

A New Tool for the Geopolitical Assessment of REE projects

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Outline

- Importance of REEs
- The need for a Geopolitical Ranking for countries with REE deposits
- Indicator selection
- Evaluation and ranking results
- Conclusions



Importance of REEs

- Global REE reserves: approx. 140 million tonnes
- Global mine production capacity: approx. 111,000 tonnes
- US, EU and Japan are the major importers of REEs
- China's demand for REEs is increasing both domestically and for their use in value-added products for export



Other Points

- Substitution of REEs is difficult and/or impossible and/or in an early development state
- The recycling potential of REEs is limited; some constraints are due to metallurgy
- A significant number of critical geopolitical events/reports related to REEs have occurred since 2010





Geopolitical aspects of REEs

- Demand for REEs is expected to rise in the future.
- Supply of REEs faces a number of constraints.
- The main end user of REEs is the defense/weapon industry.
- The world population is expected to increase.
- The global Gross Domestic Product (GDP) is expected to increase.





Geopolitical aspects of REEs

- Some of the REE deposits, like other critical/strategic materials/resources are located in areas that are contested or politically unstable.
- The added value of REE-based-end-products is multiple times higher than the actual size of global REE market.
- Disruption in REE supply may have economic consequences and create conflicts



The need for a Geopolitical Ranking for Countries with REEs

- Natural resources are often associated with internal armed conflicts.
- Total conflicts between 1946 and 2008 = 285
- Total conflicts between 1946 and 2008 = 117 (due to natural resources)
- Klare (2001): a geographical world map showing probable global contested areas for conflicts related to natural resources (oil/natural gas/pipelines, water systems, and gems/minerals and timber)



Three significant efforts for ranking mineral projects

- Behre Dolbear Group Inc. (BDG),
- Adamas Intelligence (AI) , and
- Technology Metals Research (TMR)



Behre Dolbear Group Inc. (BDG)

- A ranking model that compiles annual political risk assessments of global players in the global mining industry.
- Does not focus on specific minerals.
- Uses 7 criteria and each criterion is rated on a quantitative scale from 1 (worst) to 10 (best) and reflects conditions that promote investment growth in the mining sector.



Behre Dolbear Group Inc. (BDG)

In 2013, 25 countries were ranked on 7 criteria:

- the country's economic system,
- the country's political system,
- the degree of social issues affecting mining in the country,
- the delays in receiving permits due to bureaucratic and other issues,
- the degree of corruption prevalent in the country,
- the stability of the country's currency, and
- the efficiency of the country's tax policy.



Adamas Intelligence (AI)

- Major market reports on the most pressing issues in the critical metals and minerals sectors.
- AI does not rank countries, but ranks REE mining projects.
- AI does not consider the geopolitical risk in the ranking process.

AI covers 52 projects on a global scale based on four (4) criteria:

- Tonnes of in situ total rare earths oxides (**TREOs**) in the mineralized resource,
- Tonnes of in situ critical rare earth oxides (**CREOs**, CREOs include Nd, Eu, Tb, Dy, Y oxides) and relative abundance of CREOs,
- Hypothetical **value** of in situ **TREOs**, and
- Relative abundance of TREOs minus less-desirable $\text{La}_2\text{O}_3 + \text{CeO}_2$.



Technology Metals Research (TMR)

- Focuses on REEs and provides the “Advanced Rare-Earth Projects Index”.
- Does not consider the geopolitical risk during the ranking process.
- Ranks REE mining projects based on 5 selected criteria:
 - measured resource (MR) (metric tons),
 - TREOs (wt%),
 - TREOs (metric tons),
 - in situ TREOs (USD/ton of MR) and
 - basket price (USD/kg).



A New Ranking Model

- The above minerals projects ranking approaches are based on different criteria and provide different perspectives on the sustainability of REEs mining projects.
- This paper proposes a new ranking model, which focuses only on REE deposits and their potential exploitation.
- The results of the proposed country ranking are presented on a geopolitical map.



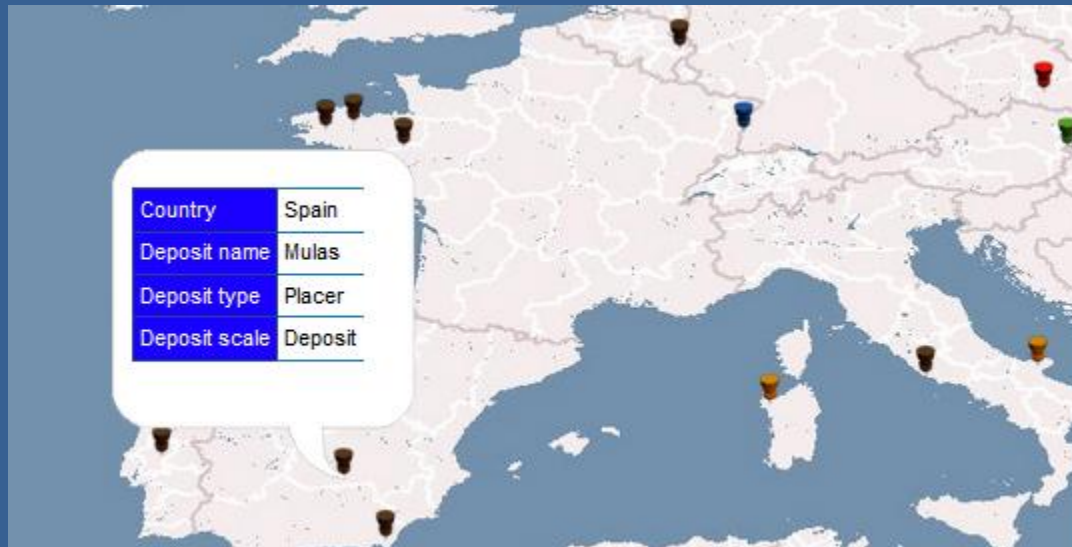
Advantages of the proposed ranking system

- The proposed country ranking system is a dynamic tool that can evolve to a geopolitical risk monitoring system
- The map provides a decision support tool for several stakeholders such as policy makers, decision makers, and mining companies
- The map can also be used to identify potential geopolitical conflicts



Map components and selection of indicators

- Independent studies by USGS and EURARE show the location on REE deposits on a global scale.
- Countries with REE deposits are depicted on a geographical map and the user can click on each occurrence to identify the specific deposit.



Analysis Methodology

- 561 REE deposits were identified in 74 countries.
- Five indicators associated to geopolitics were selected.
- Countries were ranked based on values for these five indicators



Indicator 1

- “Political Stability, Absence of Violence / Terrorism” (World Bank).
- It reflects perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.
- This indicator ranges from -2.5 (weak) to +2.5 (strong).



Indicator 2

- The country's score at the "Corruption Perceptions Index" of the Transparency International.
- A country or territory's score indicates the perceived level of public sector corruption on a Likert scale of 0 (highly corrupt) to 100 (very clean).



Indicator 3

- The “Security Apparatus” of the “Failed State Index”
- It includes pressures and measures related to internal conflict, small arms proliferation, riots and protests, fatalities from conflicts, military coups, rebel activity, militancy, bombings, and political prisoners.
- It ranges from 1 (best performance) to 10 (worst performance).



Indicator 4

- The potential conflict level of each country.
- The number of conflict episodes (between 1946 and 2008) of the Peace Research Institute Oslo (PRIO) database regarding countries with REE deposits was calculated in order to develop this indicator. This number episodes represents the conflict history (“conflict level”) in countries with REE deposits.
- 74 countries that currently have REE deposits were identified in the PRIOs database with 1145 individual conflict episodes



Indicator 5

- The Political Rights and Civil Liberties average score of countries at the “Freedom in the World Index”.
- It is measured in the Likert scale and ranges from 1 (very free country) to 7 (not free).

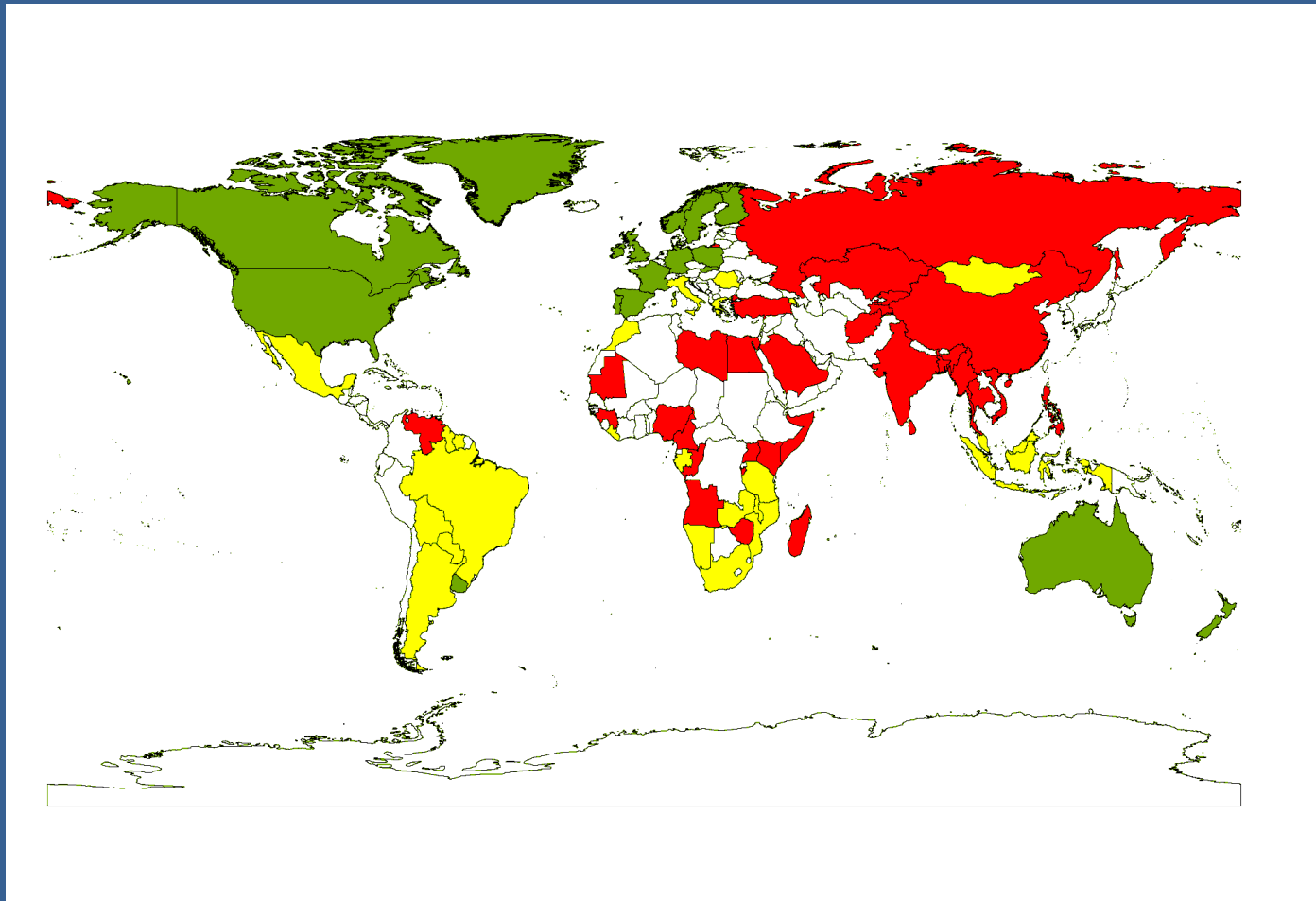


Evaluation and ranking results

- Total Country Risk Evaluation = $\sum V_{ij}$
- V_{ij} is the value of indicator i for country j
- All indicators are assumed to have the same weight
- All indicators were normalized in the range of 0 to 1
- Best performing (low risk) countries attain lower indicator values.



World map showing the indicator for geopolitical risk related to the development of REE deposits.



green=low
yellow=med
red=high



Conclusions

- A country risk ranking process was developed based on the geopolitical perspective, for geographical areas that feature REEs deposits.
- The ranking of countries was based on the comparison of five indicators and the resulting information is provided in a user-friendly form of a global map.
- A useful tool that can be used to identify/possibly predict and avoid probable future conflicts.



Conclusions 2/2

- It may be used as an indicator and/or a decision support tool for several stakeholders involved in the REE mining industry.
- This tool should not be treated as a static source of information, but as a dynamic risk monitoring system based on indicators that may change with time.



Thank you



Selected indicators, their scale and source

	Indicator	Original indicator range	Source
1	Political Stability, Absence of Violence/Terrorism	From -2.5 (weak) to 2.5 (strong)	World Bank
2	Corruption Perceptions Index	From 0 (highly corrupt) to 100	Transparency International
3	Security Apparatus	From 1 (best performance) to 10 (worst performance)	Failed State Index
4	Conflict Level	From 0 (low number of conflicts) to 244 (high history of conflicts)	Peace Research Institute Oslo (PRIO)
5	Political Rights and Civil Liberties (average score)	From 1 (very free country) to 7 (not free country)	Freedom in the World Index



Geopolitical risk ranking for the development of REE projects

Rank (low to high risk)	Country name and risk assessment	Risk value	Rank (low to high risk)	Country name and risk assessment	Indicator value
1	Denmark (Greenland)	0.2627	39	Mexico	2.4157
2	New Zealand	0.3112	40	Morocco	2.4760
3	Finland	0.3382	41	Turkey	2.5371
4	Sweden	0.5179	42	Vietnam	2.5862
5	Norway	0.5626	43	Kazakhstan	2.6663
6	Australia	0.5645	44	Madagascar	2.7003
7	Canada	0.5727	45	Thailand	2.7356
8	Germany	0.6679	46	Saudi Arabia	2.8106
9	Ireland	0.6833	47	Kenya	2.7526
10	United States	0.8104	48	Sri Lanka	2.7704
11	France	0.8538	49	Uganda	2.7956
12	Poland	0.8771	50	China	2.8354
13	Uruguay	0.9123	51	Venezuela, RB	2.8055
14	United Kingdom	0.9265	52	Bangladesh	2.7833
15	Portugal	0.9461	53	Kyrgyz Republic	2.8199
16	Slovak Republic	0.9545	54	Angola	2.8496
17	Spain	1.2802	55	Mauritania	2.9253
18	Namibia	1.4341	56	Philippines	2.8810
19	Mongolia	1.4813	57	Egypt, Arab Rep.	2.9280
20	Italy	1.4958	58	Cameroon	2.9811
21	Romania	1.5546	59	Burundi	3.0304
22	Argentina	1.5656	60	Tajikistan	3.0765
23	Greece	1.6448	61	Russia	3.0846
24	Suriname	1.8206	62	Guinea	3.0882
25	South Africa	1.8367	63	Zimbabwe	3.1205
26	Brazil	1.8468	64	India	3.1126
27	Zambia	2.0344	65	Libya	3.1771
28	Malawi	2.0359	66	Nigeria	3.2223
29	Tanzania	2.0378	67	Congo, Dem. Rep.	3.5662
30	Malaysia	2.0985	68	Afghanistan	3.8592
31	Guyana	2.1017	69	Somalia	3.9686
32	Armenia	2.1870	70	Myanmar	4.0265
33	Bolivia	2.2085	-	Korea, Dem. Rep.	N/A
34	Gabon	2.3355	-	Korea, Rep.	N/A
35	Paraguay	2.3063	-	Taiwan	N/A
36	Mozambique	2.3476	-	Ukraine (*)	N/A
37	Liberia	2.3559			
38	Indonesia	2.3549			

