Reactive Ground & Explosives

Paul White
Senior Inspector of Explosives
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North West Queensland
Mineral Province
Karumba
Westmoreland Uranium
Walford Creek Copper Lead Zinc Silver
Gold Silver Zinc Lead Croydon
Constance Range Iron
CENTURY Zinc Lead Silver
Gold Agate Creek
Paradise North Phosphate
Mount Oddie Copper
D-Tree Phosphate
Paradise South Phosphate
MOUNT GORDON Copper
LADY LORETTA Lead Zinc Silver
LADYANNE Copper
Leichhardt Copper
Rossby Copper Gold
Lead Zinc Silver Dugald River
ERNEST HENRY Copper Gold Magnetite
E1 Camp Copper Gold Magnetite
Uranium Valhalla
Barbara Copper
Julia Creek Vanadium Oil shale
Silica Spring Creek
MOUNT ISA/ENTERPRISE/
Monakoff
Ukwala Vanadium Molybdenum
Lead Silver GEORGE FISHER
BLACKSTAR Copper Lead Zinc
Copper Gold Magnetite
Zinc Mount Isa
Silver Gallium
Lorena Gold
Gypsum HUGHENDEN
Hughenden
Rare earths Mary Kathleen
Rocklands Copper
Rare earths Copper Gold Ebenezer
GREAT AUSTRALIA Copper
ELOISE Copper
Kalman
MOUNT NORMA Copper
Copper Molybdenum Rhenium Gold
Greenmount/Mount McCabe Copper
Rare earths Copper Mila
Kuridala/Hampden Copper Gold
Mount Dore Copper
Copper Gold Mount Elliott/Swan
MERLIN Molybdenum Rhenium
Phosphate Ardmore
KYNUNA Opal
Pegmont Lead Zinc
Phosphate PHOSPHATE HILL
CANNINGTON Silver Lead Zinc
Phosphate Rare earths Korella
Starra Line Copper Gold
OSBORNE Copper Gold
Winton
Gypsum CORK
Gypsum MAYNE RIVER
Gypsum EDEN VALLEY
OPALTON
Opal
Longreach
Moomba Sid Gas Pipeline
Metals
MINE (including under construction)
Ceased production / care and maintenance
Resource
Industrial minerals and rocks
MINE (including under construction)
Ceased production / care and maintenance
Resource
Gemstones MINE
Pipeline Gas
Export Port Mineral
Mount Isa Population centre
Railway
Mesozoic and Cenozoic basins
Early Palaeozoic Georgina Basin
Middle Proterozoic fold belts
Queensland Government
Prepared by Spatial & Graphic Services, Geological Survey of Queensland
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Topics for discussion

- Definition of reactive ground
- Indicators of reactive ground
- Known incidents
- Case study
- Sampling and testing for potential reactive ground conditions
- Management of reactive ground conditions

Definition of Reactive Ground

- ground that undergoes a spontaneous exothermic reaction after it comes into contact with nitrates
- the reaction involves the chemical oxidisation of sulphides (usually of iron or copper) by nitrates and the liberation of potentially large amounts of heat
- temperature rise can be as little as 2 degrees C or as much as several hundred degrees C
- the processes are unpredictable and can be so violent that it results in premature or unplanned initiation of explosives

Definition of Reactivity

- the induction time for the sulphide/nitrate reaction in a constant temperature situation (a short induction time indicates a higher level of reactivity or;
- the onset temperature for the sulphide/nitrate exotherm in a temperature ramping situation (i.e. a lower onset temperature indicates a higher level of reactivity).

Indicators of Reactive Ground

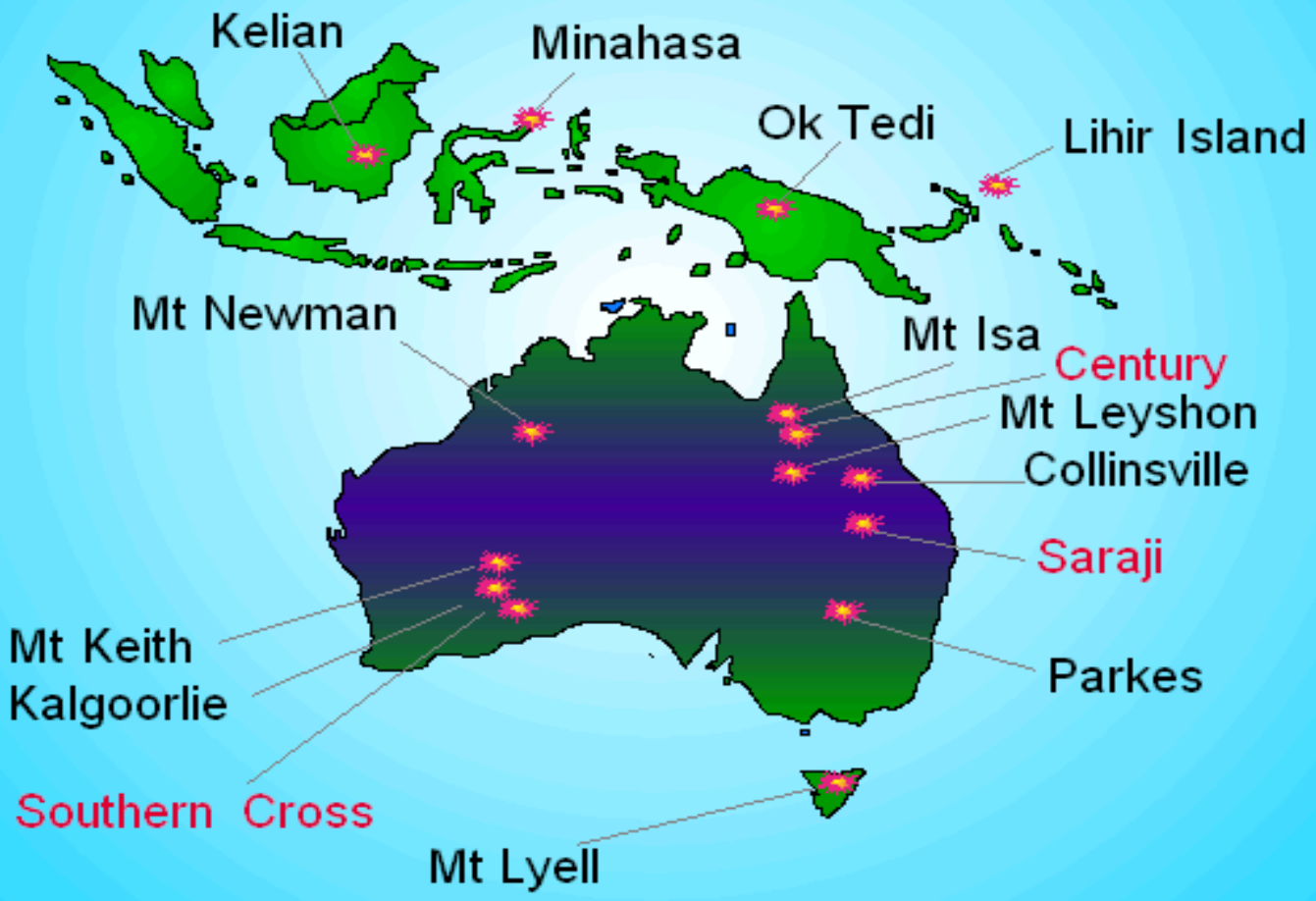
- the presence of sulphides (usually of iron or copper)
- acidic conditions (generally resulting from oxidation) which may be indicated by the colour of run off water, usually yellow-red brown in colour
- significant corrosion of rock bolts, safety meshing and fixed equipment associated with the mining operation
- the spontaneous combustion of overburden or waste rock/ore either in dumps or in the pit, especially as it is exposed to the air
- the acrid smell of sulphur dioxide caused by the naturally occurring sulphide oxidation reaction
- elevated blast hole temperatures
- elevated ground temperatures
- If any of these indicators are found then a detailed risk assessment of the use of explosives at the site shall be carried out.

Some Known Incidents

Mt Isa	**1960's- holes in the 500 ore-body became incandescent on contact with ANFO**
BHP Newman	**1983- A hole loaded with ANFO detonated while crew still on bench**
BHP Newman	**1987 – A lined hole loaded with ANFO detonated when liner split**
Mt. Lyell	**1989 – Emulsion detonated within 10 hours of loading**
Mt Leyshon	**1992 – Emulsion which had been sleeping for 3 months detonated**
Collinsville Coal	**1995 – Holes containing emulsion caught fire**
Century	**1998 – AN spilt on ground started burning after shot had been fired**
Collinsville	**1998 – A hole loaded with Sawdust/ANFO detonated**
Parkes	**2000 – Spillage caught on fire**
Collinsville	**2003 – Holes smoking**
Black Star Mine	**2005 – Unplanned initiation of 6 blast holes**
Mount Gordon	**2008 – Unplanned initiation of 3 blast holes – Deflagration of ANFO**
Lady Loretta Mine NWQ	**2018 – 3 blast holes began smoking during charge up of development heading**

Many other occurrences around the world and there have been several fatalities (More examples in AEISG Code)

Prevalence


Kelian
Minahasa
Ok Tedi
Lihir Island
Mt Newman
Mt Isa
Century
Mt Leyshon
Collinsville
Saraji
Mt Keith
Kalgoorlie
Parkes
Southern Cross
Mt Lyell

Case study

- Unplanned detonation of 6 blasts holes at North Queensland open pit mine
- Medium to large scale Lead/Zinc Mine
- Mine had known hot ground conditions but initial tests showed negative results for reactive ground at 55C for 2 hours (Post incident tests identified reactions at higher temperatures)
- Mining through historical underground workings with known and unknown voids present
- Charging shot with ANMO prill (Ammonium Nitrate/Mineral oil mixture) Pour loaded from 20 kilogram bags. Average of 50kg per hole. Non-electric detonators and 400gm boosters
- A number of holes had registered temperatures of between 58 & 62 degrees 2 days prior to the incident. These temperatures were above the recommended temperatures for the inhibited emulsion being used and a decision was made to use ANMO which had a higher temperature rating. But still limited to the initiating explosives recommended temperature of 70 degrees.

Reactive ground incident NW Queensland

Post incident sampling and screening

- Samples were initially tested at 55C for 2 hours and some of the samples showed signs of frothing and becoming very fluid
- Samples then tested at 100C for 2 hours. 4 of these samples tested slightly reactive over 80C while one sample tested highly reactive
- Samples were then tested to 110C for 10 hours. Some samples showed signs of mild frothing and one sample tested highly reactive and reached a temperature of 180C
- Mine continued to conduct screening at 105C for 10 hours.

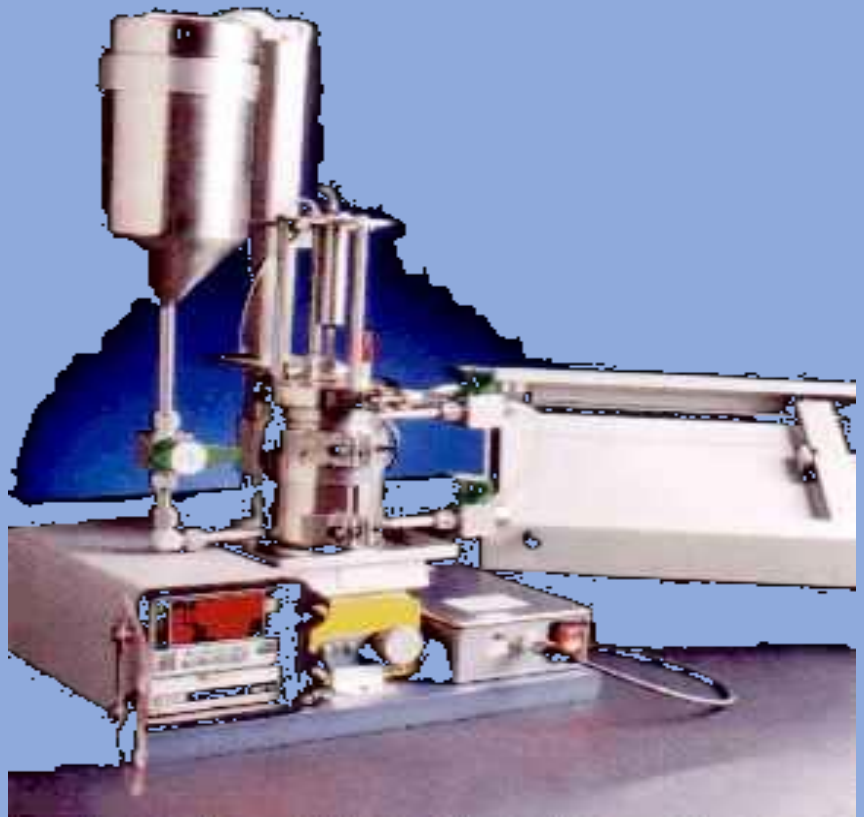
Sampling for reactivity screening

- best samples are picked from a wall or drill core samples are most useful for screening purposes (not from floors or drill cuttings)
- cannot rely on core sample tests alone
- best sample size is minimum of 0.5kg up to 1.0kg (fist size)
- records kept of sample identification, collection points and date of collection
- stored in sealed plastic bags which are robust enough to prevent mixing of samples.

Reactivity Screening

Reactivity screening is laboratory testing to determine if the site samples react with ammonium nitrate and consequently have the potential to react with ammonium nitrate based explosives.

- rock samples are crushed to a fine powder
- rock powder mixed with chemically pure ammonium nitrate and a solution to simulate the by products of sulphide rock weathering
- mixture heated to and kept at 55C the adopted standard temperature and monitored for exothermic reactions



Principals for Reactive Ground Management

- Identify if there is a risk of PRG (testing, any previous history at site)
- Case histories indicate that in the past this type of condition has only been identified following an incident (AEISG)
- Develop a risk based management plan
- Train relevant personnel in associated hazards and emergency procedures
- Look for PRG identifiers (Geologists input – sulphide levels)
- Hole temperature monitoring
- Hole loading sequence (load hottest holes last)
- Limit sleep times - fire as soon as possible after loading
- Delineation of zones (reactive non reactive)
- Control any explosive spillages
- Product selection (choose explosives products suitable for conditions - consult supplier)
- The preferred approach to reactive ground management is to be as pro-active as possible.

Don’t rush into a task. (Bull Terrier Syndrome) Assess the risk and consider the potential consequences.

Questions