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Combustion And Swelling Of Colombian Stoker Furnace Coals

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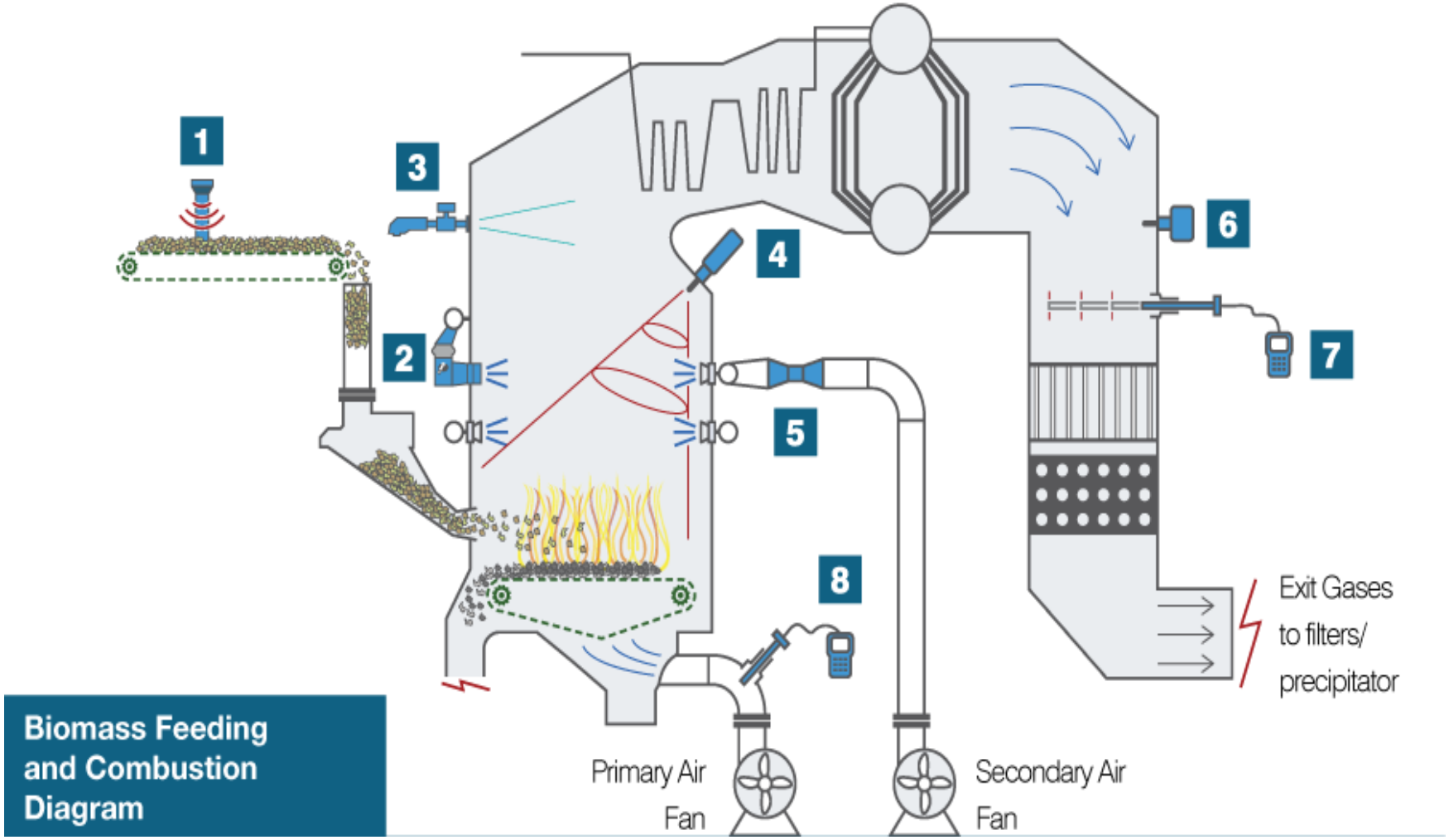
Colombian Sugar Mills

- Colombian sugar industry located in the Cauca Valley
- 13 sugar mills process 76,000 tons of sugar cane per day
- Sugar mills operate 330 days per year
- Sugar mills becoming energy producers

Sugar Mill Stoker Furnace



Stoker furnace with an over-grid feeding system

Source: ValveExport

Colombian power station:
- Mayaguez: 75-90% biomass + 10-25% coal
- La Cabaña: 70-80% coal + 20-30% biomass

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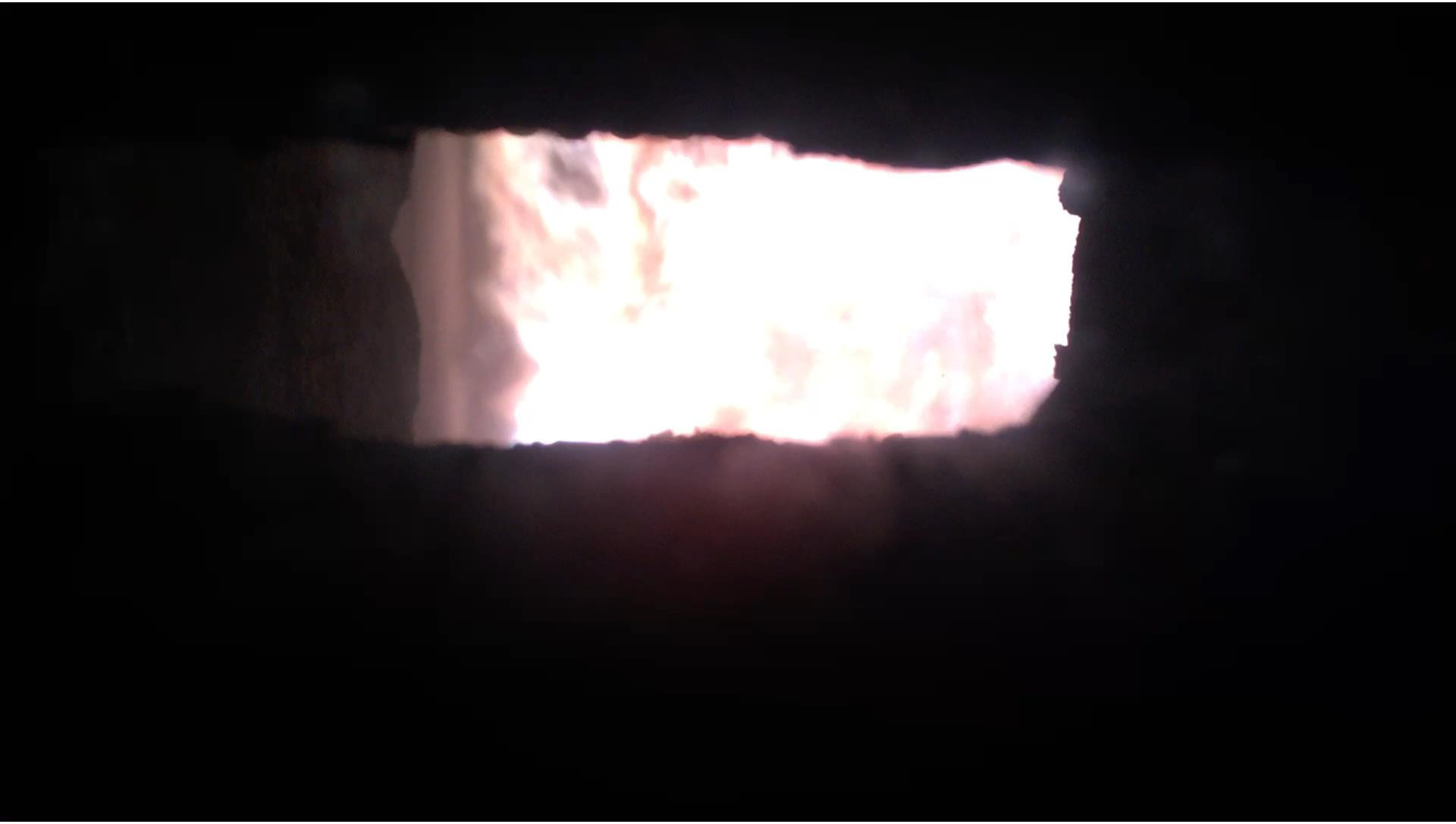
Inside the Furnace



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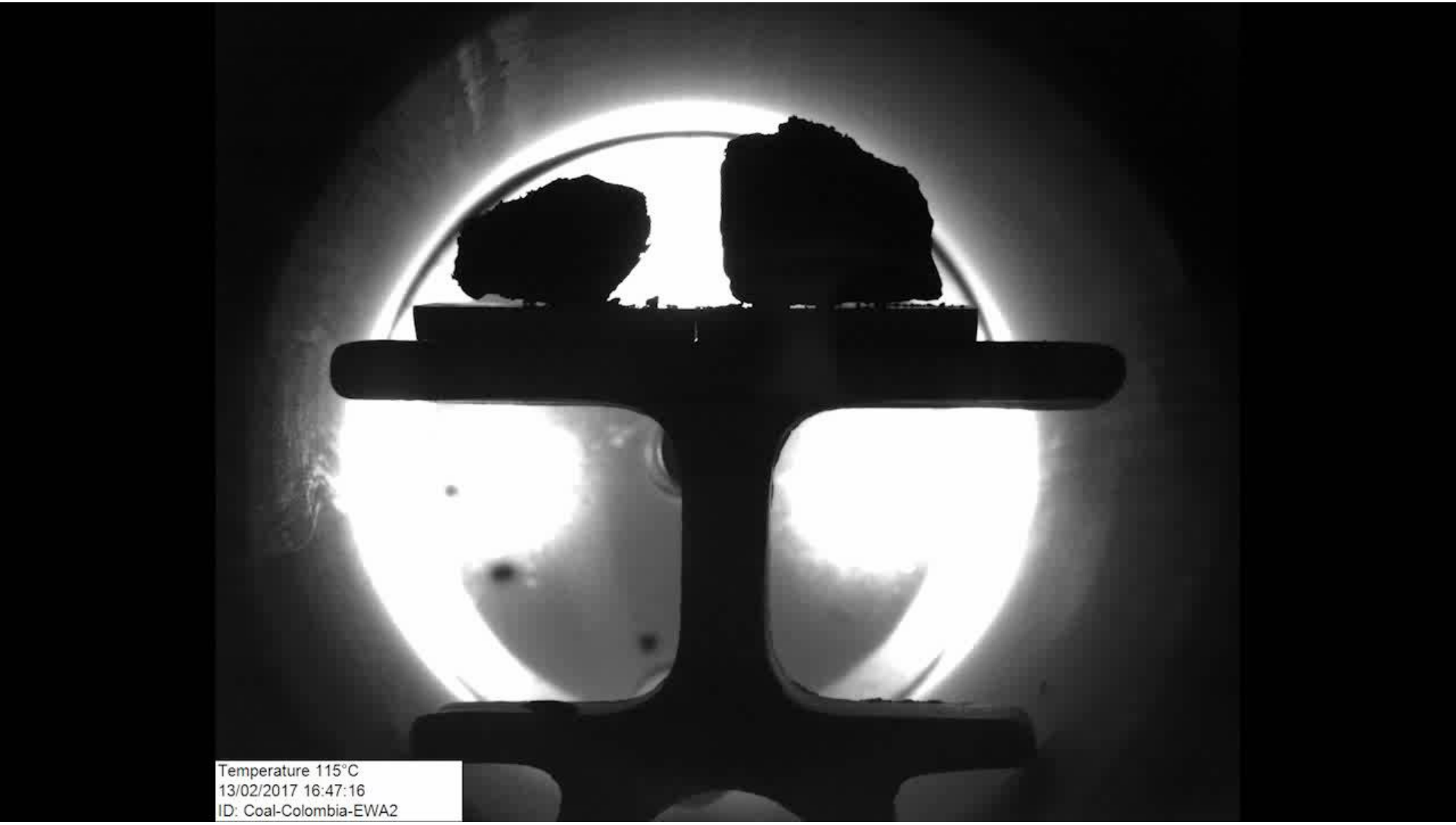
Swelling of Colombian Coals



Focus of Study

- Explore swelling and combustion of 4 Colombian Coals used in sugar mill stoker furnaces in Colombia

- Combustion analysed in 3 different furnaces:
  - Large particle size combustion in muffle furnace
  - Pulverised fuel combustion in a drop tube furnace
  - Large particle combustion in macro-tga and small particle size in mini-tga

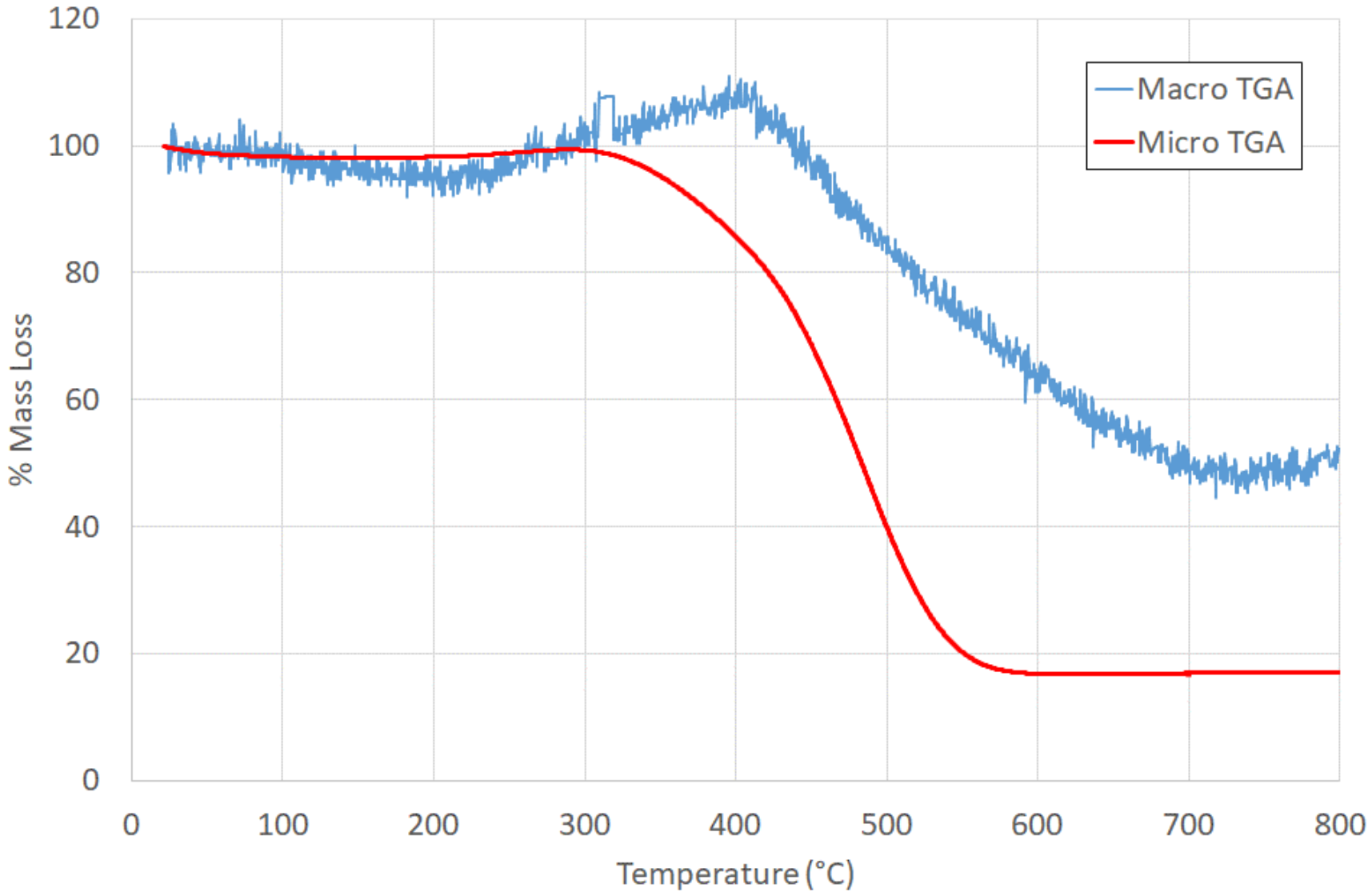
- Particle swelling analysed through 2 methods:
  - Thermal mechanical analysis (TMA)
  - Image analysis in an Advanced ash fusion oven

As Received Particle Size

Micro and Macro TGA

- Micro TGA conducted in TA Instruments Q500 for particles <300 µm
- Macro TGA conducted in bespoke vertical tube furnace for <6, 6-19, >19 mm particle sizes
- Samples tested in air in micro and macro TGA at 10°C/min ramp rate up to 800°C

Macro and Micro TGA Results – Cundina <6



Micro TGA Proximate Analysis

Sample	Moisture (%)	Dry Volatile Matter (%)	Fixed Carbon (%)	Dry Ash (%)
Antioquia 6	7.8	41.9	45.1	13.0
Antioquia 6 19	8.0	44.6	47.1	8.3
Antioquia 19	9.1	49.0	46.5	4.5
Valle 6	1.6	29.2	41.5	29.2
Valle 6 19	1.1	27.7	39.0	33.3
Valle 19	1.0	36.4	26.2	37.3
Cundina 6	1.9	34.9	48.1	16.9
Cundina 6 19	2.1	35.7	50.2	14.1
Cundina 19	1.6	37.4	51.4	11.2
Patia 6	4.6	34.9	38.6	26.5
Patia 6 19	4.2	36.8	42.0	21.2
Patia 19	4.4	46.7	47.1	6.2

Macro TGA Proximate Analysis

Samples	Relative Mass Moisture	Dry Volatiles	Fixed Carbon	Dry Ash
Antioquia 6	0.8	4.8	0.7	94.4
Antioquia 6 19	2.3	19.5	4.2	76.3
Antioquia 19	6.1	19.8	**52.7**	27.4
Valle 6	1.7	3.4	0.4	96.2
Valle 6 19	1.3	3.9	2.9	93.2
Valle 19	2.4	15.9	**31.2**	52.9
Cundina 6	0.4	0.7	0.6	98.7
Cundina 6 19	2.2	5.3	**19.5**	75.2
Cundina 19	2.2	3.7	**46.7**	51.9
Patia 6	2.3	5.5	**21.7**	72.7
Patia 6 19	2.9	8.2	**32.6**	59.2

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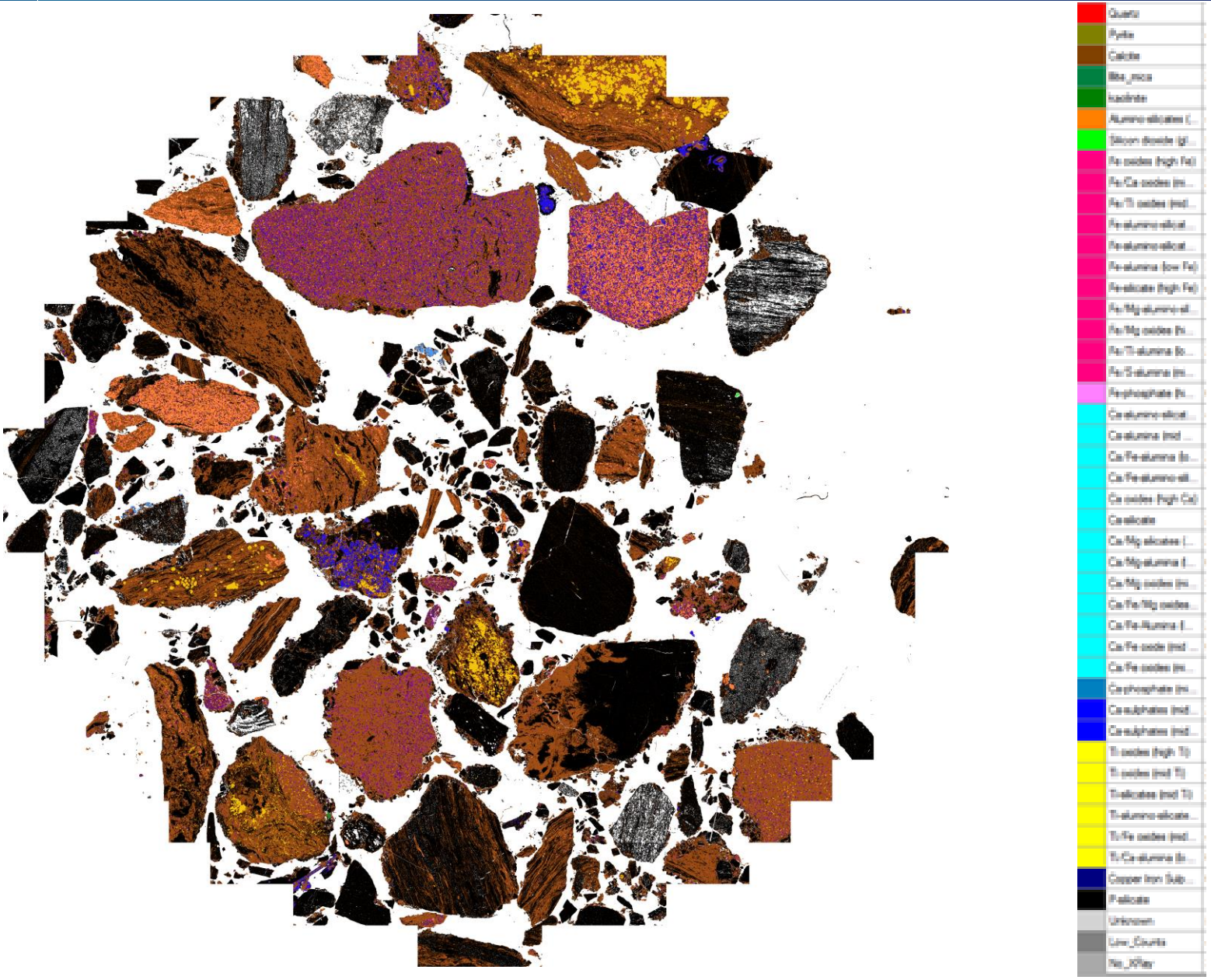
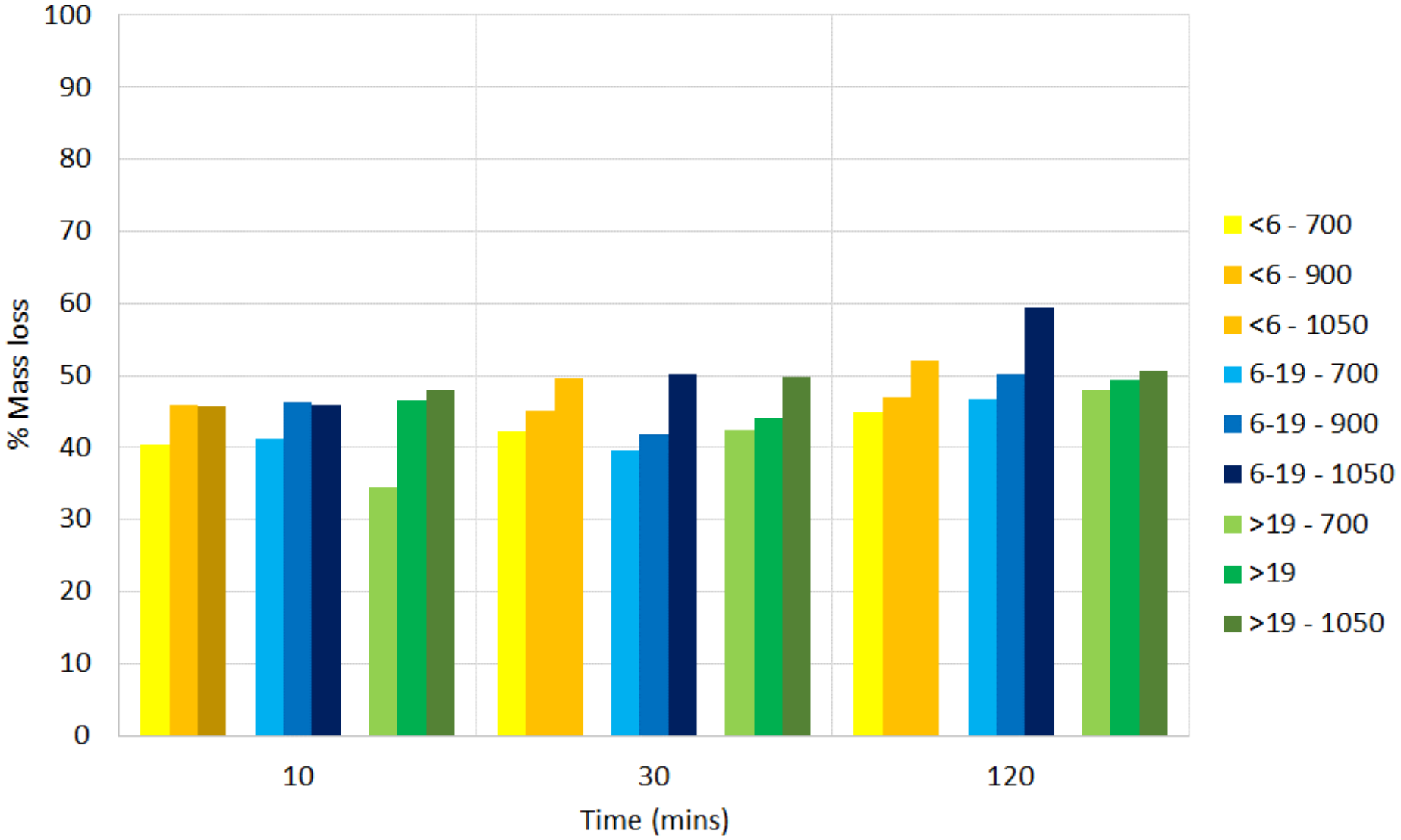
Mineral Liberation Analysis - Valle



Muffle Furnace

- 108 Samples tested in Nitrogen
- Tested at 3 particle sizes: <6, 6-19, >19 mm
- Tested at 3 temperatures: 700°C, 900°C, 1050°C
- Tested for 3 residence times: 10, 30 and 120 minutes

Weight Loss – Antioquia



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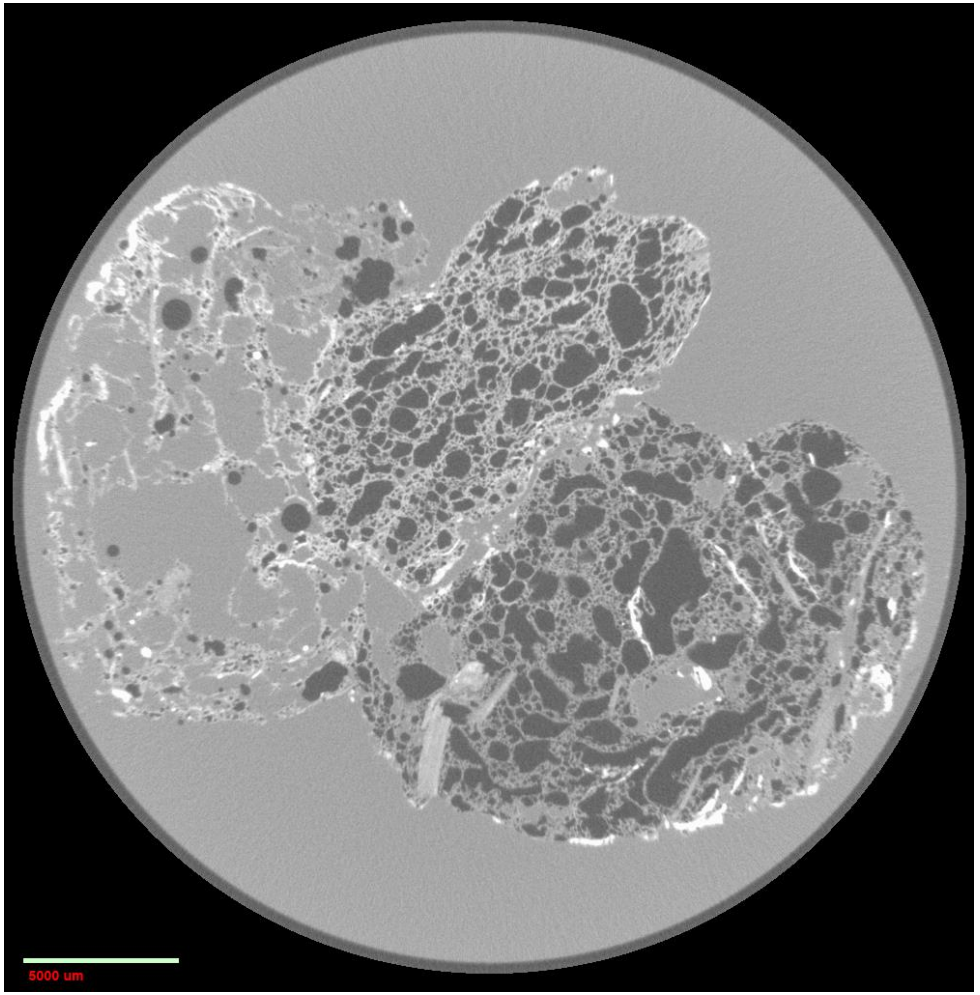
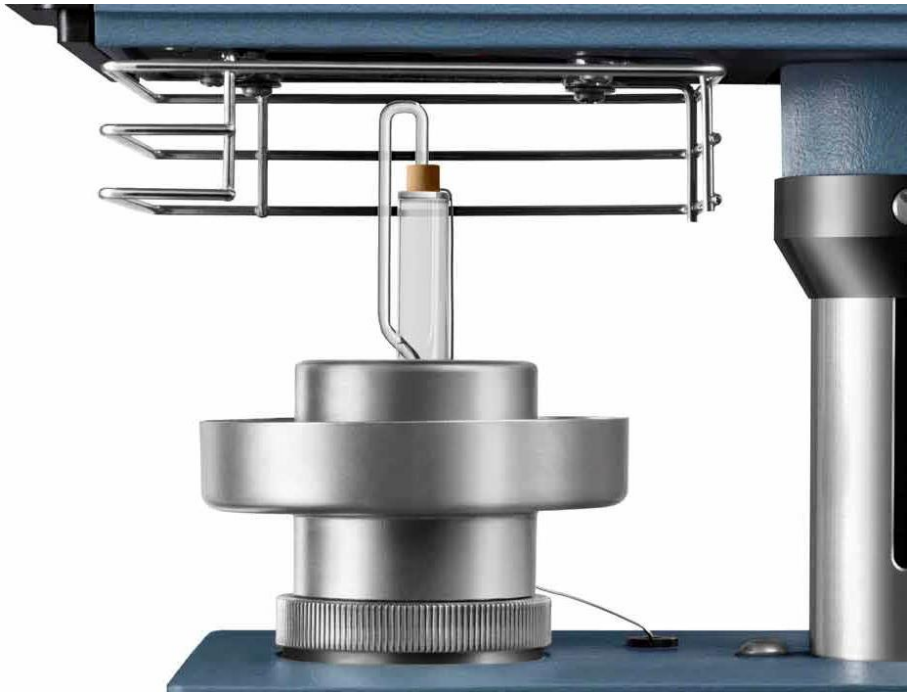
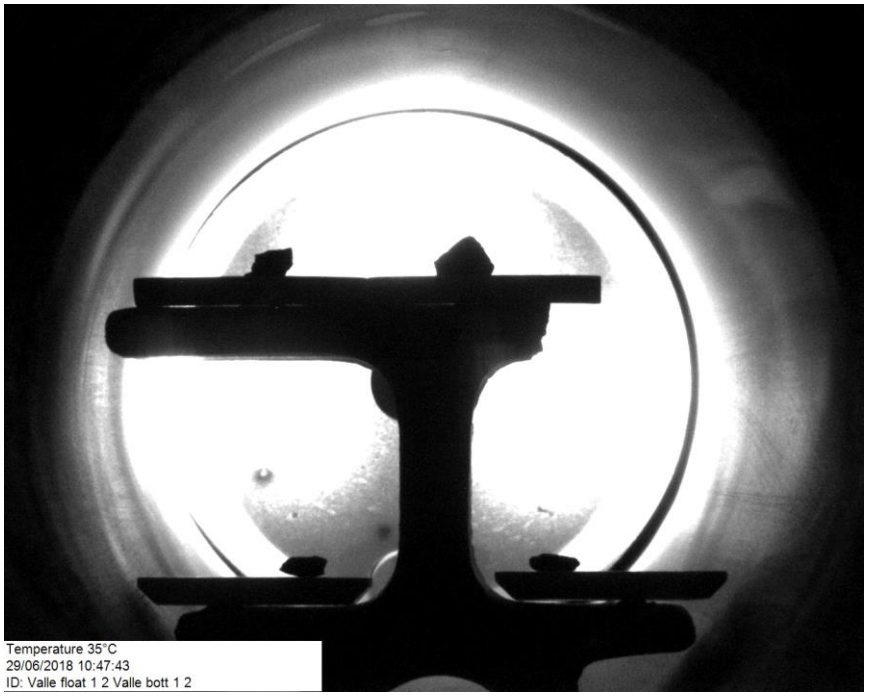
Muffle Furnace X-Ray CT



Coal Swelling

- 2 Methods used to measure swelling – Thermo-mechanical Analysis (TMA) and Ash Fusion Oven
- TMA measured height change up to 1000°C
- Ash fusion over measured height and area change up to 1000°C





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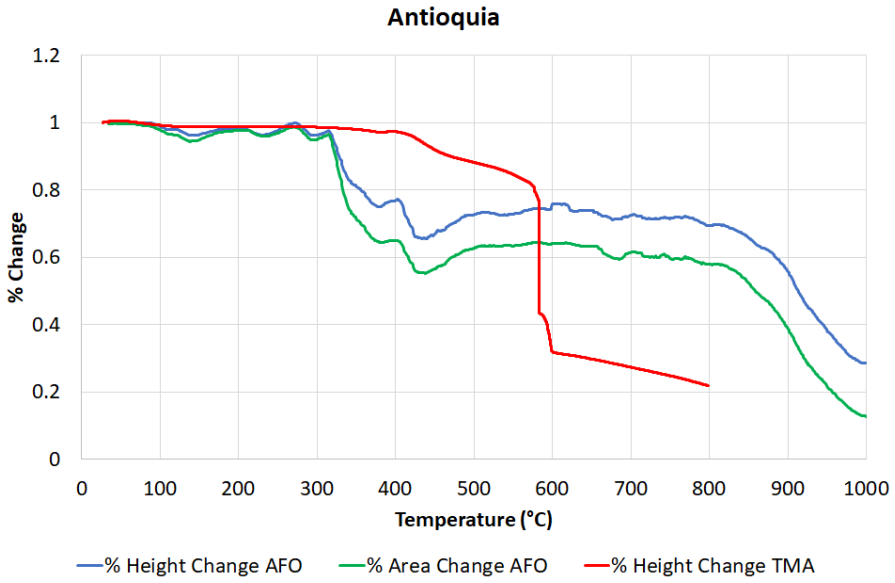
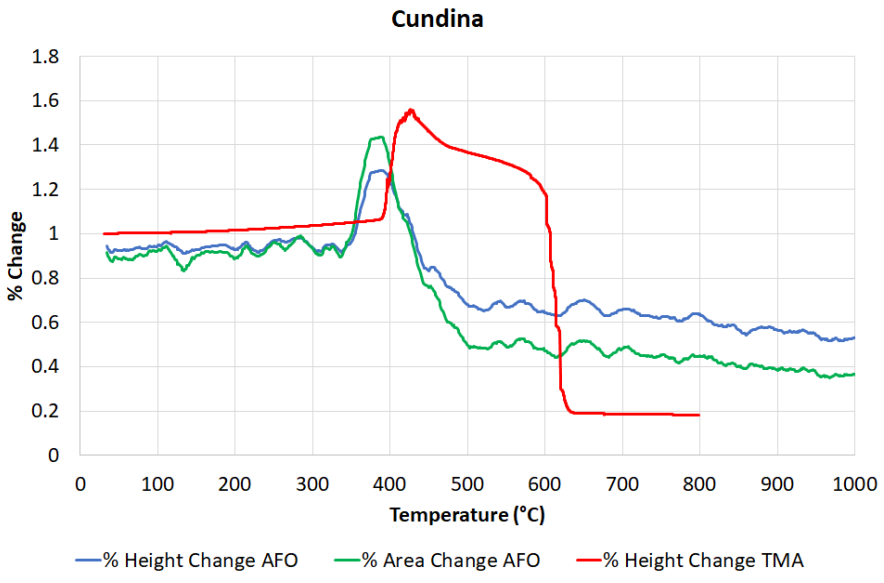
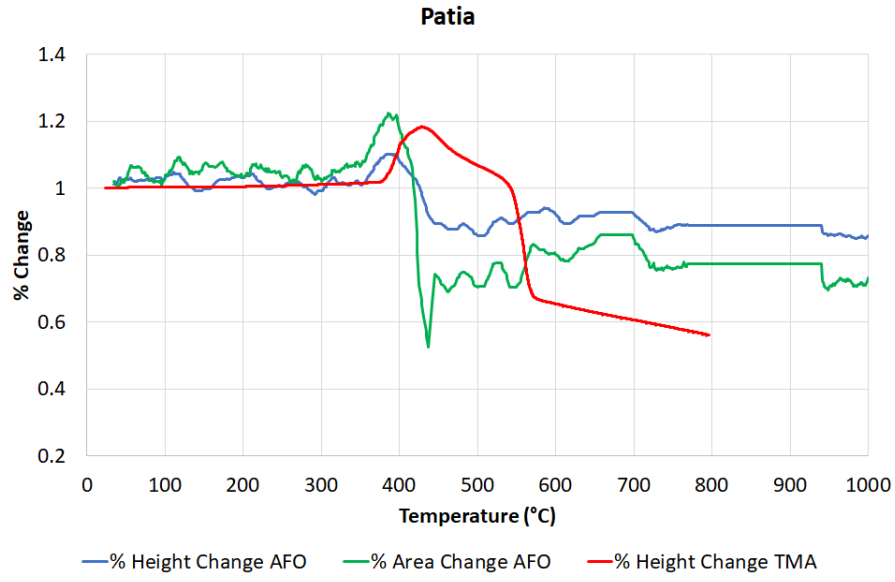
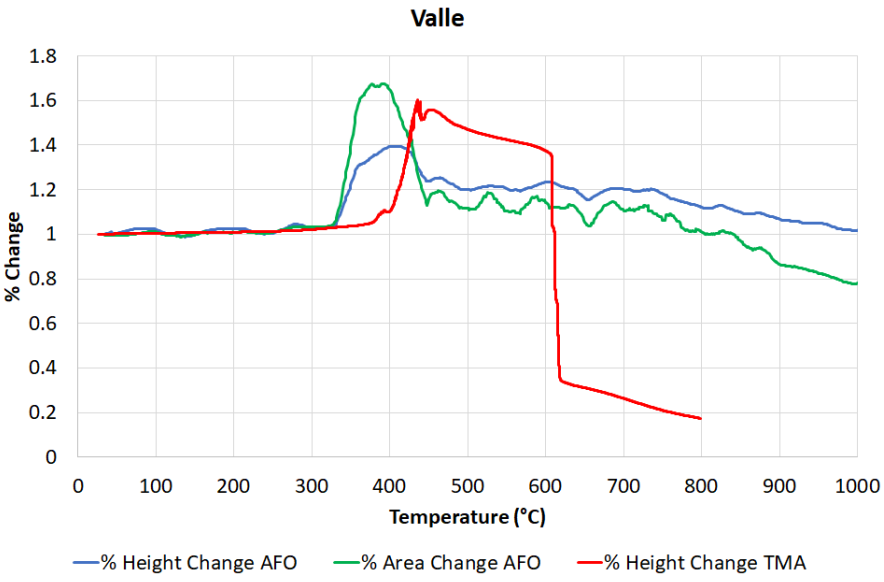
Coal Swelling – Ash Fusion Oven and TMA









Additional Findings and Future Work

- Ash Fusion Test showed that no unusual behaviour was observed with the ash
- Washing of the samples resulted in removal of substantial amount of ash from samples
- Washed samples still swelled in TMA and ash fusion oven
- Model being developed to mimic swelling behaviour using results of the study
- Potential to mix and densify bagasse waste and coal to be investigated in new project

Summary

- Combustion and swelling of Colombian stoker furnace coals investigated
- Incomplete combustion replicated in a macro tga
- Samples swelled in an inert atmosphere in muffle furnace
- Sample porosity obtained through X-ray CT
- Novel use of TMA and Ash Fusion Oven to quantify swelling of coals

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Thank you for listening

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