WMF CRITICALITY ASSESSMENT

by BRGM, CRU & McKINSEY

World Materials Forum

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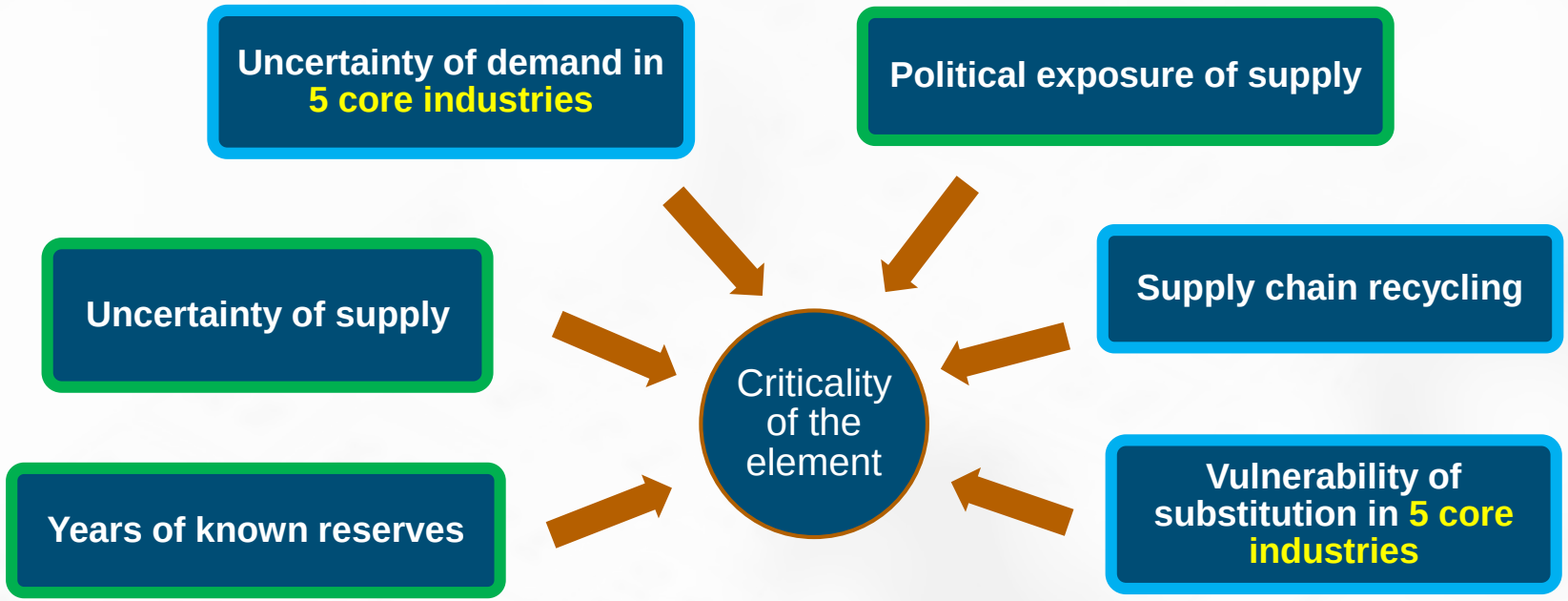
Key objectives:

- Getting the big picture on critical materials year after year
- Providing a simple and replicable decision making tool for industrial companies (both public and private)
- Defining a straightforward methodology with only 6 components both quantitative and qualitative

WMF Criticality assessment methodology: 6 components

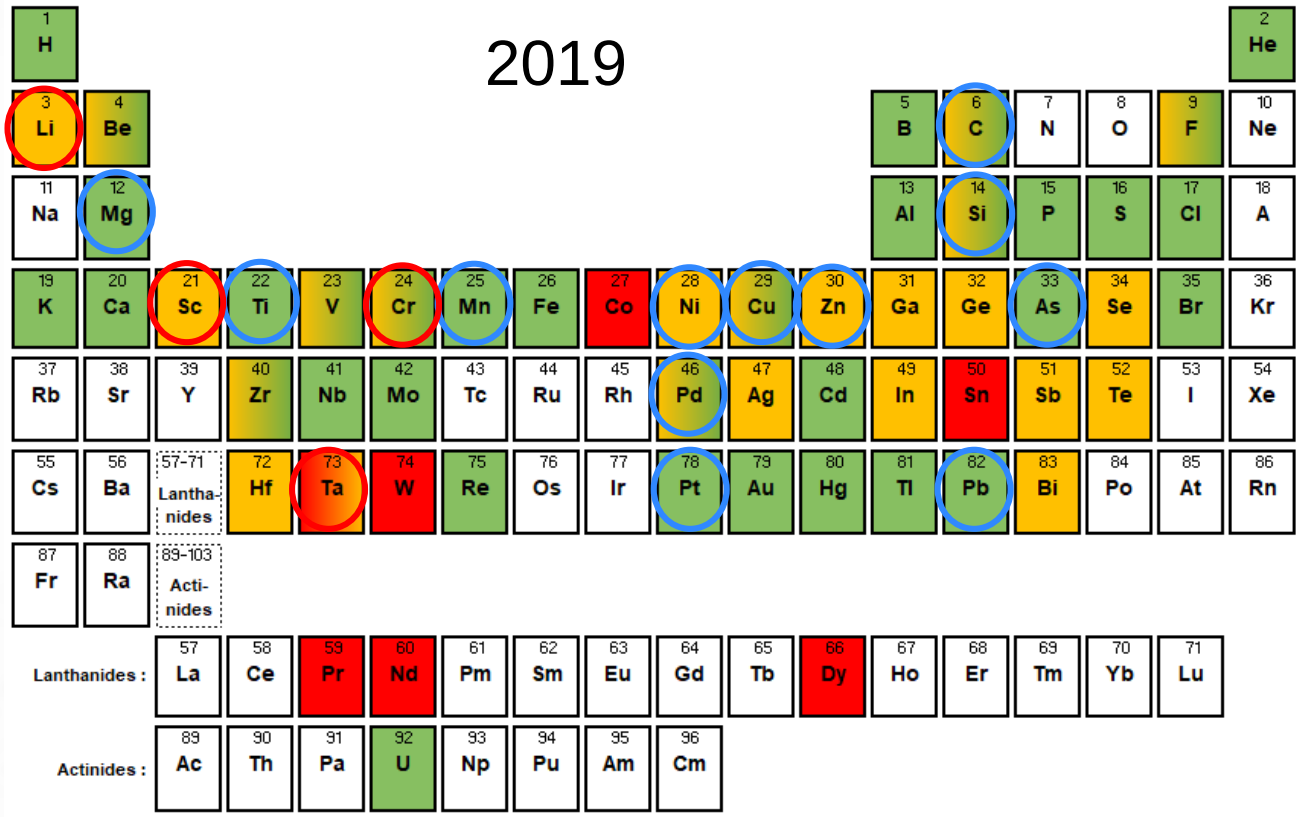


Criteria based on quantitative assessment methodology

Criteria based on qualitative assessment methodology

5 core industries at stake : energy generation, automotive body & power trains, aerospace, microelectronics for defense applications, permanent magnets for defense applications

WMF Criticality assessment by BRGM, CRU & McKinsey



Less critical in 2019: 12 elements

More critical in 2019: 4 elements

- Very high degree of risks
- High probability of risk occurrence
- Risk occurrence to be closely followed
- Low probability of risk occurrence
- Low degree of risks

Note: Elements in white have not been assessed

Key observations from the 2019 WMF criticality assessment

- **Overall improvement : 12 elements with lower criticality scores**
  - New capacities in countries with low geopolitical risk
  - New technologies allowing for using less critical materials – or substitution
  - Better geopolitical assessment (Fraser Index improvement)

- **6 raw materials remain "red" even though some improvement**

	Score 2018	Score 2019
Neodymium	14	14
Praseodymium	14	14
Dysprosium	14	13
Tungsten	13	13
Cobalt	14	13
Tin	13	12

- **4 elements with higher criticality scores but relatively low risk profiles**

	Score 2018	Score 2019	Comment for change	Overall criticality perception
Tantalum	10	11	Higher geopolitical risk	Probability of risk occurrence
Lithium	8	10	Higher uncertainty of demand	Risk occurrence to be followed
Scandium	9	10	Higher geopolitical risk	Risk occurrence to be followed
Chromium	8	9	Higher risk on known reserves	Low probability of risk

Geopolitical risk in the 2019 WMF criticality assessment

- **Fraser Institute 2018 PPI's scores were 10% higher on average compared to 2017**
  - **Huge impact on criticality perception. Illustration with key countries**

Country	2017 Score	2018 Score	% of change
China	37.46	49.39	24%
Indonesia	39.92	54.64	27%
South Africa	42.66	64.57	34%
Canada	85	88	3%
Chile	80.55	88.61	9%
Brazil	55.66	64.43	13%
DRC	35.03	34.18	-2%

  - **Despite some coherence regarding positive evolutions in the mining business environment (China, Indonesia) such index cannot account for every situation an investor will be faced with..**

Geopolitical risk in the 2019 WMF criticality assessment

- **Control Risk (www.controlrisks.com) assessment methodology ?**
  - **13 parameters, grades from 1= Very Low to 5 = Extreme (max=65)**

	DRC	Indonesia	Brazil	South Africa	Chile	Australia	Canada
Political	4	2	3	2	2	2	2
Regulatory	4	3	3	2	2	2	2
Contract	4	3	2	2	2	2	1
Integrity	5	4	3	3	2	1	2
Sovereign	4	2	2	3	2	1	1
Institutional	4	4	3	3	2	2	1
Permits	5	3	3	2	2	1	2
Labour	4	3	3	4	2	2	2
Crime	4	3	3	3	2	2	2
Terrorism	2	3	2	2	2	2	2
War	3	1	2	2	1	1	1
Civil unrest	4	3	3	3	2	2	2
Kidnap	3	1	3	3	2	2	2
TOTAL	50	35	35	34	25	22	22

Similar results overall despite a more detailed approach…

Geopolitical risk in the 2019 WMF criticality assessment

- **Keeping with Fraser Institute Policy Perception Index allows:**
  - **Accuracy and stability of the methodology**
  - **Good measure of managers and executives' perception on the attractiveness of mining countries' policies**

- **However, evident limits include:**
  - **Lack of flexibility for all complexities of the supply chains**
  - **Difficulties to capture *specific conjonctural risks* (trade wars reactions, environmental disasters, brutal changes of political regime.. etc.)**

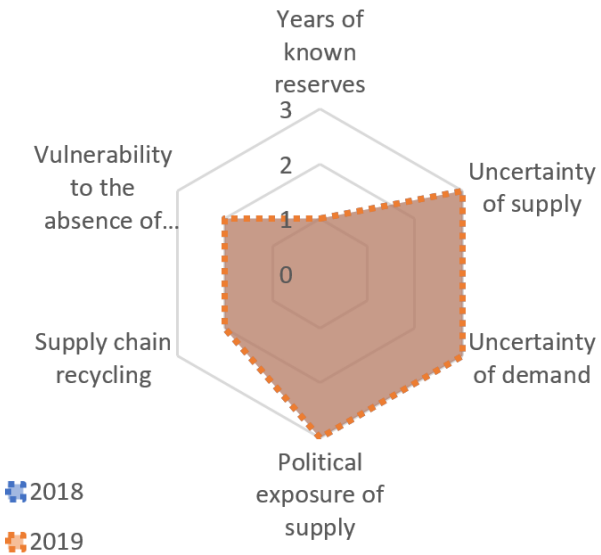
- **Conclusions:**
  - **Compound it further with other proxies (e.g. IHH index) ?**
  - **Area of research for WMF consortium for 2020**

Rare Earths on the spotlight: what has changed since 2018?

REE

Rare earths

Criticality Score



Years of known reserves

Currently more than 700 years of known reserves (120 Mt)

Uncertainty of supply

Supply deficit still higher than 50% by 2030 led by strong demand growth and limited additional supply: Chinese domestic production to be limited to 140 kt by 2020 (MIIT)

Uncertainty of demand

Key technologies & demand drivers expected to remain volatile in the short to medium term (e.g: EV motors)

Political exposure of supply

China still 1st producer (>80%) and now even 1st importer of REOs globally + Trade wars threats (Huawei story) !

Supply chain recycling

On-going progress (especially in Japan, US, China) although global recycling rate remains around 1 %

Vulnerability to the absence of substitution

In core industries (especially defence applications) substitutes remain of higher costs or lower performances

Measures with potential impact :

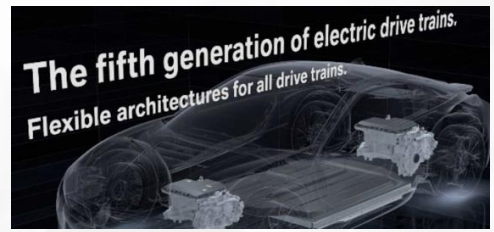
- **China's pressure on global supply : new "2011 crisis" seems unlikely**
- **Alternative sources of supply to move forward with higher risks and prices**
  (Malaysia: Lynas / US: Mountain Pass / Greenland: Kvanejveld / Russia: Tomtor / Australia…)
- **Vulnerability to the absence of substitution could lower further**
  - Further progresses in the reduction of the amount of REEs used to achieve the same performances in magnets

Fraunhofer IWKS

TOYOTA

SAMSUNG

- **Uncertainty of demand could lower with technological improvements**
  - BMW going away from REEs in 5th generation electric drives + high-temperature superconducting ceramic in wind turbines generators…



THANK YOU

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