ANGLO AMERICAN
Safety, Health & Environment Bulletin
November 2007
Bulletin No 149/2007

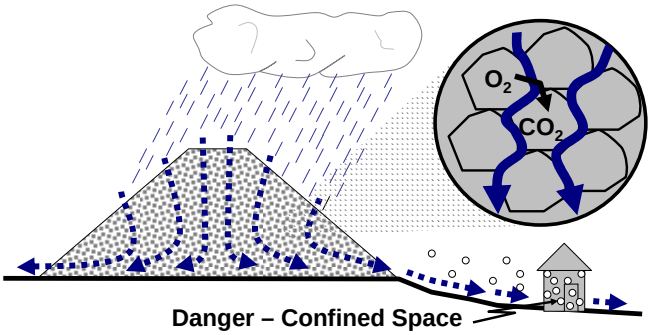
Dangers of Gas Emissions From Solid Waste Dumps

The air inside waste rock dumps can be deprived of oxygen and confined spaces downstream of these dumps may become filled with this air and toxic gases.

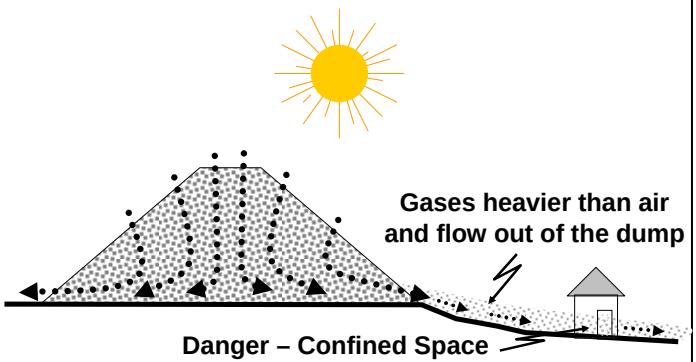
People have died when they have unknowingly been exposed to gases from a waste rock dump in a monitoring station.

WHAT TECHNICAL MANAGERS NEED TO KNOW

- Chemical reactions in rock dumps can consume oxygen, reducing the oxygen levels inside the dump and producing toxic gases.
- The oxygen-deprived air and toxic gases dissolve in water.
- Water seepage through rock dumps transports chemicals and gas to areas downstream.



- Seasonal movement of air through the dump can also force heavy gases out of the dump.
- **These gases could layer and fill confined spaces and low lying areas downstream.**



- Rock taken from underground during mining operations can become reactive when placed in rock dumps on surface.
- The potential for the development of oxygen deprived air and toxic gases inside rock dumps should be considered.
- Potential confined spaces such as buildings, holes, etc. downstream of rock dumps should be identified.
- Dump operators should be made aware of the dangers and of the circumstances where gas may be emitted from rock dumps.

Read on for the full story

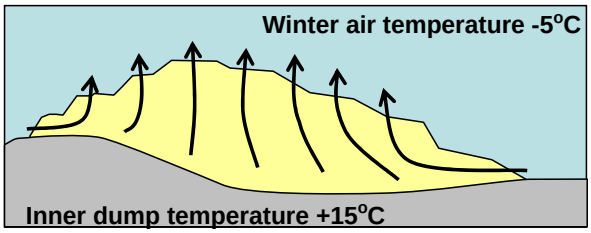
1. BACKGROUND

Four people died at a waste rock dump at a mine in British Columbia, Canada in May 2006. The deaths were due to asphyxiation of personnel monitoring seepage water qualities in an enclosed monitoring station located at the toe of the dump. Seepage water collected within the dump was led via a 325mm diameter pipeline through the building from where it connected to a water treatment facility. Asphyxiation was due to a build up of CO_2 gas and oxygen depleted air which developed within the dump and fed into the enclosed monitoring station via the pipeline.

A subsequent technical investigation was carried out into the cause of the incident by Teck Cominco. Operations are asked to assess the potential for these factors to be associated with rock/waste dumps and to use the information given here to develop appropriate safe work procedures.

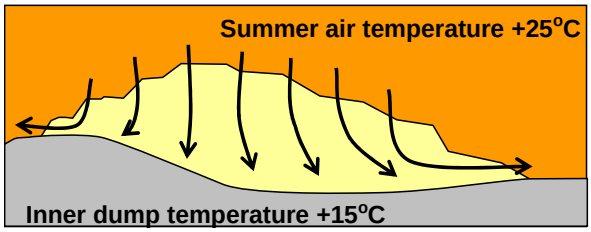
2. FUNDAMENTALS OF AIR FLOW IN WASTE DUMPS.

Most of the rock in mine waste dumps comes from well below the earth's surface and can contain components that are chemically unstable in other environments. Specifically sulphides are reactive when brought to surface and exposed to water and air. The reaction consumes oxygen and when airflow is restricted oxygen depletion can result. The reaction between sulphides and oxygen also leads to the release of acidity and metals that can contaminate water that passes through the dump. There is a secondary set of reactions that can also change the composition of air within a waste rock dump. The acidity can react with carbonates and results in the production of carbon dioxide gas.



In winter, relatively warm air within the dump is lighter than the colder outside air, so it tends to rise up and out of the dump, pulling more air into the dump base

The movement of air into and out of waste rock dumps is essentially driven by changes in temperature, barometric pressure or gas composition. Within a rock dump there are many sources of heat. The sulphide oxidation reactions, e.g. can generate significant amounts of heat and when heated, air within the dump rises upwards and outwards. Air from the surroundings is then drawn into the base of the dump. It is also possible for dumps with less sulphide materials to be cooler that the surrounding air which results in air flow out of the base of the dump.



In summer, relatively cool air within the dump is heavier than the warmer outside air, so it tends to sink and flow out of the base of the dump, pulling more air in through the dump surface

The investigations showed that air flow due to variations in barometric pressure were less likely to affect air flows within the dump than temperature effects.

Changes in air composition were also found to cause air movement in waste rock piles. For instance, when oxygen which is one of the heavier components of air is depleted by sulphide reaction, the air becomes lighter and tends to move upwards and out of the dump. Carbon dioxide is heavier than air and its formation results in CO_2 laden air to sink downwards which is why the highest concentrations of carbon dioxide are often found near the base of waste rock dumps.

The investigation also showed that soil covers on dumps restrict the air flow movement causing prolonged response to barometric and temperature changes.

3. CAUSES OF THE MAY 2006 INCIDENT.

Analysis of the dump material showed the presence of both sulphide and carbonate minerals. Carbonate materials were also found in the dump cover material. This indicated a potential to consume oxygen and produce carbon dioxide which was confirmed in analyses of air samples extracted from the dump. Temperature measurements also revealed that there was a potential for temperature driven air flow both into and out of the dump depending on ambient weather conditions. Air samples taken in May 2006 within the monitoring station indicate that the air was depleted of oxygen and contained carbon dioxide (measured 2% O_2 and 7% CO_2 compared to 21% O_2 and 0.03% CO_2 typically in normal air).

Also, there are physical attributes at the dump which cause the air to flow towards the monitoring station, namely the dump location on a slope with the monitoring station located at a low point and the drainage system under the dump toe used to collect seepage and direct it to the monitoring station. However, the toe drain was covered by the 1metre thick soil capping hence causing air, as well as water to flow to the lowest point. It was also noted that the saturated state of the soil cover at the time would further restrict air flow and cause it to funnel along the toe drain to the monitoring station.

4. POTENTIAL HAZARDS AND RECOMMENDATION

Based on the findings of the technical investigation, the presence of any of the following should be considered to significantly raise the risk level of hazards associated with waste dump air:-

- Sulphide materials in waste rock which can deplete oxygen from the air.
- Any combination of sulphide minerals and carbonate minerals, which can lead to the production of carbon dioxide.
- Air temperatures that are higher than temperatures within waste dumps, which can lead to temperature driven outflows of air at the toe of dump.
- Sharp drops in barometric pressure, which can lead to pressure driven outflows of dump air.
- Any factor that serves to concentrate or confine dump air outflows, including soil covers, toe drains and water sampling pipes, but also including coarse rock channels formed during dumping, finer rock layers formed by traffic or re-grading and localised excavations into the toe of the dump.
- Any factor that serves to limit the mixing of out-flowing gases with the surrounding air, including monitoring stations and also any other walls or berms, heavy vegetation, local ground depressions, localised barometric inversions or similar weather conditions that cause pockets of air to accumulate in depressions.

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