Case studies to ignite your understanding of combusting waste rock management and controls

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2020 BC MEND ML/ARD Workshop

Introduction

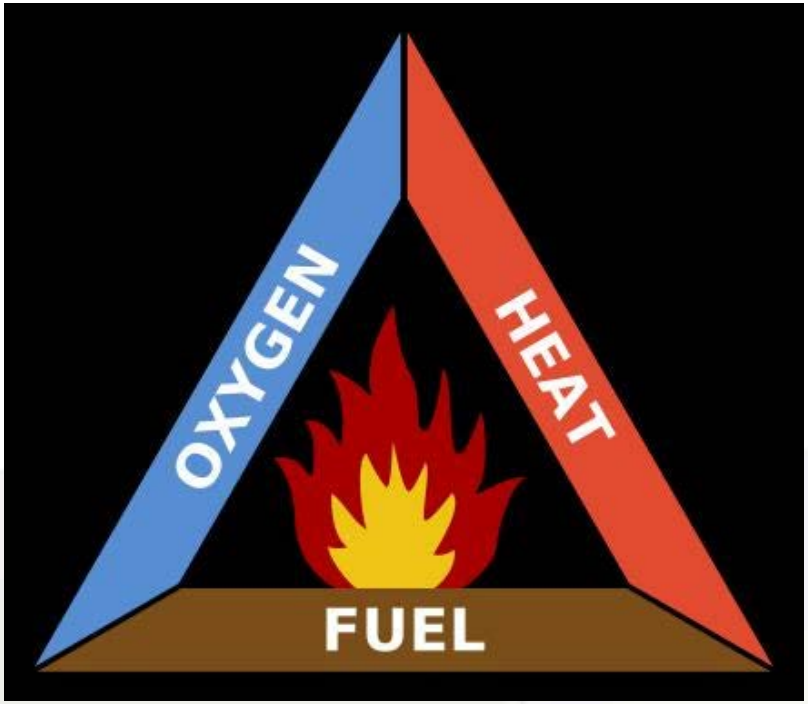
Three Case Studies

- Two mine sites with spontaneous combustion (Australia)
- One from Canada with combusting waste rock (not spontaneous)

- .....note the site specificity and range as to **why** combustion is an issue and **how it is managed**.....

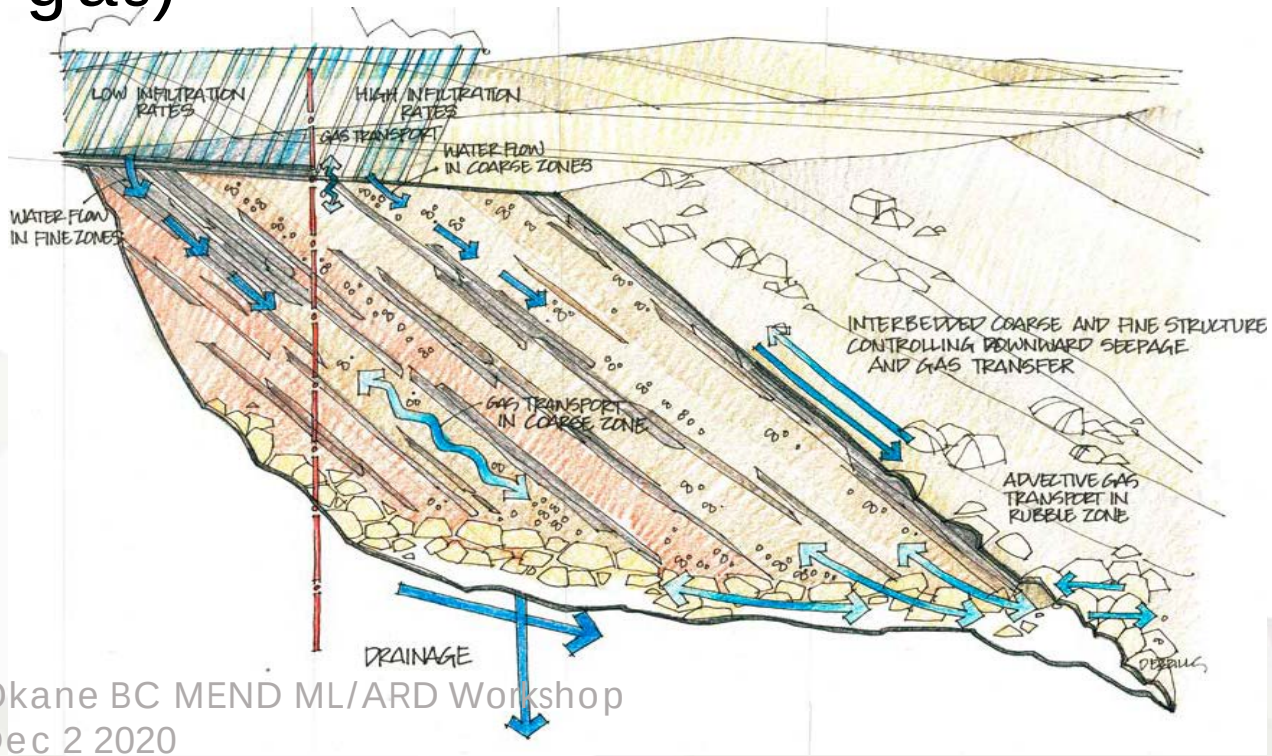
Introduction

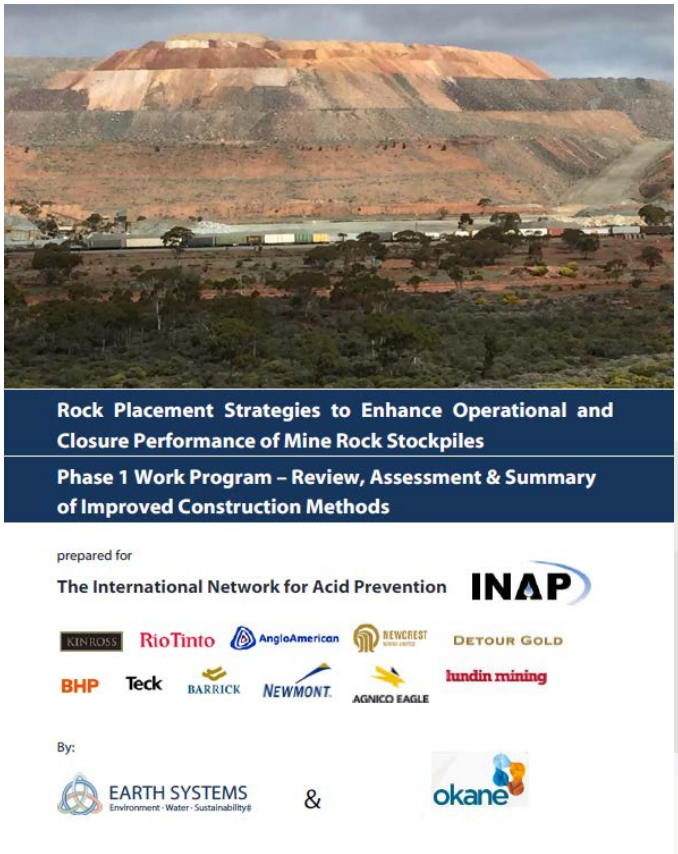
- Spontaneous combustion
  - ‘High’ reactive sulphide content and organic carbon content
- …..’good ole’ combustion
  - ‘High’ organic carbon concentration



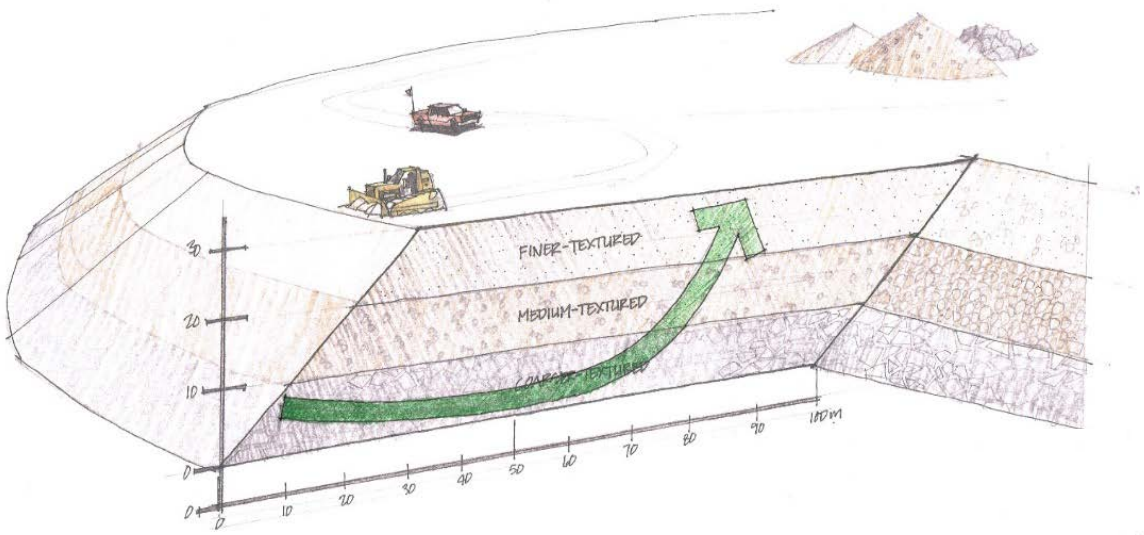
Introduction

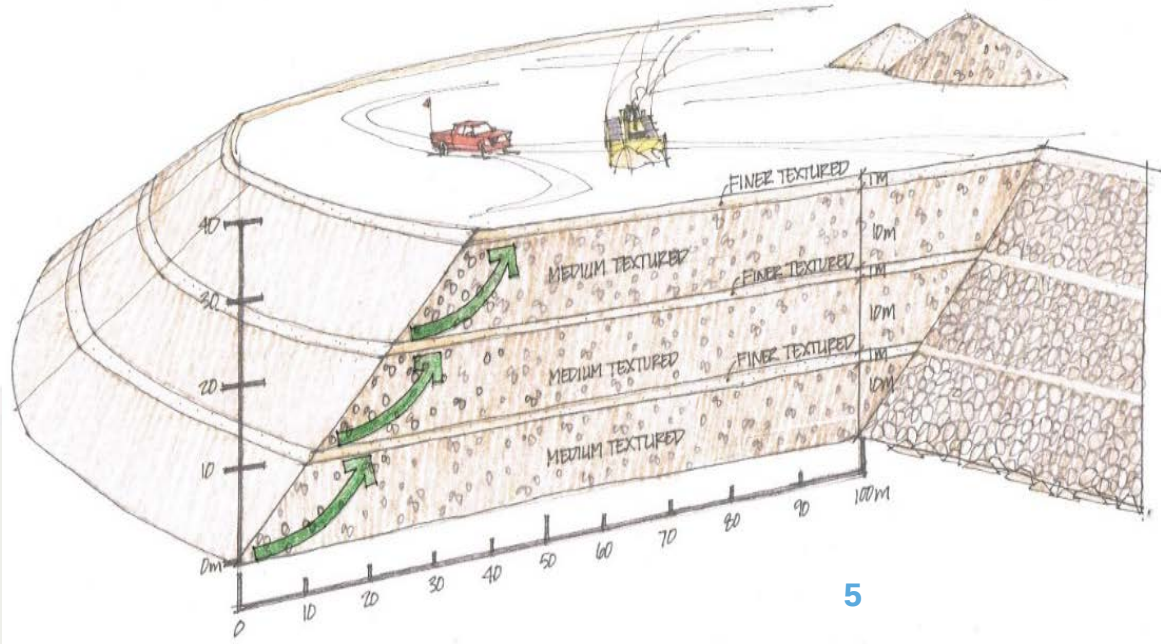
- Primary oxygen resupply mechanism in mine rock stockpiles (MRS) typically by convection (temperature induced flow of pore gas)





High vs Low Air Flow Capacity



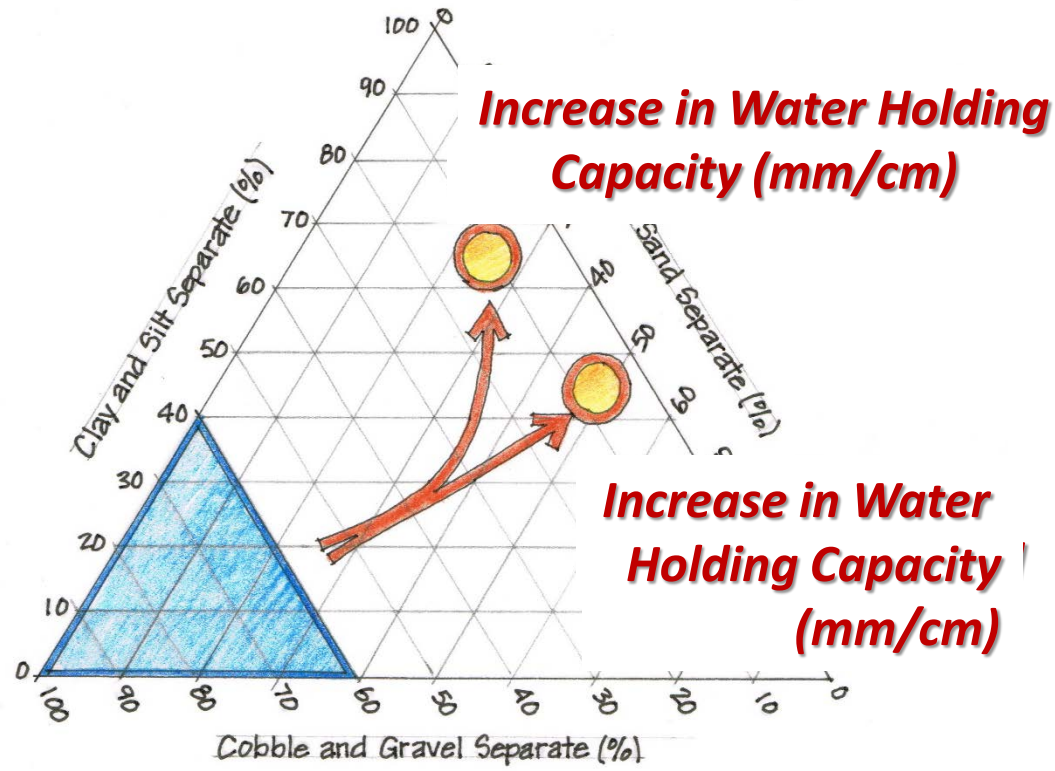


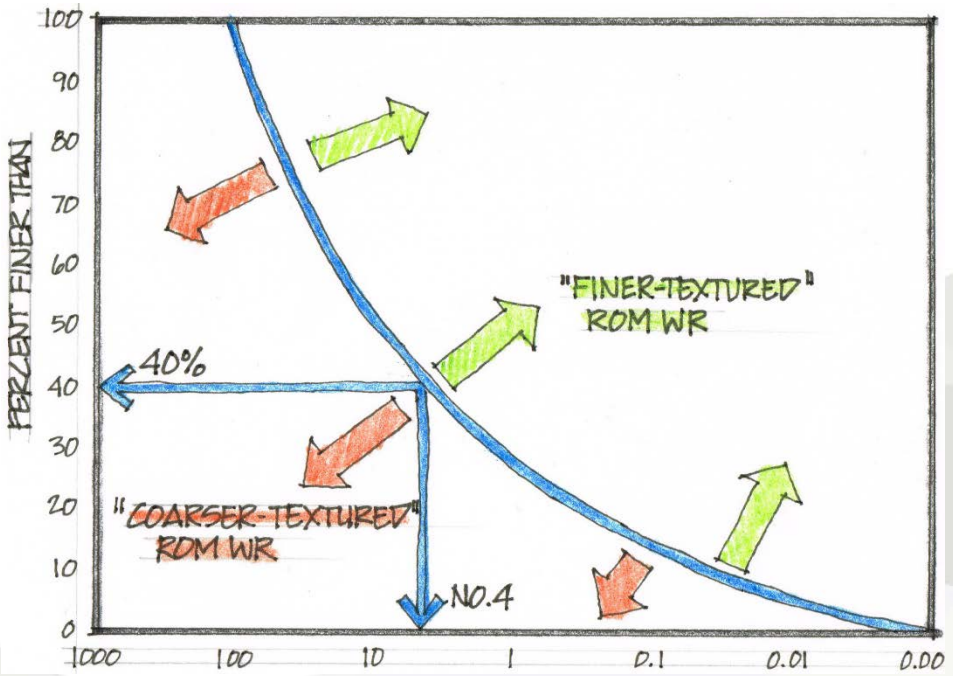
Finer- and Coarser-Textured Mine Rock

- ***Conceptualization… Finer-Textured Mine Rock***

vs.

Coarser-Textured Mine Rock





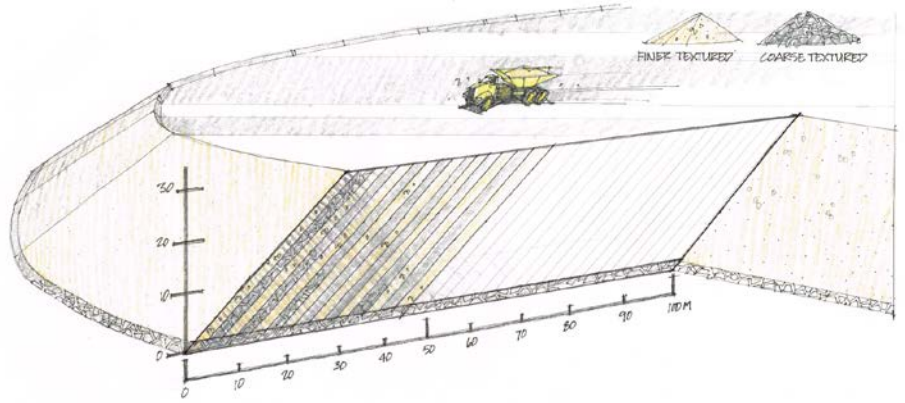
Case Study 1

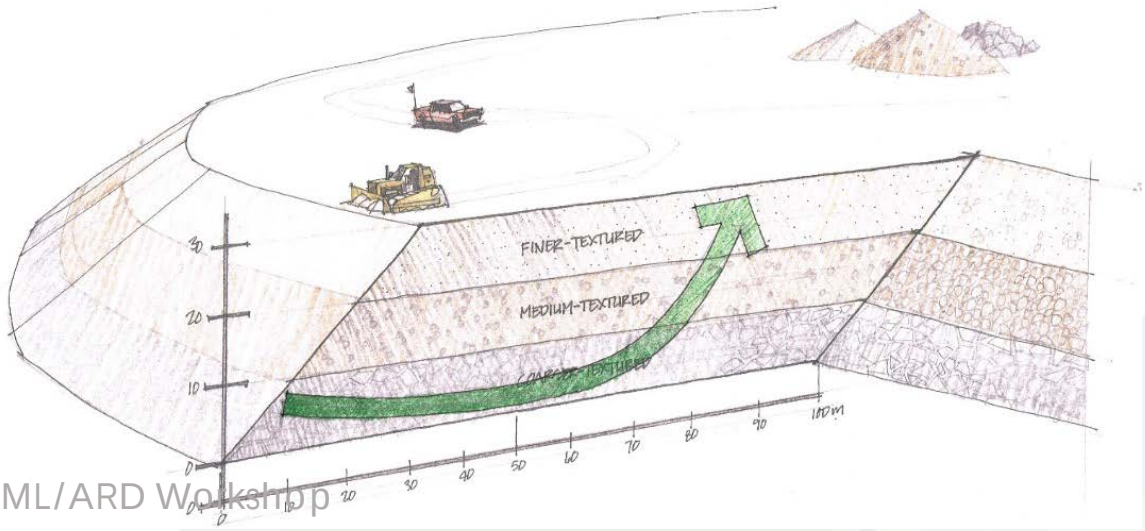
- High S, high C
- Reactive pyritic shale
- Original problem emerged with unintentional blast hole detonation

Spontaneous Combustion

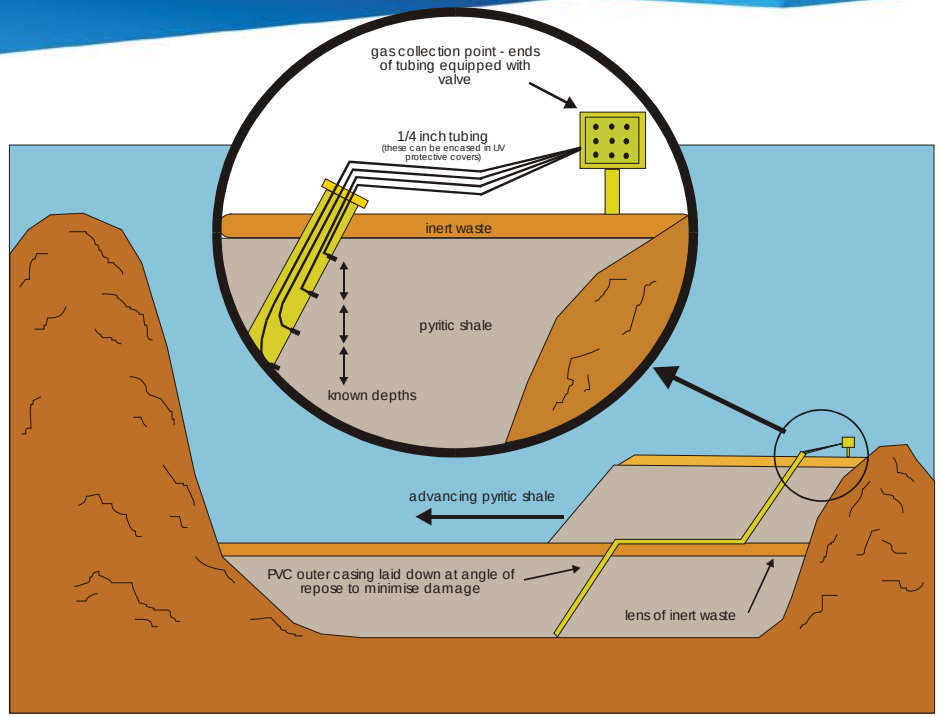
- Spontaneous combustion - ability to self heat with temperatures greater than 600^0C

MRS construction - pre 1995





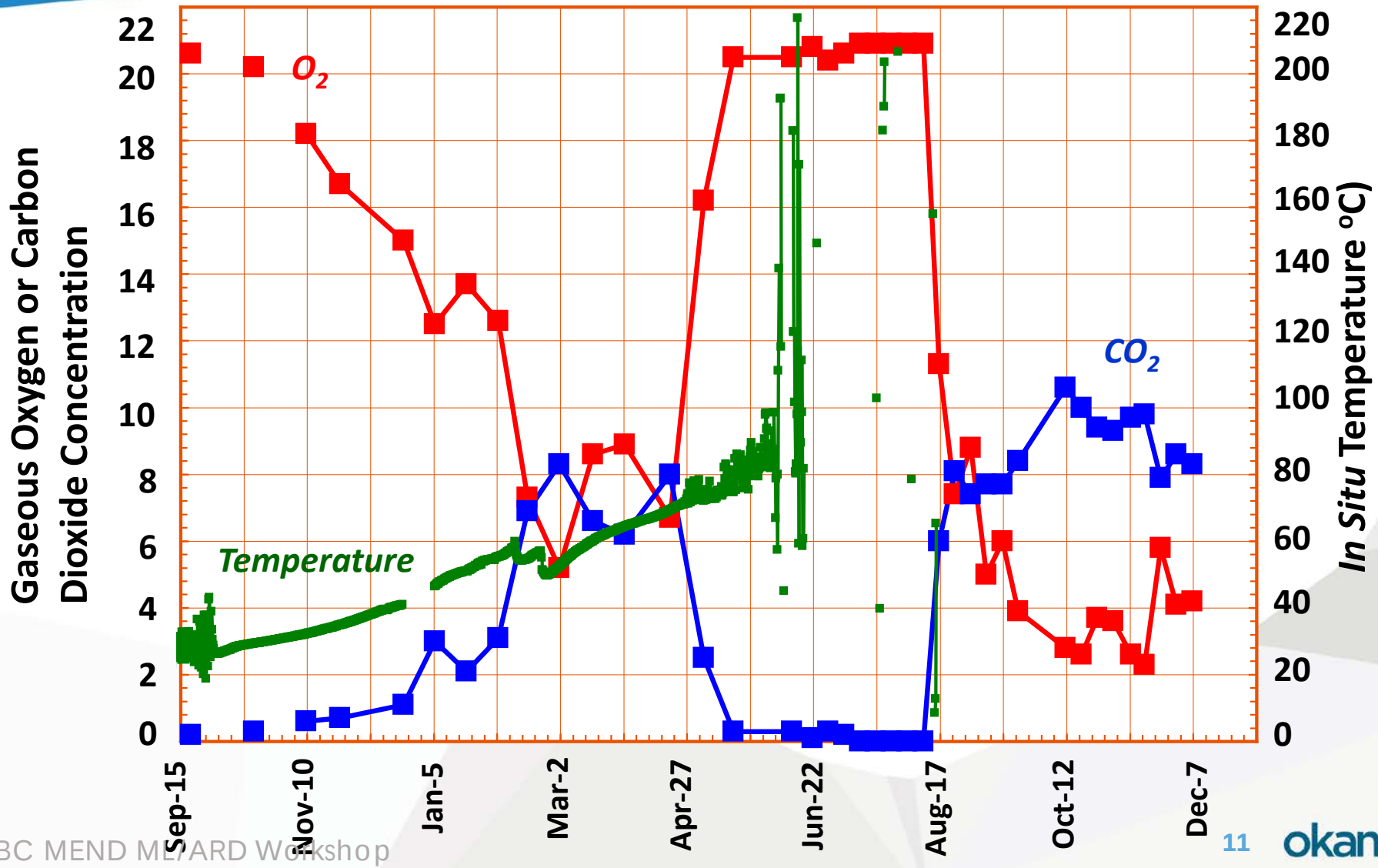
Internal MRS Dynamics – early 2000



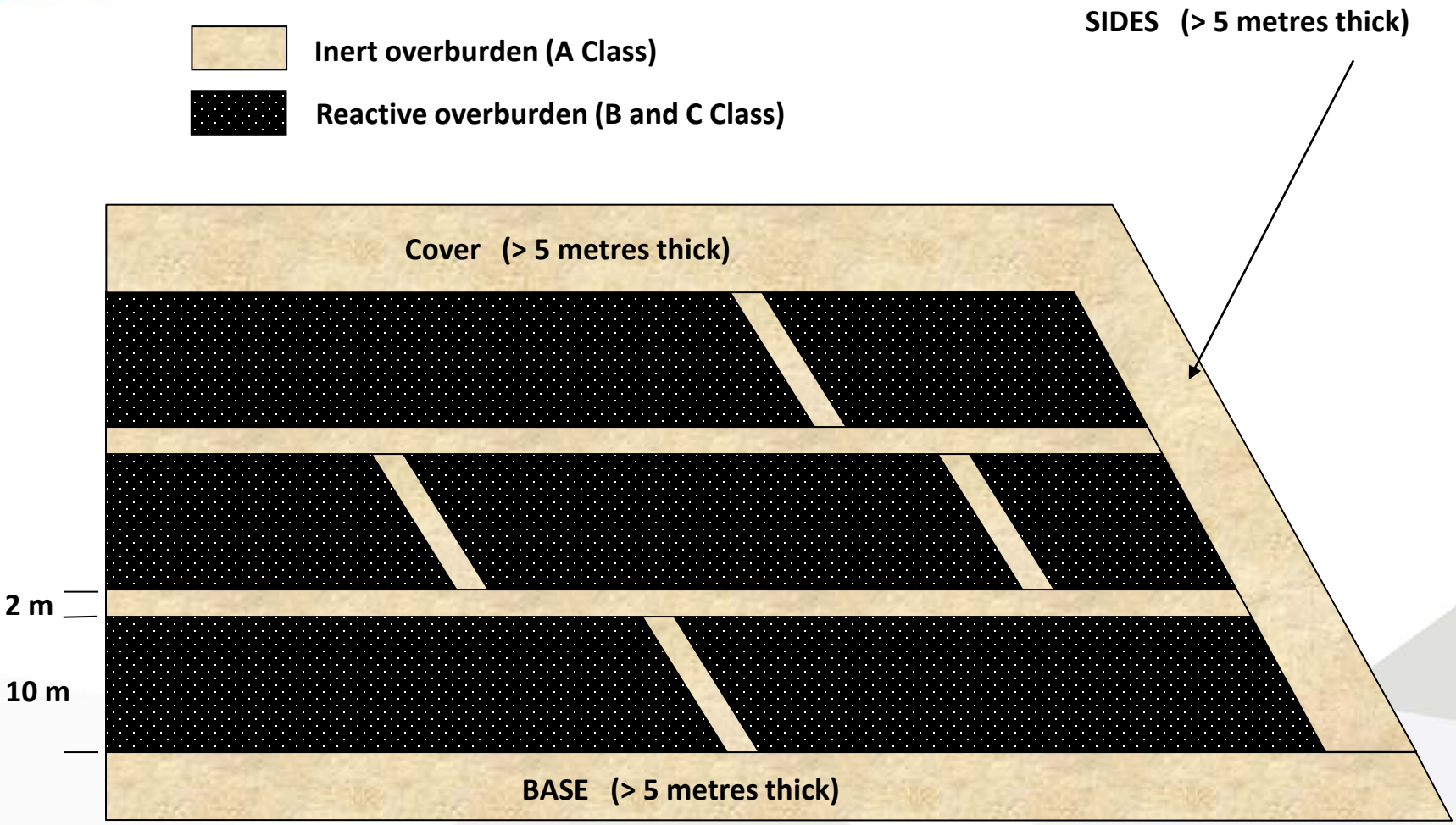
- **Capture / confirm essential data pre – spontaneous combustion**

- **Install instrumentation into a dump during construction**
- **Avoid post – installation problems**

Trial Data


Gaseous Oxygen or Carbon Dioxide Concentration
In Situ Temperature (°C)
O_2
CO_2
Temperature
0
2
4
6
8
10
12
14
16
18
20
22
0
20
40
60
80
100
120
140
160
180
200
220
Sep-15
Nov-10
Jan-5
Mar-2
Apr-27
Jun-22
Aug-17
Oct-12
Dec-7

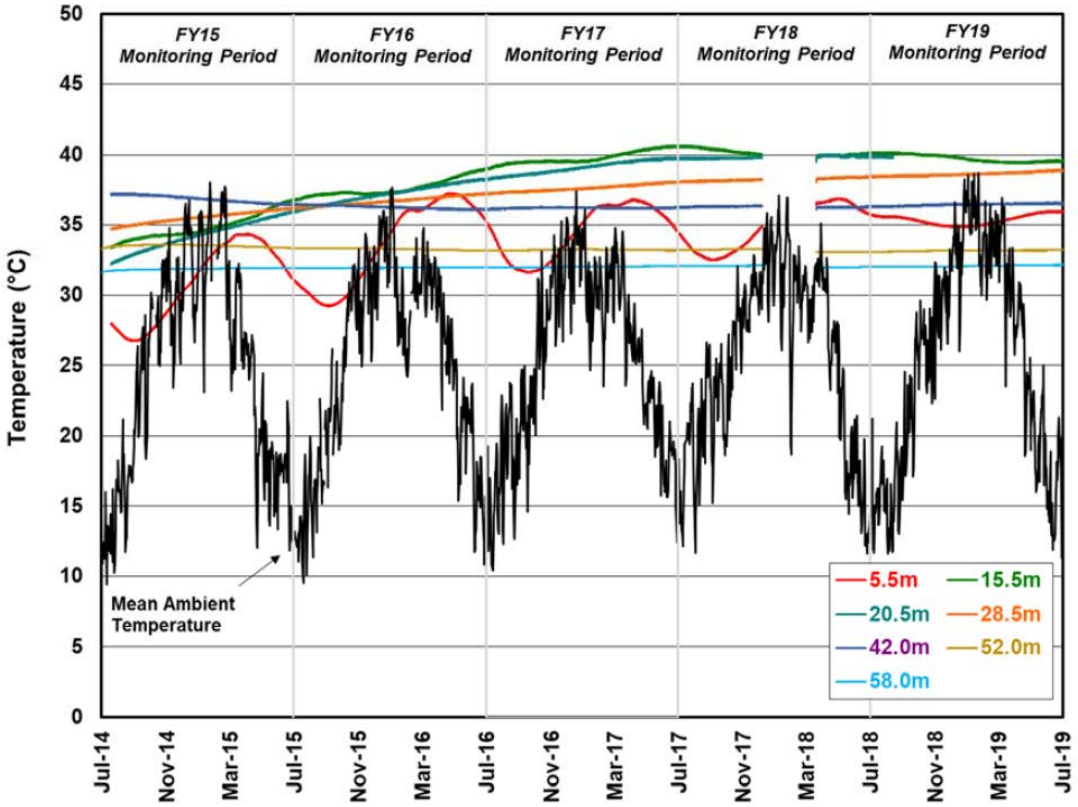
MRS Design to Limit Airflow

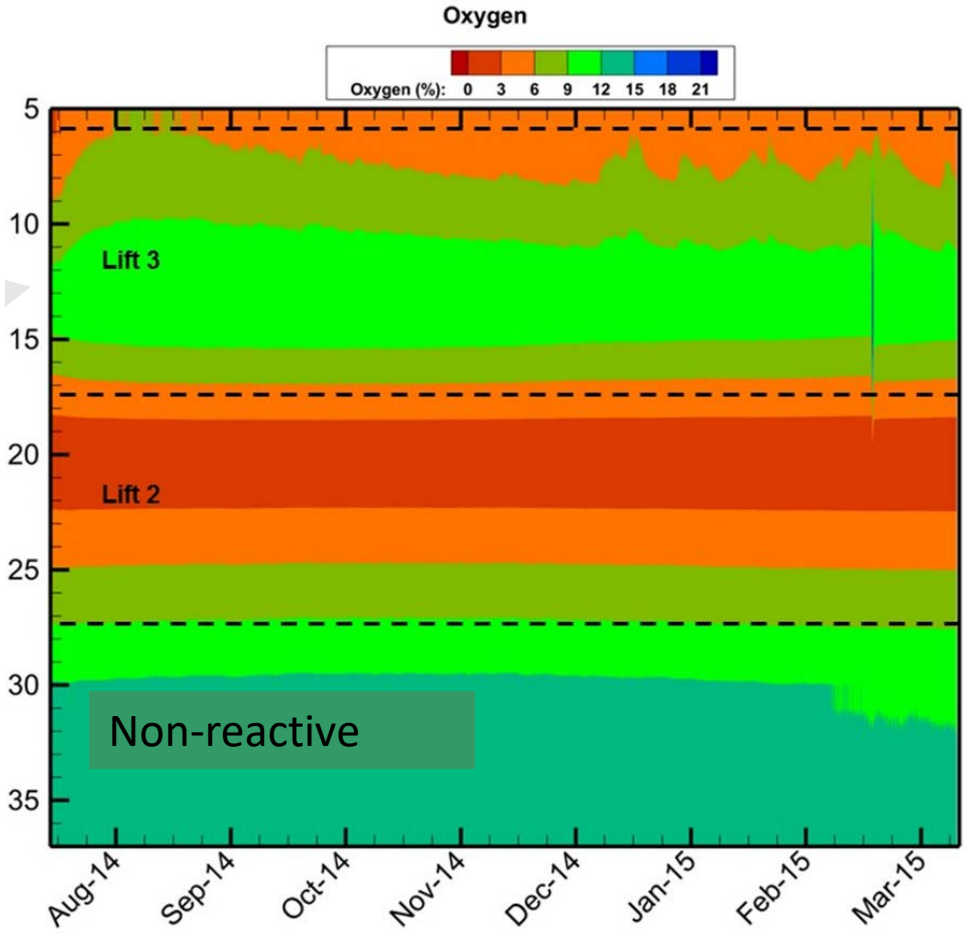


MRS Design to Limit Airflow

- Class B and C overburden ...10 m high lifts with 2 m paddock dumped layers.
- Class D overburden ... paddock dumped to allow to cool.

Limited airflow controlling temperature





Waste Rock Management strategy

Temperature risk

PAF Sulfur Content	Paddock Dumping	Co-Disposal 5 m Tip	Co-Disposal 10 m Tip	10:2 Layered PAF Co-Disposal	Co-Disposal 30 m Tip	Co-Disposal 10m Blocky NAF	Co-Disposal High Wall Tip
<1%							
1-3%							
3-5%							
5-10%							
10-18%							
>18%							

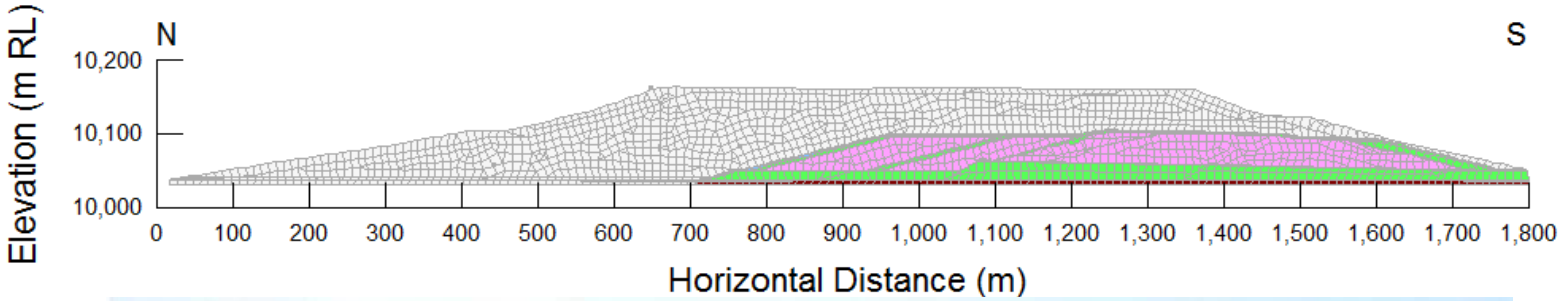
3-5% S only paddock dumping and 5m co-disposal appropriate*

<1% S all disposal methods appropriate*

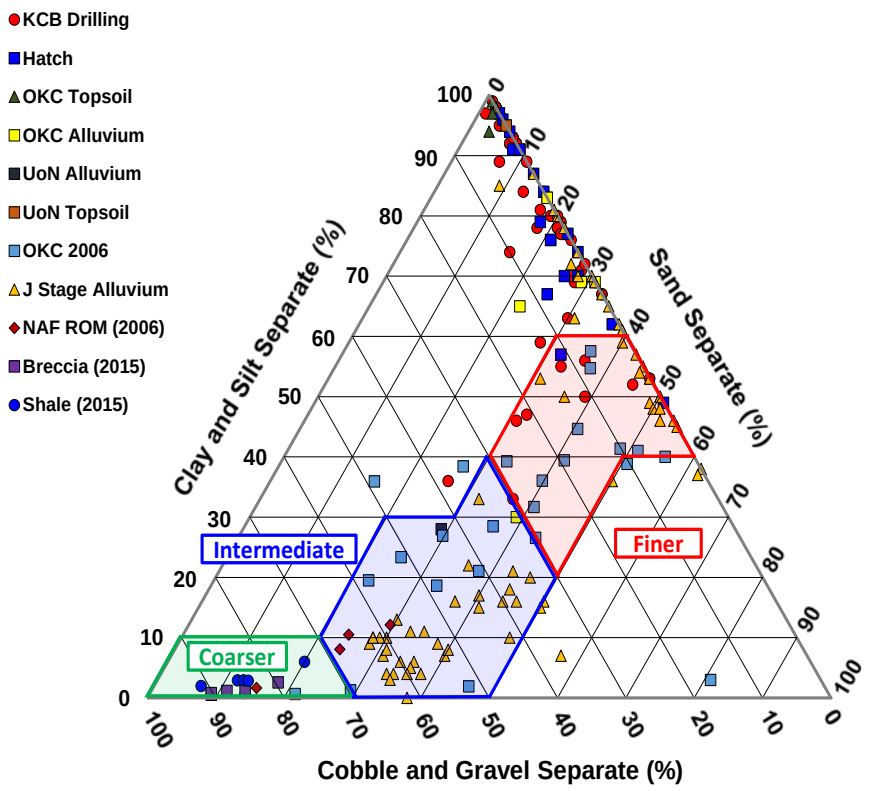
Case Study 2

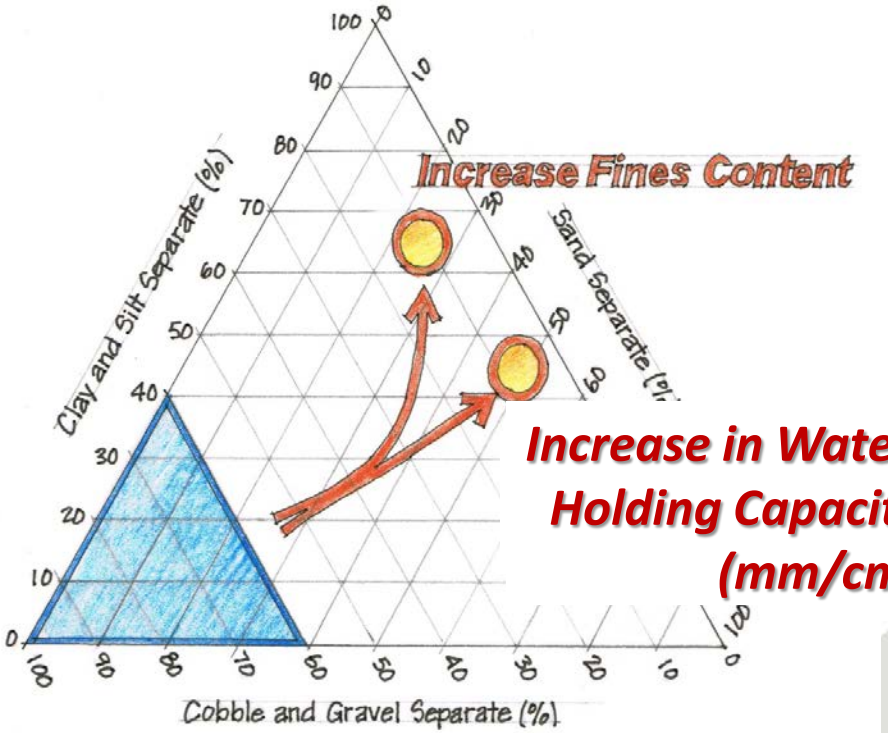
- Spontaneous combustion – pyritic shales
- High visibility of combustion severely affecting stakeholder perception

Case Study 2

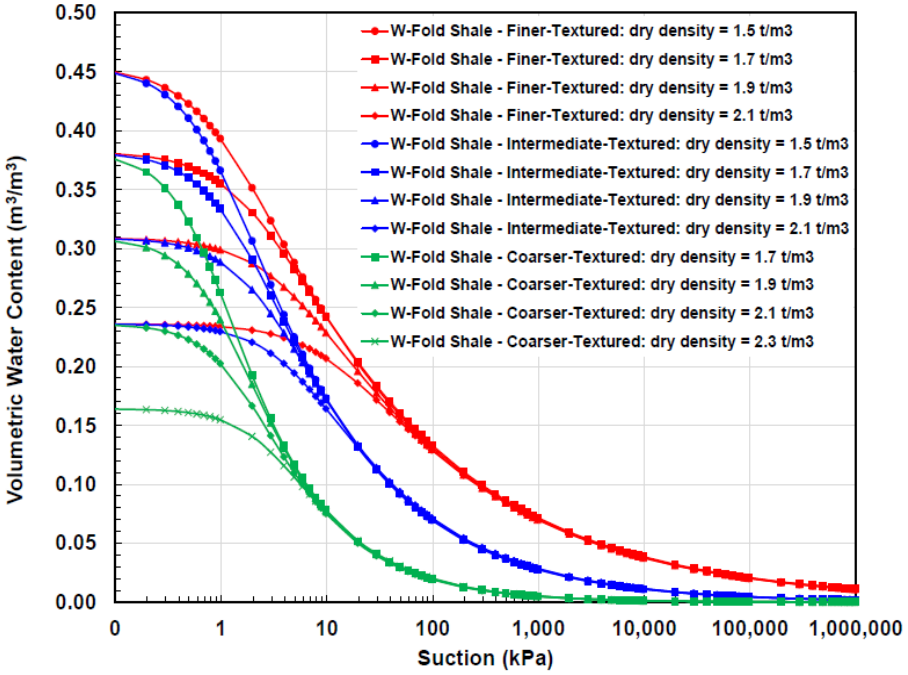

N
S
Elevation (m RL)
10,200
10,100
10,000
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
1,600
1,700
1,800
Horizontal Distance (m)

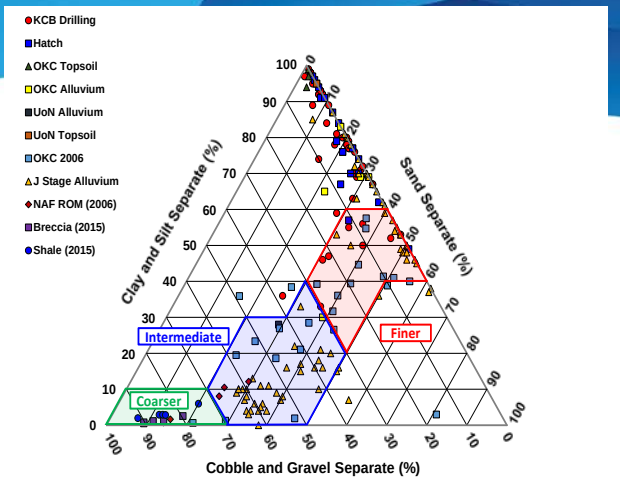
Detailed material characterization

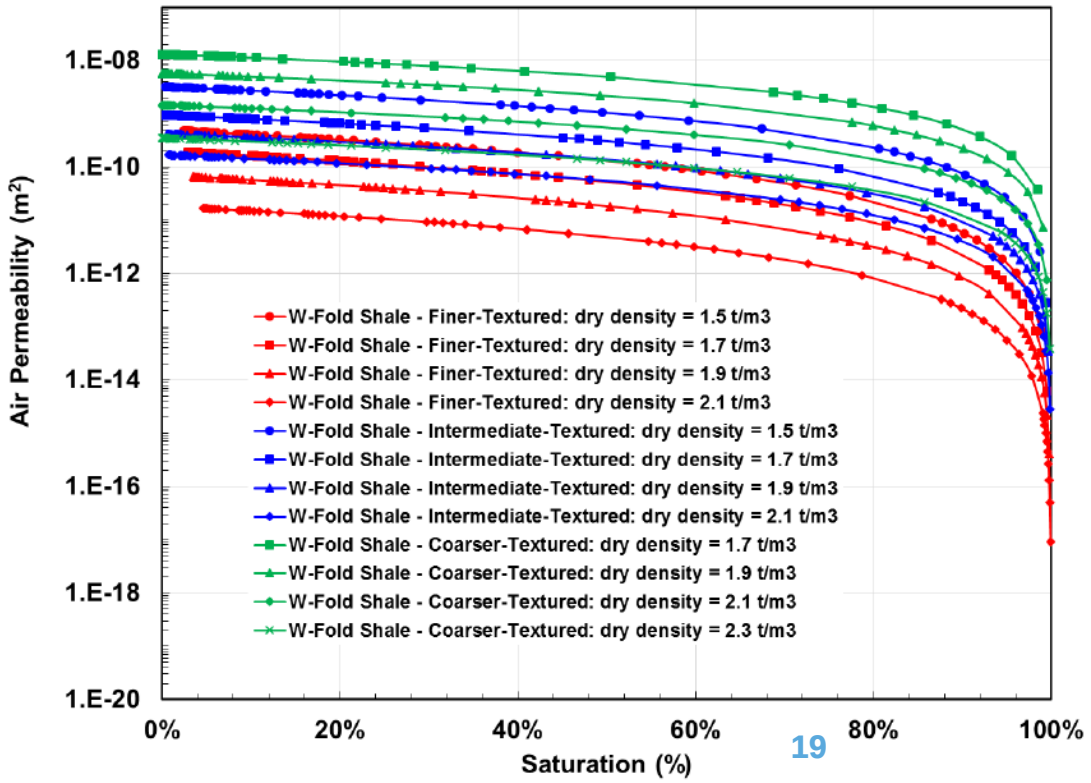




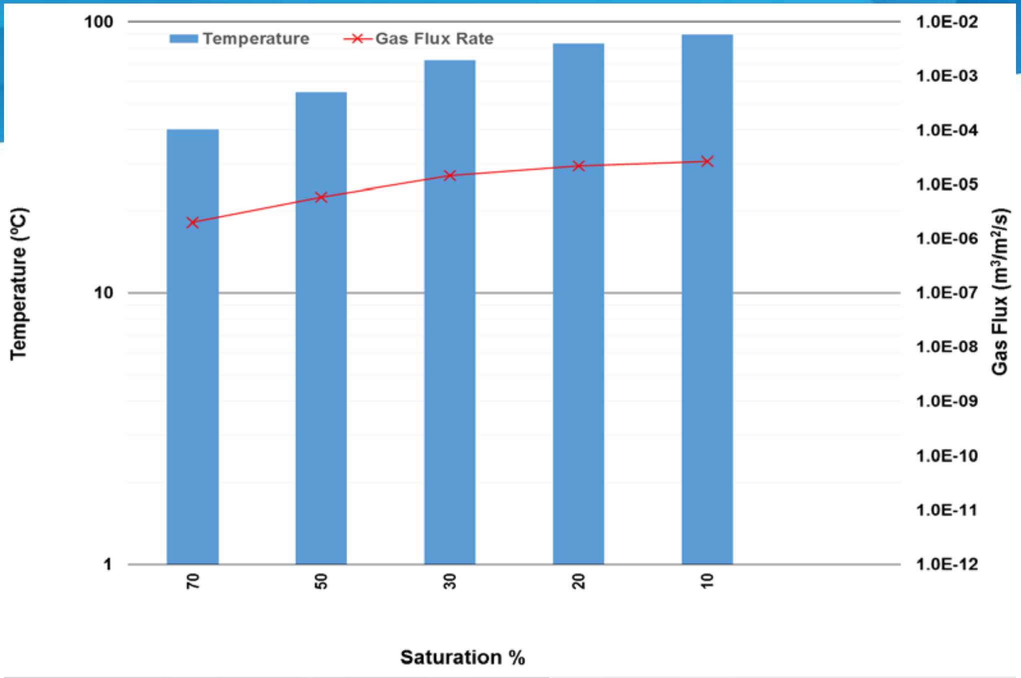
Detailed material characterization

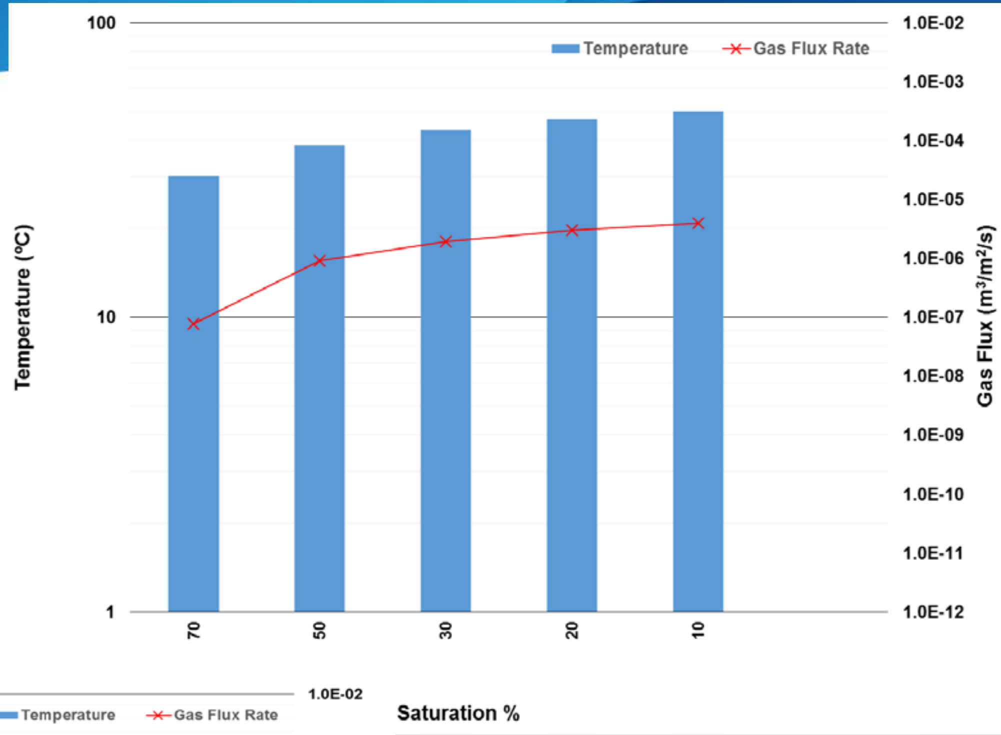


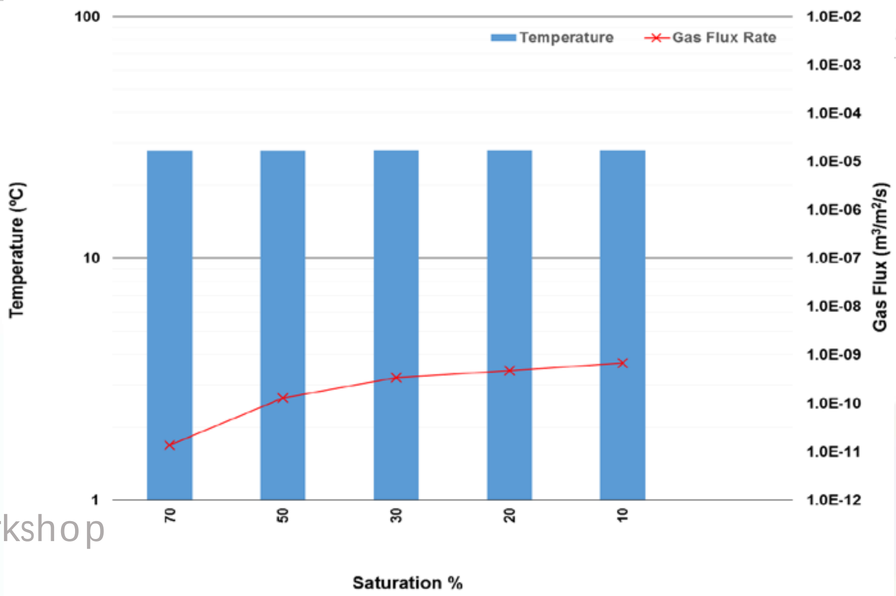




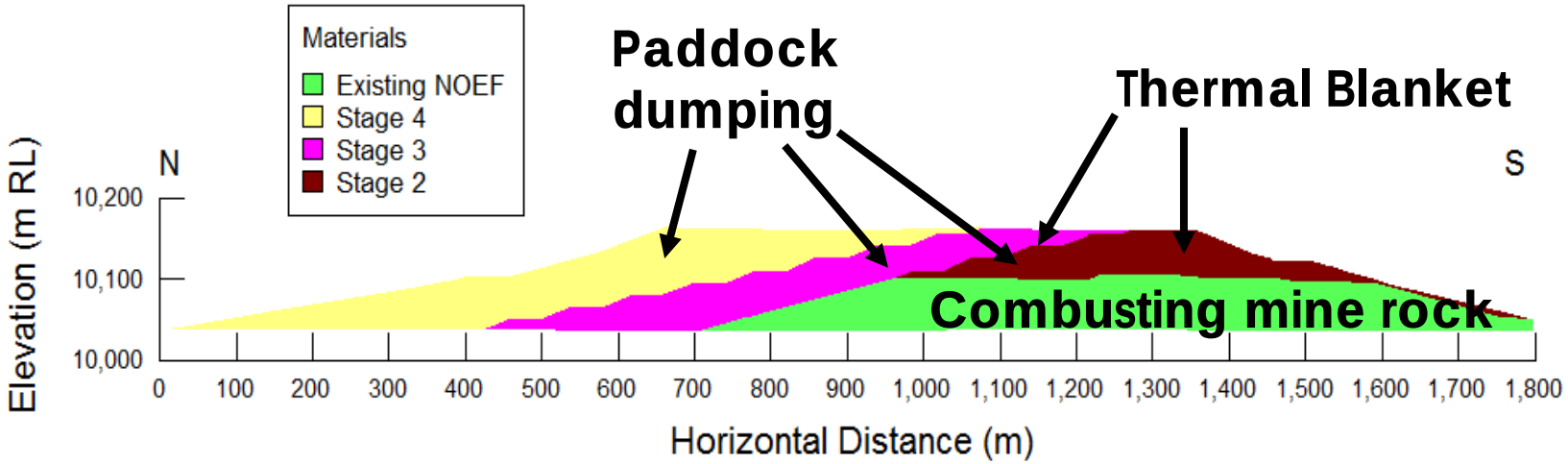
Modelling linking gas flux to temperature







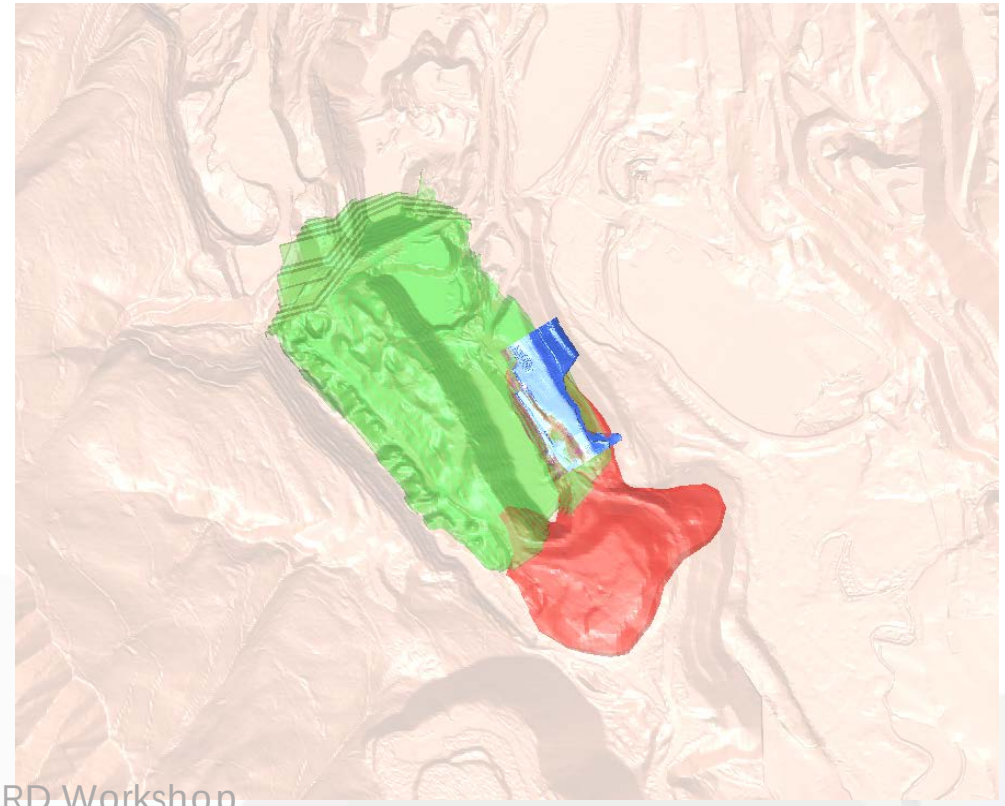
Case Study 2 Management Plan



- Detailed management plan developed for various stages of pit development
- Plan implementation and performance monitoring in progress

Case Study 3

- Removal of ~6.5MBCM of material within a combusting waste zone
- Low S, high organic carbon



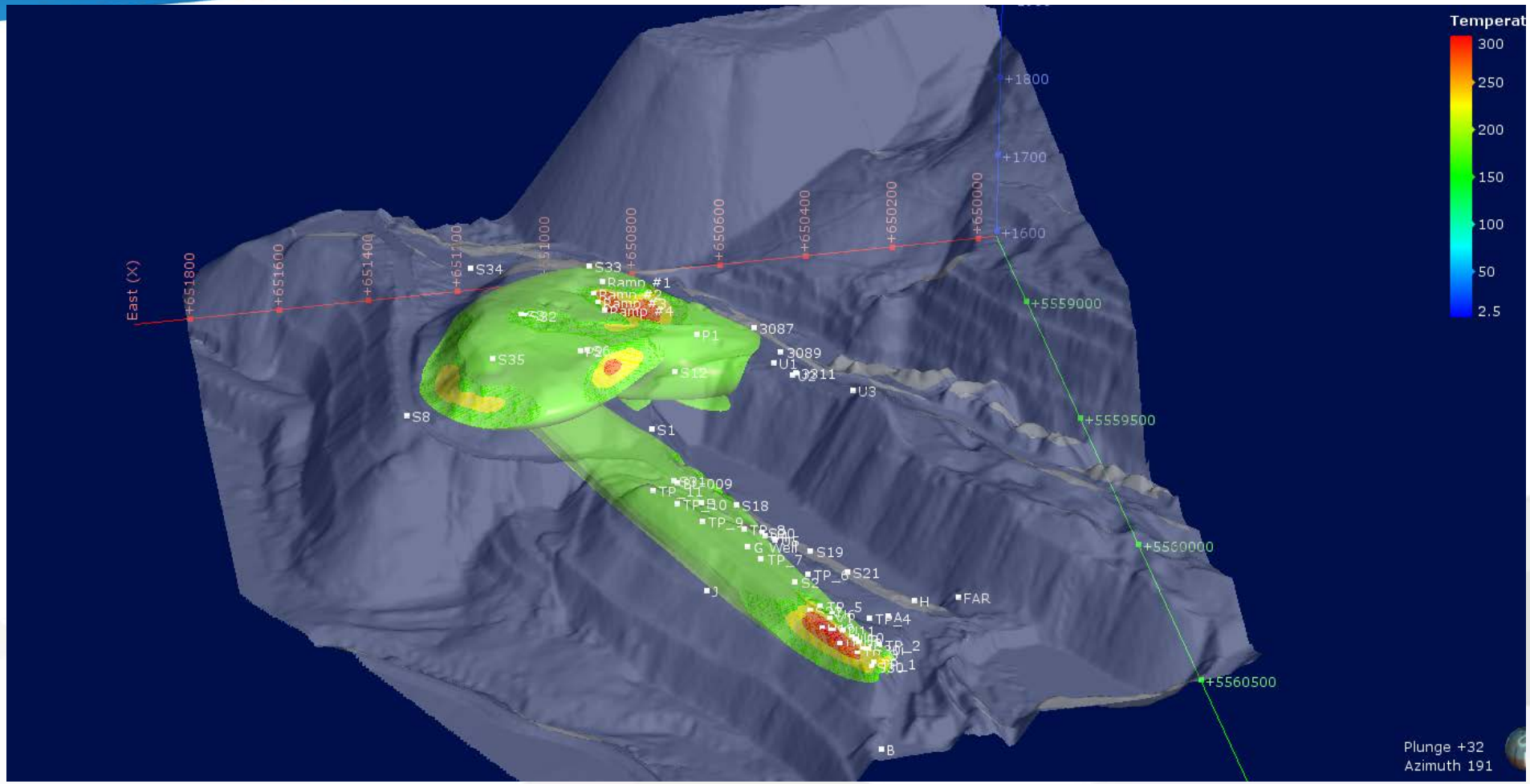
Pit expansion

Combusting mine rock

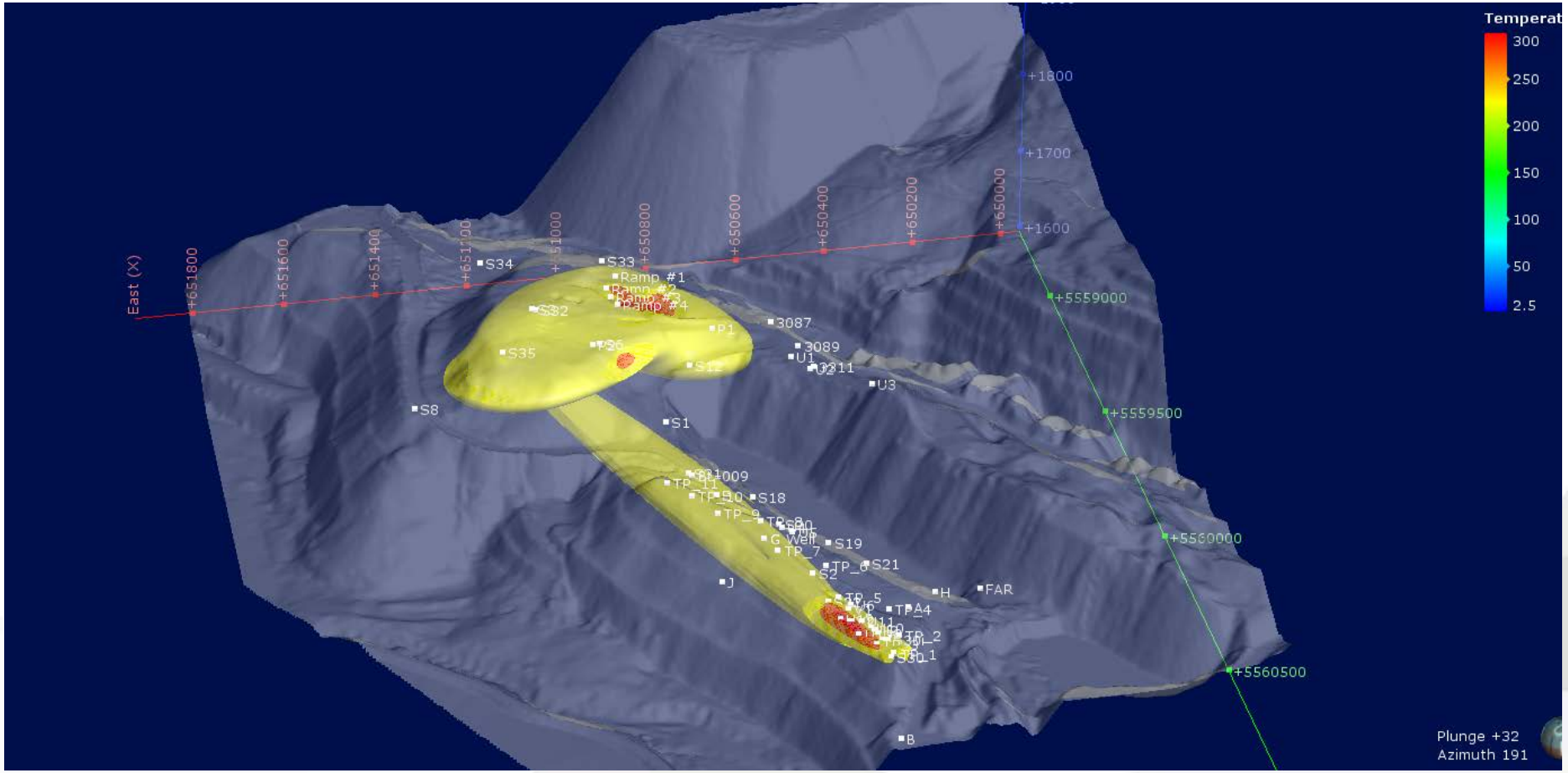
Combusting mine rock

Define combusting zones

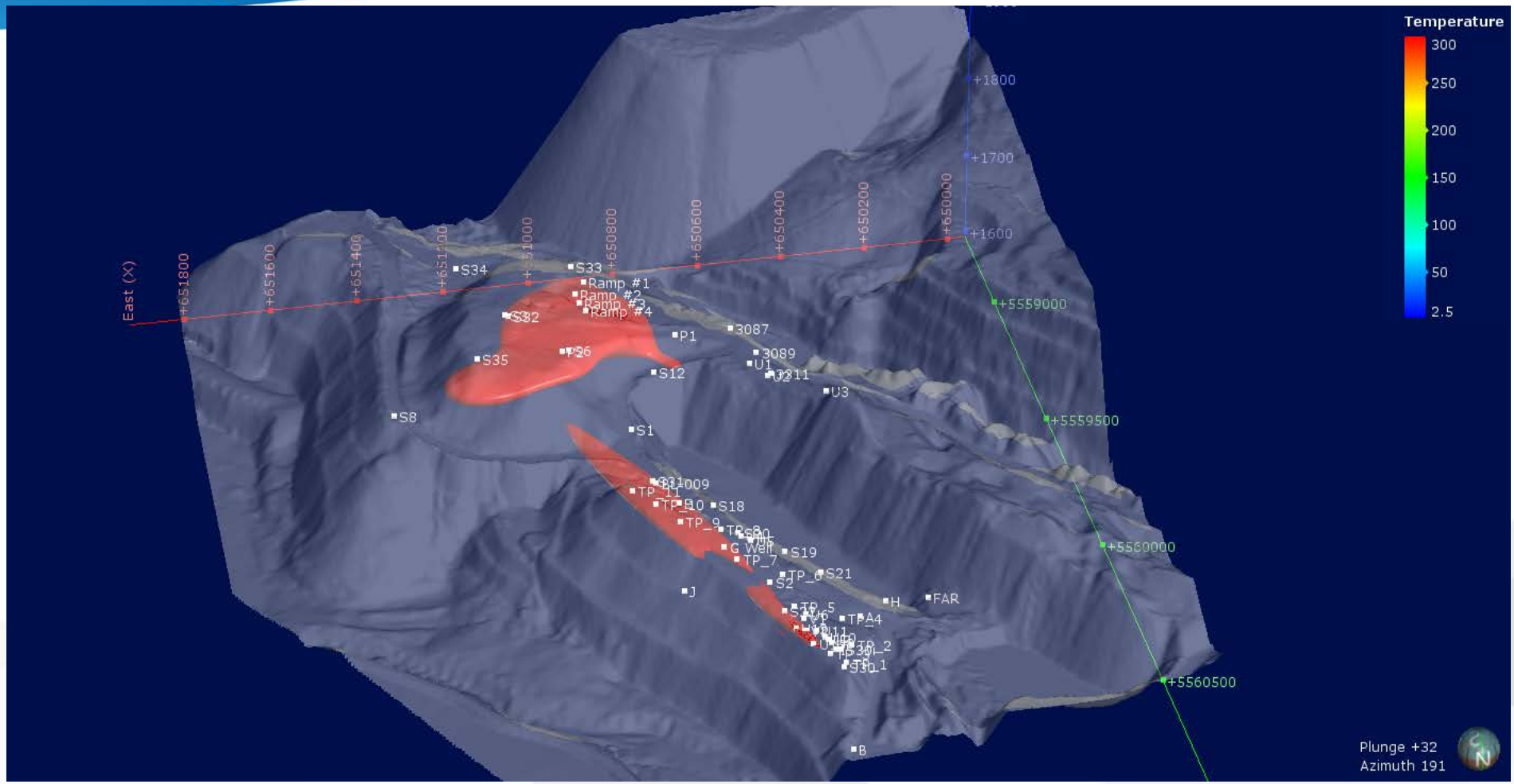
Combustion zones



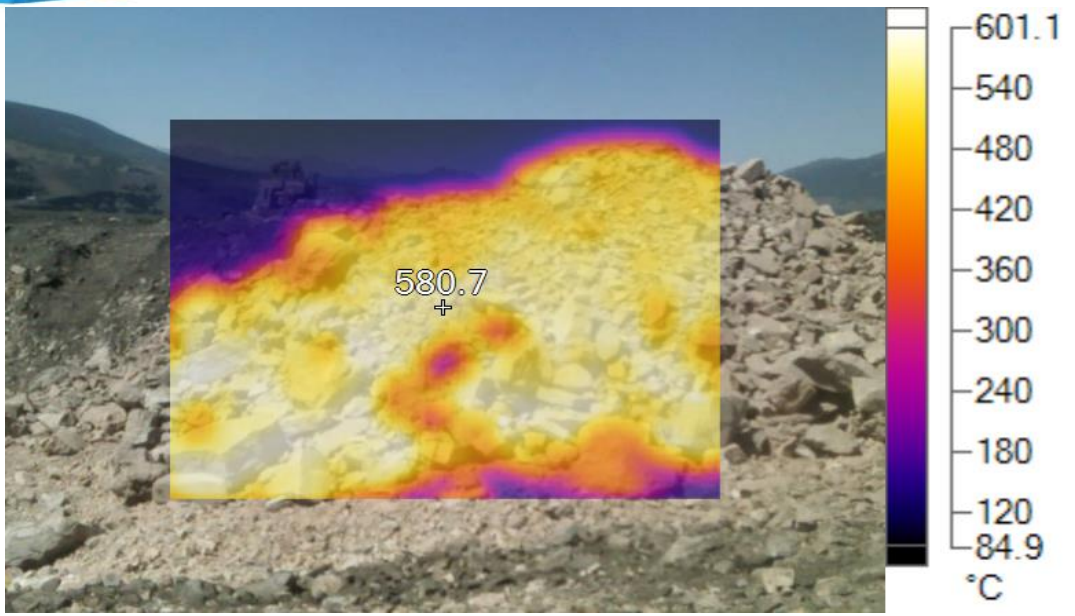
Combustion zones



Combustion zones



Trial Program – Equipment



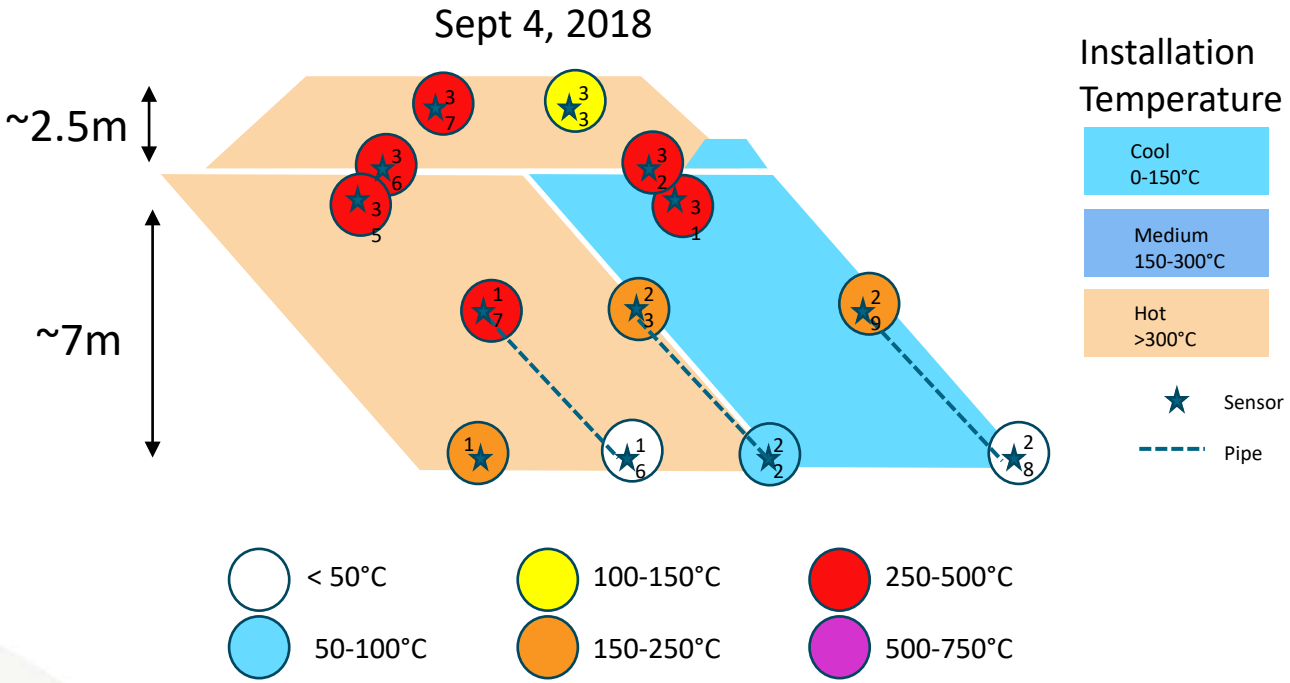
Dust and air quality

Table 5.3
Comparison of Yellow and Blue Gas Concentrations

Colour of Gas	SO_2 (ppm)	VOCs (ppm)	NO (ppm)	NH_3 (ppm)	NO_2 (ppm)	CO (ppm)	H_2S (ppm)	LEL (% LEL)	CO_2 (% Vol)
Yellow	19.9	653.56	19.5	285	0.6	1500 (MAX)	33.3	32	0.61
Blue	19.9	44.0	41.5	0	0	71	0	0	N/A

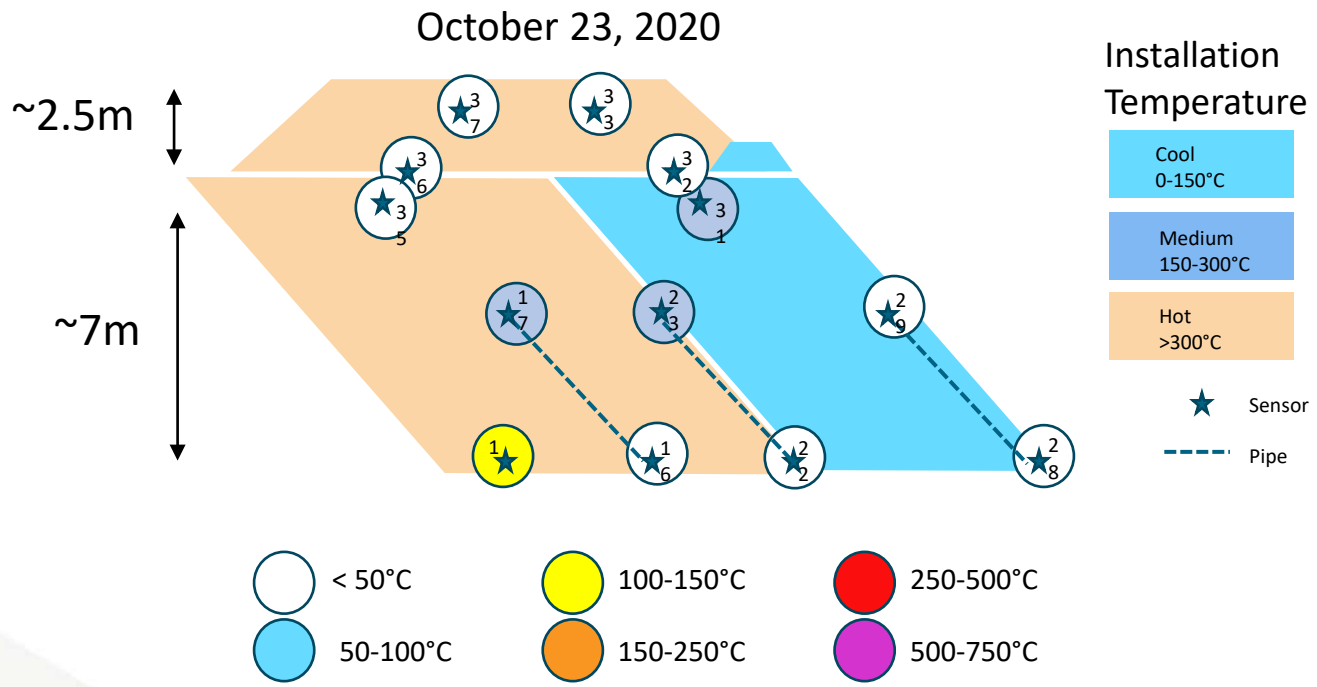
What is our current understanding?

Trial program



Sensor	Temp
sp1	162
16	43
17	337.5
22	53.5
23	209.5
28	13
29	218.5
31	347.5
32	295.5
33	119
35	429.5
36	398
37	307.5

Trial program

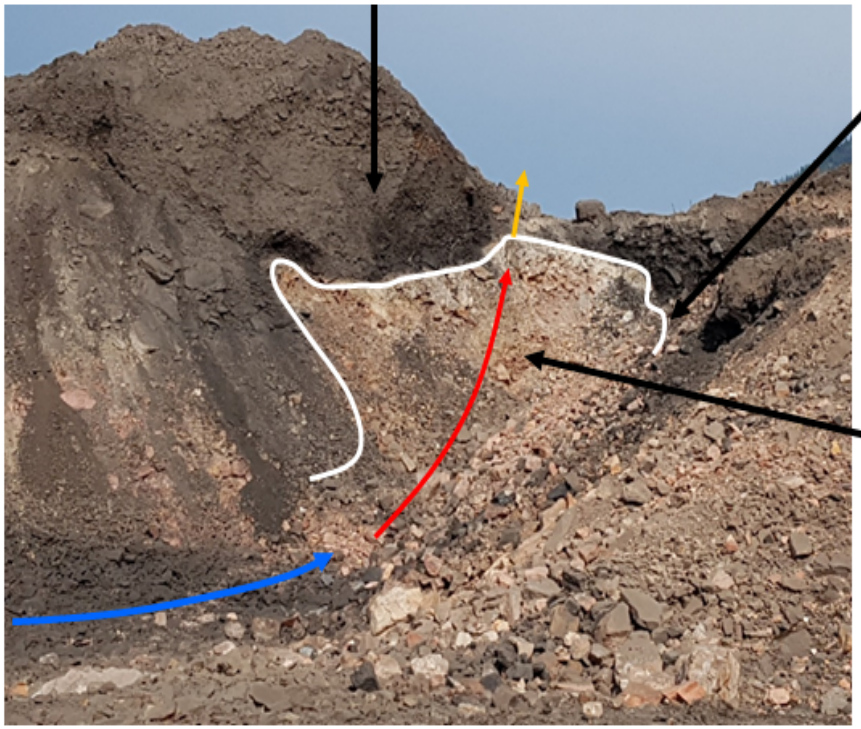


Sensor	Temp
sp1	126
16	22
17	63
22	35
23	74
28	0
29	36
31	87
32	20
33	11
35	45
36	26
37	36

Conceptual model

Black, high carbon (fuel) waste rock – temperature less than 150 deg C, zone into which combustion is likely to progress given fuel source and proximity to high temperature

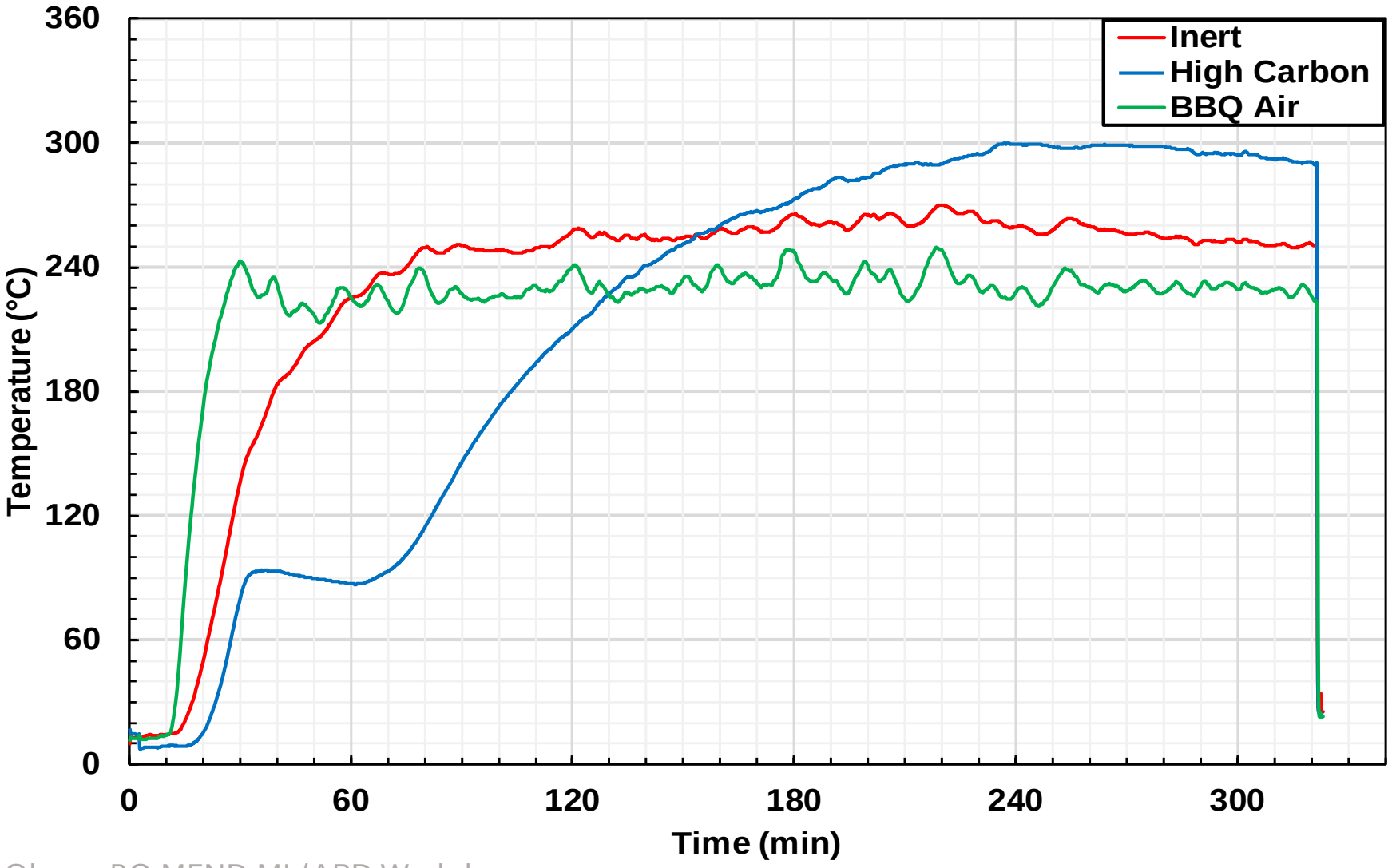
Burning front with sufficient fuel, temperature and oxygen



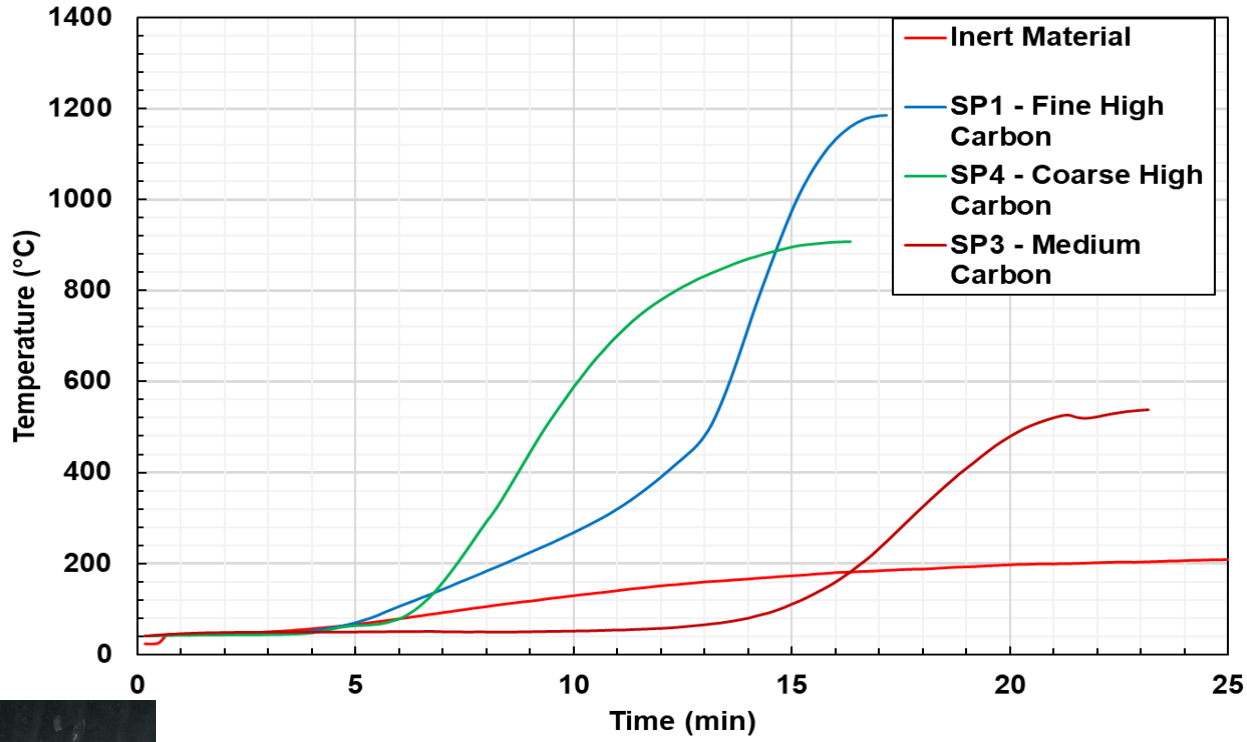
Hot (greater than 300 deg C) waste rock, lighter colour and lower (consumed) organic carbon concentration. High thermal mass but no or limited active combustion due to fuel scarcity.

Lateral influx of atmospheric O_2 through coarse and high permeability segregated layers at base of lifts, flow of O_2 upward through hot combustion zone, surface venting of heated air

Standard self-heating testing



Forced air (oxygen flux) is critical!



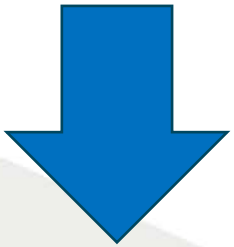
Control of oxygen availability

Case Study 3 Management strategy

- Thin, exposed surficial lifts sufficient to cool combusting mine rock
- Option for in-pit disposal has emerged
  - Pit to be flooded and combusting mine rock submerged
- Currently working through mine plan and material balance/schedule for thin lift cooling and in-pit disposal (flooding and submersion)

Conclusion

- Integrate material characterization with MRS design….
- …..control structure and placement
  - ….control hydrology and water retention
    - ……control gas (oxygen) flow……



Manage combustion

Thank You!

- **Contact info@okc-sk.com with questions or to chat!**

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