Archean orogenic lode gold in the Superior Province of Manitoba: Recent results on structural controls, relative timing and orogenic context of mineralization

Scott Anderson
Manitoba Geological Survey
• Superior Province: geological overview
• Superior Province: gold endowment
• Orogenic lode gold deposits: characteristics
• Recent results:
  1) Stull Lake belt (Twin Lakes) • structural controls
     • relative timing
     • orogenic context
  2) Rice Lake belt (San Antonio)
• Preliminary conclusions; future plans
Superior Province

Golden Opportunities

Superior Province

Wabigoon

Uchi

Wawa

Abitibi

Bienville

English R.

Winnipeg R.

Pikwitonei

Berens R.

Island L.

Oxford L. - Stull L.

Northern Superior

Molson L.

Bird R.

Winnipeg R.

Quetico

Wawa

Minto

Ashuanipi

La Grande

Opinaca

Opatica

Kapuskasing

Utsalik

Douglas Harbour

Sugluk

Minnesota River Valley

Minto

English R.

Quetico

Wawa

Abitibi

Pontiac
NW Superior Province

> 2.8 Ga continental terranes and isotopic influence

- 3.5-2.81 Ga Northern Superior superterrane
- 3.0 - 2.87 Ga North Caribou terrane
- 3.17 - 2.81 Ga Winnipeg River terrane

Greenstone belts
- Mainly continental affinity
- Mainly oceanic affinity

OLG deposits
- >50,000 oz. Au
- >1,000,000 oz. Au

(Percival et al., 2000)
**Golden Opportunities**

NW Superior Province: Orogenic Lode Gold deposits

**Over 41 million ounces discovered to date**

>50,000 oz. Au)
**Over 3.5 million ounces discovered to date**

### NW Superior Province: Manitoba OLG deposits

<table>
<thead>
<tr>
<th>Deposit</th>
<th>Greenstone belt</th>
<th>Ounces Au</th>
<th>Discovery year</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Antonio</td>
<td>Rice Lake</td>
<td>1,970,000</td>
<td>1911</td>
</tr>
<tr>
<td>Twin Lakes</td>
<td>Stull Lake</td>
<td>530,000</td>
<td>1989</td>
</tr>
<tr>
<td>Little Stull</td>
<td>Stull Lake</td>
<td>220,000</td>
<td>1986</td>
</tr>
<tr>
<td>Gods Lake</td>
<td>Gods Lake</td>
<td>160,000</td>
<td>1932</td>
</tr>
<tr>
<td>Oxford Lake</td>
<td>Oxford Lake</td>
<td>150,000</td>
<td>1986</td>
</tr>
<tr>
<td>Central MB</td>
<td>Rice Lake</td>
<td>140,000</td>
<td>1915</td>
</tr>
<tr>
<td>High Rock Is.</td>
<td>Island Lake</td>
<td>120,000</td>
<td>1934</td>
</tr>
<tr>
<td>Gunnar</td>
<td>Rice Lake</td>
<td>100,000</td>
<td>1921</td>
</tr>
<tr>
<td>Packsack</td>
<td>Rice Lake</td>
<td>90,000</td>
<td>1917</td>
</tr>
<tr>
<td>Ogama</td>
<td>Rice Lake</td>
<td>60,000</td>
<td>1915</td>
</tr>
</tbody>
</table>

(>50,000 ounces)
Orogenic Lode Gold Deposits: Characteristics

- Accretionary plate margins
- Granitoid - greenstone terranes
- Spatially associated with regional-scale shear zones marking major terrane boundaries
- Regional greenschist-facies metamorphism
- Fe-rich rock-types (chemical traps)
- Quartz-carbonate vein systems
- High degree of structural control
- Evidence for syn to late-kinematic emplacement
Orogenic lode gold deposits: Structural analysis

Detailed structure analysis provides constraints on:

- Processes and controls
  - Relative timing
- Orogenic context

DEPOSIT GENESIS

FORMULATE EXPLORATION STRATEGIES
NW Superior Province: MGS structural mapping

- **Golden Opportunities**

3.5-2.81 Ga Northern Superior superterrane
3.0-2.87 Ga North Caribou terrane
3.17-2.81 Ga Winnipeg River terrane

Mainly oceanic affinity
Mainly continental affinity

Greenstone belts
Meta-sedimentary belt
Granitoid rocks

(Percival et al., 2000)
Gods Lake – Stull Lake region

- Gods Lake
- Twin Lakes
- Little Stull Lake
SW Stull Lake belt

Twin Lakes deposit

Map showing the distribution of different rock types and geological features in the SW Stull Lake belt. The map includes symbols for:
- Diabase dike
- Hornblende tonalite to granite
- Biolite tonalite to granodiorite
- Tonalite to granodiorite gneiss
- Greywacke-mudstone turbidite; polymictic conglomerate; iron formation
- Intermediate to felsic volcaniclastic rocks; plagioclase-phyric andesite
- Pillowed and massive basalt; gabbro; iron formation; derived amphibolite
- Iron formation
- Antiform
- Shear zone, fault
## Sharpe Lake - Twin Lakes: Provisional summary of deformation

<table>
<thead>
<tr>
<th>Deformation structures</th>
<th>Shortening direction</th>
<th>Regional structure</th>
<th>Tectonic significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D&lt;sub&gt;1&lt;/sub&gt;</strong> Bedding-parallel S&lt;sub&gt;1&lt;/sub&gt; foliation; rare isoclinal F&lt;sub&gt;1&lt;/sub&gt; folds</td>
<td>?</td>
<td>Early thrust faults?</td>
<td>Onset of collisional orogenesis?</td>
</tr>
<tr>
<td><strong>D&lt;sub&gt;2&lt;/sub&gt;</strong> Regional S&lt;sub&gt;2&lt;/sub&gt; foliation; isoclinal, doubly-plunging F&lt;sub&gt;2&lt;/sub&gt; folds; steep L&lt;sub&gt;2&lt;/sub&gt; stretching lineation; ductile shear zones (north over south shear)</td>
<td>NE-SW</td>
<td>Belt-scale isoclinal F&lt;sub&gt;2&lt;/sub&gt; folds; High-T shear zones on belt margins; SLWSZ and TLSZ</td>
<td>Collisional orogenesis; early Kenoran Orogeny; sinistral transpression?</td>
</tr>
<tr>
<td><strong>D&lt;sub&gt;3&lt;/sub&gt;</strong> Mylonitic S&lt;sub&gt;3&lt;/sub&gt; in east-trending, ductile &gt; brittle, dextral shear zones; WSW-trending S&lt;sub&gt;3&lt;/sub&gt; crenulation cleavage; F&lt;sub&gt;3&lt;/sub&gt; folds</td>
<td>NW-SE</td>
<td>Crustal-scale, greenschist-facies shear zones; SLWSZ and TLSZ (late)</td>
<td>Dextral transpression; terminal Kenoran Orogeny</td>
</tr>
<tr>
<td><strong>D&lt;sub&gt;4&lt;/sub&gt;</strong> Brittle &gt; ductile faults</td>
<td>?</td>
<td></td>
<td>Late-orogenic shortening</td>
</tr>
</tbody>
</table>
Twin Lakes Deposit: Cross section

“C” ZONE

“B” ZONE

“A” ZONE

LEGEND

- Fluvial sedimentary rocks
- Feldspar-porphyry dike
- Plagioclase-phyric andesite
- Felsic - intermediate tuff
- Greywacke, mudstone; iron formation
- Mafic volcanic rocks; gabbro

SECTION 14850 E

Section Looking West
Twin Lakes Deposit: Longitudinal section

Seeber West Zone

Seeber Central/Twin West Zone

Twin Lake Zone

Fall 2004 Drilling Area

B Zone

C Zone

Fall 2004 Drilling Area

>10.00 g/t Au/m
5.00 - 10.00 g/t Au/m
Fall 2004 Drilling
Winter 2004 Drilling
2003 Drilling
Pre 2003 Drilling
Hole ID g/t Au / metre
‘Golden Opportunities’

Twin Lakes Deposit: mineralization style

- Early sericite-ankerite alteration (incompetent)
- Later quartz-albite alteration (competent)
- Brittle failure
- Structural permeability
- Syn-kinematic veins (qtz-aspy + Au)

TL04-190 (C-zone)
Twin Lakes Deposit: relative timing

- Syn - D2 mineralization
- GSC04-5 (B-zone)
**Golden Opportunities**

**Rice Lake belt**

- **Platform-rift sequence (ca. 2.99 Ga)**
- **Volcanic rocks (ca. 2.72-2.73 Ga)**
- **Tonalitic intrusive rocks (2.7 to 3.0 Ga)**
- **Siliciclastic rocks (ca. 2.7 Ga)**

- **English River terrane**
  - **Paragneiss, orthogneiss granite (ca. 2.66-2.69 Ga)**
  - **Limestone, quartzite**

- **Uchi terrane**
  - **Tonalite, quartz diorite (ca. 2.73 Ga)**
  - **Tonalitic intrusive rocks (ca. 2.87-2.90 Ga)**

- **North Caribou terrane**
  - **Paragneiss, orthogneiss granite (ca. 2.66-2.69 Ga)**
  - **Limestone, quartzite**

- **Manigotagan Sheet Zone**
  - **Ross River pluton**
  - **Wallace assemblage**

- **Wanipigow Shear Zone**

- **Manitoba-Ontario**

- **Geological contact**
  - **Gold occurrence; gold deposit**

- **50°45’ 51°00’ North**
- **96°15’ 95°15’ East**

- **Lewis-Storey assemblage**

- **10 km**

- **Manitoba**
  - **Ontario**

**Key Features**

- **Wallace assemblage**
- **Lewis-Storey assemblage**
- **Ross River pluton**
- **Manigotagan Sheet Zone**
- **Wanipigow Shear Zone**

**Terranes**

- **English River terrane**
- **Uchi terrane**
- **North Caribou terrane**

**Rocks**

- **Paragneiss, orthogneiss granite**
- **Limestone, quartzite**
- **Tonalite, quartz diorite**
- **Siliciclastic rocks**
- **Tonalitic intrusive rocks**
- **Volcanic rocks**

** Dates**

- **2.99 Ga**
- **2.72-2.73 Ga**
- **2.7 Ga**
- **2.73 Ga**
- **2.87-2.90 Ga**
- **2.66-2.69 Ga**
- **2.7 to 3.0 Ga**
### Central Rice Lake belt: Provisional summary of deformation

<table>
<thead>
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<th>Shortening direction</th>
<th>Deformation structures</th>
<th>Regional structure</th>
<th>Tectonic significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D₁</strong></td>
<td>?</td>
<td>None observed</td>
<td>Tilting</td>
</tr>
<tr>
<td><strong>D₂</strong></td>
<td>?</td>
<td>Local, weak, layer-parallel S₂ foliation</td>
<td>Thrust faults</td>
</tr>
<tr>
<td><strong>D₃</strong></td>
<td>NNE-SSW</td>
<td>Regional NW- to WNW-trending S₃; L₃ stretching lineation; upright F₃ folds</td>
<td>Macroscopic folds; Gold Creek syncline and Horseshoe Lake anticline</td>
</tr>
<tr>
<td><strong>D₄</strong></td>
<td>NW-SE</td>
<td>Regional SW- to WSW-trending S₄; L₄ intersection lineation; Z-asymmetric F₄ folds</td>
<td></td>
</tr>
<tr>
<td><strong>D₅</strong></td>
<td>NNW-SSE</td>
<td>WNW- to NNW-trending high-strain zones; L₅ lineation; F₅ folds; S₅ shear-band cleavage</td>
<td>Dextral transcurrent shear zones</td>
</tr>
<tr>
<td><strong>D₆</strong></td>
<td>E-W</td>
<td>Open, north-trending F₆ crenulations</td>
<td>Open folds at Rice Lake</td>
</tr>
</tbody>
</table>
San Antonio assemblage
- Quartz arenite, polymictic conglomerate

Round Lake section
- Heterolithic conglomerate

Townsite section
- Dacite tuff breccia
- Pillowed basalt, minor volcaniclastic rocks
- Gabbro
- Felsic volcanic sandstone and conglomerate

Projection of workings
- Shaft
- Younging direction
- Geological boundary (approx., extrapolated)

(Modified from Poulsen et al., 1996)

San Antonio mine geology

Hares Is.

San Antonio sill

Melagabbro

Leucogabbro

Hotel

A

A'

C (projected)

B (projected)

D (projected)

Angular unconformity

Disconformity

‘Unit A’

‘Golden Opportunities’

Rice Lake

0 200 metres

(‘Golden Opportunities’

Manitoba Geological Survey

1928

Manitoba

Balancing the Future

(MGS)
Level 15, San Antonio mine

- Dacite
- Gabbro
- Felsic epiclastic rocks
- Stockwork vein (38-type)
- Shear-hosted vein (16-type)
- Shear zone
- Mine workings

Modified after Rhys (2001)

Golden Opportunities
San Antonio-type vein systems: relative timing

16-type
38-type
S$_3$-S$_4$-S$_5$

Syn to post-D$_5$ mineralization (?)
Conclusions and future work

• SLB and TLB - complex structural evolution
  • TL and SA deposits - high degree of structural control
    • Syn-tectonic vein (+Au) emplacement

Twin Lakes deposit
• syn-D$_2$
• early tectonic

San Antonio deposit
• syn to post-D$_5$ (?)
• late tectonic

What is the absolute age of mineralization?

• How did the deposits form?

• Where should we look for more?

Re-Os (apy)

U-Pb (ti, mz)