The Thermochronologist's Progress

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The Thermochronologist's Progress

Context and complexion of our discipline

Accomplishments and progress

Key issues and future directions
25 Years of Thermochronology?

the dachshund of time (via BSNYC)
NSF Awards Database:
"thermochronometry" or "thermochronology" in title or abstract (duplicates removed)

Awards = 238 ($41 million)
Users and Players
The quaternary system modelers – thermochronologists – mineralogists – geologists

- Complete solid solution
- More components possible
User and Player Worldviews
**QUIZ: Thermochronology’s Achievements**

List thermochronology’s game-changing outcomes. What fundamental measurements or ideas are in textbooks or known by the educated public?

*You have 23 seconds.*

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td><em>rates?</em></td>
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<tr>
<td>2.</td>
<td><em>dates?</em></td>
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<td>3.</td>
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<td>9.</td>
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<td>10.</td>
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25 50 Years of Progress?
Progress

Understanding
Impact
Sensitivity
Background
Standardization
Precision
Your favorite(s)

M-Law
T-chron

Years Ago

Relative Progress
Rock was hot...
...now it’s not!
I’m a-gonna give ya rates an’ dates...

* sung to the tune "Rock around the Clock"
Quantitative Thermochronology

Process > Thermal Field > Ages
Ages > Temperature History > Process
Quantitative Thermochronology

Process > Thermal Field > Ages
Ages > Temperature History > Process

Large numbers of dates
Good, well-known precision
Perfect kinetics
All too often...

- Modest numbers of dates
- Uneven, uncertain precision
- Blanket, ill-constrained kinetics
  (often using just 1–2 systems)
Recap

Thermochronology is a venerable and established field

It’s an enabling tool for a large and diverse user base

The glass is only fractionally full when it comes to achieving true “quantitative thermochronology”

Our penchant for curiosity-driven research is great, but successful applications pay the bills

So, what’s needed?
## I. Understand Systematics

### Example: *In vacuo* crushing:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Treatment or History</th>
<th>Fraction Released Mechanically</th>
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<tbody>
<tr>
<td>Durango Standard</td>
<td>Standard, gem quality, fast-cooled</td>
<td>0.5%</td>
</tr>
<tr>
<td>Young Tibetan apatite</td>
<td>Good actor, fast cooled</td>
<td>2.6%</td>
</tr>
<tr>
<td>Young Himalayan apatite</td>
<td>Good actor, fast cooled</td>
<td>2.6%</td>
</tr>
<tr>
<td>Young Himalayan apatite</td>
<td>Good actor, fast cooled</td>
<td>3.4%</td>
</tr>
<tr>
<td>Appalachian apatite</td>
<td>OK? actor, very slow cooled</td>
<td>6.4%</td>
</tr>
<tr>
<td>Appalachian apatite</td>
<td>Bad actor, very slow cooled</td>
<td>9.4%</td>
</tr>
<tr>
<td>Durango Standard</td>
<td>Soaked, 100 bar $^4$He</td>
<td>16.4%</td>
</tr>
<tr>
<td>Durango Standard</td>
<td>Soaked, 31 bar $^4$He</td>
<td>48.3%</td>
</tr>
<tr>
<td>Appalachian apatite</td>
<td>Soaked, 12.2 bar $^4$He</td>
<td>51.9%</td>
</tr>
<tr>
<td>Young Himalayan apatite</td>
<td>Bad actor, fast cooled</td>
<td>53.1%</td>
</tr>
<tr>
<td>Appalachian apatite</td>
<td>Soaked, 12.2 bar $^4$He</td>
<td>63.7%</td>
</tr>
</tbody>
</table>

Zeitler, Enkelmann, Thomas, Ancuta, Watson, in prep.
2. Improve Kinetics

More $^4\text{He}/^3\text{He}$ and $^{40}\text{Ar}/^{39}\text{Ar}$ MDD

Bring out the bombs! More lab kinetic studies

Kinetic standards for at least apatite and feldspar

Community agreement on kinetic values and uncertainties, an open and updating kinetic database

Standardized data protocols, error handling
3. Improve Throughput

Remember Moore’s Law

Identify weak links (crushing, separation, picking, ...)
(watch an episode of “Unwrapped” on Food Network)

Cheaper and faster analysis (quadrupoles for Ar?)

Automated data-reduction workflows

Community goal: increase throughput by 10X or more
Conclusions

Keep up that creative, curiosity-driven work, but...

...Be the user

...Keep our eyes on the prize

...Think bigger and more supportively as a community:

One crustal reflection profile = maybe $2,500,000

That’s ~10,000 dates! What could we do with that?
I. Understand Systematics

Example:

![Helium Solubility in Apatite Diagram]

Zeitler, Enkelmann, Thomas, Ancuta, Watson, in prep.