Abandoned Mines – Overview and Risk Assessment

Presenter: Rob Stevens, Ph.D., P.Geo. Senior Associate Mine Closure, IGF

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IGF INTERGOVERNMENTAL FORUM on Mining, Minerals, Metals and Sustainable Development

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Federal Ministry for Economic Cooperation and Development

Webinar Schedule

- Overview of Abandoned Mines – Rob Stevens, IGF
- Legacy Site Management in the Andean Region:
  - Achim Constantin, Head Project Manager, MinSus-BGR (Andean countries cooperation)
- IGF Abandoned Mines Inventory and Risk Assessment Tool and Namibian Case Study – Rob Stevens, IGF
- Abandoned Mine Assessment in El Salvador
  - Mirna Bonilla Argumedo, General Director of Hydrocarbons and Mines, El Salvador
- Remining Tailings Project – Jonathan Hamisi - IGF

Presentation Overview

- What are abandoned mines?
- Hazards at abandoned mines
- Impacts of abandoned mines (receptors)
- Risk Assessment: probability and consequence
- Challenges with risk assessment

What is an Abandoned Mine?

Abandoned mines are sites that are no longer operating and where there is no mine owner. Abandoned mines have the potential to create a wide range of hazards including safety issues for people and wildlife, environmental contamination and risks to human health.

- It is a global issue and with tens of thousands of abandoned mine sites around the world:
  - 5,700 in Ontario, Canada
  - 52,200 in the US on Bureau of Land Management land
  - More than 6,000 in South Africa; and
  - 1,338 in Chile and many more around the world.

Assessing Abandoned mines?

Assessing abandoned mines requires an understanding of the potential hazards associated with the site and the risks those hazards present to people and the environment in order to develop and implement a remediation plan.

- Hazards
- Risks – Consequence and Probability
- Remediation plan

Abandoned Usakos Tourmaline Mine

Potential Hazards at Abandoned Mines

- **Contaminated Water:** metals, chemicals, acid drainage, sediment
  - Waste rock, tailings, underground openings, pit, surface run off
- **Dust and airborne particles**: metals, chemicals, gases, sediment
  - Tailings, waste rock, former building sites
- **Contaminated soil**: chemicals, contaminated vegetation
  - Plant area, maintenance areas, roads and labs
- **Slope Stability**: failure, falling hazard, ASM miners
  - Open pits, underground working, waste rock piles, dams

Potential Hazards at Abandoned Mines

- **Underground Openings**: hazardous openings, contaminated water flow, gasses
  - Adits, shafts, breakthroughs
- **Buildings**: contamination, unstable, sharp protrusions
  - Mill, labs, maintenance shops and office buildings
- **Safety**: physical & chemical hazards, falling, injury
  - Open pits, steep waste rock, trenches, dam faces

Hazards Associated with Different Types of Mines

- Medium to large scale metal and coal mines
  - Full range of hazards are possible
- ASM
  - Numerous small unstable openings, safety, mercury, soil contamination, surface water contamination.
- Quarries
  - Physical and safety, dust, possible chemical depending on the material and how it was processed.
- Exploration sites
  - Trenches, drill and camp sites, roads, fuel storage and waste.

Abandoned ASM Shafts – Near Geita Tanzania

Risks at Abandoned Mines - Receptors

Receptors are those entities that may be impacted by an abandoned mine site

- People:
  - Water contamination, dust and airborne particulates, food contamination, safety hazards
  - Impact to cultural sites
- Livestock and Wildlife
  - Water, forage, safety, endangered species
- Surrounding Environment:
  - Waterways, protected areas, endangered species
- Property and Businesses:
  - Damage buildings, crops and infrastructure, loss of income, loss of tourism

Acid-Rock Drainage, Davis Mine Massachusetts

Opportunities at Abandoned Mines

- Bats
- Lakes
- Unique micro ecosystems
- Historic sites, archeological benefits
- Tourism; rock hounding and climbing
- Education and training centre
- Underground cooling/storage
- Repurposing potential – can post-mining land uses still apply?

Grate that allows bats to move in and out of an abandoned mine adit in Arizona

Community Involvement in Abandoned Mine Assessment

Community engagement and involvement can and should be an important part of assessing risks associated with abandoned mines and developing restoration approaches. Some community aspects that needs consideration include:

- Report abandoned mines to support compiling an inventory
- Informed of assessments
- Transparency
- Participation
- Community restoration and partnerships
- Restoration work supports community goals and provides a benefit.

Risk Assessment

- Risk assessment identifies hazards that pose unacceptable risks
    - Consider sources of information, desktop versus site assessment, risks to assessors
- Identifies the problem not the solution
- Is generally qualitative or semi-quantitative
- Can provide a ‘coarse grained filter’ to identify sites that require follow-up and more detailed assessment
- May require specific communication plan with communities to manage concerns and expectations
- May require assessment of how climate change will impact sites in the future

Risk Assessment

Risk = P x C

- Hazards and Receptors
  - What are the hazards at the abandoned site and who/what are the receptors that might be impacted by the hazards
  - Subdivide hazards into components and sub-components to identify probability and consequence effectively
- Probability (P) or Likelihood
  - What is the probability or likelihood that an identified hazard or risk will occur
  - E.g. Failure of a dam or contamination of surface water
- Consequence (C)
  - What is the consequence if the hazards or risk occurs to various receptors
  - E.g. consequence of a dam failure on people, businesses and the environment

Steps in Risk Assessment

1. Identify **hazards**
2. Identify **receptors** – people, animals, environment, property
3. Assess **Likelihood** of occurrence of hazards
4. Assess **Consequences** of hazards to the receptors
5. **Categorize** the hazard on a risk assessment matrix
6. **Prioritize** for follow-up

Abandoned Usakos Tourmaline Mine

Risk Rating Matrix

Probability/Likihood			Consequence				
			Negligible	Minor	Moderate	Major	Significant
			1	2	3	4	5
	Almost Certain	E	Medium 11	High 16	High 20	Extreme 23	Extreme 25
	Likely	D	Medium 7	Medium 12	High 17	High 21	Extreme 24
	Possible	C	Low 4	Medium 8	High 13	High 18	High 22
	Unlikely	B	Low 2	Low 5	Medium 9	High 14	High 19
	Very Unlikely	A	Low 1	Low 3	Medium 6	Medium 10	High 15

Risk-Analysis Probability or Likelihood - ICMM

Likelihood rating of the risk occurring

Likelihood	
Almost certain (5) **>90%**	Greater than 90% likelihood of occurring Has happened, will probably happen during the mine life and there is no reason to suspect it won't happen
Likely (4) **30%–90%**	Likelihood of occurring is equal to or more than 30% and less than 90% This consequence is not uncommon in the mining and metals industry/area
Possible (3) **10%–30%**	Likelihood of occurring is equal to or more than 10% and less than 30% There is a possibility of this risk occurring as it has occurred before (albeit infrequently) in the mining and metals industry/area
Unlikely (2) **3%–10%**	Likelihood of occurring is more than or equal to 3% and less than 10% There are no specific circumstances to suggest this could happen
Improbable (1) **<3%**	Likelihood of occurring is less than 3% It would require a substantial change in circumstances to create an environment for this to occur, and even then, this is a rare occurrence

ICMM – Integrated Mine Closure – Good Practice Guide, 2019

Consequence

ICMM

Consequence rating of the risk occurring

Consequence rating					
Consequence type	**Insignificant (1)**	**Minor (2)**	**Moderate (3)**	**High (4)**	**Major (5)**
Schedule	Less than 1% impact on overall project timeline	May result in overall project timeline overrun of equal to or more than 1% and less than 3%	May result in overall project timeline overrun of equal to or more than 3% and less than 10%	May result in overall project timeline overrun of equal to or more than 10% and less than 30%	May result in overall project timeline overrun of 30% or more
Financial	Less than 1% impact on the overall budget of the project	May result in overall project budget overrun of equal to or more than 1% and less than 3%	May result in overall project budget overrun of equal to or more than 3% and less than 10%	May result in overall project budget overrun of equal to or more than 10% and less than 30%	May result in overall project budget overrun of 30% or more
Safety	First-aid case	Medical-treatment case	Lost-time injury	Permanent disability or single fatality	Numerous permanent disabilities or multiple fatalities
Environment	Lasting days or less; affecting small area (metres); receiving environment altered with no sensitive habitats and no biodiversity value (eg urban/ industrial areas)	Lasting weeks; affecting limited area (hundreds of metres); receiving environment altered with little natural habitat and low biodiversity value	Lasting months; affecting extended area (kilometres); receiving environment comprising largely natural habitat and moderate biodiversity value	Lasting years; affecting area on sub-basin scale; receiving environment classified as having sensitive natural habitat with high biodiversity value	Permanent impact; affecting area on a whole basin or regional scale; receiving environment classified as highly sensitive natural habitat with very high biodiversity value

ICMM – Integrated Mine Closure – Good Practice Guide, 2019

Risk Assessment Matrix for Abandoned Site in Namibia

	SEVERITY OF CONSEQUENCES				
PROBABILITY INDEX	NEGLIGIBLE (A)	LOW (B)	MODERATE (C)	HIGH (D)	CATASTROPHIC (E)
HIGH (4)	OP1_SHS12tf; P1_SHS12tf;	OP1_SHS12ga; P1_SHS12ga		OP1_SHS12pe; P1_SHS12pe	
MEDIUM (3)	LW1_SHS12pe, tf; LW2_SHS12pe,tf; LW3_SHS12pe,tf,; AI2_SHS13pe,tf	LW1_CHS7pe,tf;ga; LW3_CHS1pe,tf,ga			
LOW (2)	AI1_SHS13tf; P2_SHS13tf ; P3_SHS12tf	AI1_SHS13pe; P2_SHS13pe; P3_SHS12pe;			
NEGLIGIBLE (1)	LW1_SHS12pe, tf; LW2_SHS12pe,tf; LW3_SHS12pe,tf,; AI2_SHS13pe,tf,				

Challenges in Risk Assessment

- It is often a qualitative process where different assessors will assign higher or lower risk based on their perceptions and risk tolerance
- Often incomplete or unknown data that can make risk assessment difficult
- How do you answer the questions of ‘how much contamination is too much’ or ‘when is the safety risk too high’?
- Lack of resources for development and implementation of a remediation plan
- Community concerns or changes in community land use
- Climate change may change the ‘status quo’ of an abandoned site

Funding Mechanism for Abandoned Mines

1. **Government –** provides annual or periodic funding to address abandoned mines
2. **Pooled Funds** – Western Australia, Northern Territory, Queensland

- Mine operators contribute to a pooled financial assurance fund.
  - In WA and QLD the income from the fund supports rehabilitation of abandoned mines.
  - In NT, there is a pooled fund to specifically cover abandoned and relinquishment mines; Annual non-refundable levy of 1% of financial assurance amount.

3. **Production Levy** – Ontario, coal mines in the US

- A fee on current production.
  - In Ontario aggregate producers pay a small portion of licensing fees into an abandoned mine fund.
  - In the US - Surface Mining Control and Reclamation Act (SMCRA) in the U.S. imposes a levy on the coal mining industry according to production levels. As of September 2022 over $12 billion has been collected.

Funding Mechanism for Abandoned Mines

4. **Government – Industry Agreements/Partnerships** – Yukon Territory

- Agreement with private sector to address historic issues in return for mineral rights to an abandoned site with remaining resources.
- Government provides some funding, but so does industry
- Potential for redevelopment

5. **Community partnerships - Sudbury Ontario**

- Community takes an active role in rehabilitating and cleaning up local abandoned sites with help from government, NGO's and mines.
    - In Sudbury Ontario decades of smelter effluent killed off large swaths of forest next to the city.
    - Citizens of Sudbury took a leading role in restoring the land.

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IGF Abandoned Mines Inventory and Risk Assessment Tool

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WELCOME!
Abandoned Mines Inventory and Risk Assessment Tool
Acknowledgements
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IGF: Intergovernmental Forum on Mining Minerals Metals and Sustainable Development
BGR: Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
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Corrections and Suggestions
We encourage feedback and recommendations on this tool. If you have suggestions, recommendations or corrections, please send an email to Secretariat@igfmining.org
Welcome
A -Site Summary
B - Site Information
C - Mine Site Components
D - Receptors
E - Hazards and Rankings
F - Site Risk Ranking

Aims of the Tool

- Relatively quick and easy method of creating an inventory and risk assessment of an abandoned site – particularly where non exist.
- Undertaken one site at a time.
- Site data required – the more then better
- Assessment of multiple sites allows for prioritization across a region.
- Does not require a field visit – but assessment should be verified with a field visit.
- Remediation plans can be developed based on the tool and prioritization of sites.

Usakos Tourmaline Mine - Namibia

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Usakos Tourmaline Mine - Namibia

Thank you to Namibian Ministry of Energy and Mines and the Geological Survey for allowing me to use this site as an example

Usakos Tourmaline Mine - Namibia

- Mine operated during German colonial time and possibly as late as the 1940's.
- Located close to the town of Usakos with a population of approximately 4,500.
- Adjacent to the Khan river

Usakos Tourmaline Mine - Namibia

Usakos Tourmaline Mine – Open Pit

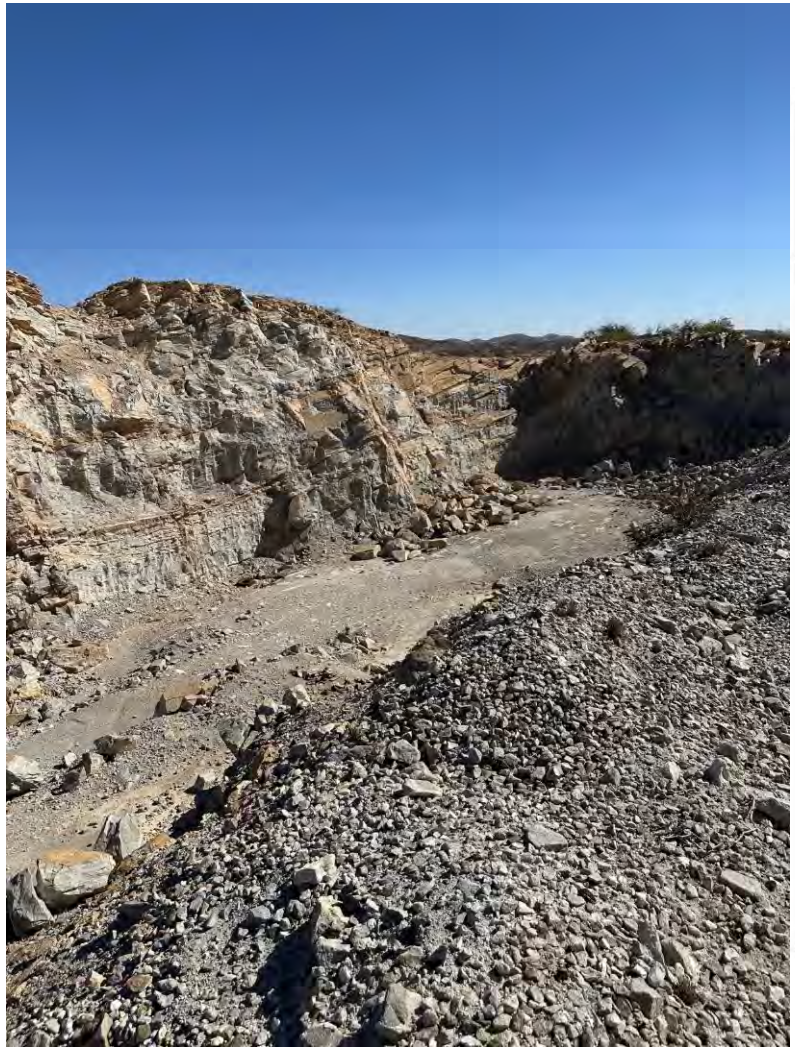

PHOTO	INSTALLATION and DESCRPTION
	OP1 – open pit with steep side walls which are highly fractured and jointed. Unstable with failure evident on the wall

Usakos Tourmaline Mine – Process Plant

P1 – cylindrical shaped pits, remnants of a processing plant. Add depth approximated by throwing stones

Usakos Tourmaline Mine - Buildings

P2 – building remnants of a refinery.

Usakos Tourmaline Mine – Waste Rock and Tailings

LW1 – vegetated fine grained tailing dumps, covered with waste rocks.

LW3 – vegetated heaps of dry tailing dumps close to a river.

Usakos Tourmaline Mine - Namibia

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IGF Remining Tailings Project - Survey

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