Revising the Basement Map of the Lower Peninsula; New Constraints from Cores and Cuttings

Peter J. Voice, William B. Harrison III, and Joyashish Thakurta

Department of Geosciences, Western Michigan University and the Michigan Geological Survey
Geologic Background

• Prior datasets
  – Geophysical data (Gravity and Magnetic anomaly maps)
  – Basement maps based on well samples
  – Geochronological datasets
The Hinze Basement Map Dataset
14 wells – lithologic samples from cuttings

Hinze and Merritt, 1969
Mid-Michigan Anomaly

Penokean Province

Grenville Province

Central Province
Revision of Basement Map
3 additional wells + refinements to geophysical datasets

Hinze et al. 1975
Revision of Basement Map
3 additional wells + refinements to geophysical datasets

Hinze et al. 1975
<table>
<thead>
<tr>
<th>Well</th>
<th>Location</th>
<th>Method and material</th>
<th>Age (Ma)</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>McClure #2 State-Beaver Island</td>
<td>Charlevoix Co.</td>
<td>Rb-Sr and K-Ar Biotite from cuttings</td>
<td>1040; 1090</td>
<td>Lidiak et al. 1966</td>
</tr>
<tr>
<td>St. Blair 2-24</td>
<td>Grand Traverse Co.</td>
<td>U-Pb Zircon from granite</td>
<td>1472 ± 2</td>
<td>Hoppe et al. 1983</td>
</tr>
<tr>
<td>Taylor</td>
<td>Lenawee Co.</td>
<td>Rb-Sr Biotite from granite and granite-gneiss</td>
<td>890-970</td>
<td>Summerson, 1962</td>
</tr>
<tr>
<td>St. Clair #1 Hurst</td>
<td>St. Clair Co.</td>
<td>Rb-Sr and K-Ar Biotite from biotite-gneiss cuttings</td>
<td>900, 970</td>
<td>Lidiak et al. 1966</td>
</tr>
<tr>
<td>Colvin and Associates, Voss</td>
<td>Washtenaw Co.</td>
<td>Rb-Sr Gneiss (?) cuttings</td>
<td>840</td>
<td>Lidiak et al. 1966</td>
</tr>
<tr>
<td>Colvin and Associates, Meinzinger</td>
<td>Washtenaw Co.</td>
<td>Rb-Sr Gneiss cuttings</td>
<td>920</td>
<td>Lidiak et al. 1966</td>
</tr>
</tbody>
</table>

Most samples taken from cuttings
1. Mixed samples from multiple footages
2. Likely time-averaging multiple geologic ages (with a dominant mode slightly younger than Grenville age)
3. Many of the ages are “Model Ages”
<table>
<thead>
<tr>
<th>Well</th>
<th>Location</th>
<th>Method and material</th>
<th>Age (Ma)</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>McClure #2 State-Beaver Island</td>
<td>Charlevoix Co.</td>
<td>Rb-Sr and K-Ar Biotite from cuttings</td>
<td>1040; 1090</td>
<td>Lidiak et al. 1966</td>
</tr>
<tr>
<td>St. Blair 2-24</td>
<td>Grand Traverse Co.</td>
<td>U-Pb Zircon from granite</td>
<td>1472 ± 2</td>
<td>Hoppe et al. 1983</td>
</tr>
<tr>
<td>Taylor</td>
<td>Lenawee Co.</td>
<td>Rb-Sr Biotite from granite and granite-gneiss</td>
<td>890-970</td>
<td>Summerson, 1962</td>
</tr>
<tr>
<td>St. Clair #1 Hurst</td>
<td>St. Clair Co.</td>
<td>Rb-Sr and K-Ar Biotite from biotite-gneiss cuttings</td>
<td>900, 970</td>
<td>Lidiak et al. 1966</td>
</tr>
<tr>
<td>Colvin and Associates, Voss</td>
<td>Washtenaw Co.</td>
<td>Rb-Sr Gneiss (?) cuttings</td>
<td>840</td>
<td>Lidiak et al. 1966</td>
</tr>
<tr>
<td>Colvin and Associates, Meinzinger</td>
<td>Washtenaw Co.</td>
<td>Rb-Sr Gneiss cuttings</td>
<td>920</td>
<td>Lidiak et al. 1966</td>
</tr>
</tbody>
</table>

Only Well where the geochronological sample is not a composite sample
More Recent Interpretations of the basement of the Lower Peninsula

Bornhorst and Brandt, 2009

Whitmeyer and Karlstrom, 2007
New Data

• Basement Well Collection at MGRRE
  – 9 wells with core
  – 35 wells with cuttings (10 mounted sets, 25 sets in vials)

• Two additional Basement wells with core
  – 1 currently in the BEG collection; the other is missing
  – Published reports on geology from the St. Blair #2-24
Available wells

Red – core available
Green – Unmounted Cuttings
Orange – Mounted Cuttings
Available wells – Cores

St. Blair #2-24 – at BEG

Volmerling #1 – lost

Other wells – at MGRRE

St. Blair #2-24

St. Sims #2-7

Sparks #1-8

Volmerling #1

Consumer Power BD 1-7 and Consumer Power BD 2-7

Lindsay Hostetler et al. #1 and Clark #1

Arco Gaglio #1-13

Cupp #1-11

Consumers Power BD 139
Hinze and Merritt, 1969
Southwestern Michigan

- Cupp #1-11 (St. Joseph Co.), the Lindsay Hostetler et al. #1, Clark #1, and Arco Gaglio #1-13 (Branch Co.)
- Mix of heavily fractured metasediments/meta-igneous rocks as well as unmetamorphosed granites
- Paleosols at basement-basin contact developed from granites
Fine-grained, phenocrystic granite

Arco Gaglio #1-13, 1637 m (5371 ft.)
Pristine, feldspathic porphyritic granite

Cupp #1, 1547.8 m (5078 ft)
Pristine, feldspathic porphyritic granite with feldspar veins

Cupp #1, 1547.1 m (5076 ft)
Partial alteration of feldspars and groundmass to clays

Cupp #1, 1546.9 m (5075 ft)
Partial alteration of feldspars and groundmass to clays

Cupp #1, 1546.5 m (5074 ft)
Mt. Simon Sandstone – block right above previous picture

Cupp #1, 1546.5 m (5074 ft)
Banded Gneiss, 1652.6 m (5422 ft), Lindsay Hostetler et al. #1
Banded Gneiss with pyrite seam, 1649 m (5410 ft), Lindsay Hostetler et al. #1
Amphibolite with veins lined with K-spar, 1648 m (5407 ft), Lindsay Hostetler et al. #1
Southeastern Michigan

• Consumer Power (BD 151) #1-7, (BD 152) #2-7 and BD #139 (St. Clair Co.)
  – Metamorphosed igneous rocks
  – Granite-gneisses, granitic orthogneisses
  – The #1-7 exhibits a paleosol at the basin basement contact
Banded orthogneiss

Consumer Power BD #1-7, 1437.7 m (4717 ft)
Banded orthogneiss with sand-filled fissure

Consumer Power BD #1-7, 1437 m
Transition from granite gneiss to lateritic paleosol enriched in clays

Consumer Power BD #1-7, 1436 m
Transition from granite gneiss to lateritic paleosol enriched in clays with contact with the Mt. Simon Sandstone

Consumer Power BD #1-7, 1436 m
Banded orthogneiss with feldspar veins

Consumer Power BD #139, 1410 m
Granite Gneiss

Consumer Power BD #139, 1407 m
Northeastern Michigan

- State Sims #2-7 Arenac County
- 2\textsuperscript{nd} deepest well in the state
- Banded gneisses – presumably orthogneisses
Conclusions

New data points – show that Hinze’s basement provinces exist
• More lateral variability within each province – basement heterogeneity
Further Work

• Integrate Cuttings data especially in thumb region and southwestern MI

• Age dates from granites in St. Joseph-Branch Counties and from granite-gneisses in St. Clair Co.
  – See if match with current basement province models

• Further study of Paleosols – timing, paleoenvironmental conditions
Acknowledgements

- William Hinze
- Rob Van Der Voo
- Paul Potter
- Paul Daniels and Diana Morton-Thompson
- Mark Baranoski
- John Esch