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 and evolutive methodology with both quantitative and qualitative KPIs
- *This year, a* NEW KPI representing environmental footprint will be presented by CRU with the idea of getting WMF participants input and integrating it into 2021 assessment

WMF Criticality assessment by BRGM, CRU & McKinsey

- **WMF current methodology is based on 6 quantitative and qualitative KPIs:**
  - Each criteria rated from 1 to 3

1 **Years of known reserves**	Calculation based on reserves published by USGS and actual production in year N
2 **Uncertainty of supply**	Calculation as ratio of mine capacity of existing mines and likely new projects in N+10 over demand in N+10
3 **Uncertainty of demand**	Qualitative assessment of the predictability of main demand drivers in 5 core industries (regulations & technology changes)
4 **Political exposure of supply**	Calculation as weighted average of shares of top producing countries (>80% world supply) times Fraser Institute Policy Perception Index score
5 **Supply chain recycling**	Qualitative assessment of current recycling technologies and recycling routes
6 **Vulnerability to the absence of substitution**	Qualitative assessment of availability of alternative materials for key applications in 5 core industries

Quantitative assessment

Qualitative assessment

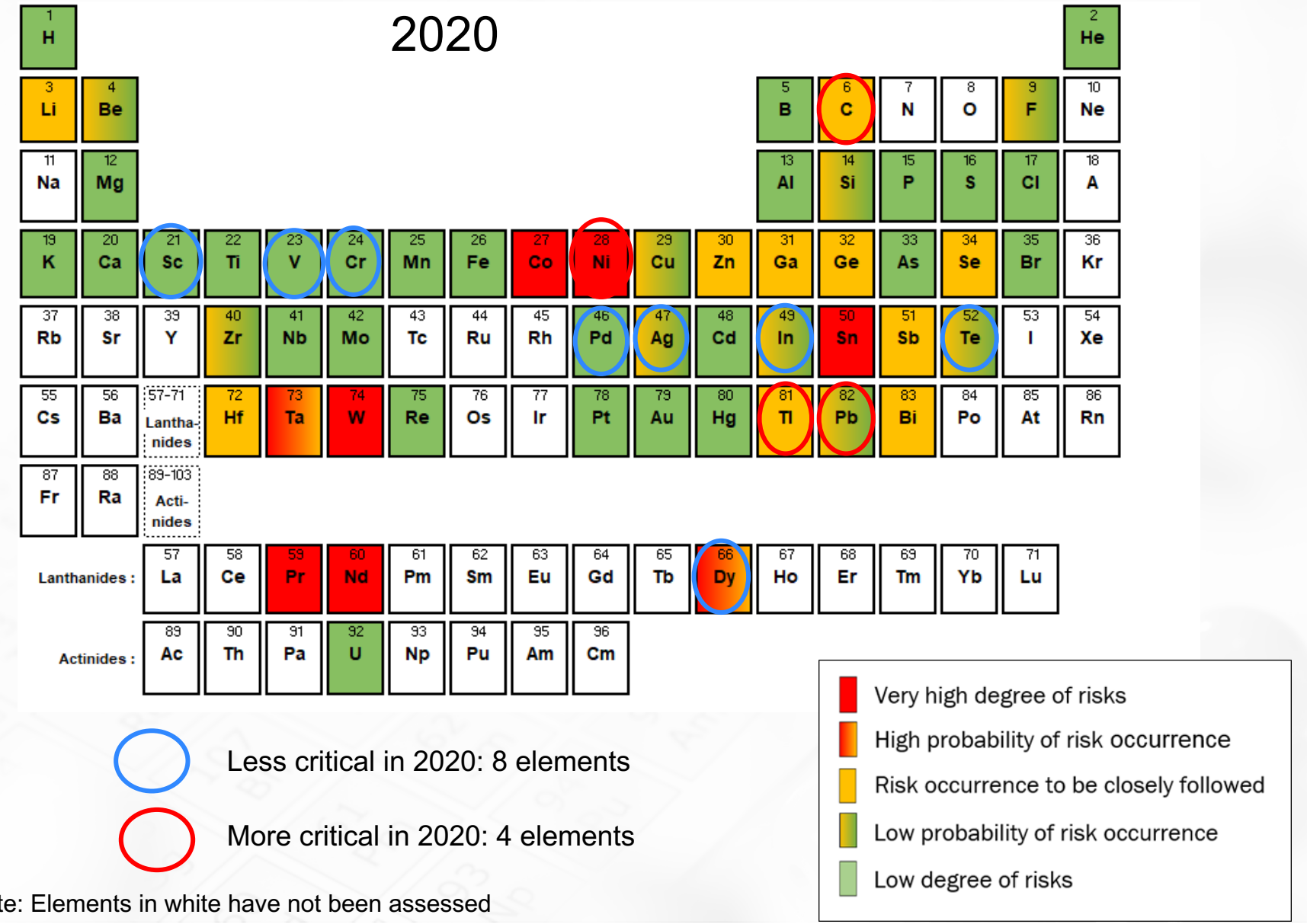
WMF Criticality assessment by BRGM, CRU & McKinsey

- **WMF current methodology is based on 6 quantitative and qualitative KPIs:**
  - Most critical elements are the ones with total score above 11
  - 2020 : Nickel becomes red, Dysprosium goes to red-orange

Sum of scores and color coding

	Tungsten	Cobalt	Nickel	Tin	Neodymium	Praseodymium
1.Years of know reserves	2	1	2	3	1	1
2.Uncertainty of supply	2	1	1	2	2	2
3.Uncertainty of demand	2	3	3	2	2	2
4.Political exposure of supply	3	3	2	2	3	3
5.Supply chain recycling	2	3	2	1	2	2
6.Vulnerability to substitution	3	2	2	2	2	2
2020 Criticality score	**14**	**13**	**12**	**12**	**12**	**12**

WMF Criticality assessment by BRGM, CRU & McKinsey



Note: Elements in white have not been assessed

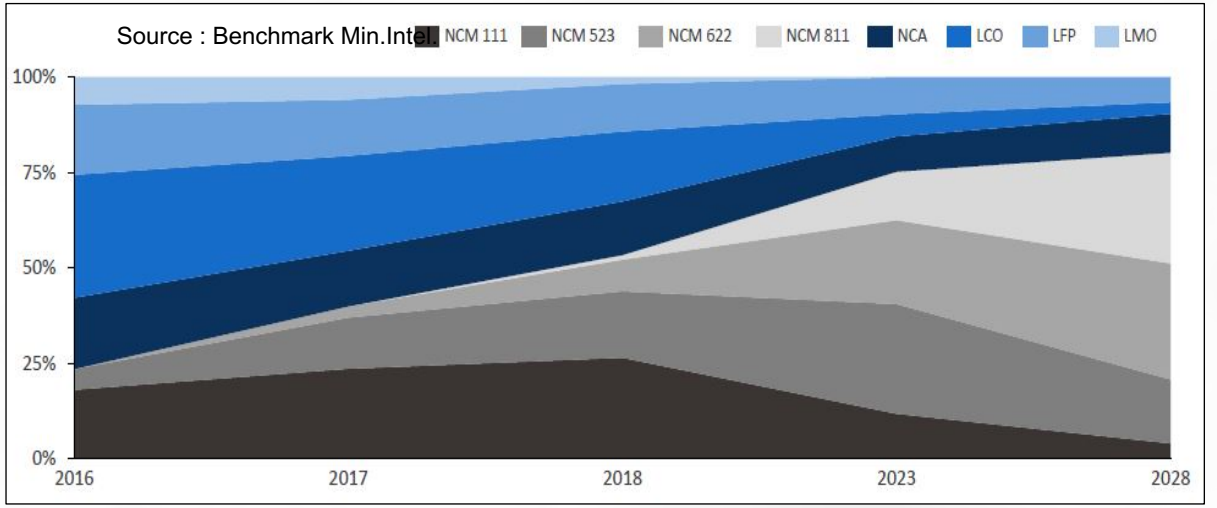
Key observations from the 2020 WMF criticality assessment

- **“Battery materials” remain on the spotlight : Nickel becomes red**
  - Constraints on availability in the next 5-10 years are still very high
  - Frazer index evolution (e.g. Indonesia becoming the new focus point for nickel)
- **Rare Earths and Tungsten: vulnerability of supply chains for core applications**
  - Steady but slow progress on substitution (e.g Dysprosium goes to red-orange)
  - Alternatives sources progressively emerging
- **Tin : deficit of exploration weighs on price volatility**
  - No fundamental changes in 2020

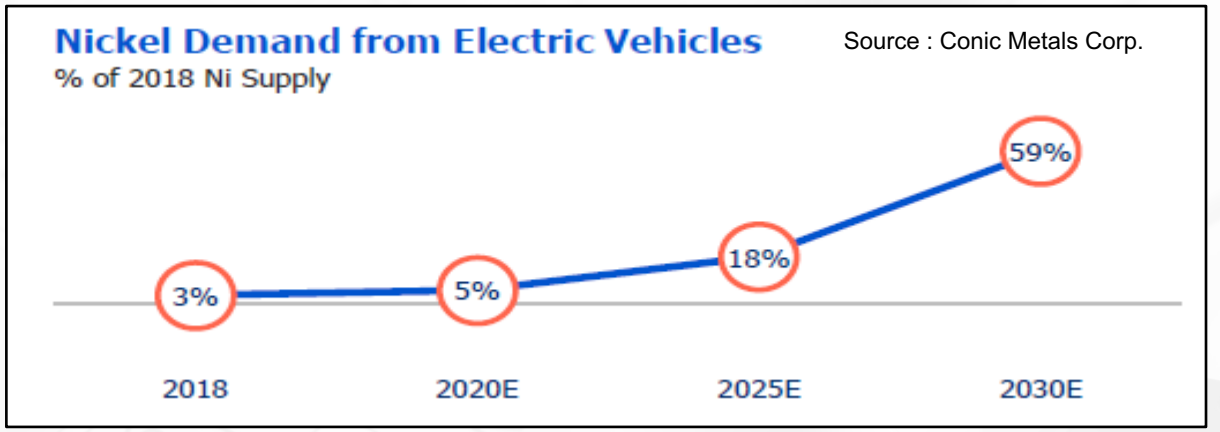
Nickel : increased pressure from Li-ion batteries

❑ Rise in demand for high-energy density Li-ion batteries

- High-nickel compositions (in grey) to account for >70% of battery manufacturing **in *2025***

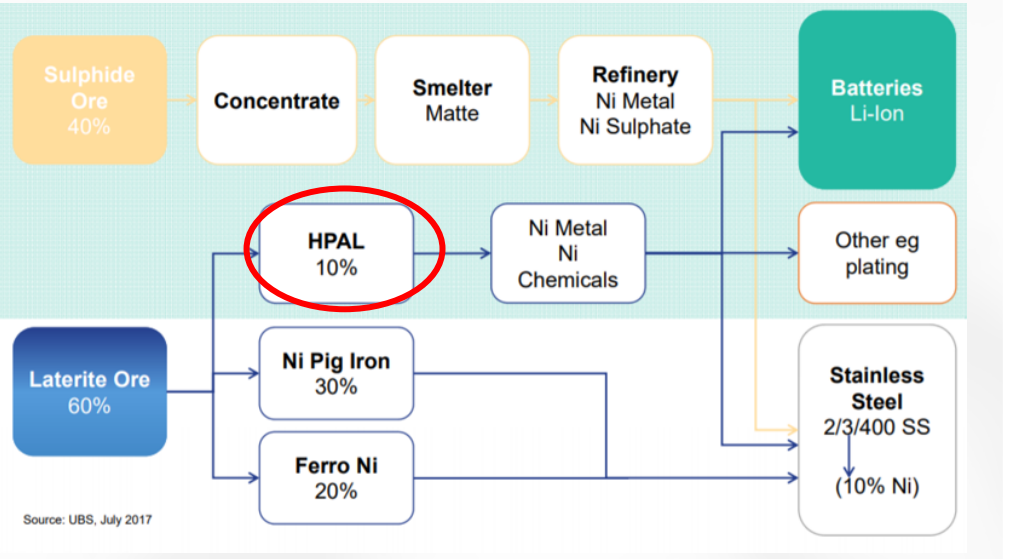


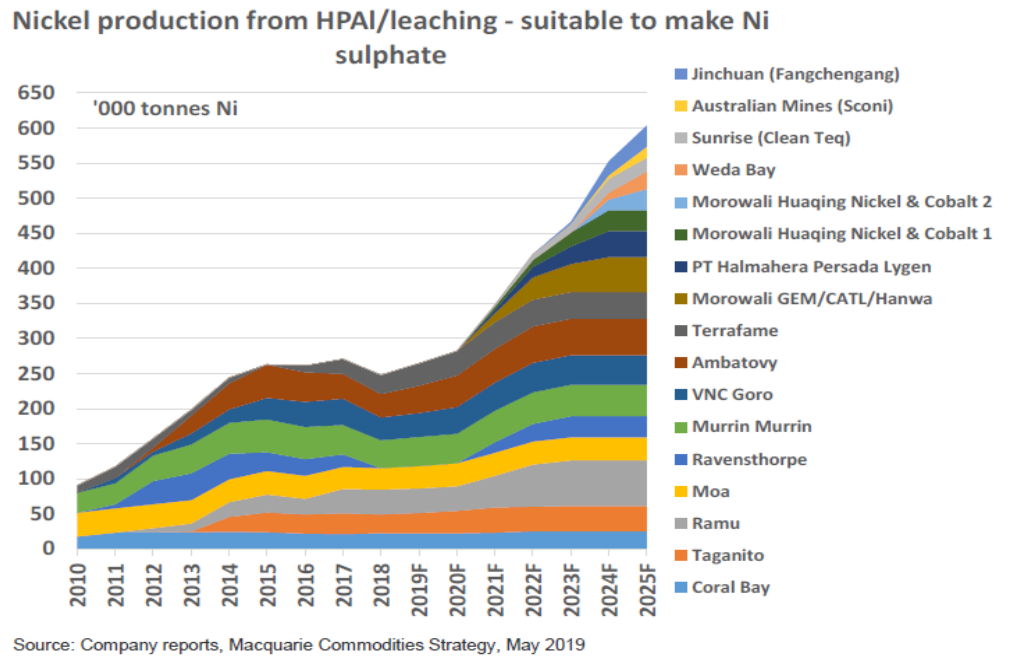
- Battery uses to gain increasing shares of total Ni demand



Nickel : increased pressure from Li-ion batteries

- **Growing competition to produce "class 1" nickel suitable to produce Ni sulphates for batteries**
  - Laterite Resources (178 Mt identified) vs. Sulphide Resources (118 Mt identified)*
  - High Pressure Acid Leaching (HPAL) is the preferred option with numerous challenges
  - Only 8 HPAL plants in the world today
- **600 kt capacity build up by 2025**
  - Integrated production (Jinchuan et SMM
  - Capacity conversion (BHP Nickel West)
  - New comers (CleanTeq, Sconi, Morowali)





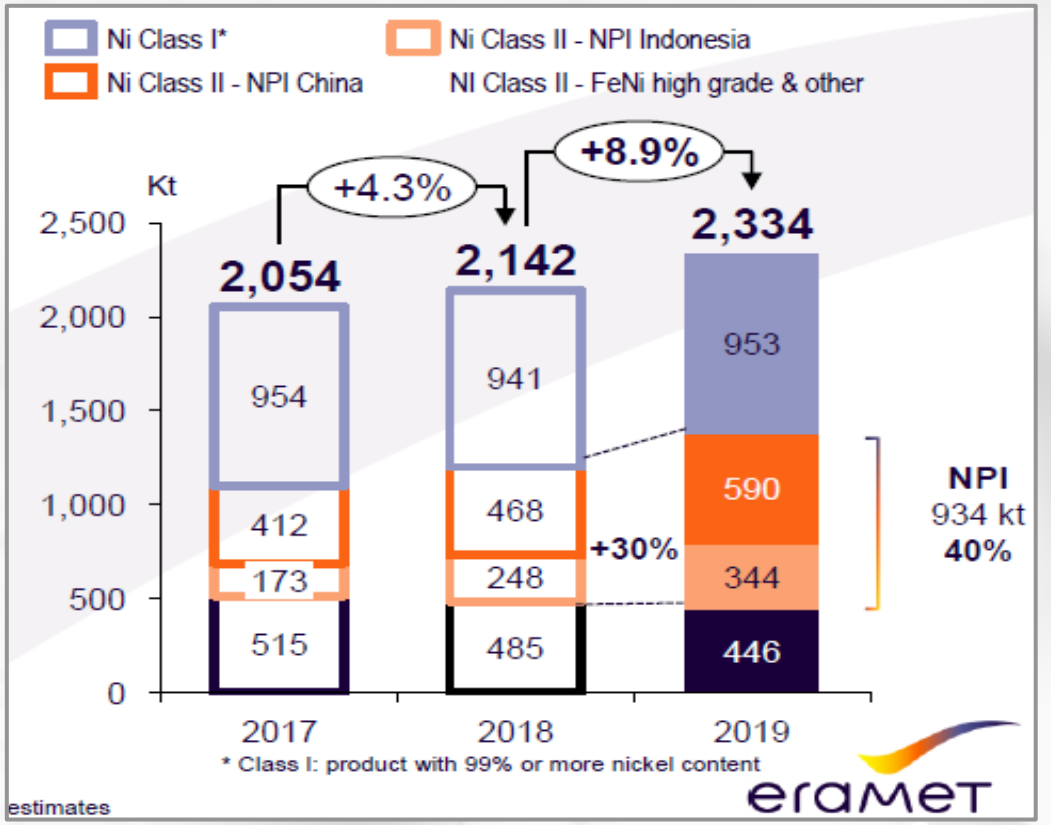
Source: Company reports, Macquarie Commodities Strategy, May 2019

Mudd et al., 2014

Nickel : increased pressure from Li-ion batteries

❑ Indonesia : the swing factor

- Chinese investments could lead to 100 kt Ni sulphate capacity in Indonesia by 2023
- Challenge to convert Nickel Pig Iron (NPI) as a new source for batteries : HPAL vs. leach plants
  - Tsingshan/GEM project



青山控股
TSINGSHAN HOLDING GROUP

Cobalt, nickel sulphate: Huayou Cobalt to build integrated battery supply chain in Indonesia and China

Published on June 5, 2020

❑ Ni to remain under tension until 2023!

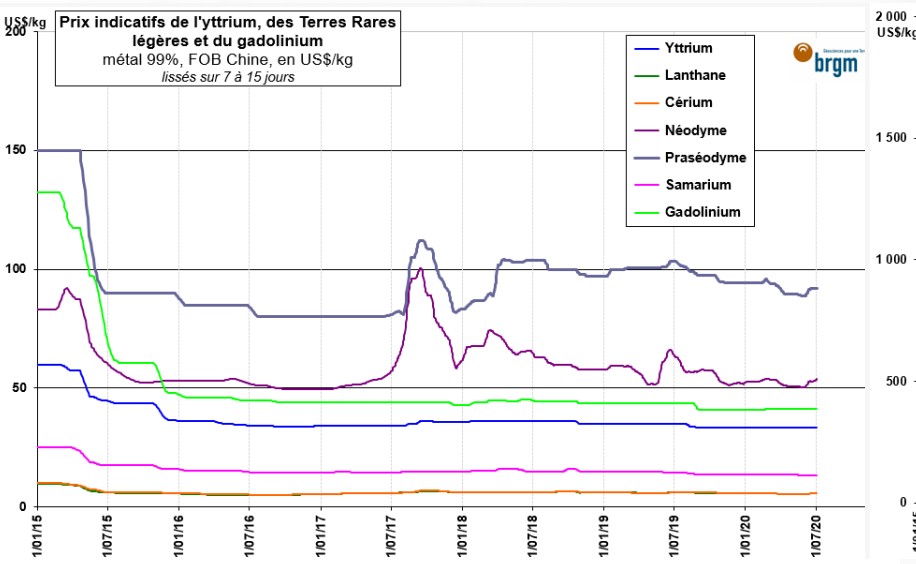
Rare Earths : business as usual ?

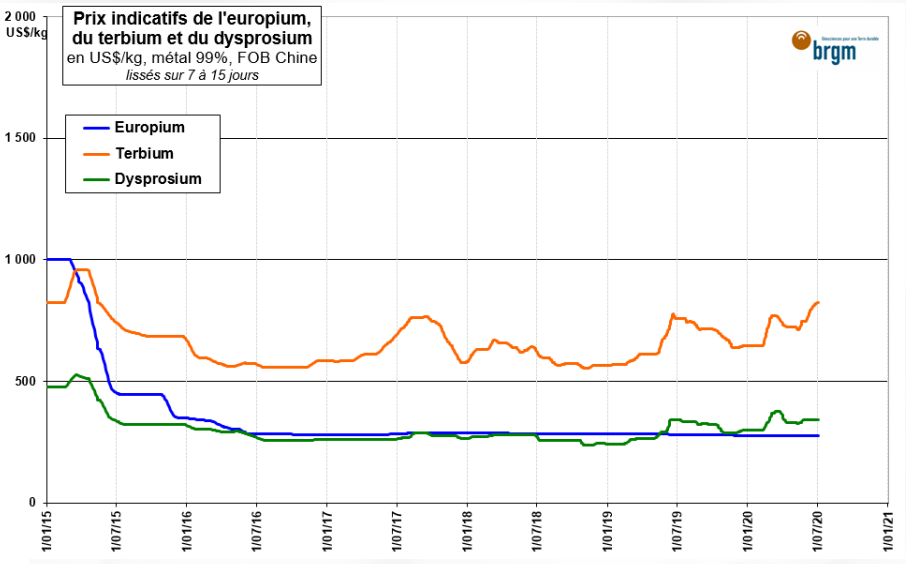
❑ Limited impact of the COVID crisis on price dynamics

- Most Chinese capacity not operating at full capacity before crisis (utilization rate <40%)
  ➡ minimal effect of the lockdown period
- Steady prices along 2020 (except Tb relative volatility)

❑ Chinese quotas expected to remain unchanged in 2020

- H1 refined quotas: **63,500 t REO** allocated between the 6 state-owned enterprises
- China expected to account for up to **87% of global refined production** in 2020 (roughly the same as in 2015)





Securing new supply of Rare Earths: the case of USA

- **Pentagon commitment to funding new rare earths facilities in the US**
  - In late 2019, Pentagon announced funding up to 40 M US$ to build REEs separation pilot plants
  - MP Materials and Lynas Blue selected for 2 plants in Texas and Colorado. Funding confirmed on 22nd July

- **MP Materials to be listed on the NYSE after agreeing to merge with Fortress Value Acquisition Corp.** : https://mpmaterials.com/news/

Securing new supply of Rare Earths

❑ The case of Australia

- **Several projects recognized of « National Interest ». Pilot plants expected in 2021:**
  - Browns Range- Northern Minerals
  - Nolan's Bore – Arafura
  - Lynas Corp. planning to expand in Australia. Resumed operations in Malaysia on May 4th.

❑ The case of Greenland and Russia : at the heart of conflicting geopolitical interests around their REEs potential

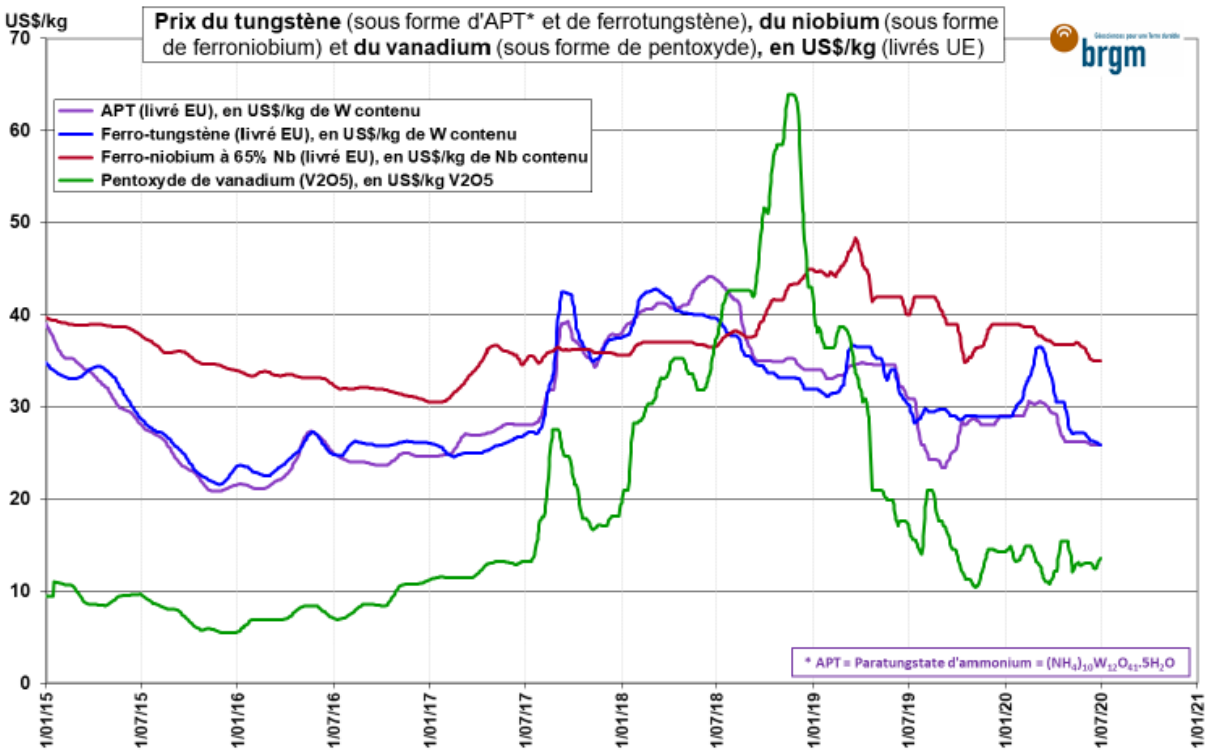
- **Kvajnevjeld project (Greenland):**
  - Shenghe/China Nat. Nuclear Corp. : 32 kt/y concentrates capacity
  - Trump offering to « purchase Greenland » in 2019
- **Tomtor project at the Russian / Chinese border:**
  - construction expected in 2021 with 20 kt REO/y capacity

➡ **A few more years to reduce criticality**

Tungsten - A vulnerable supply chain

❑ A vulnerable supply chain

- GDP-led market
- Chinese dominance maintained with quotas and pressure on the main suppliers
- Volatility in prices expected in the second half of 2020
- Global demand for tungsten expected to contract by 10-20% y-o-y in 2020



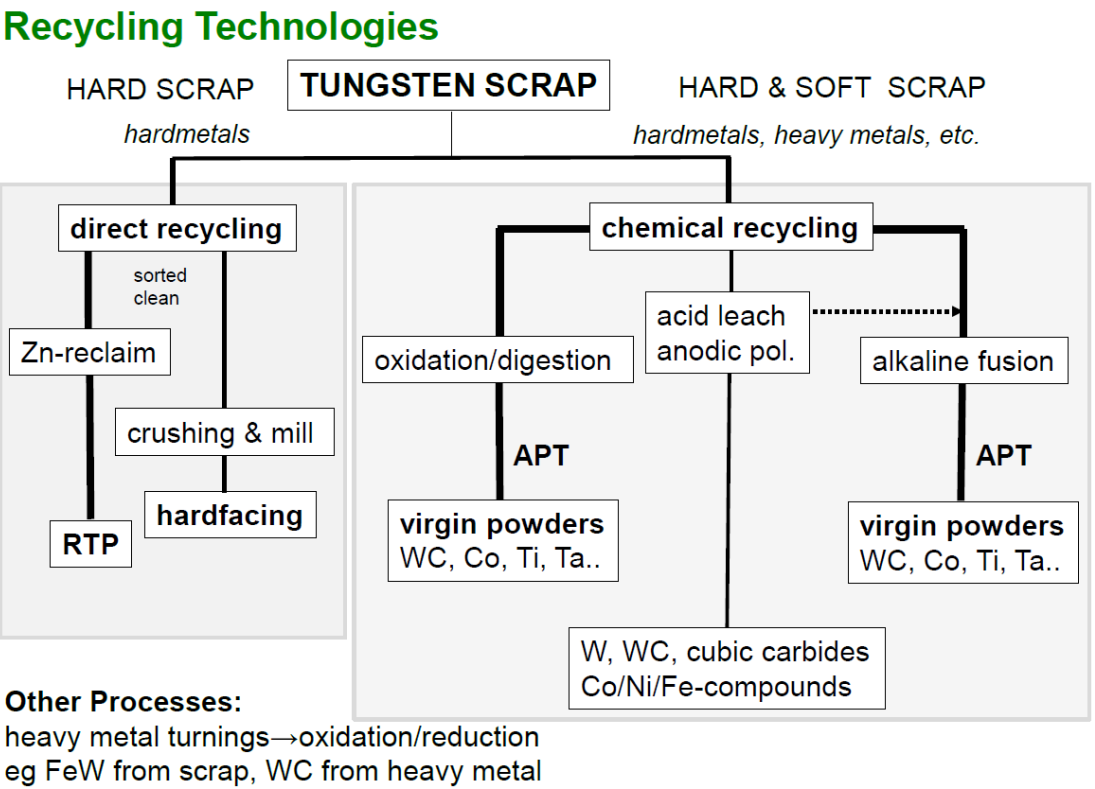
Moves in the Tungsten market

❑ Growing alternatives to the Chinese monopoly

- Vietnamese producer **Masan Resources** moves to vertical integration with acquisition of HC Starck in June (W metal and carbide powders)
- Canadian **Almonty** is building the 2nd largest mine outside China (Sangdong in South Korea. Reserves are 7.89 Mt grading 0.47% WO_3) with 15-years offtake in the US.
- Eurasian tungsten mine projects could add more than 11 ktpy of new supply by 2029 if all are brought on-line successfully, the largest of any region
- Renewed interest for ROW refiners and tool makers to reduce their dependence on Chinese raw materials (Sandvik)

Moves in the Tungsten market

❑ Tungsten recycling still in progress



➡ **Tungsten 1 to 2 years away to move away from the “reds”**

THANK YOU

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