

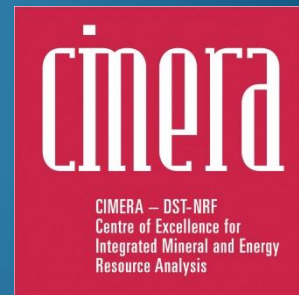
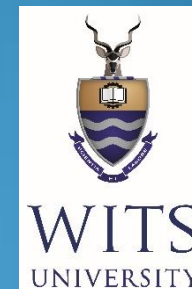
Have the Wheels Fallen Off your “Hype Cycle”? A retrospective look at criticality: tantalum, rare earth elements and lithium.



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Eimear Deady²

¹ University of the Witwatersrand

² British Geological Survey





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.



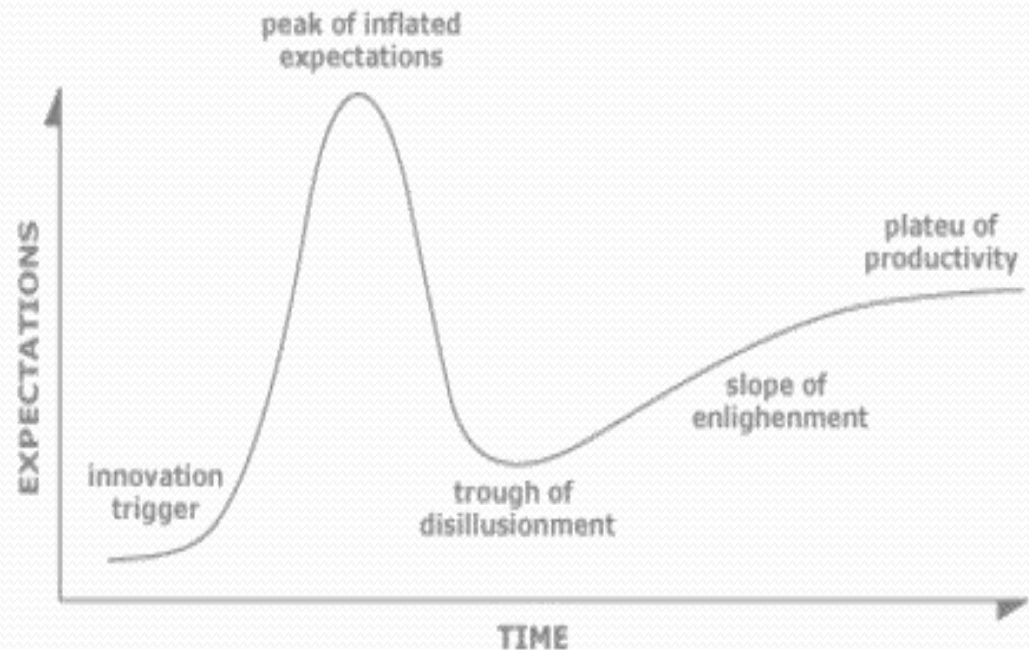
What is the “Hype Cycle”

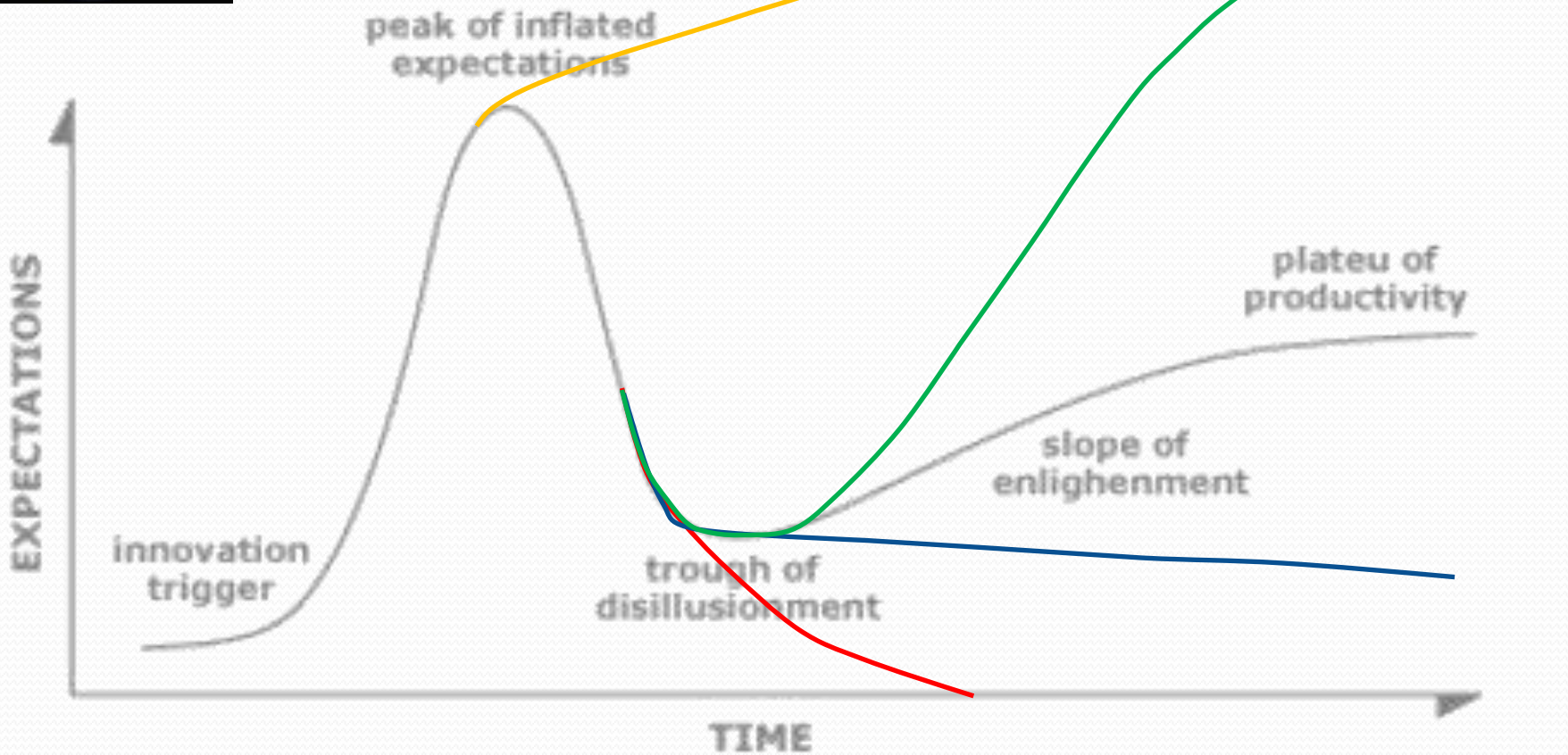
Developed by Fenn (1995) working for the Gartner Group to describe the performance of emerging technologies.

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

2014 GARTNER HYPE CYCLE

Current as of July 2014



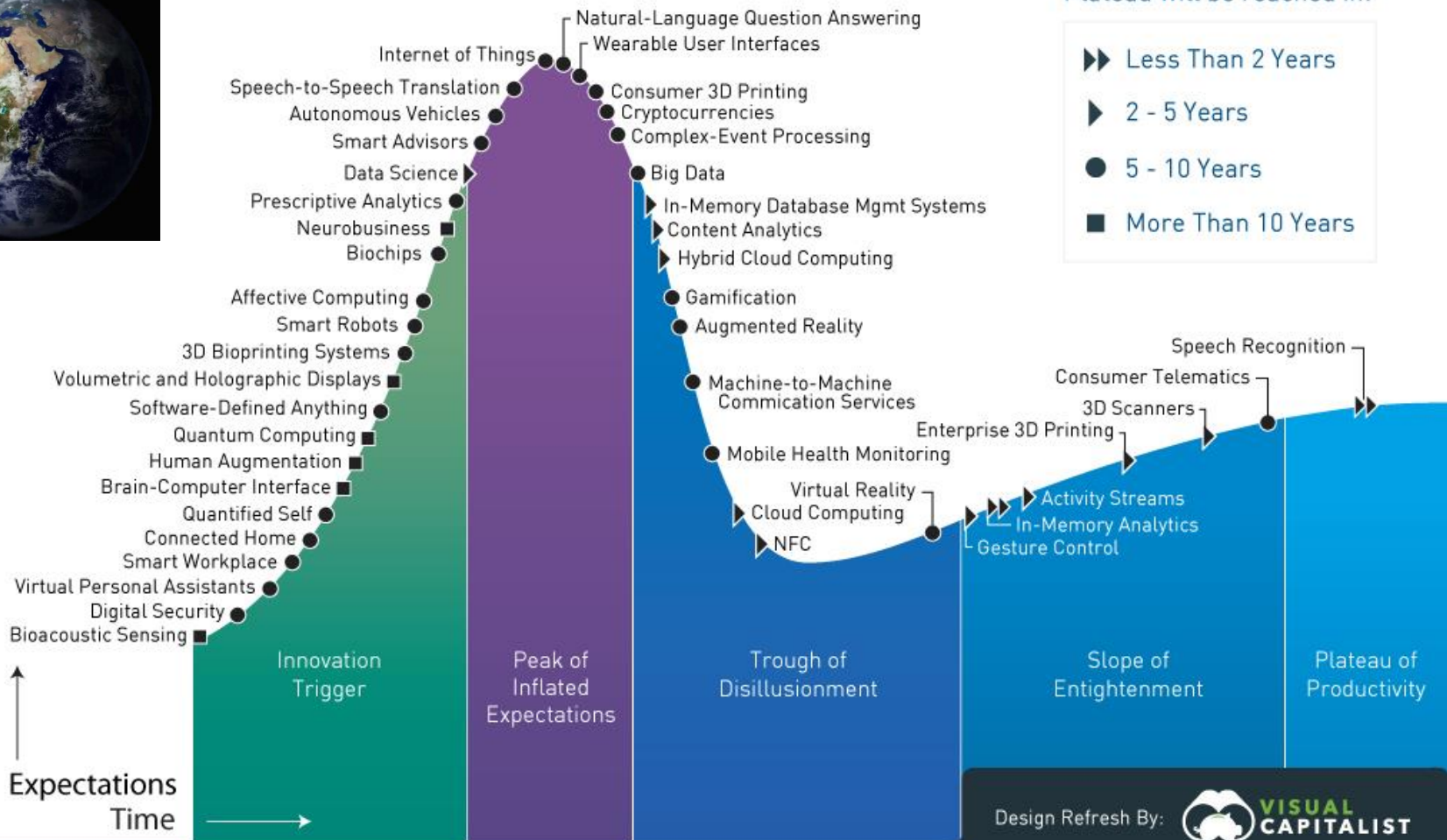
What is this?

Hype Cycles offer a snapshot of the relative maturity of technologies, IT methodologies and management disciplines. They highlight overhyped areas, estimate how long technologies and trends will take to reach maturity, and help organizations decide when to adopt.



Plateau will be reached in:

- ▶▶ Less Than 2 Years
- ▶ 2 - 5 Years
- 5 - 10 Years
- More Than 10 Years

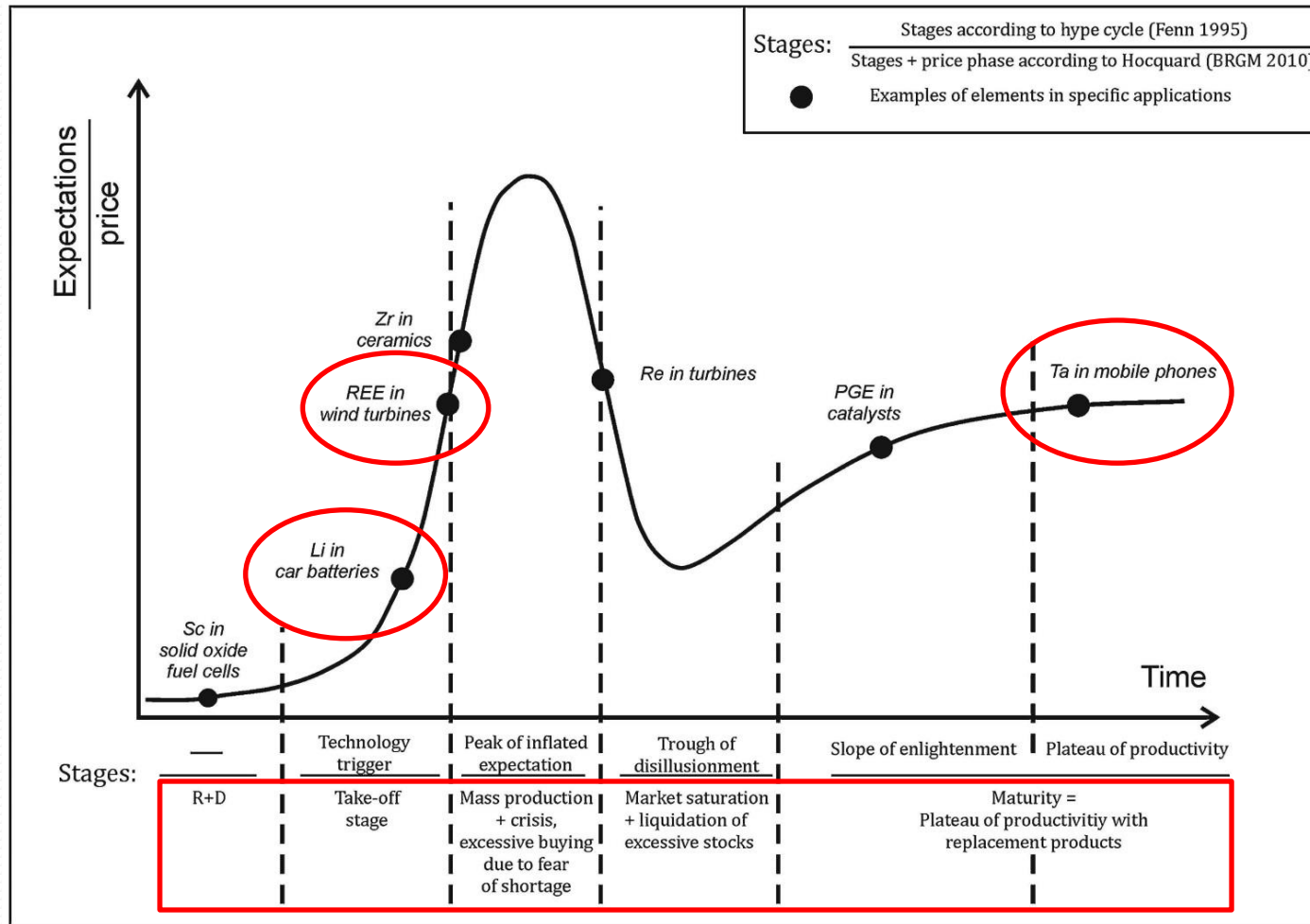


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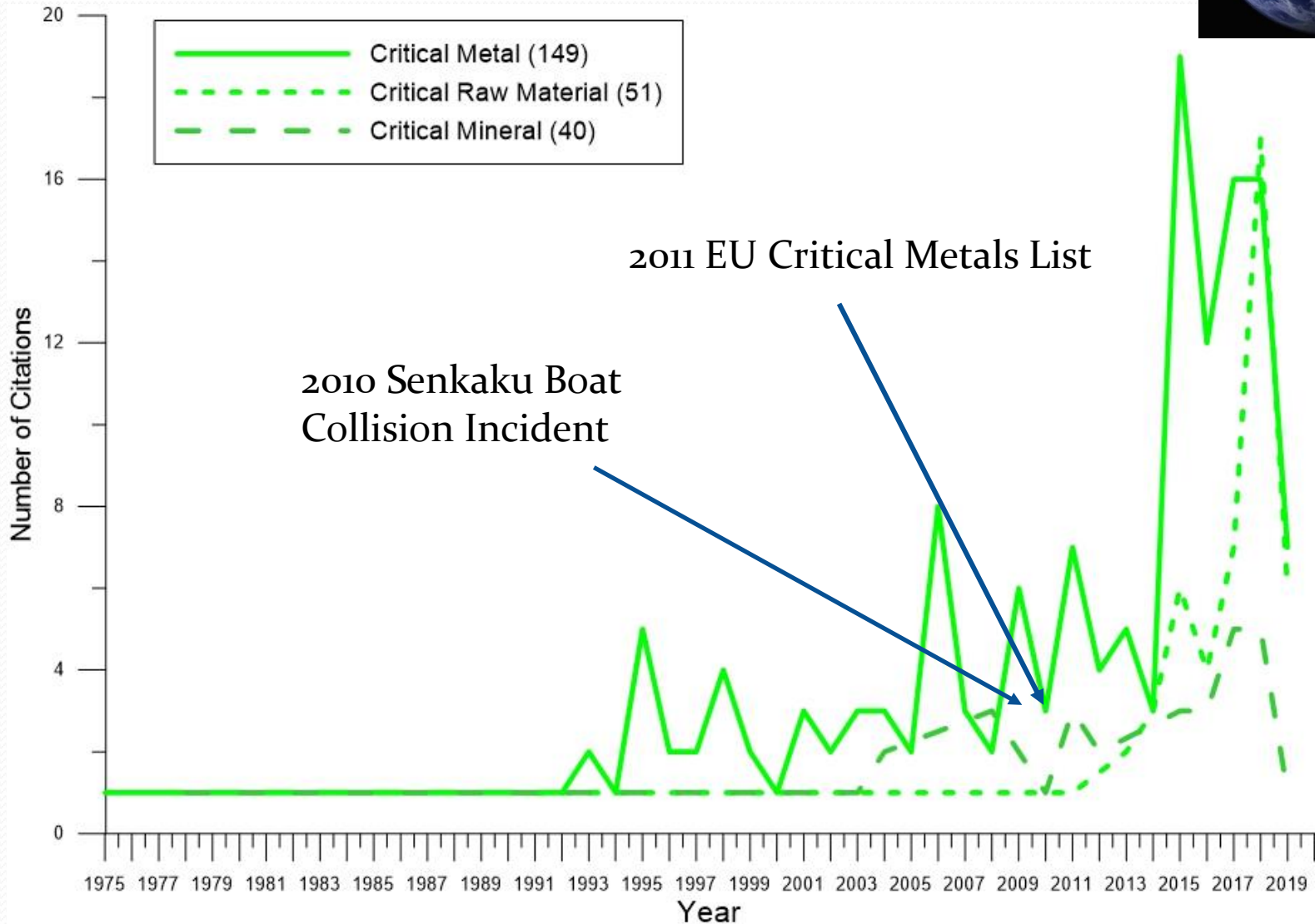


Hype cycle applied to commodities:

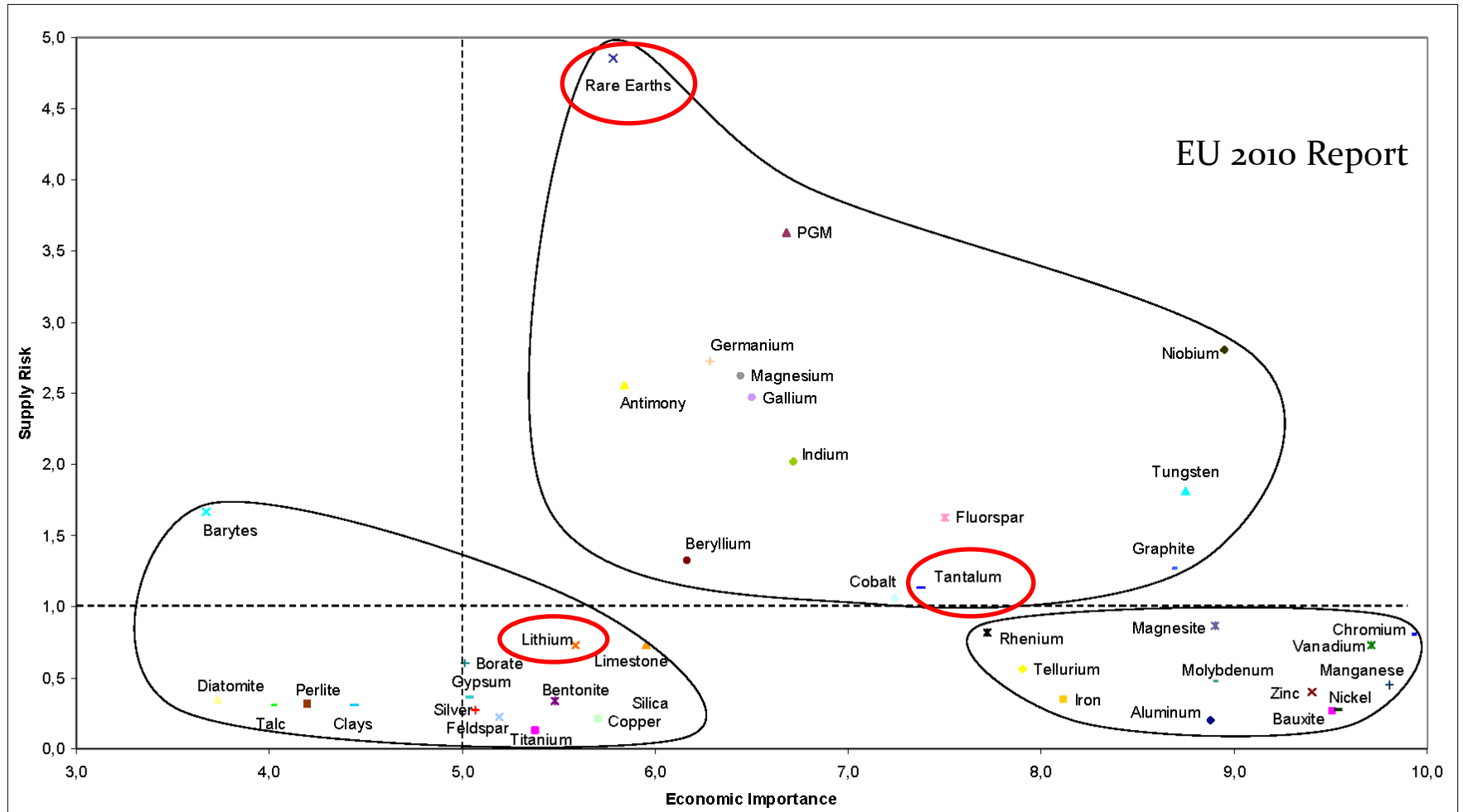
do commodity prices, share prices and citations reflect the same trends?



Looking at world production, world price and also citations in Web of Science. The results of your labours.



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)

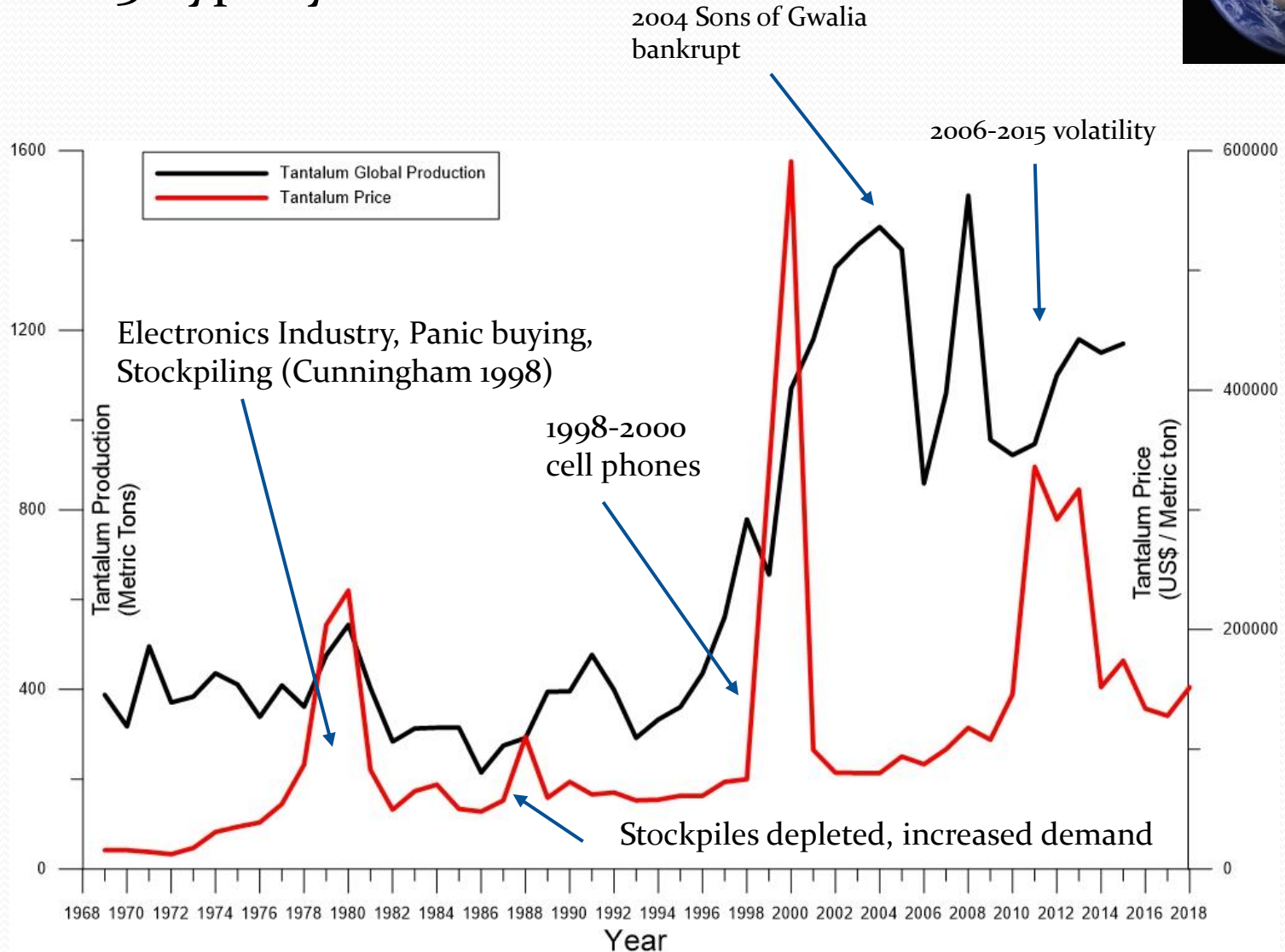


Greenbushes
(Australia)





3 hype cycles?

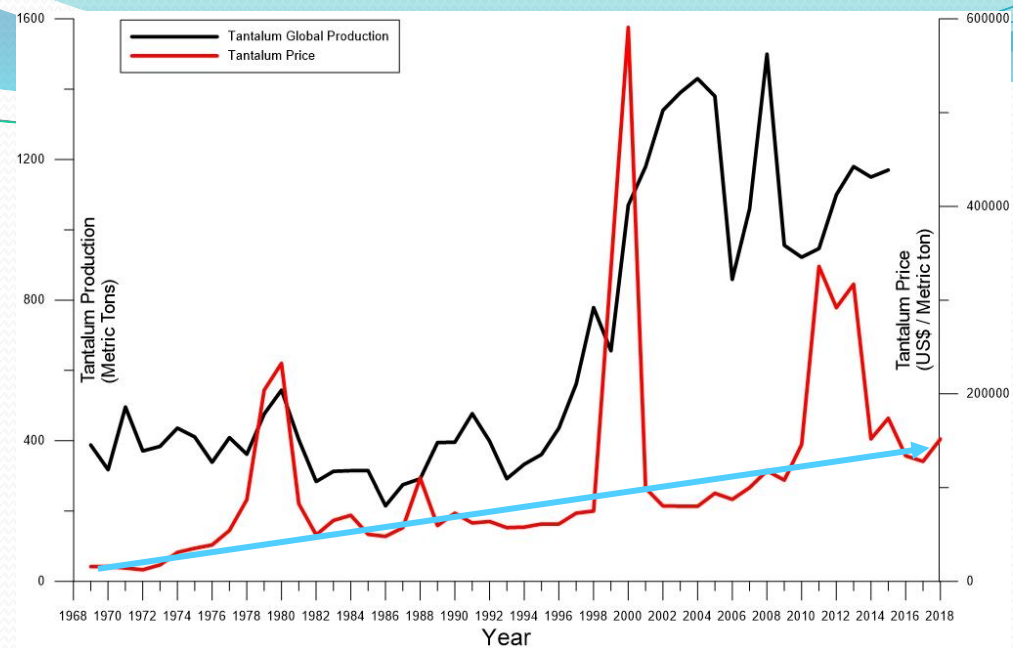


According to Roskill (2016) in the early 2000's "rapidly growing demand for tantalum was based on the wholly unfounded belief that a tantalum shortage was imminent."

Demand decreased, no shortage, prices tumbled -

Classic "Hype Cycle"

NB: Prices post-collapse gradually increased and were above pre-hype levels, production also increased, to reach - "The Plateau of Productivity"



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

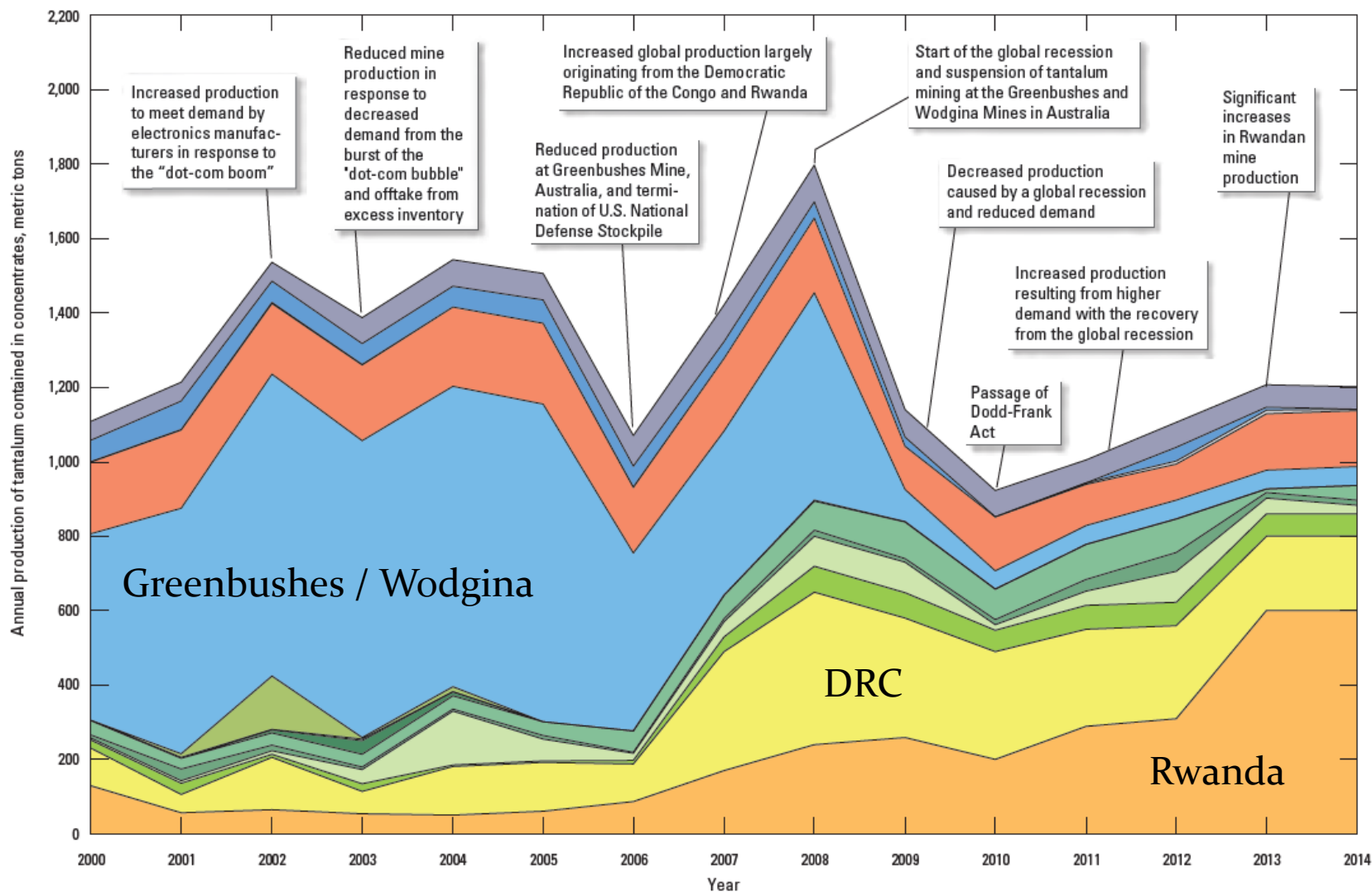
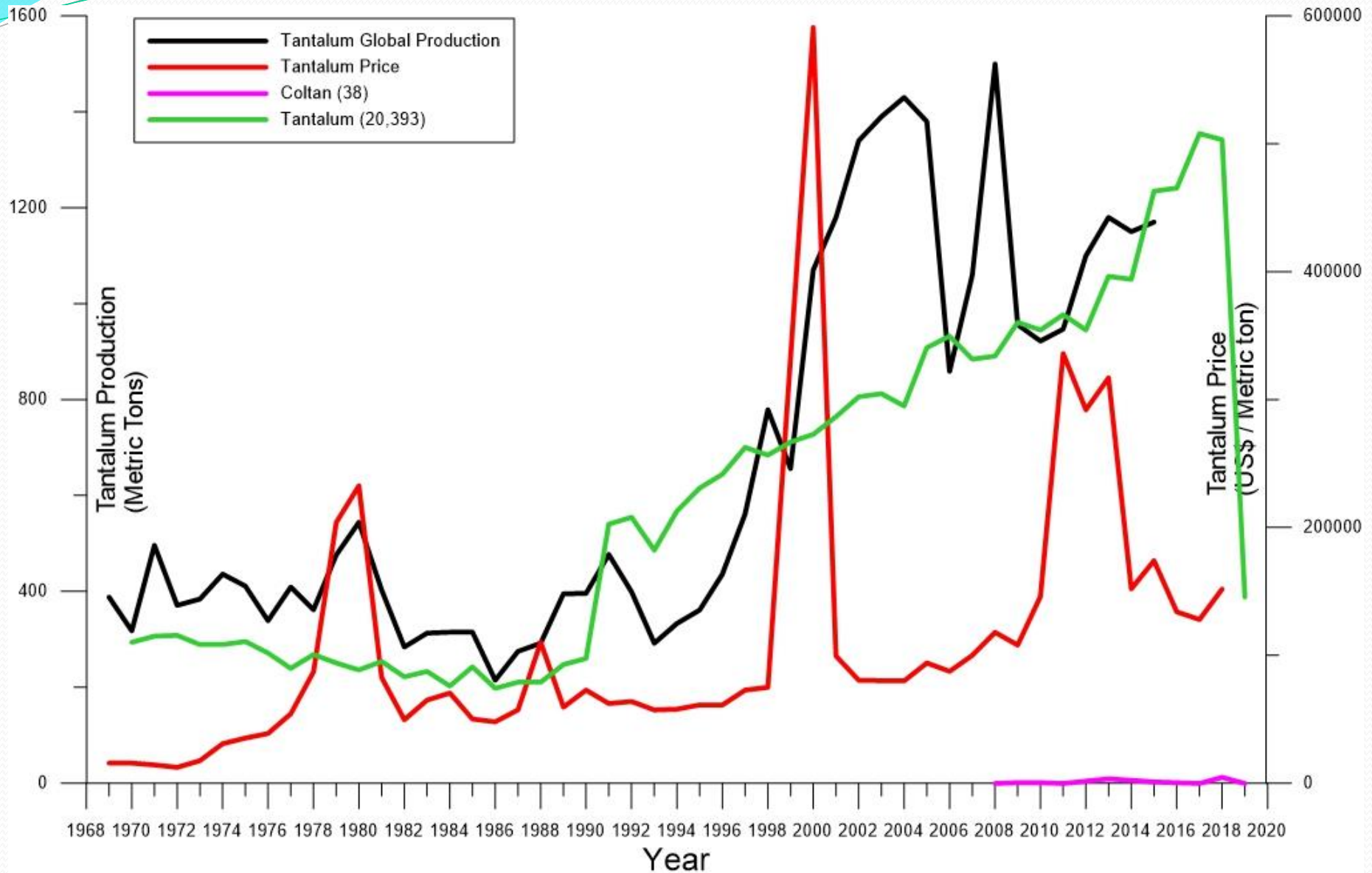


Figure 2. Annual mine production of tantalum contained in concentrates by country and events that affected mine production, 2000–2014.

EXPLANATION			
Country			
China	Australia	Namibia	Nigeria
Canada	Zimbabwe	Ethiopia	Democratic Republic of the Congo
Bolivia	Uganda	Burundi	Rwanda
Brazil	Somalia	Mozambique	

Combined with Web of Science Citations



REE

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



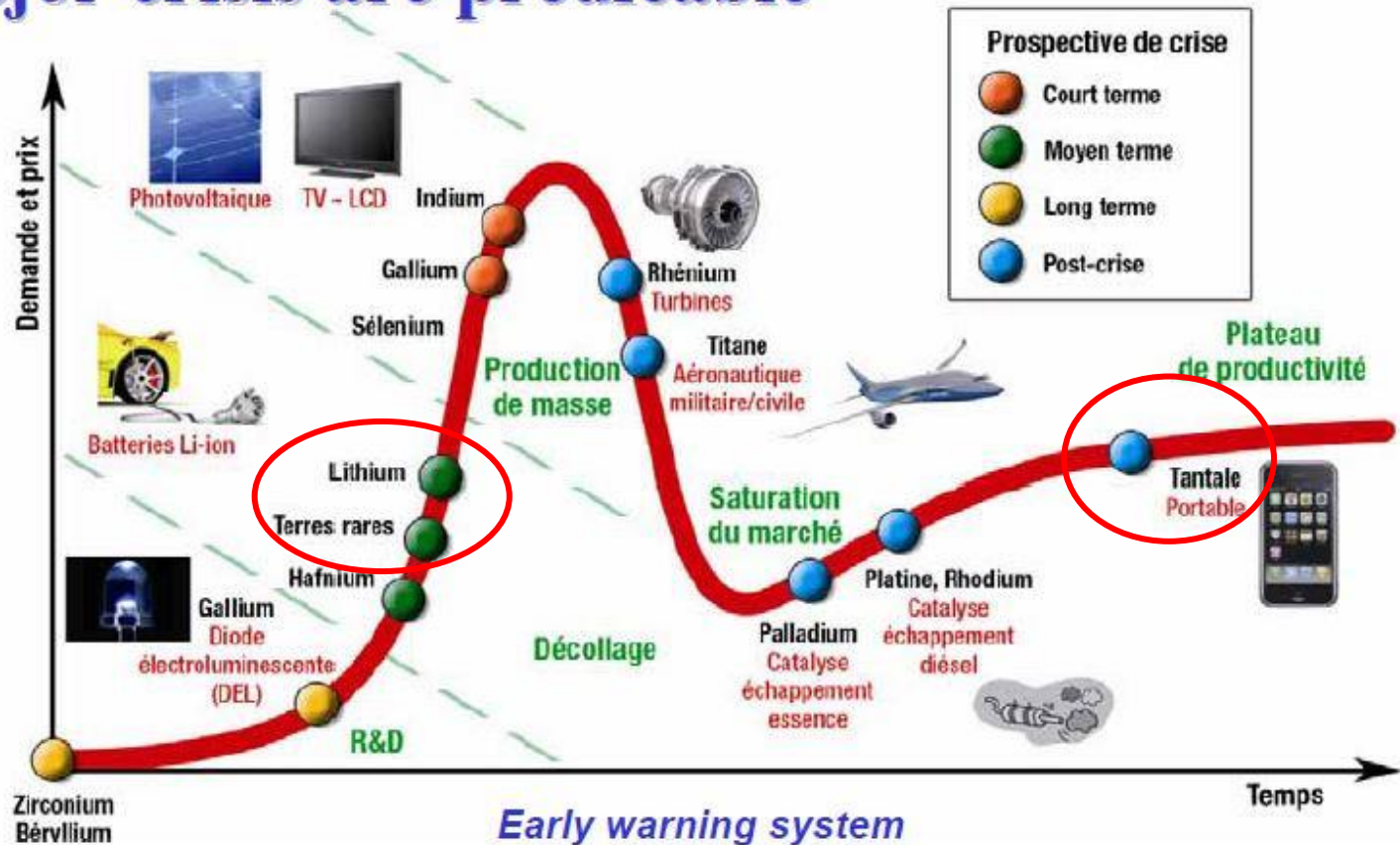
Glenover
(South Africa)



Nkombwa (Zambia)

Rare Metals : new products and price crisis

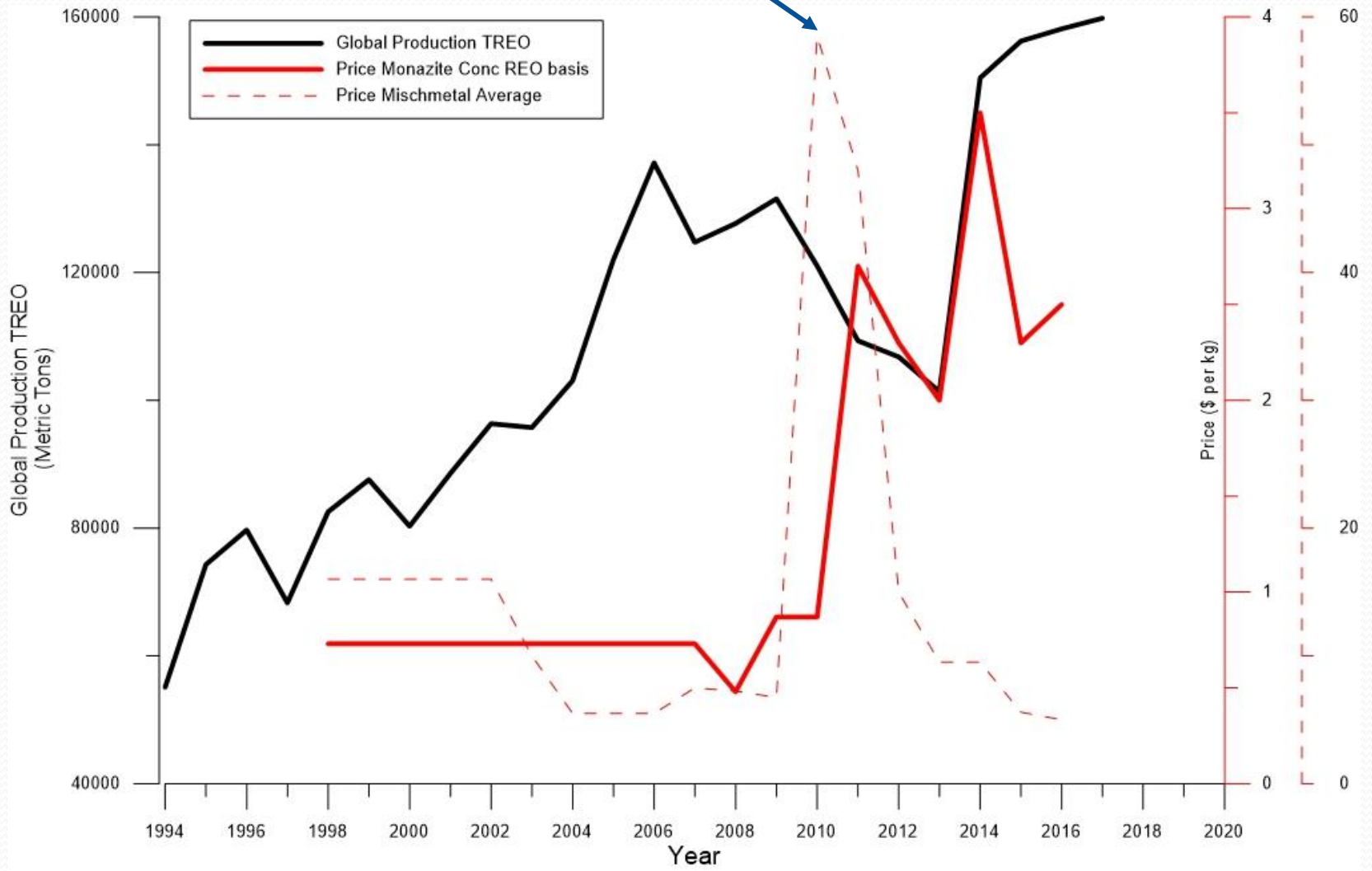
Major crisis are predicable



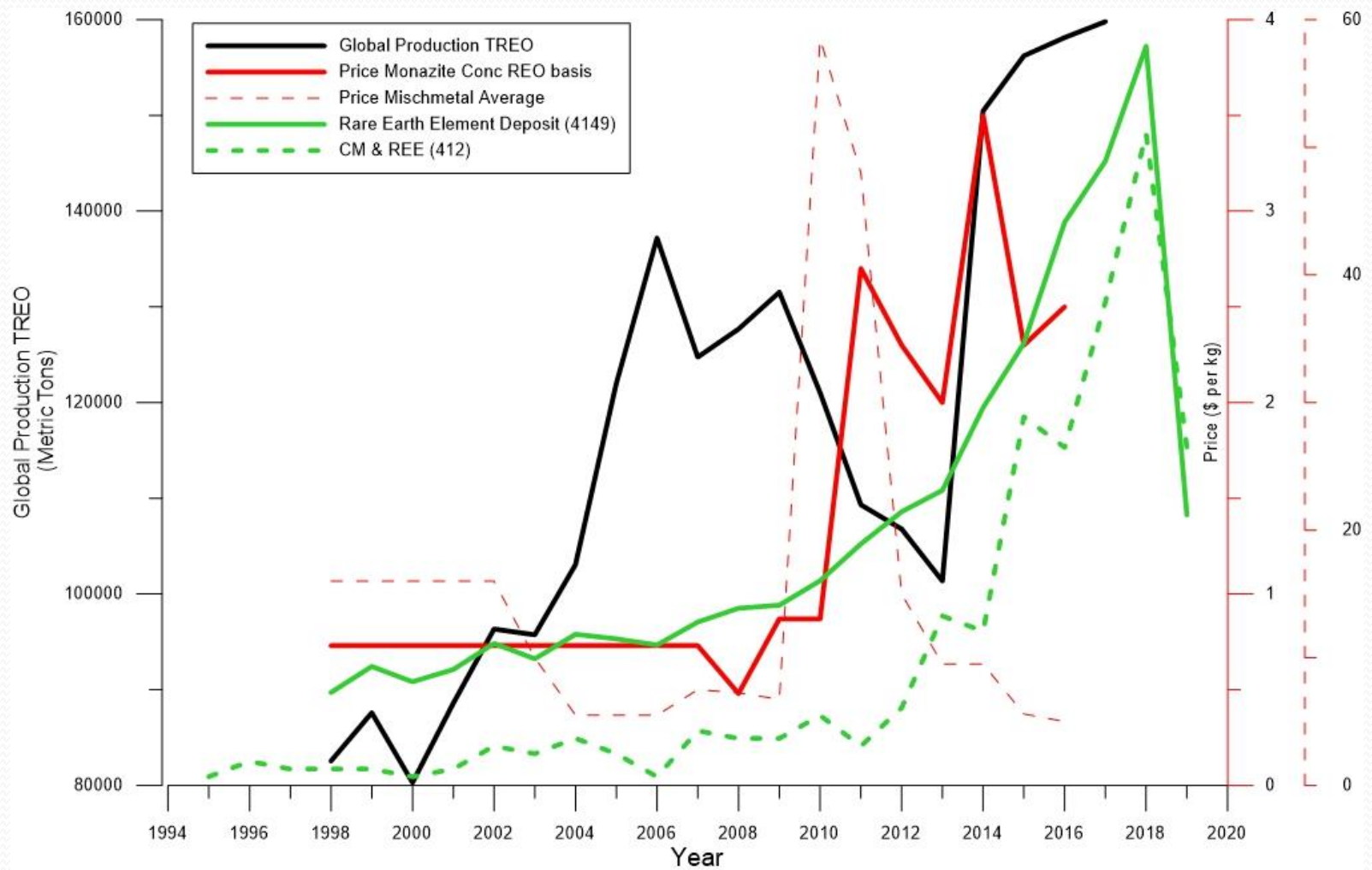
Relating the hype cycle and critical metals is not new!!

Hocquard **2010** BRGM Presentation at Ifri Round Table Brussels
(Institute Francais des Relations Internationales)

Peak REE Price (2011)



Production data from USGS and BGS, Price data from BGS



AFRICAN REE DEPOSITS WITH ESTABLISHED RESOURCES

(data from Technology Metals Research <http://www.techmetalsresearch.com/> 2016)

Deposit	Country	Source	Mt	%TREO	Contained REO (kt)	% HREO
Ngualla Hill	Tanzania	Carbonatite	195	2.26	4400	0.33
Zandkopsdrift	South Africa	Carbonatite	42.48	2.08-2.28	949	1.69
Tantalus	Madagascar	Ion-adsorbtion Clays	560.6	0.09	561	4.37
Songwe	Malawi	Carbonatite	31.8	1.38-1.62	469	1.67
Glenover	South Africa	Carbonatite	10.37	2.23	231	1.45
Kangankunde	Malawi	Carbonatite	2.53	4.24	107	0.19
Steenkampskraal	South Africa	Vein	0.665	14.0	93	1.79
Wigu Hill	Tanzania	Carbonatite	3.3	2.16	61	0.10
Xiluvo	Mozambique	Carbonatite	1.1	2.05	23	1.81
Lofdal	Namibia	Carbonatite	6.16	0.29	18	20.50
Mrima Hill	Kenya	Carbonatite	159.4	3.61-4.40	6	2.20

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

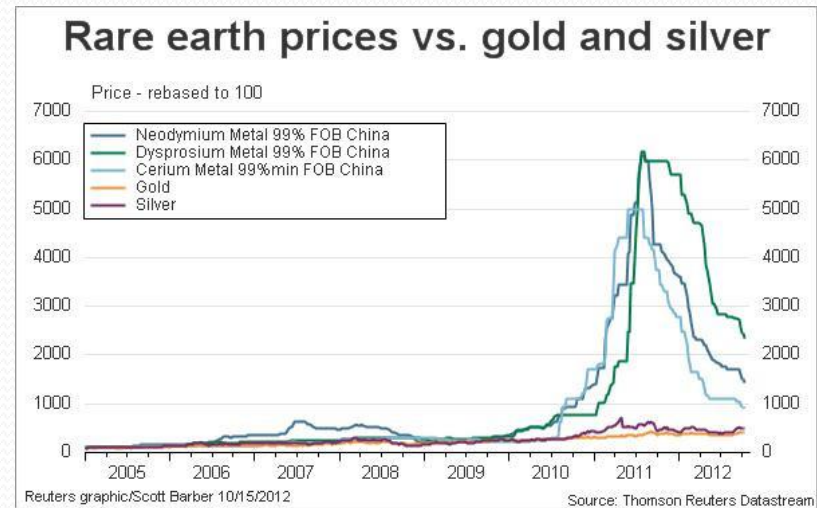
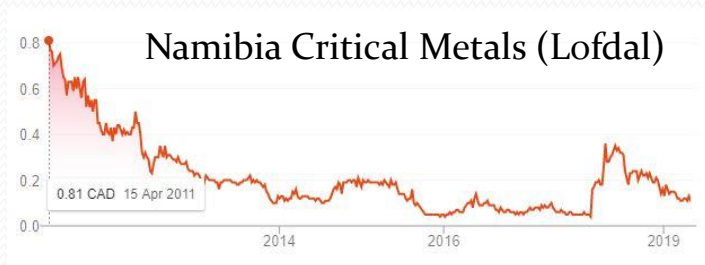
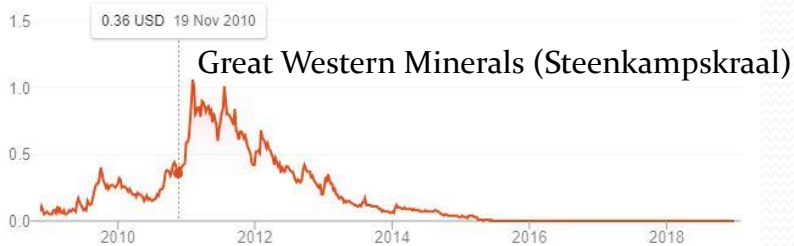
Greenland 36 Mt

Africa 10 Mt



Location No.	Location Name	Deposit Type	Location No.	Location Name	Deposit Type
1	Bayan Obo, China	Fe-REE-Nb deposit	11	Orissa, India	Monazite by-product, coastal placers
2	Weishan, China	Bastnasite-barite veins	12	Eneabba, Australia	Monazite by-product, coastal placers
3	Maoniuping, China	Bastnasite-barite veins	13	Capel and Yoganup, Australia	Monazite by-product, coastal placers
4	Xunwu and Longnan, China	Lateritic clay	14	Mount Weld, Australia	Lateritized carbonatite
5	Chavara, India	Monazite by-product, coastal placers	15	Dubbo, Australia	Altered alkaline complex
6	Perak, Malaysia	Xenotime by-product, tin placers	16	North Stradbroke Island, Australia	Monazite by-product, coastal placers
7	Mountain Pass, USA	Bastnasite-barite carbonatite	17	Elliot Lake, Canada	Uraniferous conglomerate
8	Lovozero, Russia	Loparite in peralkaline complex	18	Green Cove Springs, USA	Monazite by-product, placer
9	Aktyus, Kyrgyzstan	Polymetallic deposit	19	Camaratuba, Brazil	Monazite by-product, coastal placers
10	Northern Sri Lanka	Monazite by-product, coastal placers	20	Steenkampskraal, South Africa	Monazite-apatite vein

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

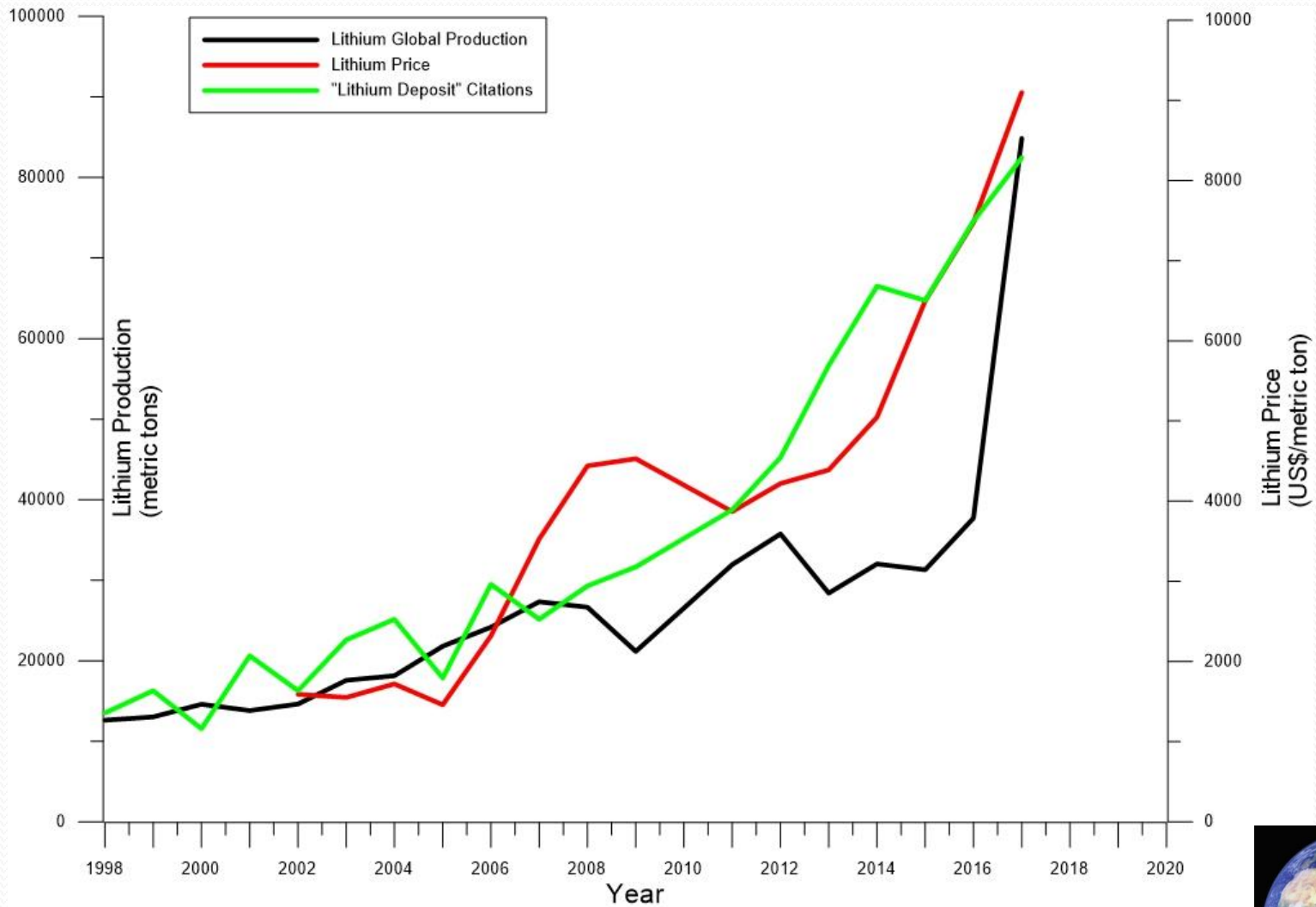


Bikita
(Zimbabwe)

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



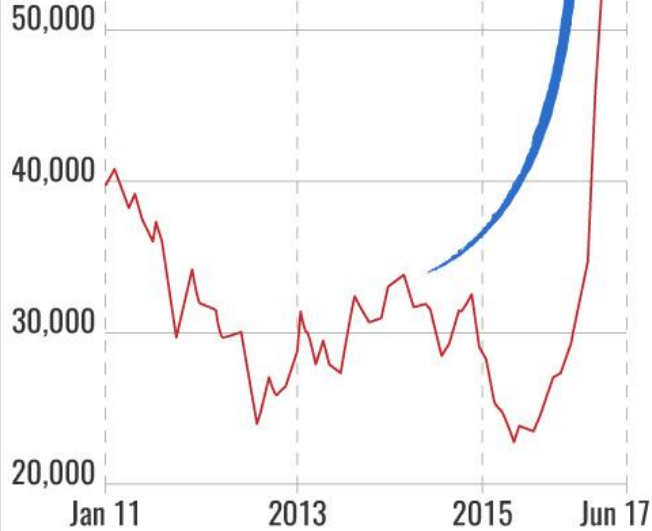
Rubicon & Helicon (Namibia)



Production data from BGS World Mineral Statistics (NB recalculated from mineral data to lithium where necessary). Price data from metalary.com

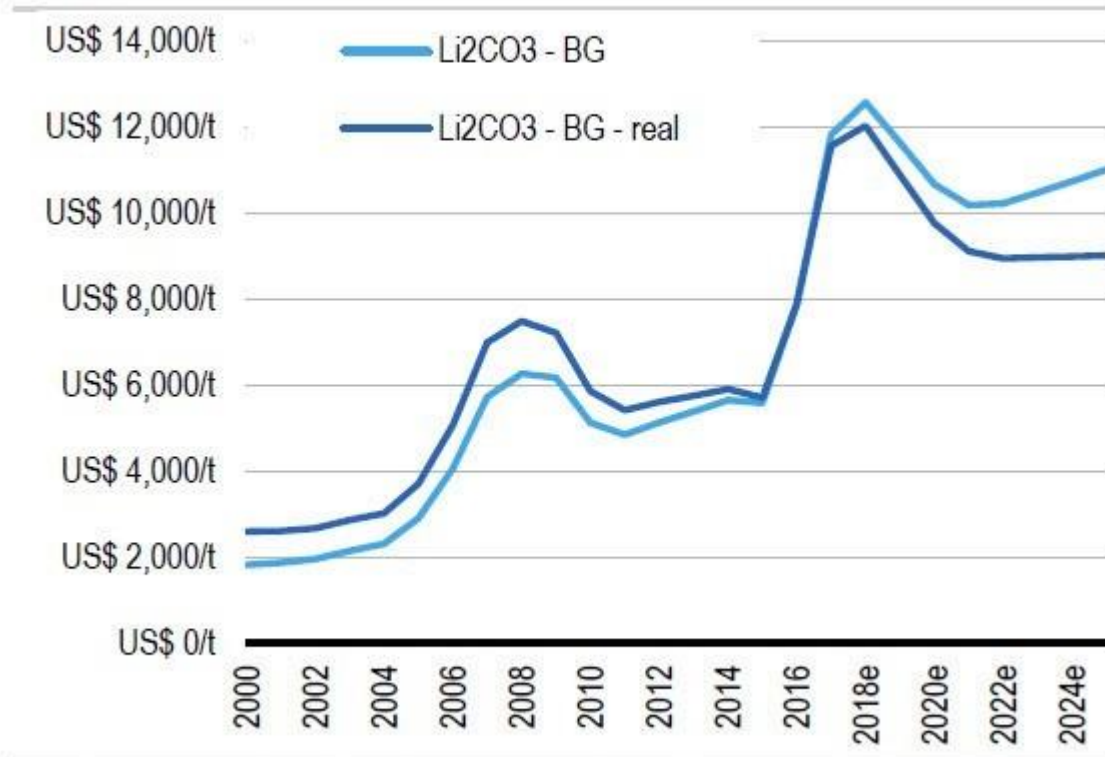


Lithium Prices are Soaring



DATA SOURCE: BENCHMARK MINERALS

Figure 84: Lithium carbonate – battery grade – prices



Source: Roskill, Benchmark Mineral Intelligence, UBS estimates

The Edelson Institute

The exploration expenditure figures are difficult to quantify but there was definitely a hard-rock lithium exploration boom in 2017-2018.



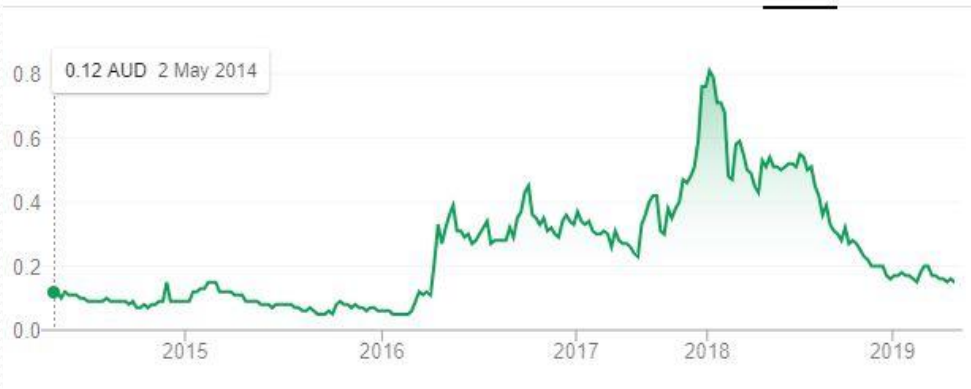
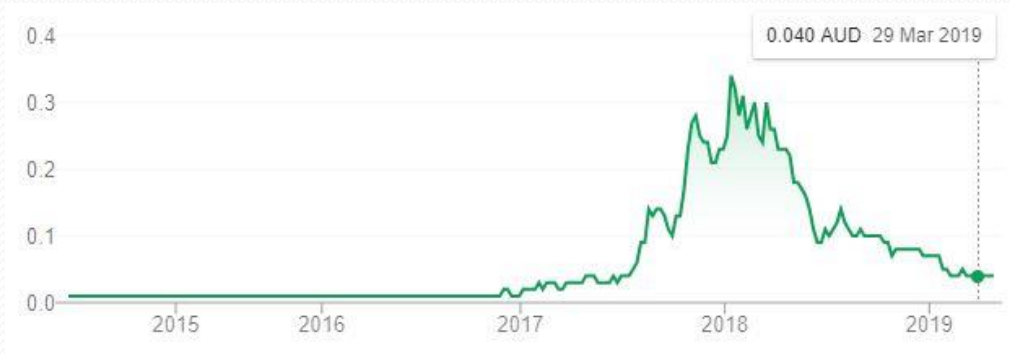
	Project	Company		Ore	Grade (Li ₂ O)	Contained LiO ₂
Zim	Bikita	Bikita Minerals	Kesler, 1978 Clarke, 2011	10.8 Mt 10.8 Mt	1.4% 0.58%	
Zim	Kamativi	CAT Strategic Metals	2018 (NI43-101)	26.3 Mt	0.28%	0.073 Mt
Zim	Acadia	Prospect Resources	2017 (SAMREC)	40.5 Mt	1.44%	0.583 Mt
Zim	Zulu	Premier African Minerals	2017 (SAMREC)	20.1 Mt	1.06%	0.213 Mt
Namibia	Helicon & Rubicon	Desert Lion Energy	Historical	1.1 Mt	1.4%	
DRC	Manono-Kitolo		Historical	7.86 Mt	0.76%	
DRC	Manono-Kitolo		Historical	35 Mt	0.6%	
DRC	Manono Project	AVZ Minerals	2018 (JORC)	259.9 Mt	1.63%	4.236 Mt
Ghana	Egyasimanku Hill	IronRidge Resources	Historical	1.48 Mt	1.66%	
Mali	Goulamina	Birimian	2017 (JORC) 2018 (JORC)	32.9 Mt 103 Mt	1.37% 1.34%	1.380 Mt
		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)

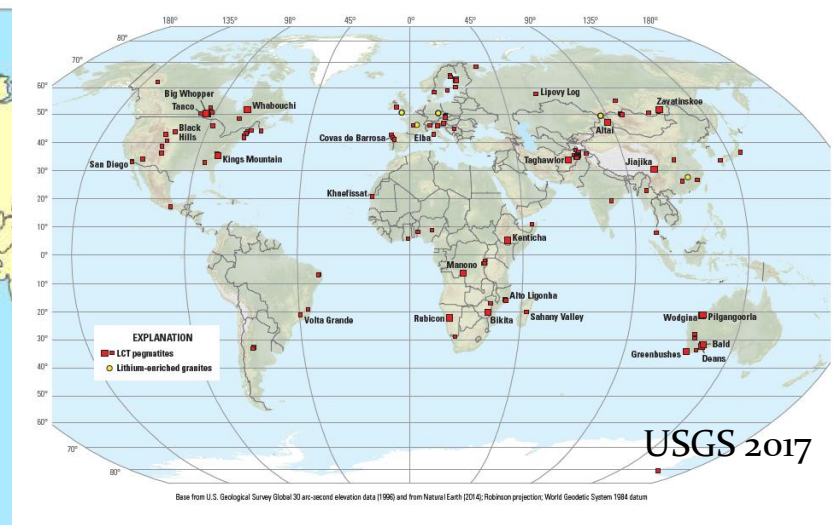
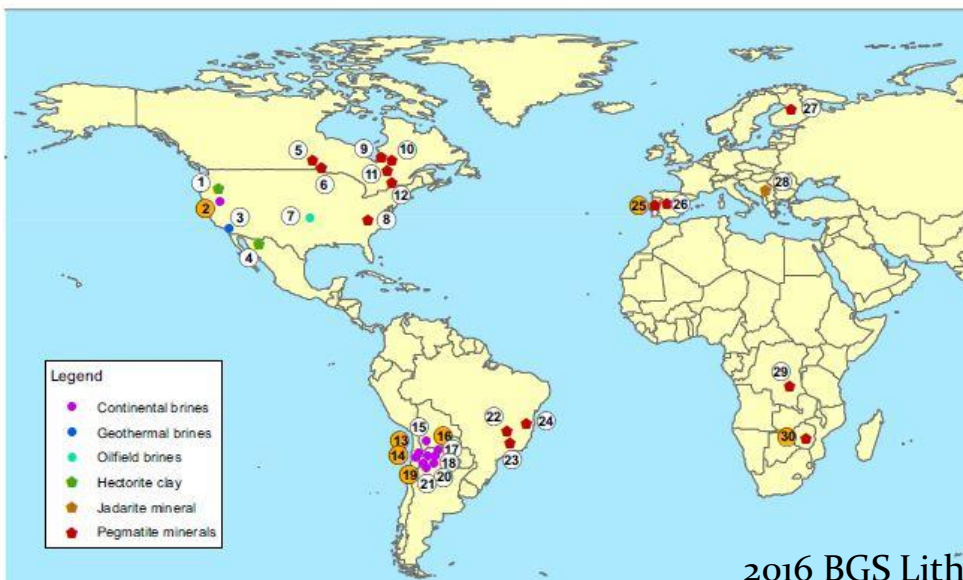


Birimian
(Goulamina)

Prospect Resources
(Arcadia)



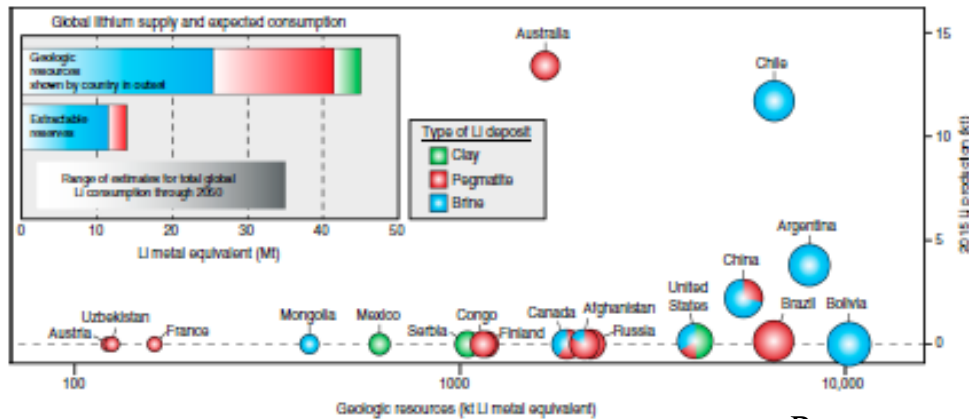
One major effect of the hype cycle is a stimulus to exploration and an increase in the resource base – this is a **GOOD** thing



2016 BGS Lithium Profile

Key to Numbers

(1) Kings Valley, USA	(8) Kings Mountain, USA	(15) Salar de Uyuni, Bolivia	(22) Mibra, Brazil	(29) Manono, D. Rep. of Congo	(36) Sichuan Aba, China
(2) Silver Peak, USA	(9) James Bay, Canada	(16) Salar de Claroz, Argentina	(23) Volta Grande, Brazil	(30) Bikita, Zimbabwe	(37) Jiajika, China
(3) Salton Sea, USA	(10) Rose, Canada	(17) Salar de Cauchari, Argentina	(24) Jequitinhonha, Brazil	(31) Zhabuye Salt Lake, China	(38) Maerkang, China
(4) Sonora, Mexico	(11) Whabouchi, Canada	(18) Salar de Rincon, Argentina	(25) Guarda, Portugal	(32) Dangxiongcuo, China	(39) Ningdu, China
(5) Tanco, Canada	(12) Val d'Or, Canada	(19) Salar de Hombre Muerto, Argentina	(26) La Fregeneda, Spain	(33) West Taiji Nai'er, China	(40) Greenbushes, Australia
(6) Separation Rapids, Canada	(13) Salar de Atacama	(20) Sal de Los Angeles, Argentina	(27) Lantta (and 3 others), Finland	(34) East Taiji Nai'er, China	(41) Mount Caflin, Australia
(7) Magnolia, USA	(14) Salar de Atacama	(21) Sal de Vida, Argentina	(28) Jadar, Serbia	(35) Qinghai Salt Lake, China	(42) Mount Marion, Australia



Benson, 2017

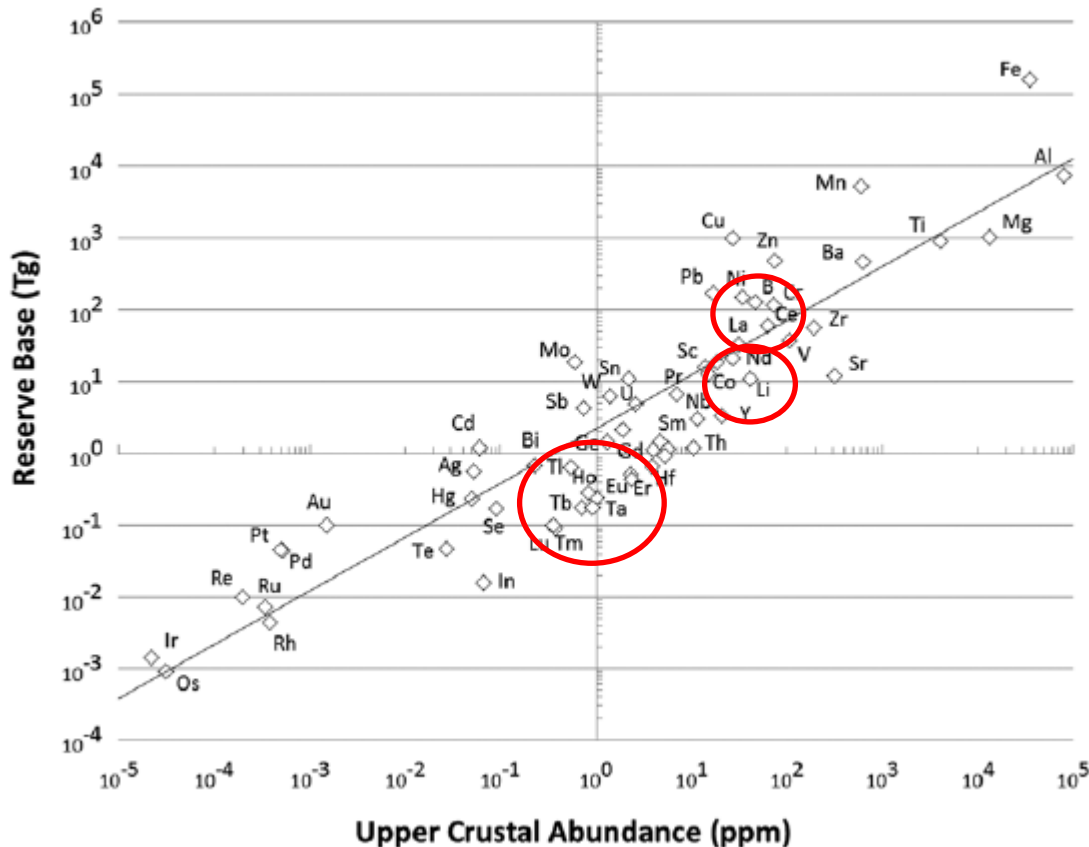
Africa is under-represented and where is Bikita?



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)

Disruptive Technology

The 4th Industrial Revolution



Buzzwords or Reality – who is going to gamble?

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.

<https://www.theverge.com/2019/2/22/18235941/daimler-bmw-mobility-joint-venture-billion-dollars> 22nd February 2019

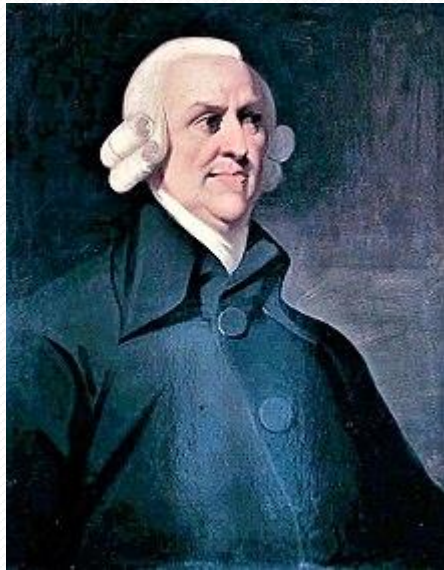
Is it a co-incidence that the potential lack of REE caused tremors in the car industry – perhaps they don't want to be caught in an uncertain future again.

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”

