Have the Wheels Fallen Off your “Hype Cycle”? A retrospective look at criticality: tantalum, rare earth elements and lithium.

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What is a Critical Metal / Mineral / Material?

Serious answer: “Critical metals are metals whose availability is essential for high-technology, green and defence applications, but vulnerable to politically or economically driven fluctuations in supply. At present, this designation applies particularly to the rare-earth elements (REE), tantalum (Ta), niobium (Nb), lithium (Li), molybdenum (Mo) and indium (In)” (~2010 http://criticalmetalsmeeting.com)

Text in red would not have been in earlier definitions: Any definition depends on the country you are in, the technology / industry you are interested in, your perceived risk of future supply, and perceived demand. ALL of these are subject to change. (Nex, 2015). Critical metals in Africa are not necessarily the same as those in Europe! This has obvious implications for Global vs National criticality and how it is assessed.

(BTW, What happened to cobalt and graphite!!)

Cynical answer: Any metal or material that can be so declared to enhance the ‘spin’ produced by a junior exploration company OR to increase the chances of obtaining research funding in the academic environment OR to enable producing companies to increase prices OR to justify in-depth studies by government departments / NGOs.
What is the “Hype Cycle”

Developed by Fenn (1995) working for the Gartner Group to describe the performance of emerging technologies.

Somewhat “Zen-like” in terminology

Not really a cycle and doesn’t predict what happens to the emerging technology – there is only one outcome.

Possibly better envisaged as a feedback loop rather than a cycle.
A myriad of paths is possible – the peak of inflated expectations could be a blind summit!
Time scales will vary
Hype cycle applied to commodities: do cmdty prices, share prices and citations reflect the same trends?

Welmer & Dalheimer 2012 Min Dep (Raw Materials)
Looking at world production, world price and also citations in Web of Science. The results of your labours.

2010 Senkaku Boat Collision Incident

2011 EU Critical Metals List
The report that started it all?
Tantalum

Obtained typically from tantalite; rare-metal pegmatites (LCT), some production from pyrochlore in carbonatites, co-production from tin deposits until the tin crisis of the early 1980’s.

Principle use in electronic capacitors; cell phones, hard drives, hearing aids, pacemakers.

Production and price not transparent – individual contracts between producers and processors, Published statistics frequently combined with niobium.

Until mid-2000’s production dominated by TANCO (Canada) and Wodgina / Greenbushes (Sons of Gwalia, Australia)
3 hype cycles?

2004 Sons of Gwalia bankrupt

Electronics Industry, Panic buying, Stockpiling (Cunningham 1998)

1998-2000 cell phones

Stockpiles depleted, increased demand

2006-2015 volatility

Production Data USGS 2017

Price data: metalary.com (1999-present) and USGS 1999 (pre-1998)
According to Roskill (2016) in the early 2000’s “rapidly growing demand for tantalum was based on the wholly unfounded belief that a tantalum shortage was imminent.”

Demand decreased, no shortage, prices tumbled – Classic “Hype Cycle”

Price increases (3rd hype cycle) 2010-2014 probably due to a combination of factors: Tanco, Greenbushes and Wodgina closures, Care & Maintenance (2008-2011), production now dominated by Central African pegmatites (Rwanda), reopening of Greenbushes & Wodgina?

Designation as a conflict mineral and the Dodd-Frank Act of 2010.

Other new projects are not active mines (yet?) (Abu Dabbab, Nuweibi, Upper Fir, Kanyika): there are still plenty of untapped resources
Figure 2. Annual mine production of tantalum contained in concentrates by country and events that affected mine production, 2000–2014.
Combined with Web of Science Citations
Not rare, just difficult to extract.

1965-1985: Most production from Mountain Pass

1984: China starts producing

From 1988: >80% of the world’s REE produced in China

2002: Mountain Pass closes

2010: Senkaku Incident

2012: >200 Junior exploration companies looking for REE deposits

Castor & Hedrick, 2006; Paulick & Machacek, 2017
Relating the hype cycle and critical metals is not new!!

Hocquard 2010 BRGM Presentation at Ifri Round Table Brussels
(Institute Francais des Relations Internationales)
Production data from USGS and BGS, Price data from BGS
<table>
<thead>
<tr>
<th>Deposit</th>
<th>Country</th>
<th>Source</th>
<th>Mt</th>
<th>%TREO</th>
<th>Contained REO (kt)</th>
<th>% HREO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ngualla Hill</td>
<td>Tanzania</td>
<td>Carbonatite</td>
<td>195</td>
<td>2.26</td>
<td>4400</td>
<td>0.33</td>
</tr>
<tr>
<td>Zandkopsdrift</td>
<td>South Africa</td>
<td>Carbonatite</td>
<td>42.48</td>
<td>2.08-2.28</td>
<td>949</td>
<td>1.69</td>
</tr>
<tr>
<td>Tantalus</td>
<td>Madagascar</td>
<td>Ion-adsorption Clays</td>
<td>560.6</td>
<td>0.09</td>
<td>561</td>
<td>4.37</td>
</tr>
<tr>
<td>Songwe</td>
<td>Malawi</td>
<td>Carbonatite</td>
<td>31.8</td>
<td>1.38-1.62</td>
<td>469</td>
<td>1.67</td>
</tr>
<tr>
<td>Glenover</td>
<td>South Africa</td>
<td>Carbonatite</td>
<td>10.37</td>
<td>2.23</td>
<td>231</td>
<td>1.45</td>
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<tr>
<td>Kangankunde</td>
<td>Malawi</td>
<td>Carbonatite</td>
<td>2.53</td>
<td>4.24</td>
<td>107</td>
<td>0.19</td>
</tr>
<tr>
<td>Steenkampskraal</td>
<td>South Africa</td>
<td>Vein</td>
<td>0.665</td>
<td>14.0</td>
<td>93</td>
<td>1.79</td>
</tr>
<tr>
<td>Wigu Hill</td>
<td>Tanzania</td>
<td>Carbonatite</td>
<td>3.3</td>
<td>2.16</td>
<td>61</td>
<td>0.10</td>
</tr>
<tr>
<td>Xiluvo</td>
<td>Mozambique</td>
<td>Carbonatite</td>
<td>1.1</td>
<td>2.05</td>
<td>23</td>
<td>1.81</td>
</tr>
<tr>
<td>Lofdal</td>
<td>Namibia</td>
<td>Carbonatite</td>
<td>6.16</td>
<td>0.29</td>
<td>18</td>
<td>20.50</td>
</tr>
<tr>
<td>Mrima Hill</td>
<td>Kenya</td>
<td>Carbonatite</td>
<td>159.4</td>
<td>3.61-4.40</td>
<td>6</td>
<td>2.20</td>
</tr>
</tbody>
</table>

Added to resource inventories between 2010 and 2016
From 2011-2015 defined mineral resources of REE outside of China doubled:

40 Mt to 98 Mt

Canada 38 Mt
Greenland 36 Mt
Africa 10 Mt
Commodity Prices and Stock Prices show sympathetic trends - unsurprisingly

From a commercial perspective timing is everything. If you miss the first hype cycle you might catch the next one.

Is it a good time to buy REE stocks?
Lithium

Obtained from brines or pegmatites
EV’s – Li-ion batteries
Climate Change
Legislation

Bikita (Zimbabwe)

Rubicon & Helicon (Namibia)
Production data from BGS World Mineral Statistics (NB recalculated from mineral data to lithium where necessary). Price data from metalary.com
The exploration expenditure figures are difficult to quantify but there was definitely a hard-rock lithium exploration boom in 2017-2018.
<table>
<thead>
<tr>
<th>Project</th>
<th>Company</th>
<th>Ore</th>
<th>Grade (Li₂O)</th>
<th>Contained LiO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zim</td>
<td>Bikita Minerals</td>
<td>10.8 Mt</td>
<td>1.4%</td>
<td>0.58%</td>
</tr>
<tr>
<td>Zim</td>
<td>Kamativi CAT Strategic Metals</td>
<td>26.3 Mt</td>
<td>0.28%</td>
<td>0.073 Mt</td>
</tr>
<tr>
<td>Zim</td>
<td>Acadia Prospect Resources</td>
<td>40.5 Mt</td>
<td>1.44%</td>
<td>0.583 Mt</td>
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<tr>
<td>Zim</td>
<td>Zulu Premier African Minerals</td>
<td>20.1 Mt</td>
<td>1.06%</td>
<td>0.213 Mt</td>
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<tr>
<td>Namibia</td>
<td>Helicon &amp; Rubicon Desert Lion Energy</td>
<td>Historical</td>
<td>1.1 Mt</td>
<td>1.4%</td>
</tr>
<tr>
<td>DRC</td>
<td>Manono-Kitolo Historical</td>
<td>7.86 Mt</td>
<td>0.76%</td>
<td></td>
</tr>
<tr>
<td>DRC</td>
<td>Manono-Kitolo Historical</td>
<td>35 Mt</td>
<td>0.6%</td>
<td></td>
</tr>
<tr>
<td>DRC</td>
<td>Manono Project AVZ Minerals 2018 (JORC)</td>
<td>259.9 Mt</td>
<td>1.63%</td>
<td>4.236 Mt</td>
</tr>
<tr>
<td>Ghana</td>
<td>Egyasimanku Hill IronRidge Resources Historical</td>
<td>1.48 Mt</td>
<td>1.66%</td>
<td></td>
</tr>
<tr>
<td>Mali</td>
<td>Goulamina Birimian</td>
<td>32.9 Mt</td>
<td>1.37%</td>
<td>1.380 Mt</td>
</tr>
</tbody>
</table>

| Total    |                           | 449.8 Mt           | 6.412 Mt      |

The newly determined hard-rock resources in Africa equate to approximately 3 Mt of Li. (Global production of Li is in the region of 80,000 tpa)
Unsurprisingly the same trends are seen in share prices
(Data from Google Finance)

AVZ Minerals
(Manolo)

Birimian
(Goulamina)

Prospect Resources
(Arcadia)

One major effect of the hype cycle is a stimulus to exploration
and an increase in the resource base – this is a **GOOD** thing
Africa is under-represented and where is Bikita?
Published Resources and Reserves are not sufficient for forecasting – although its what we use.

Reserve Base (RB)

RB in Tg (10^{12} g)

Not Stock-exchange compliant!!

Resource Base derived from Upper Crustal Abundance

Figure from Graedel & Nassar (2013 GSL SP393)
BMW and Daimler, two giants in the automobile sector, are pooling their resources in a joint mobility effort that spans autonomous cars, ride-hailing, electric scooters, car-sharing, and electric car charging. The two companies announced on Friday that their intention is to spend $1.13 billion on the venture, an eye-popping sum designed to make the rest of the industry sit up and take notice. 

Is it a co-incidence that the potential lack of REE caused tremors in the car industry – perhaps they don’t want to be caught in an uncertain future again.

How many of you will own a vehicle in 50 years time?
Commodity / Critical Material hype cycles reflect short term fluctuations based on the perception of shortages and often optimistic forecasts of demand, panic buying and/or optimistic expectations of price increases.

Long term trends are more reliable and provide much better indicators of growth.

- Are you suffering from inflated expectation or wallowing in the trough of disillusionment.
- Perhaps we need to be on the slope of (Scottish?) enlightenment.

Adam Smith
(1723-1790) author: *The Wealth of Nations*

James Hutton
(1726-1797) “The Father of Geology”