Radiation, risk perception and raw material exploration: science communication and social license

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Technology metals

Within our modern world, high-tech communications and low carbon energy and transport are growing the need for raw materials (Fig 1). Alkaline rocks and carbonatites are key sources for such raw materials. Two thirds of advanced REE exploration projects are in alkaline igneous rocks and carbonatites.

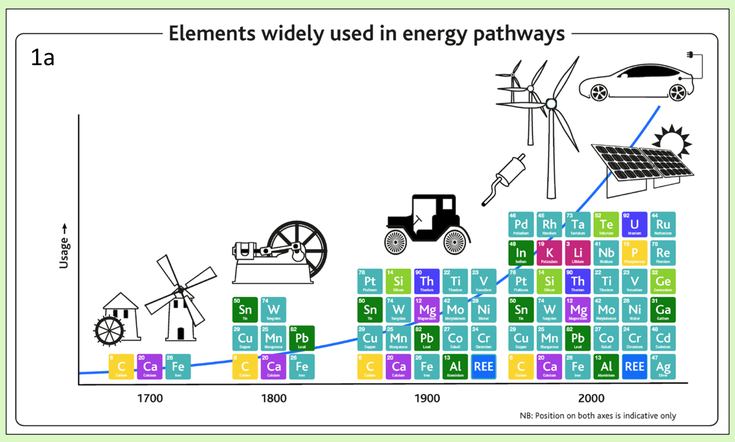
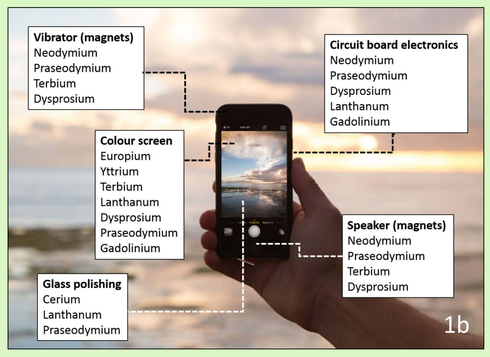
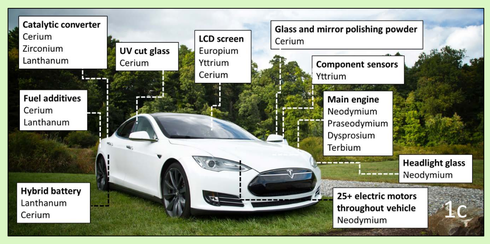


Fig 1: a) Modern technology for a low carbon economy and for hi tech communications require many more raw materials than in the past. b, c) Metals in smartphones and cars.





However, most alkaline rock and carbonatite-related ore deposits contain tens to hundreds of parts per million thorium and smaller amounts of uranium (Tables 1, 2 and Fig 4). Therefore, radiation can be a key hazard at exploration and mine sites (but sometimes perception is worse than reality).

Fig 2: Protests against Norra Kärr mine plans, Sweden, 2018 [1]

Table 1	Dose over natural background radiation
Dental x-ray	0.01 mSv
Full body CT scan	10 mSv
Accepted public rate	1 mSv/yr
Accepted worker rate	20 mSv/yr

"Before the factories were built, there were just fields here as far as the eye can see. In the place of this radioactive sludge, there were watermelons, aubergines and tomatoes" (Quote from Guardian article about rare earth mines in China, 2012[2])

Table 2	Rock types	U	Th
Igneous	Granites, rhyolites and intermediate igneous rocks	1-50 ppm	8-56 ppm
	Basalts and other mafic rocks	0.1-1 ppm	0.1-4 ppm
	Ultramafic rocks	0.001 – 1 ppm	<0.1 ppm
And for comparison:			
	Coals, lignites, peats	1-6000 ppm	

Table 1: Context, compare Fig 4, column 3: Accepted dose rates[3]

Table 2: Context, compare Fig 4, column 2: radiation levels in different rocks types. Adapted from Tye [4]

Case study comparisons

Our study of publically available data on radiation levels at exploration projects and mines, compared with records of protests associated with these sites, shows that:

- Protests about exploration projects and mines are associated with a wide range of concerns, sometimes, but not always, including radiation (Fig 3, Fig 4).
- Radiation levels in ore deposits, waste materials and by-products from mines vary considerably between different sites, but can be higher than in other rocks (Table 2, Fig 4).
- In some cases high levels of radiation-related concern are found at sites with lower radiation levels (Fig 2, Fig 4).
- Insufficient trust and community engagement are repeatedly associated with protests associated with exploration and mine sites (Fig 4).

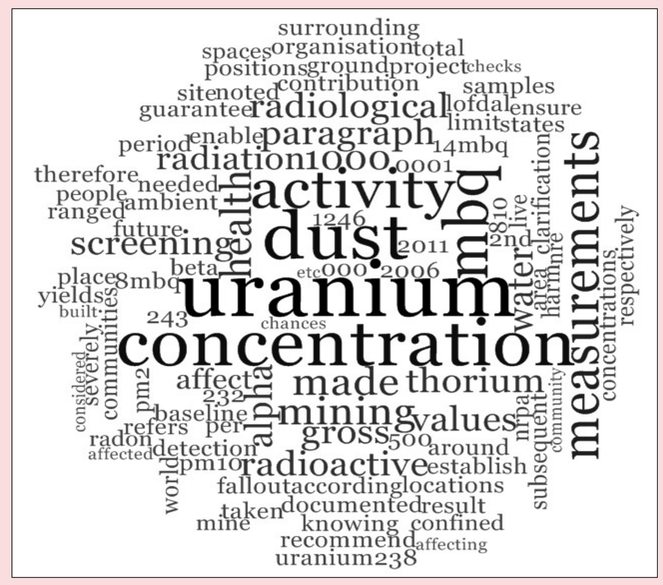


Fig 3: Community stakeholder consultation, Lofdal, Namibia. Comments associated with radiation. U mining is important and well-known in Namibia. Analysis of data in Speiser[5]

Perception

Perception of radiation risk is important and needs to be addressed at all exploration projects in alkaline rocks and carbonatites. Background levels of radiation and concentrations of uranium and thorium in ore should be published as early as possible in exploration, even if these levels are low. No information is likely to lead to assumption of a problem.

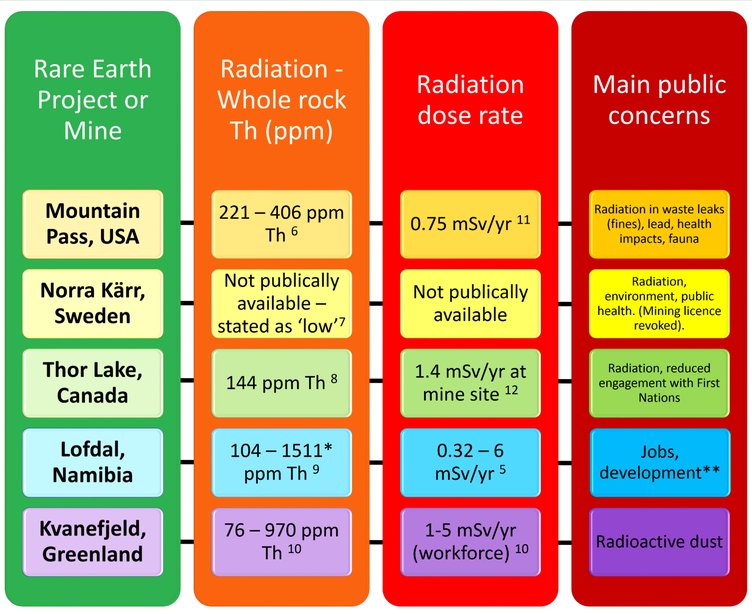


Fig 4: Comparisons between a selection of case studies – radiation and public concern.

* High levels not in proposed mine area. **Despite some higher radiation levels main concerns at Lofdal were socioeconomic. Radiation was mentioned (Fig 3) but not of high concern, perhaps due to familiarity with U mining..

Communication

Best practices for good community – company relations and communication echo best practice lessons learned in volcanic and other risk management scenarios, reflecting the wider issues about science engagement and communication.

Essential and key to effective relationships between communities and specialists working together are:

- **Trust development,**
- **Community engagement**
- **Transparency**

References:

1: Kettil (2018) https://www.jp.se/article/debatt-dricksvatten-eller-gruva/; **2:** Bontron (2012) https://www.theguardian.com/environment/2012/aug/07/china-rare-earth-village-pollution; **3:** ICRP (2007) ICRP Publication 103. Ann. ICRP 37 (2-4); **4:** Tye et al. 2017. *BGS Internal Report*, OR/17/001; **5:** Speiser (2016) ESA report for Lofdal; **6:** Castor (2008) The Canadian Mineralogist, 46, 779-806; **7:** Breda-Ruud (2019) REIA conference, Brussels, Nov 2019; **8:** Micon (2013) Technical report disclosing results of the feasibility study on the Nechalacho REE project. 291 pp; **9:** Wall et al. (2008) Canadian Mineralogist, 46, 4, 861-877; **10:** Sørensen et al. (2011) Bulletin of the Geological Society of Denmark 59:69-92; **11:** International Atomic Energy Agency (2011) Safety Reports Series No. 68, Vienna, Austria; **12:** Linlin (2014) Unpub MASc thesis. University of British Columbia; **13:** Sørensen et al. (2011) Bulletin of the Geological Society of Denmark 59:69-92.