Meeting demand for critical metals – societal dimensions

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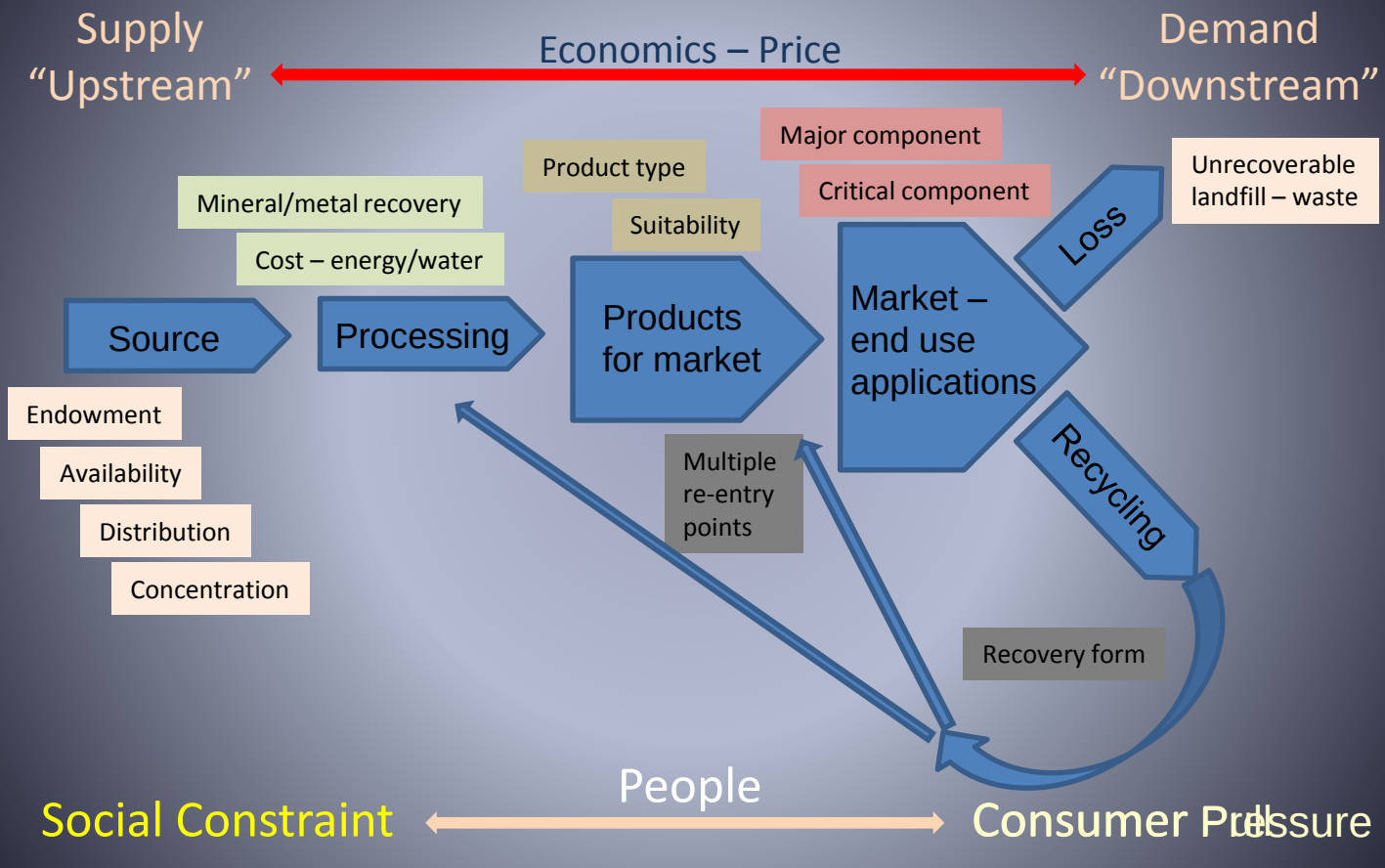
Societal issues – major challenges for resource availability

- Renewable energy technology – major/rare metals
- Significant global resources for all metals – subject to discovery, definition and development
- Specific challenges for rare/critical metals:
  - Identification and processing
  - By-products, market size and demand volatility
- Jurisdictional-people challenges – complex, unpredictable and no fixed timelines

Metals – value chain



Background: source of critical metals

- Rare metals: typically minor components of rare minerals (exceptions: Li, Sb, and REE)
- Understanding of the distribution and concentration of rare metals is relatively poor – knowledge gap
- Only a few jurisdictions have major economic endowments/production in rare metals

Background: processing challenges

- Most rare metals end up in complex concentrates shipped from mines to smelters/refineries
- Major metal markets influence supply – inflexible to changes in demand for rare metals
- Development of treatable complex recycle streams is equally challenging – R&D and innovation

Mining in general

- People, power and water
- Land – ownership and rights; conflicts: water, agriculture, fishing, heritage
- Visible issues….

2015 – Samarco

2014 – Mt Polley

2013 – Minas Conga

Metals for use in renewable energy technologies – specific issues

- Conflict, child labor, black market – DRC
- Artisanal mining – DRC, China
- Waste rock, tailings, residues – e.g., radioactivity in some REE waste streams

Jurisdictions, regions, communities and indigenous people

- Jurisdictions: economics and politics – resource nationalization, downstream processing, variable standards/regulations
  - Can drive substitution – e.g., Co, Nd, Dy
- Regions – uneven distribution of benefits
- Communities – maximizing benefit/impact
- Indigenous people, natural land owners – potential for conflict but opportunities for change

New opportunities – business, partnerships and technology

- New partnerships, business models – downstream connections (e.g., Tesla), processing, added value
- New approaches to mining: remote, less waste, more efficient, and distributed/shared benefits
- Regulation and certification – source and recycling
- Pressure from manufacturers, suppliers and customers – challenges for clean energy technologies with limited suppliers

The next 10-15 years

- Increasing demand from renewable energy and other technologies – requires new resources & operations
- Other supply constraints:
  - Global trade issues and resource nationalization
  - Increasing societal expectations; global and local issues, instant connectivity, increasing challenges
- Mitigated by sustainability/technology and new business, partnership and social deals
- Technical and non-technical innovation required