Mines of the future: a question of scale in ore bodies?

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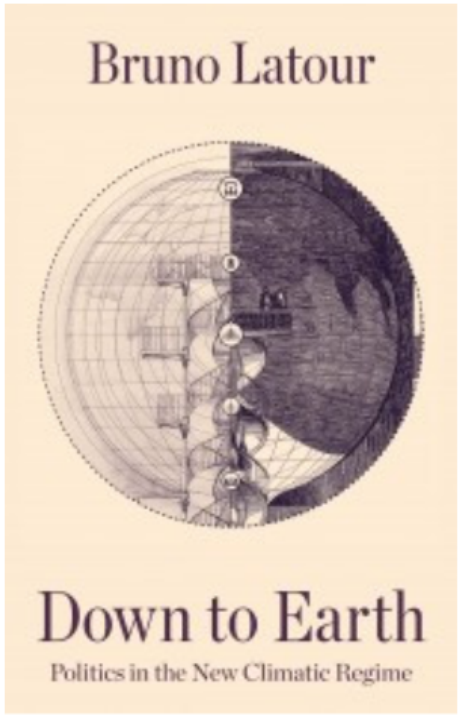
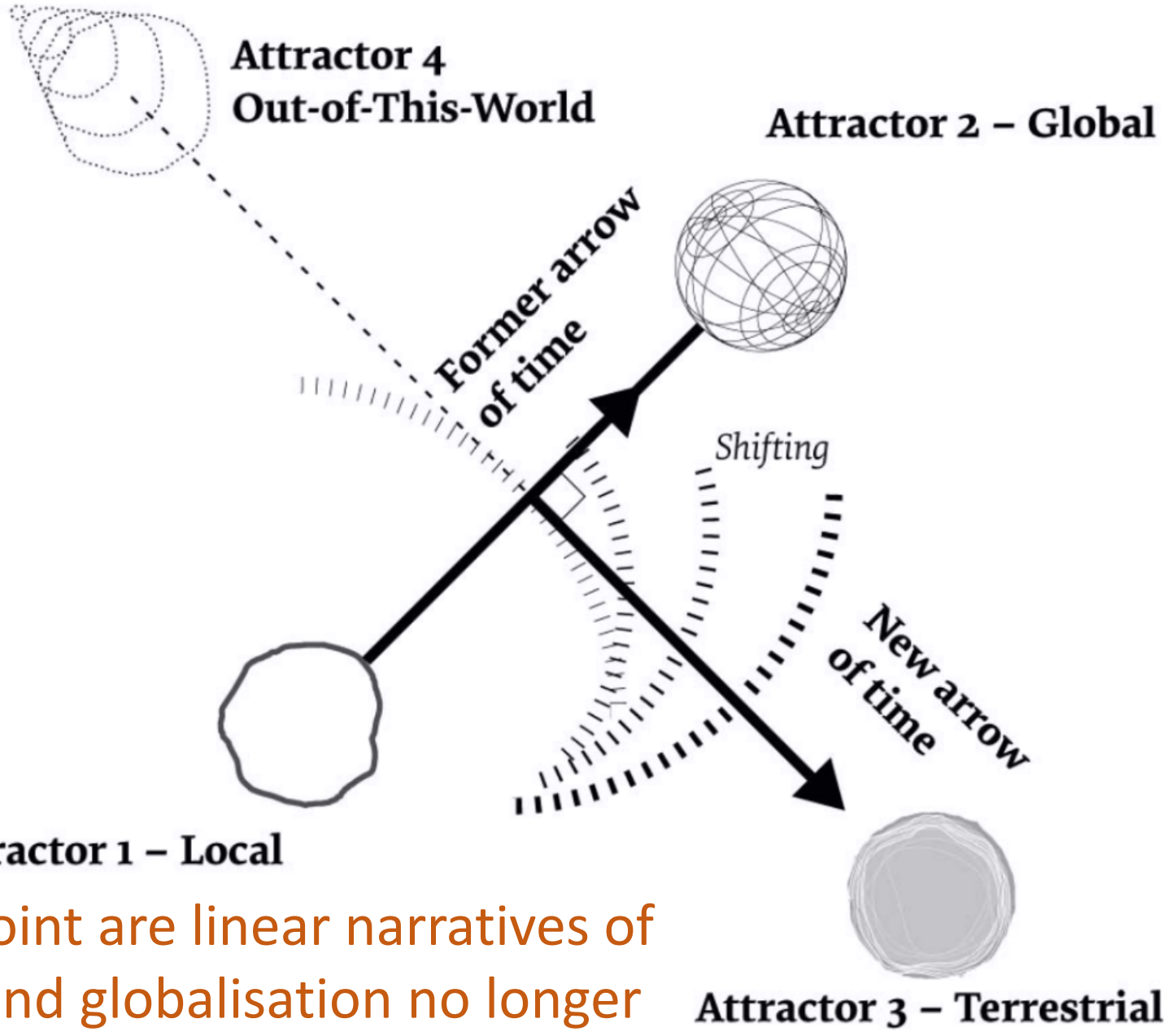
Two main drivers:

1. Economic forcing – security of supply chains for continued business growth: linear narratives of progress feature increased globalisation

2. Socio-environmental forcing – up to and beyond Net Zero goals, the Terrestrial Attractor demands attention and reorients the modernisation front…

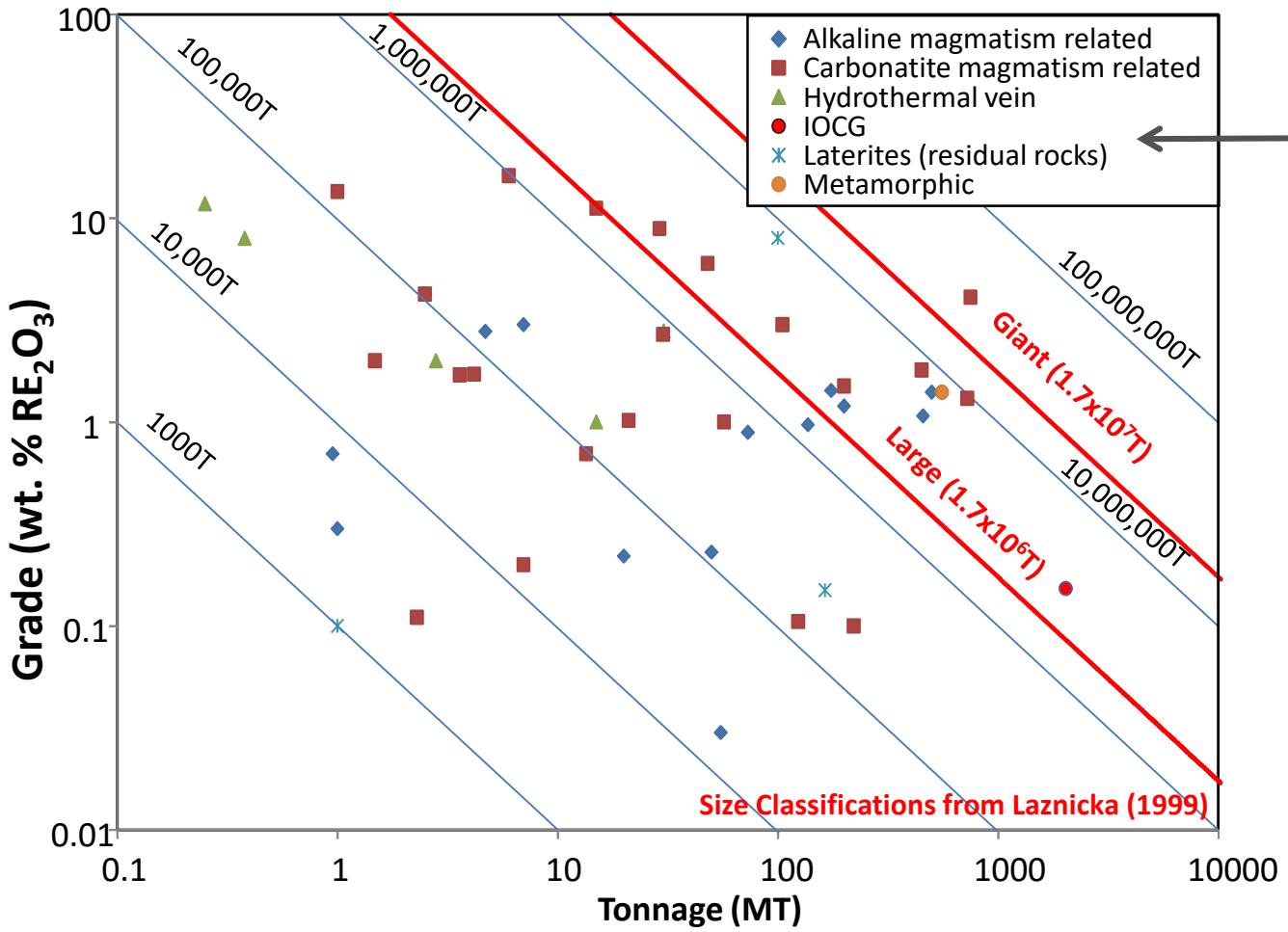
"The new universality consists in the feeling that the ground is in the process of giving way."





At what point are linear narratives of progress and globalisation no longer fit for purpose?

Few critical metal deposits classify as giant deposits, but they can be sourced from geologically and geographically variable localities globally



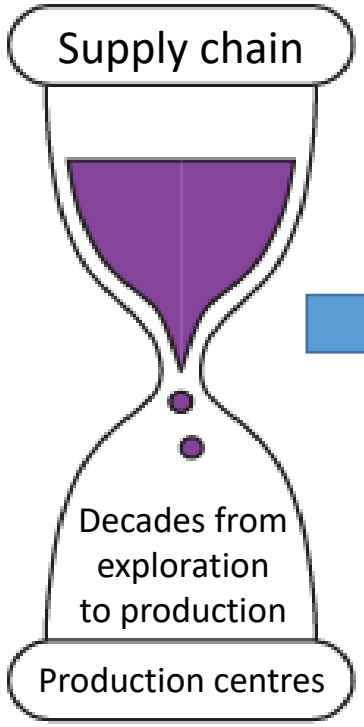
Geology does not limit supply of many critical raw materials

Grade-tonnage plot for resource estimates in REE deposits from Orris and Grauch (2002) and Long et al. (2010).

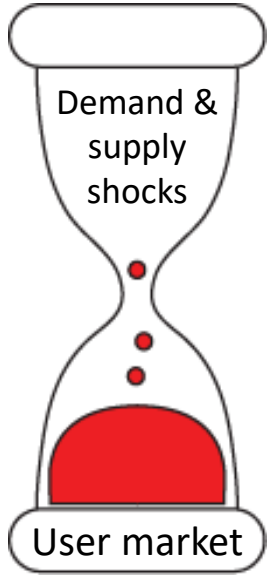
(Smith et al., 2016, with size classifications after Laznicka (1999).

Response to demand and Price volatility

Mining $ Processing/ refining $ Intermediate products $ End products $ End of life reprocessing



Global concentration of production and bottlenecks in the the supply chain



Real or perceived Supply-demand imbalances create price volatility

Can small ore deposits be brought into production more rapidly?

Integrated Mobile modularised Plant and Containerised Tools for selective, low-impact mining of *small high-grade deposits*

This project is funded by the EU Horizon 2020 Programme; Grant no 730411

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A value chain context:

- Technology development and procurement
- Logistics: transportation, deployment with testing on mine sites
- Support activities: human resources, environmental management

Olovo Mine, Bosnia and Herzegovina; photo courtesy Richard Roethe, Mineco

IMP@CT

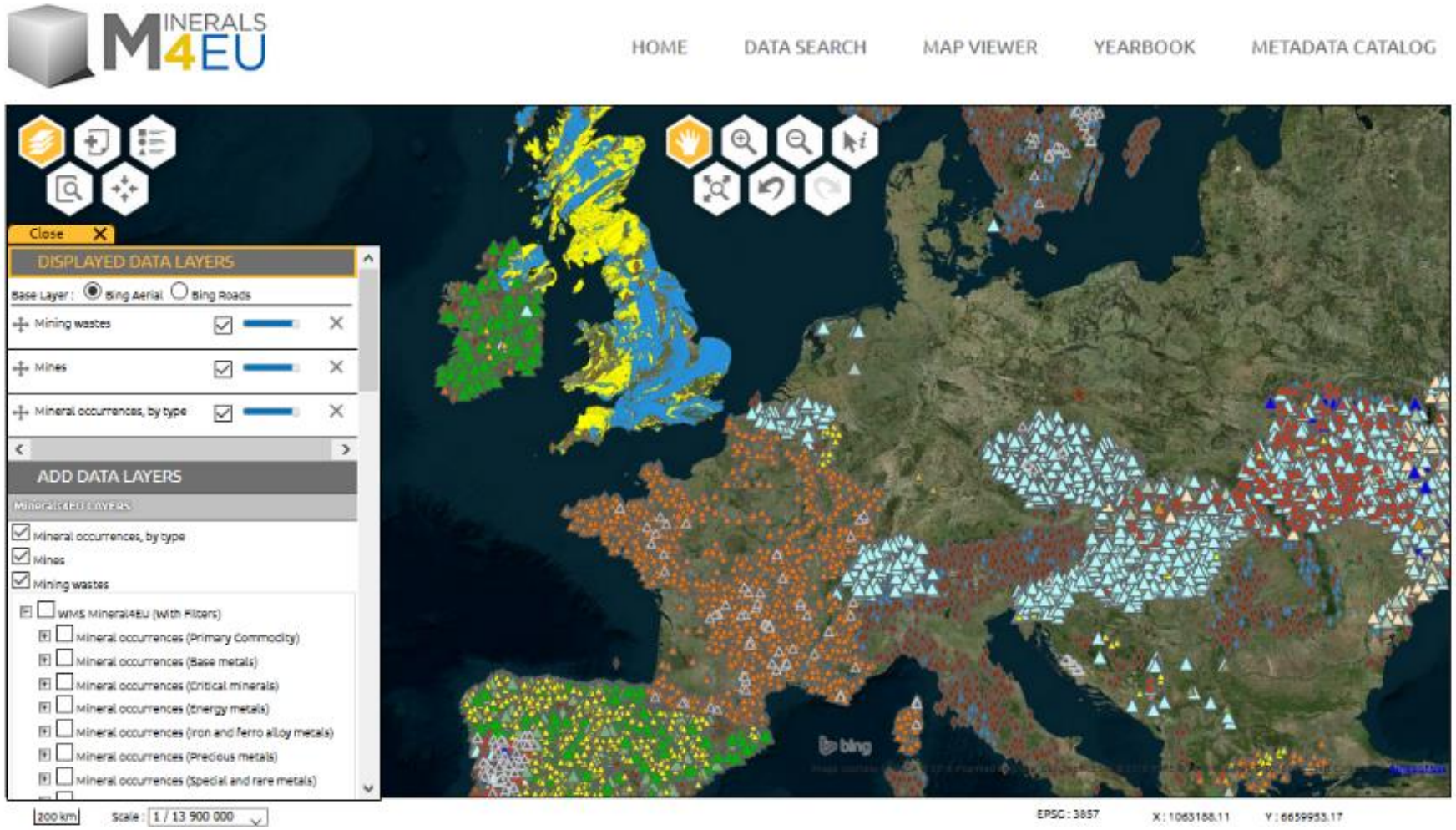
Innovations to make a small, high-grade ore deposit economically competitive with large-scale mines?

Moore et al., 2021
Resources Policy

Innovations for small-scale mining were tested at a new (conventional) mine site in cooperation with environmentally and socially aware individuals who have a collective community expectation for their quality of life.

Olovo Municipality, Bosnia: first underground mine since the Balkans conflict opened in May 2018.

Multiple small deposits in Europe



Interactive visualisation of georeferenced data sets on the EU-MKDP Platform.

Multi-criteria tool for small-scale high-grade complex deposits. This tool is openly and freely accessible on the web-based portal of the Minerals4EU EU-MKDP.

A large number of mineral deposits are indicated as potential small deposits.

http://minerals4eu.brgm-rec.fr/

Géosciences pour une Terre durable
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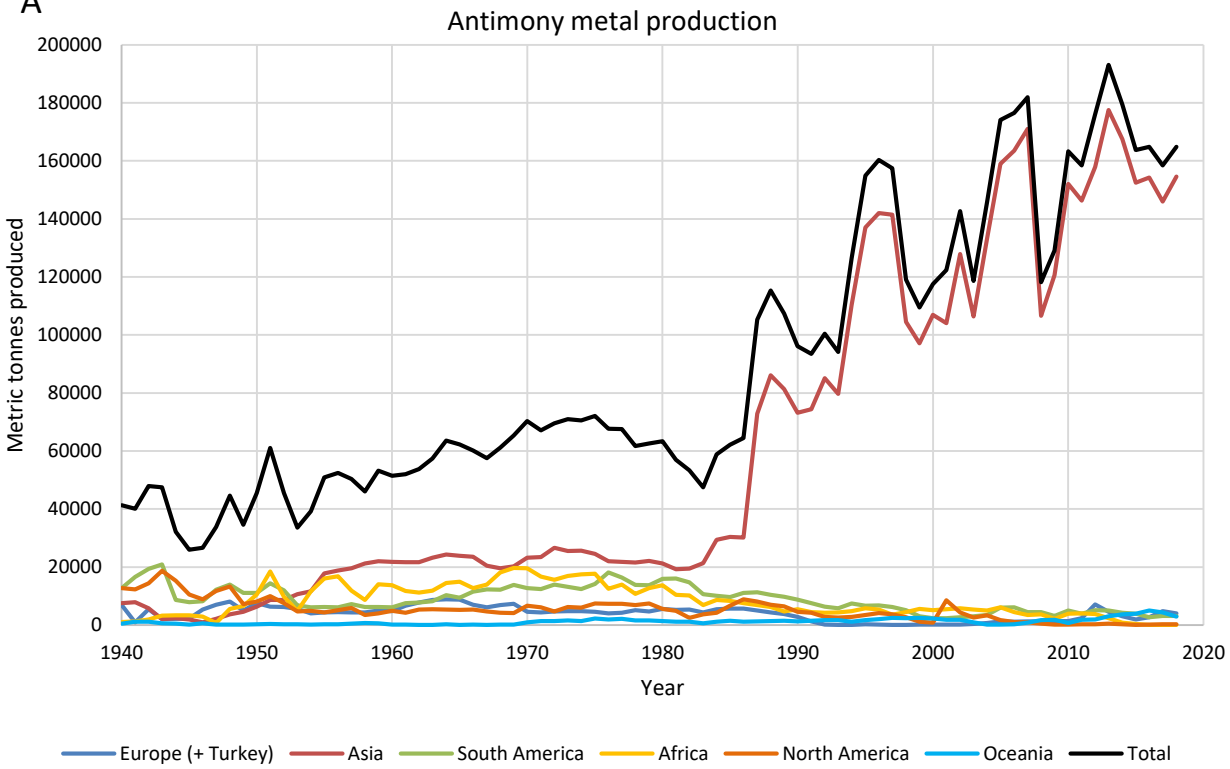
(A) Historic production data for antimony between 1930 and 2018. Note the rapid rise in production in China during the 1980's.

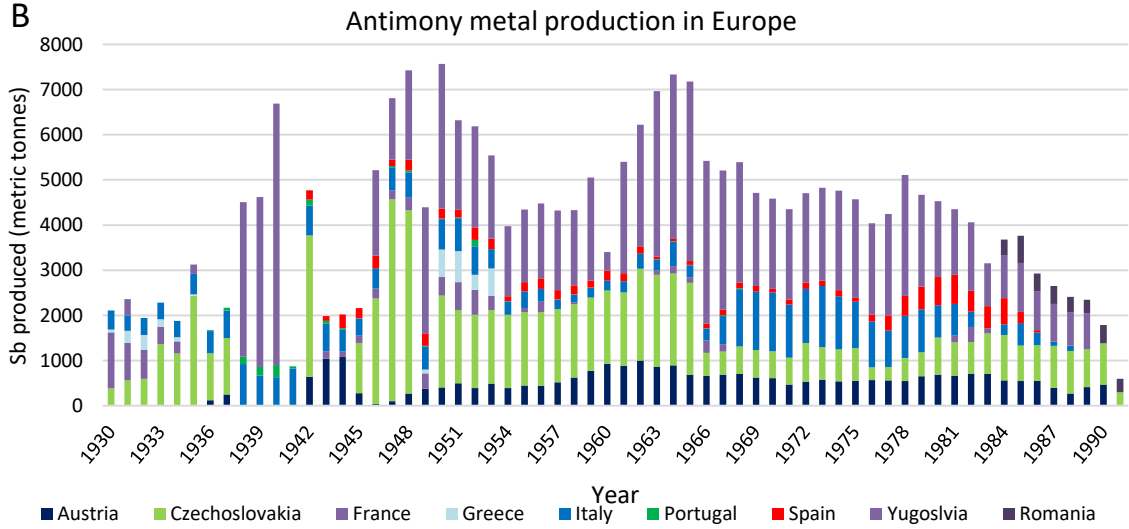
(B) Antimony production for European countries only. Note that France and Italy have produced significant quantities of Sb, from deposits that do not appear in the small deposit query tool.

Primary data from World Mineral Statistics Database (BGS). Images from Harvey et al (unpublished).

A



B



(Yugoslavia and Czechoslovakia cannot be separate in the historical data.)

How do we increase access to reliable and complete, up-to-date information on multiple small ore deposit types?

What are the potential relative roles of, and partnerships between, Geological Survey and Exploration company?

Where does the investment come from for exploration of small ore deposits?

What are the geological challenges particular to exploration of small high-grade ore deposits?

What are the tools that are needed to early predict whether to proceed with exploration of small ore deposits?

What are the tools that are needed to characterise geological uncertainty and metallurgical variability in small ore deposits?