle a basin-wide, margin-wide problem of correlation and reconstruction of the Late Proterozoic landmass was inspiring. The causes of rifting and glaciation as inferred from the geologic record remain in our imaginations. The dialogue that developed among scientists of different disciplines shows that we may be able to tackle these problems more effectively by using an holistic approach, rather than by using a more fragmented and myopic vision of the Late Precambrian landscape. We need more of these integrated conferences, taking a basin-wide perspective, with all points of view being brought to bear and enthusiastically debated. We also need to keep our feet on the ground, and to keep reminding ourselves of what the rock record is really telling us.

This NUNA Research Conference was a tremendous success. Part of this success was due to the fact that we were sequestered in the field, isolated from the distractions of urban life and entertainment, and able to focus on the problems at hand. The choreography and the dialogue worked so well because there were only 35 participants. In our view, the addition of another 15 or 20 people would have required changing the character of the conference. While the venues were clearly chosen for their convenient geological settings, it is clear to us that the cozy isolated mountain settings greatly enhanced productive dialogue. The participants were a bit spoiled in Invermere, where the Panorama Ski Resort provided a magnificent setting and very good facilities and hospitality. The community association and local school board in Valemount were also very accommodating in providing the use of their more modest facilities and in providing another venue from which to see another view of different successions in more northern outcrop areas. Although the timing of the conference was a bit difficult for those in universities, it was perfect for the weather, and we really only lost one day to snow on one of the post-conference field trips. A set of abstracts of papers has been prepared, as well as an illustrated guide to all of the field trips. Because of the enthusiastic response of all participants, we are all hoping that there will be another Windermere conference in 3 years — and maybe even in Australia!



Geological Association of Canada
Mineral Deposits Division

GREENSTONE GOLD and CRUSTAL EVOLUTION

Nuna Conference Volume

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