Investigating the Stabilisation of Organic Carbon in Sandy Soils by Kaolinite & Associated Minerals

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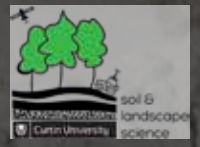

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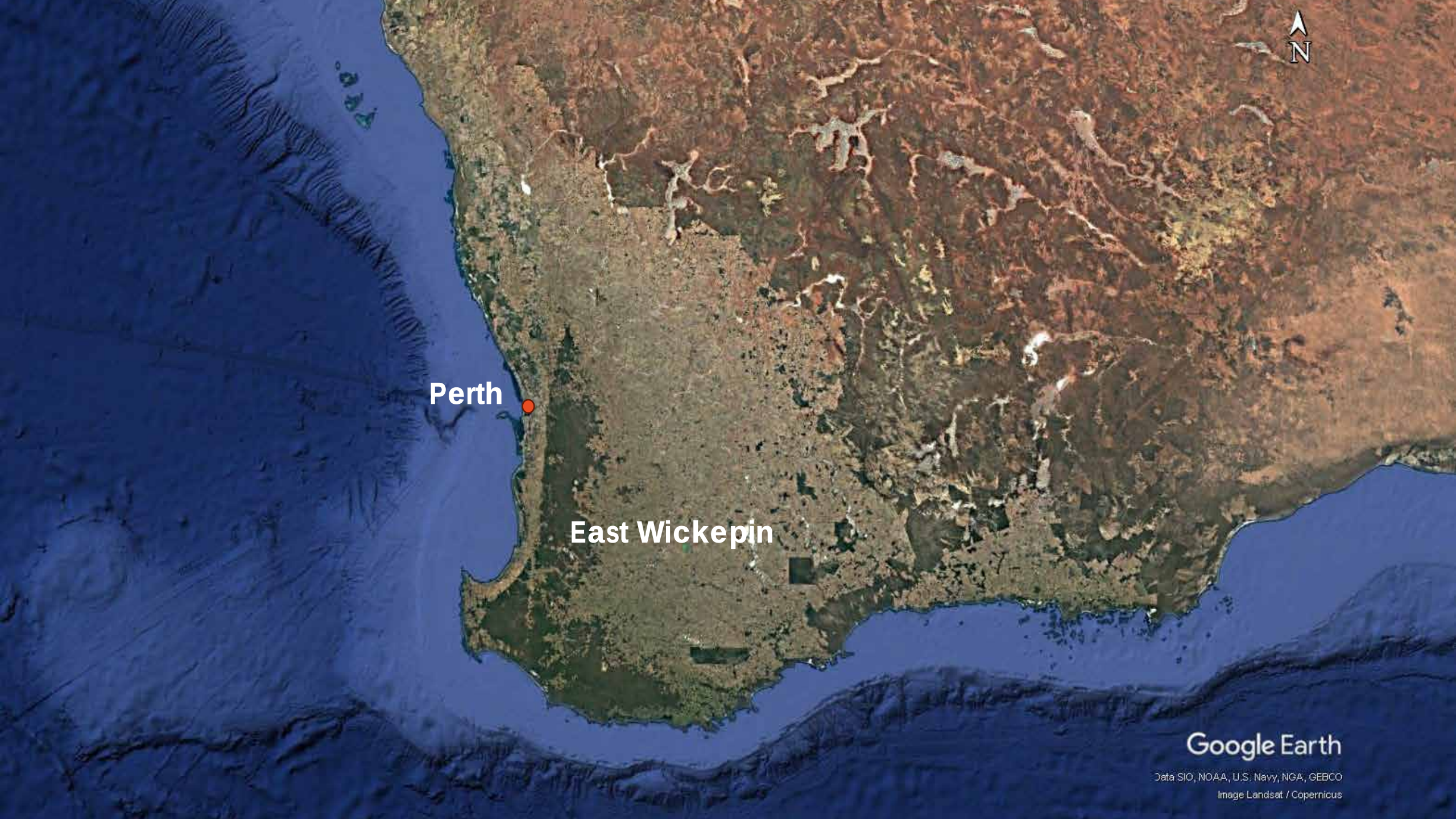
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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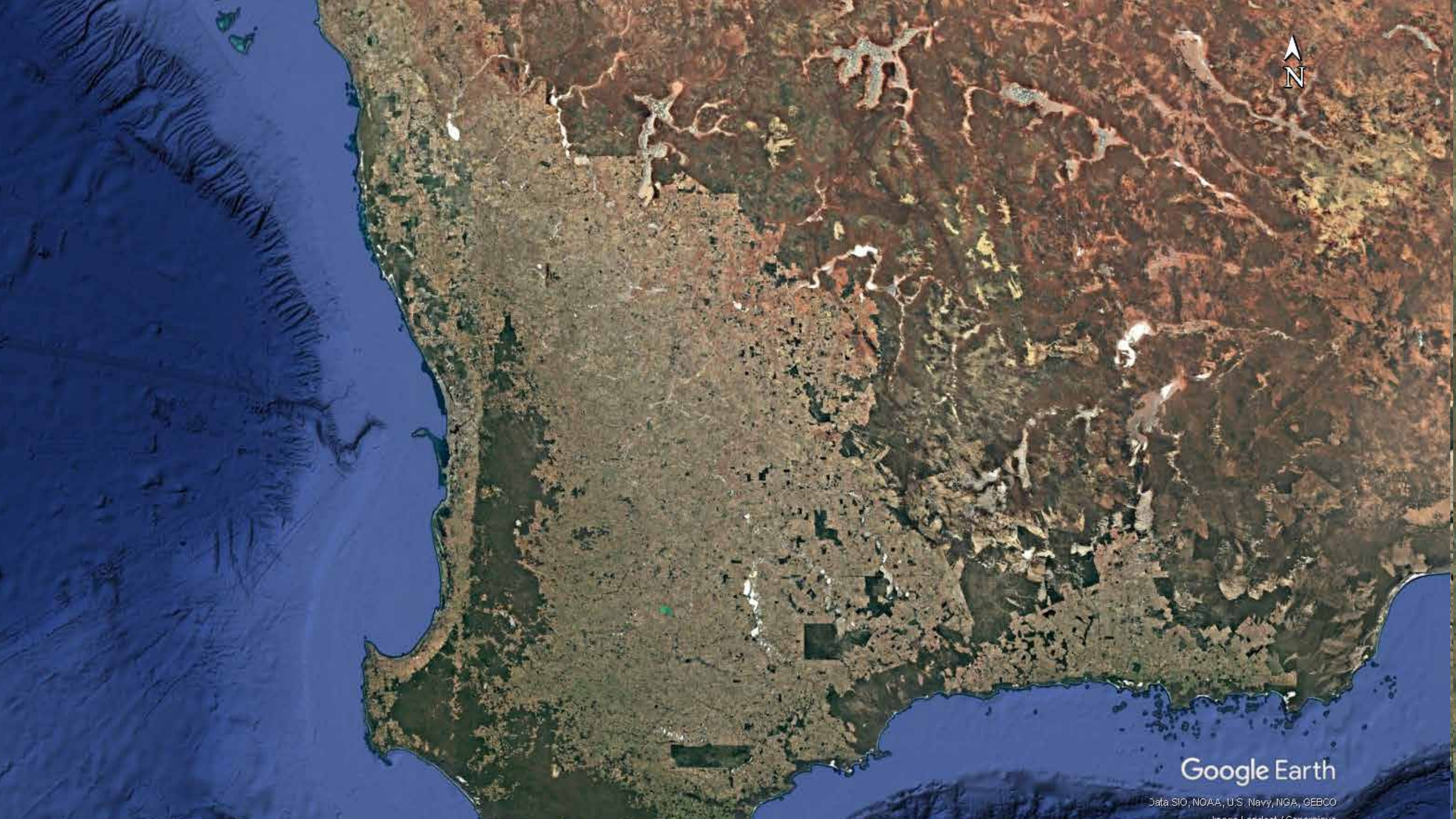
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO

WA Kaolin Limited

Photo credit: WA Kaolin

Open-pit mining

gravel

overburden

unused
stockpiled on site

extracted
and
processed

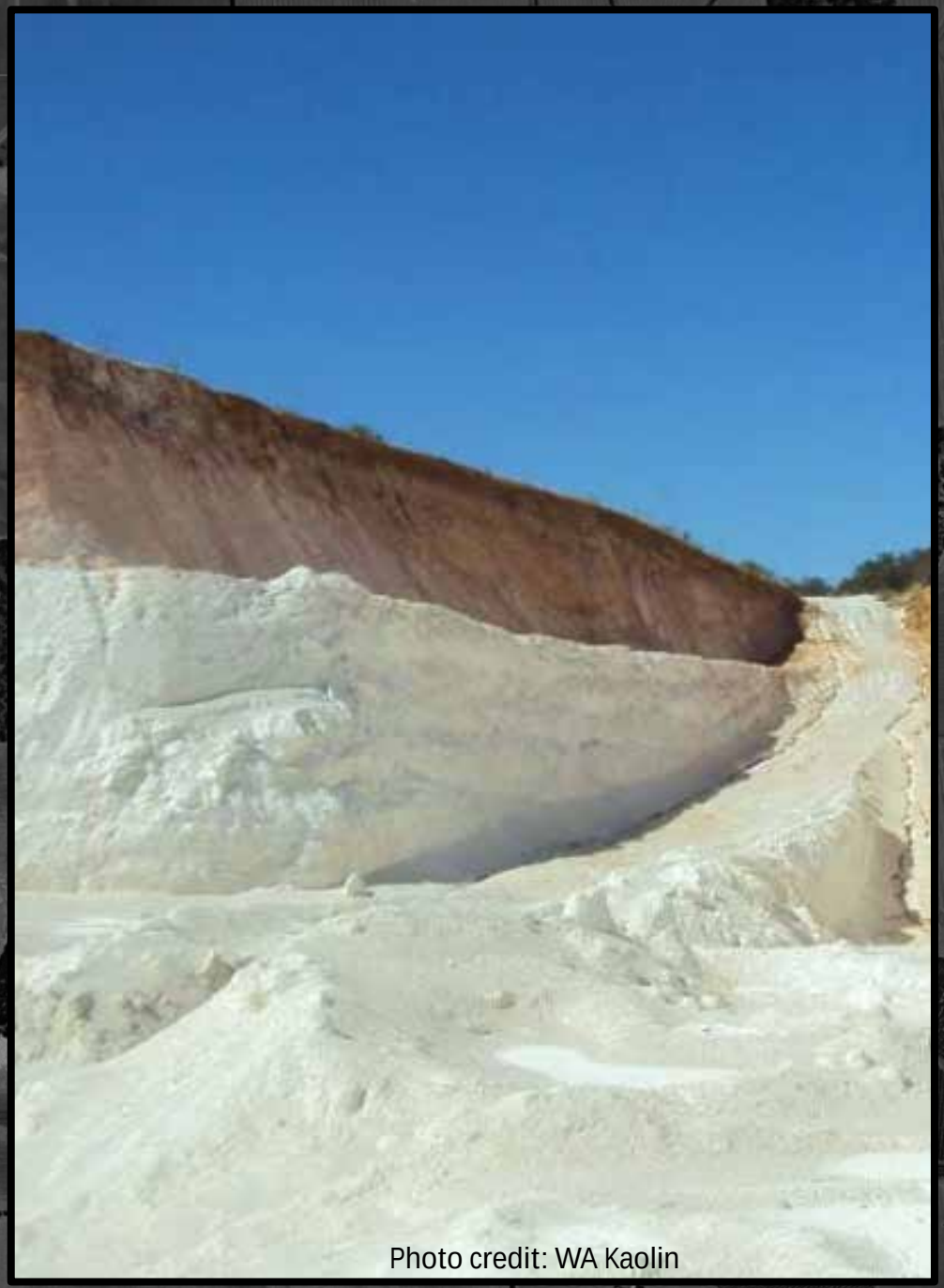
kaolin
ore

~88%

~12%

‘Kaosil’
(by-product)

kaolinite
(final product)



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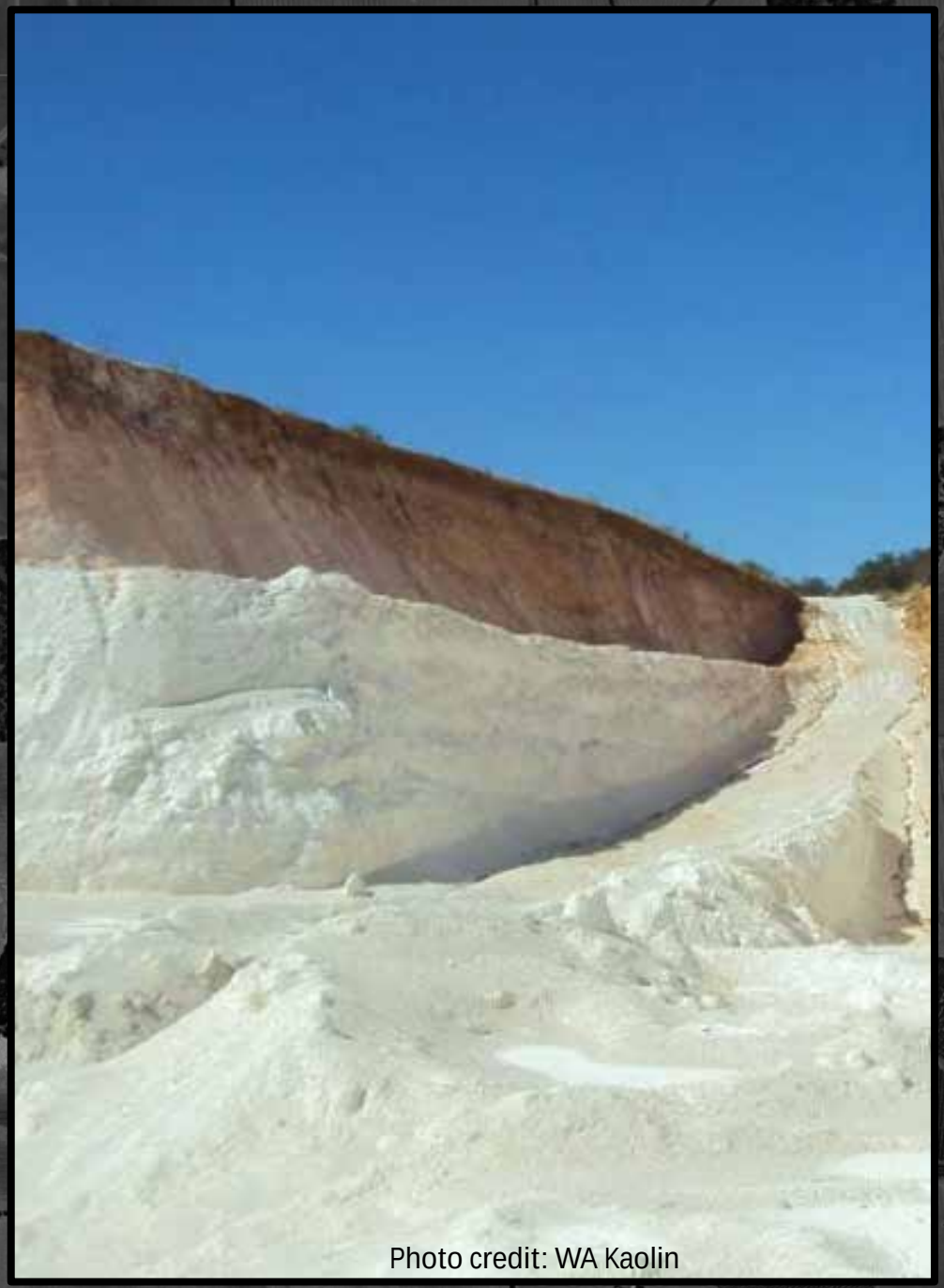


Photo credit: WA Kaolin

Amend Weathered Sandy Soils

Adding clay

Increase moisture and nutrient holding capacity

Improve productivity

Increase the carbon sequestration potential of the soil

Carbon neutral farming

Before adding clay-based by-products to soil

1. Characterise these by-products
    a) How much clay?
    b) What other minerals?

2. How well do the by-products bind and stabilise organic carbon?
    a) Is there a difference between by-products?

1. Characterisation of by-products

Dominant minerals

Fourier-transform Infrared Spectroscopy **(FT-IR)**

X-Ray Diffraction **(XRD)**

Tescan Integrated Mineral Analyser **(TIMA)**

X-Ray Florescence **(XRF)**

Thermogravimetric Analysis **(TGA)**

1. Characterisation of by-products

Dominant minerals → Fourier-transform Infrared Spectroscopy **(FT-IR)**

X-Ray Diffraction **(XRD)**

Detailed mineraology → Tescan Integrated Mineral Analyser **(TIMA)**

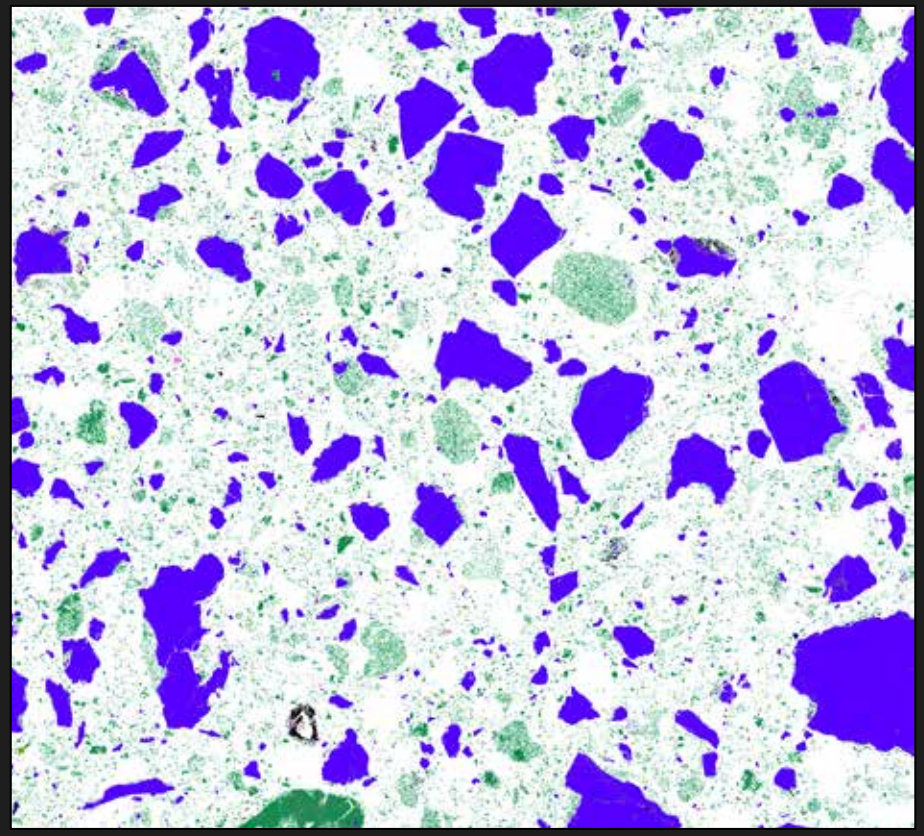
X-Ray Florescence **(XRF)**

Thermogravimetric Analysis **(TGA)**

Tescan Integrated Mineral Analyser (TIMA)

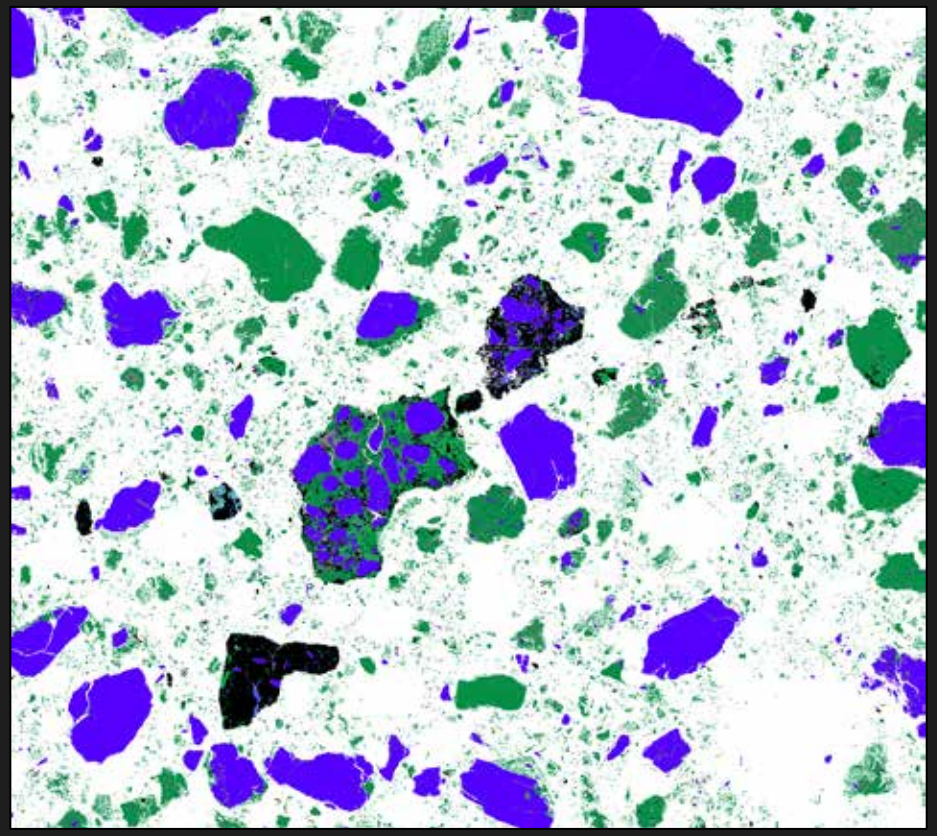
SEM + EDS

Kaosil (KC)



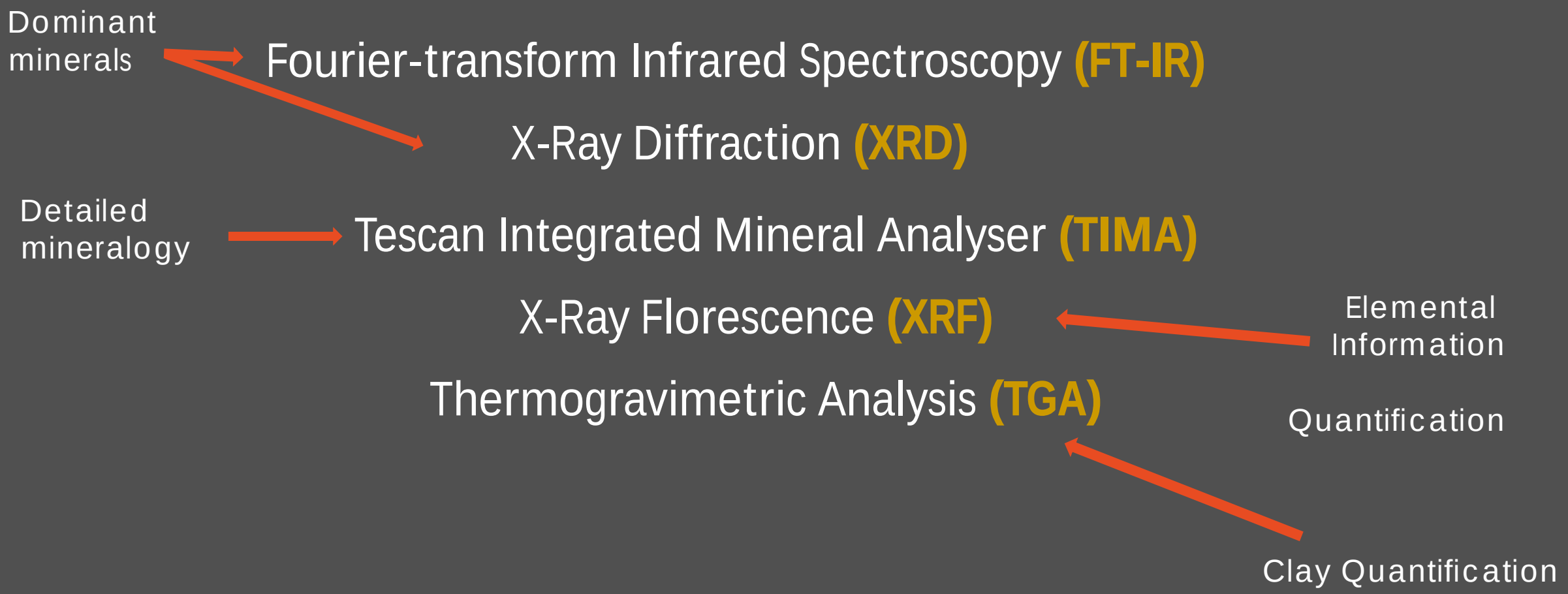
- Quartz 69.51
- Kaolinite 25.80
- Muscovite 0.32
- Rutile 0.09
- Ilmenite 0.02
- Zircon 0.02
- Beryl 0.01
- [Unclassified] 2.34
- Holes 1.87

Overburden (OBC)

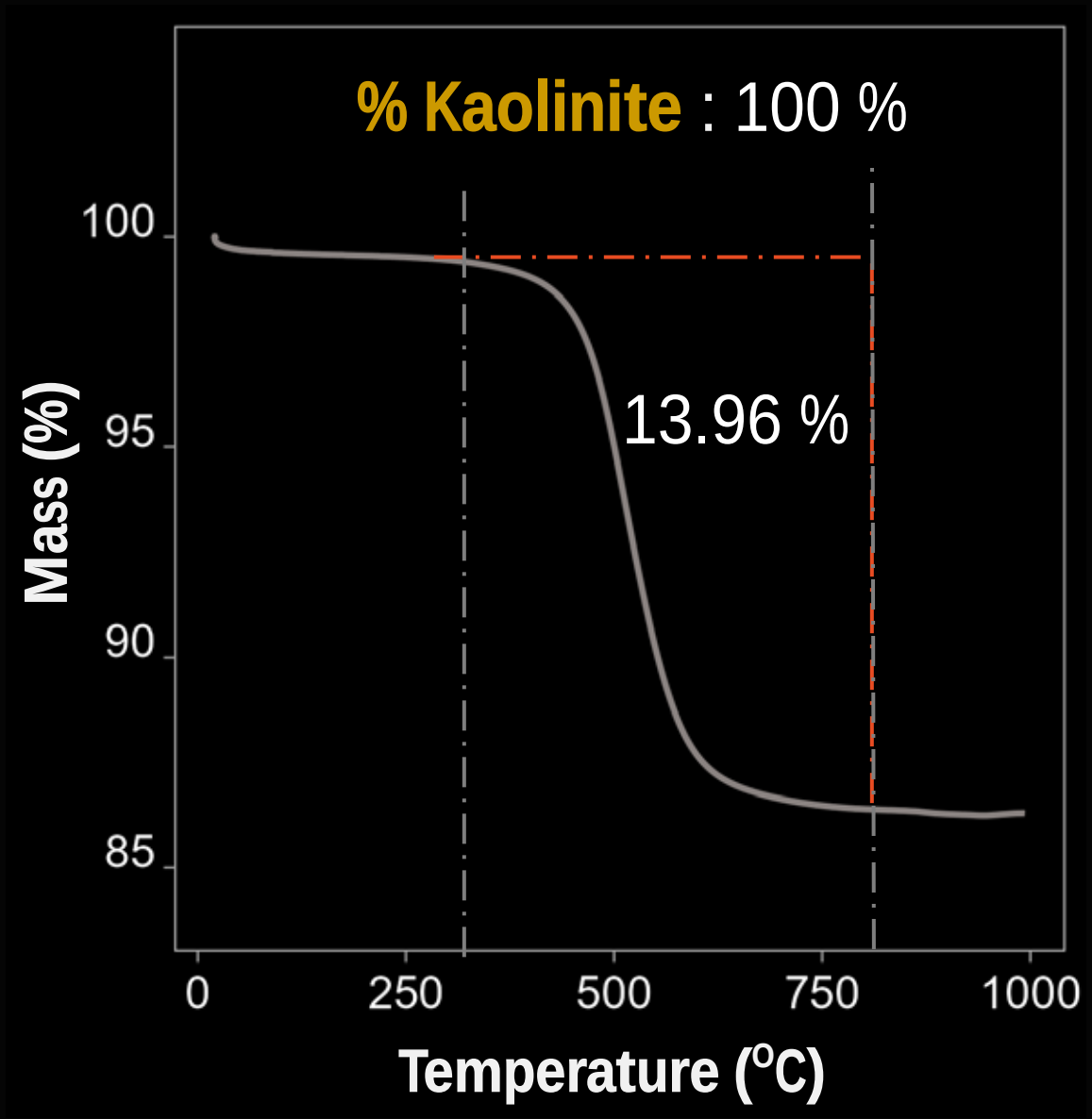


- Quartz 40.8
- Kaolinite 42.61
- Muscovite 0.01
- Rutile 0.02
- Schorl 0.03
- Plagioclase 0.01
- Hematite 0.27
- Goethite 0.11
- Al2SiO5 polymorphs 1.29
- Chlorite-Chamosite 0.28
- [Unclassified] 8.68
- Holes 5.74

1. Characterisation of by-products



Thermogravimetric Analysis (TGA)



$$Al_2Si_2O_5(OH)_4 \xrightarrow{600\,^{\circ}C} Al_2Si_2O_7 + 2H_2O$$

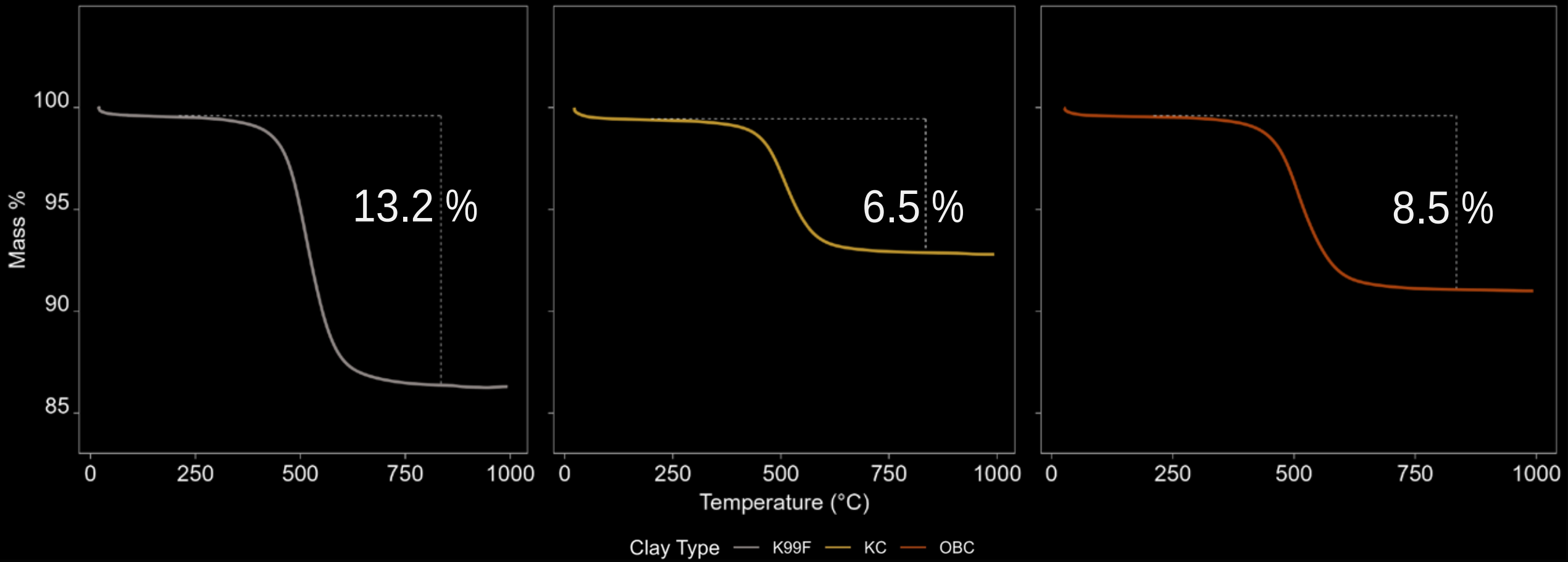
dehydroxylation

Molar mass of Kaolinite	258.16 g/mol
Molar mass of H2O	18.0 g/mol

$$\text{Mass loss} \quad X \quad \frac{\text{Molar mass of Kaolinite}}{\text{2 X molar mass of H2O}}$$

Thermogravimetric Analysis (TGA)

% Kaolinite : 94.66 % 46.6 % 60.9 %



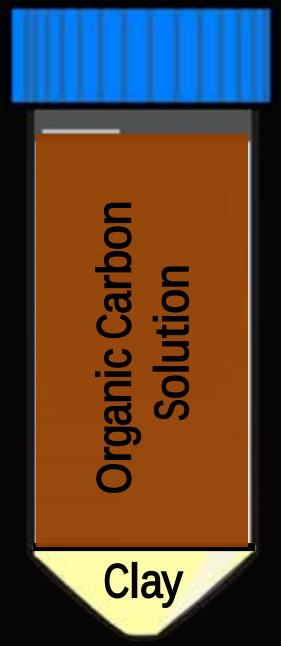
Stoichiometric (XRF) **95.8 %** **47.7 %** **60.2 %**

	K99F	Kaosil	Overburden
% Kaolinite	95 %	47 %	60%
SSA (m2/g, <50 micron sieved)	10.3	10.3	9.1
CEC (cmol/kg)	<1	<1	1

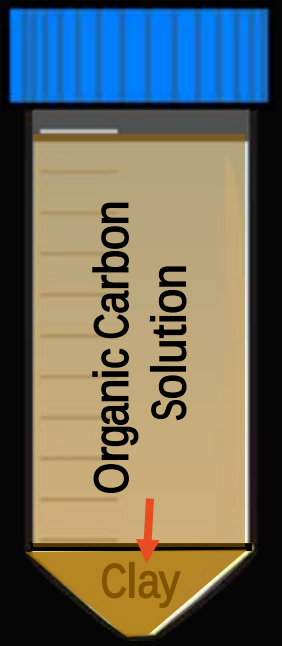
2. Understanding the Adsorption Capacity of the by-products

How well can they bind organic carbon?

Adsorption Experiments



6 hours



Initial OC Concentration: 100 mg/L

Final OC Concentration: 30 mg/L

Adsorption: 100 – 30 = 70 mg/L

2. Understanding the Adsorption Capacity of the by-products

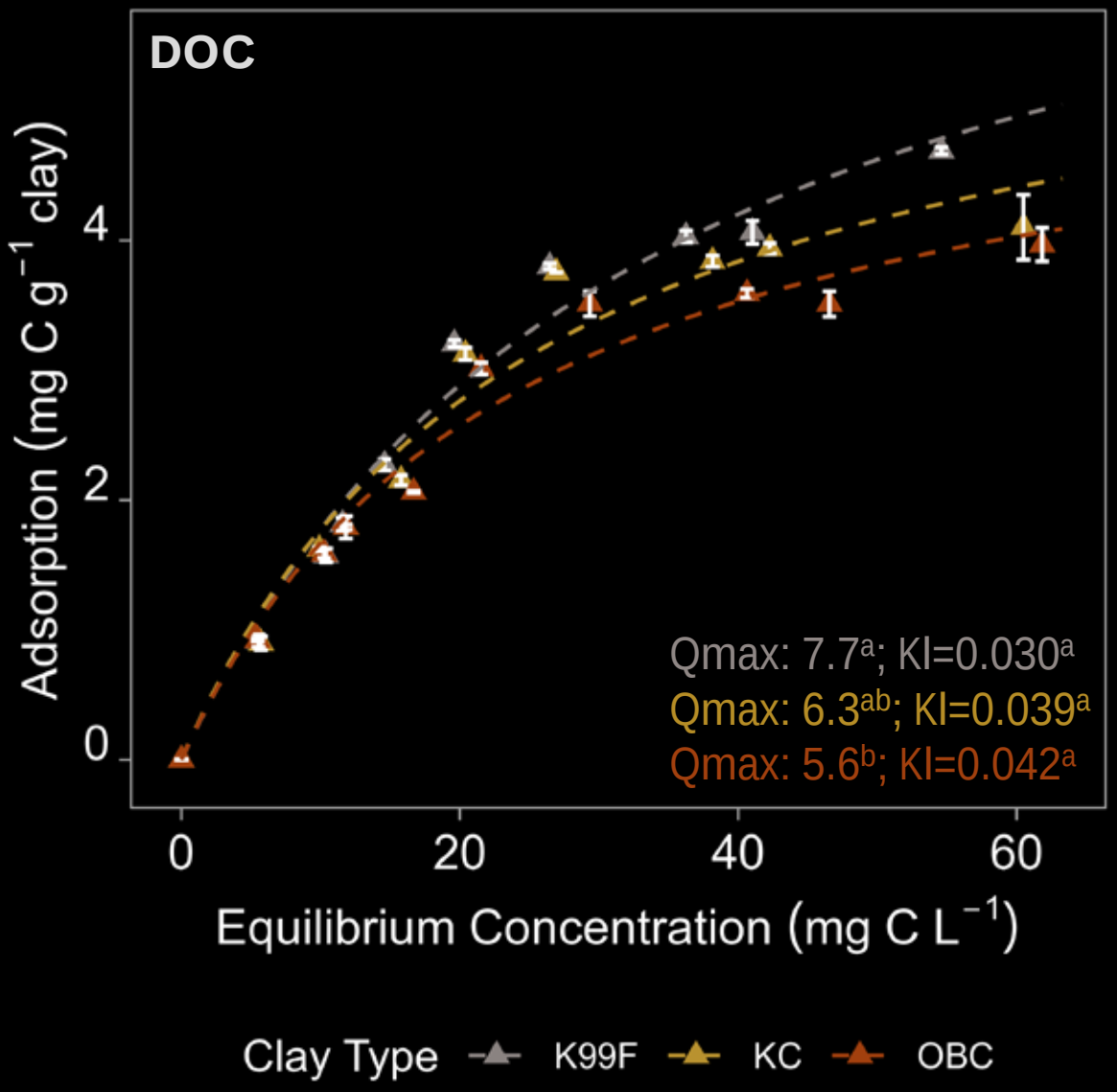
How well can they bind organic carbon?

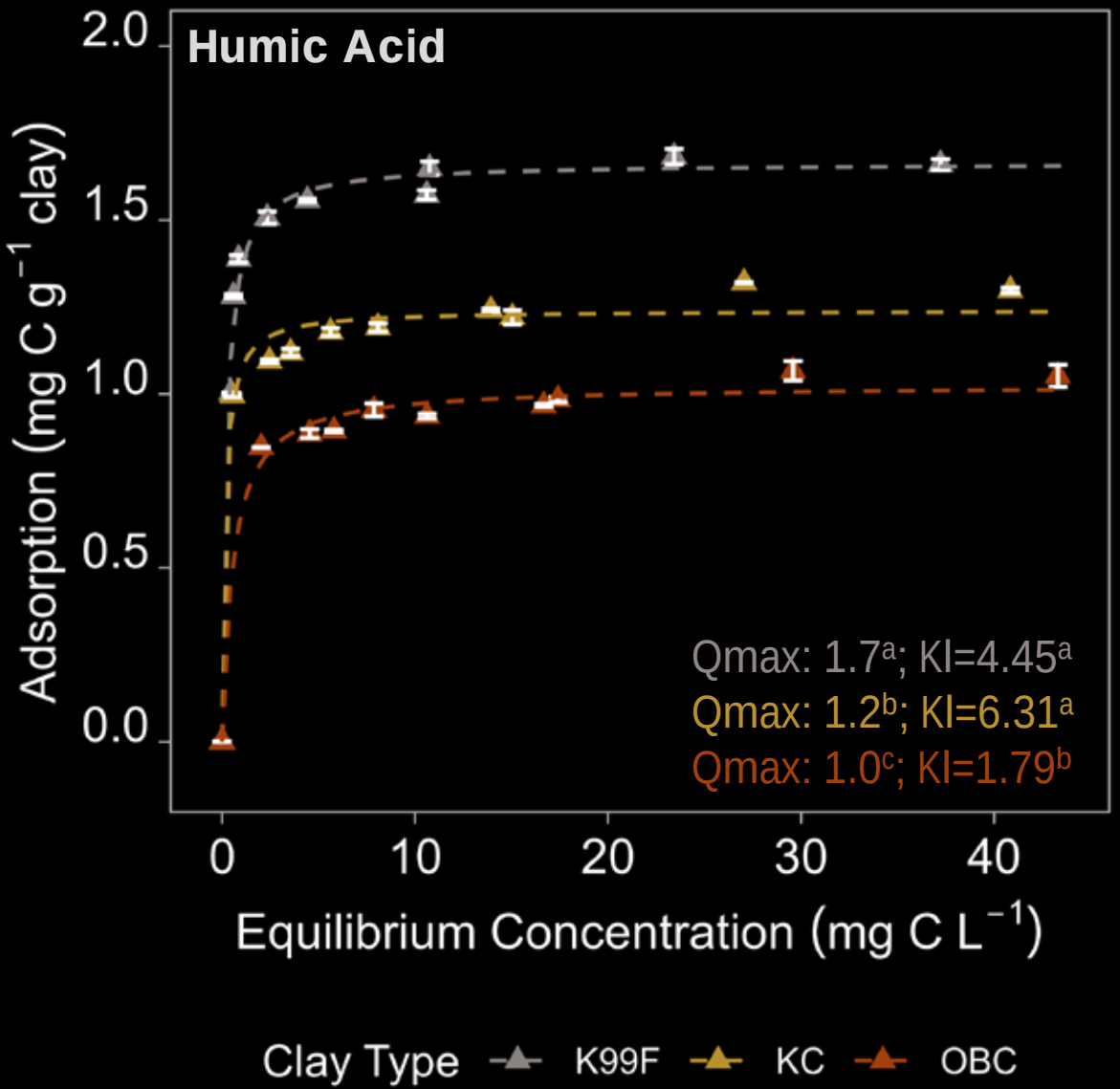
Adsorption Experiments

Clay: K99F, KC, OBC (<50 micron fraction)

Organic carbon (OC): DOC (dissolved organic carbon), Humic Acid

Initial OC Concentration: 9 different concentrations





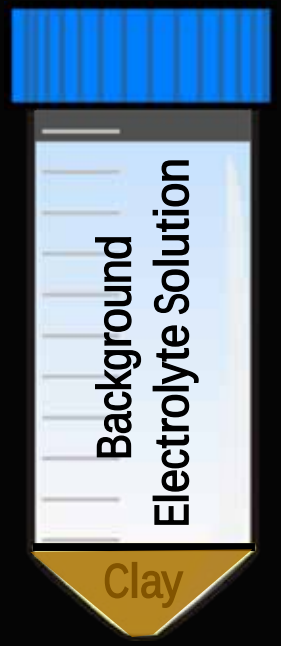
Langmuir Isotherm models

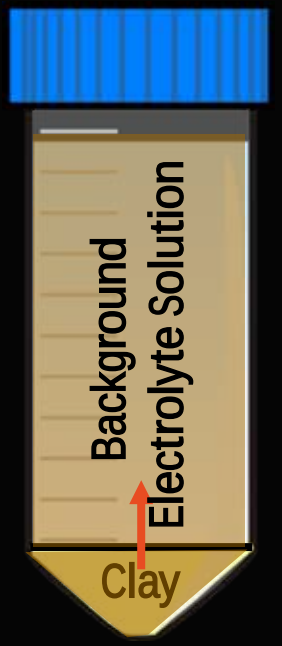
$^{a, b}$ – significantly different ($p < 0.05$)
Generalised nonlinear least squares fit with Tukey's pairwise post-hoc

2. Understanding the Desorption Capacity of the by-products

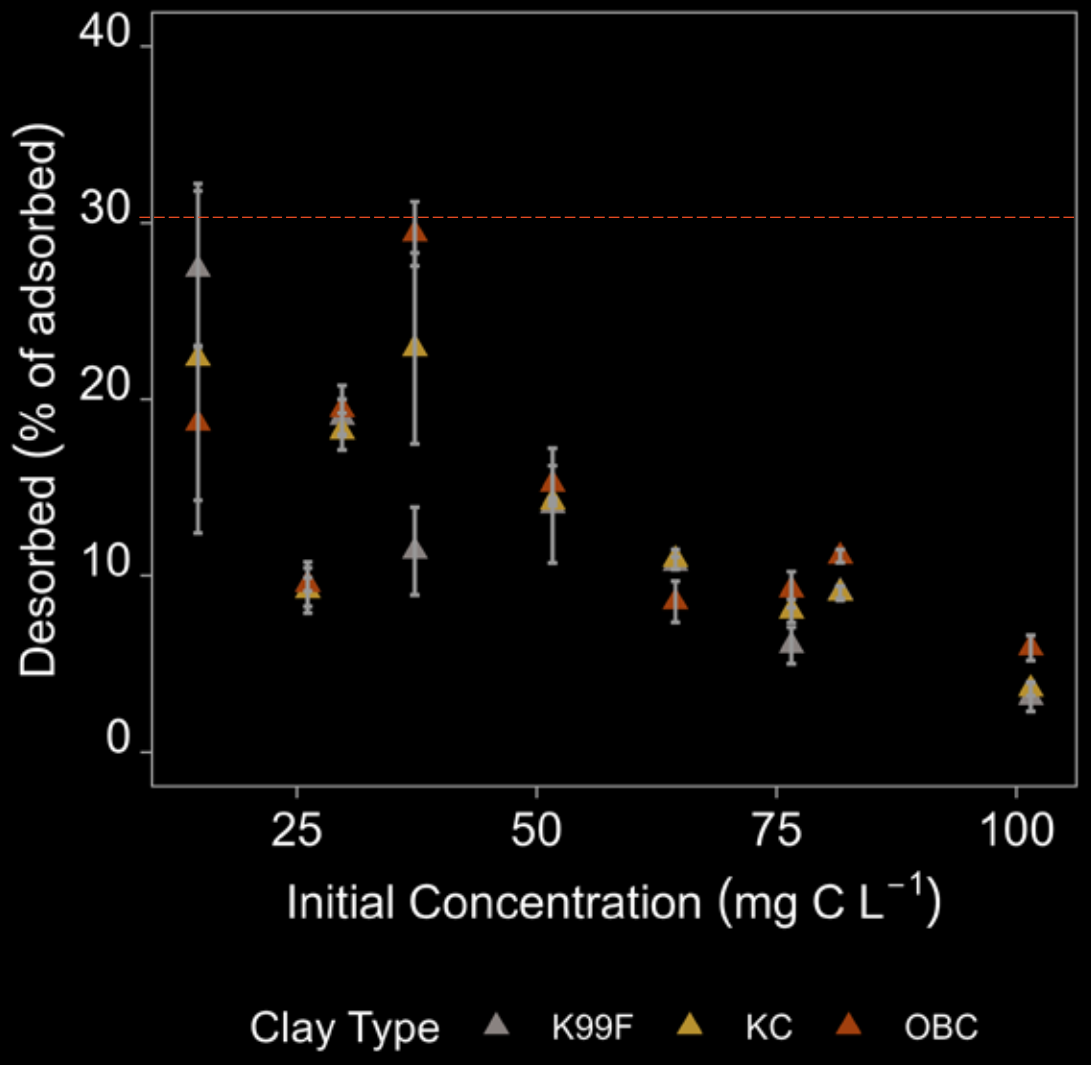
How stable is the binding?

Desorption Experiments

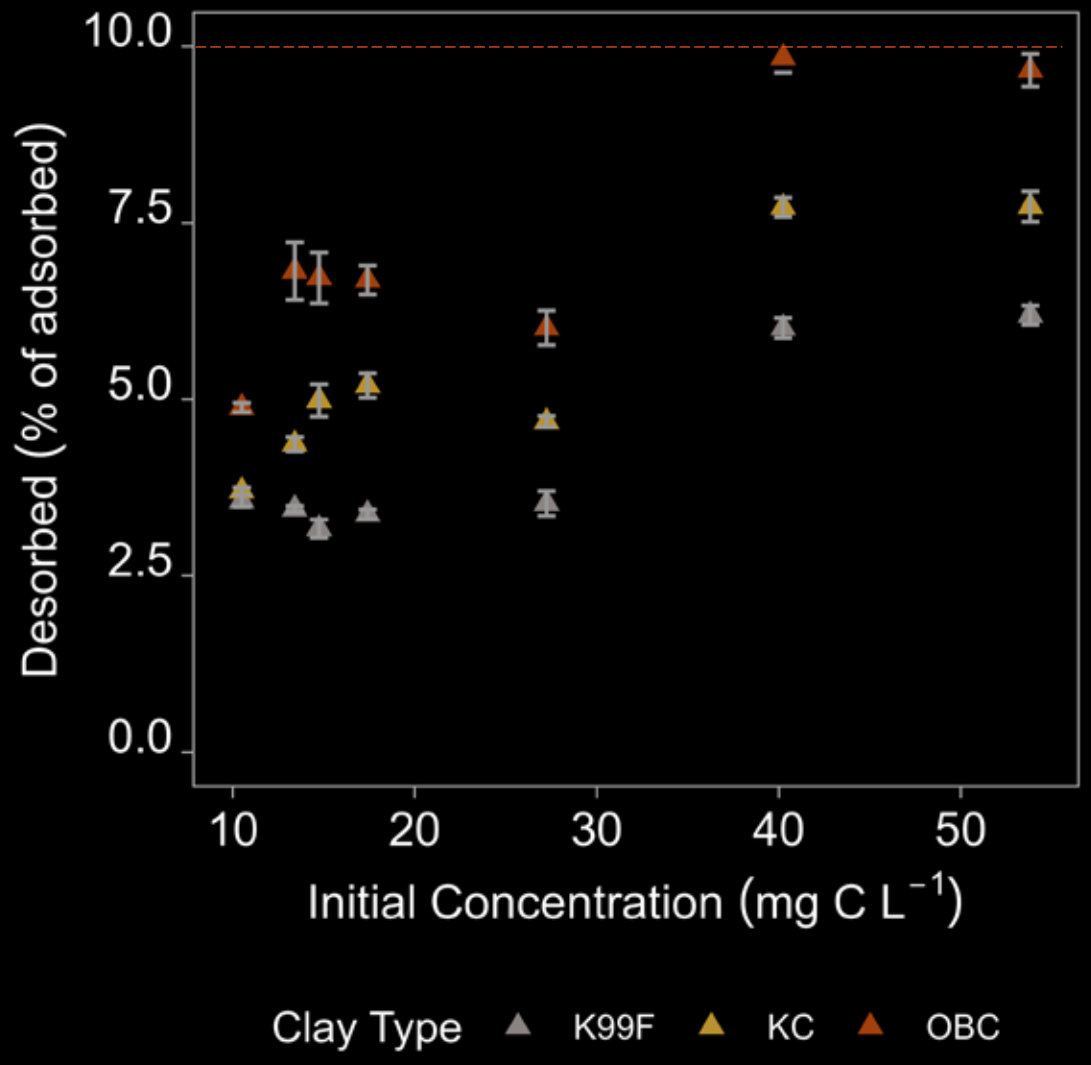


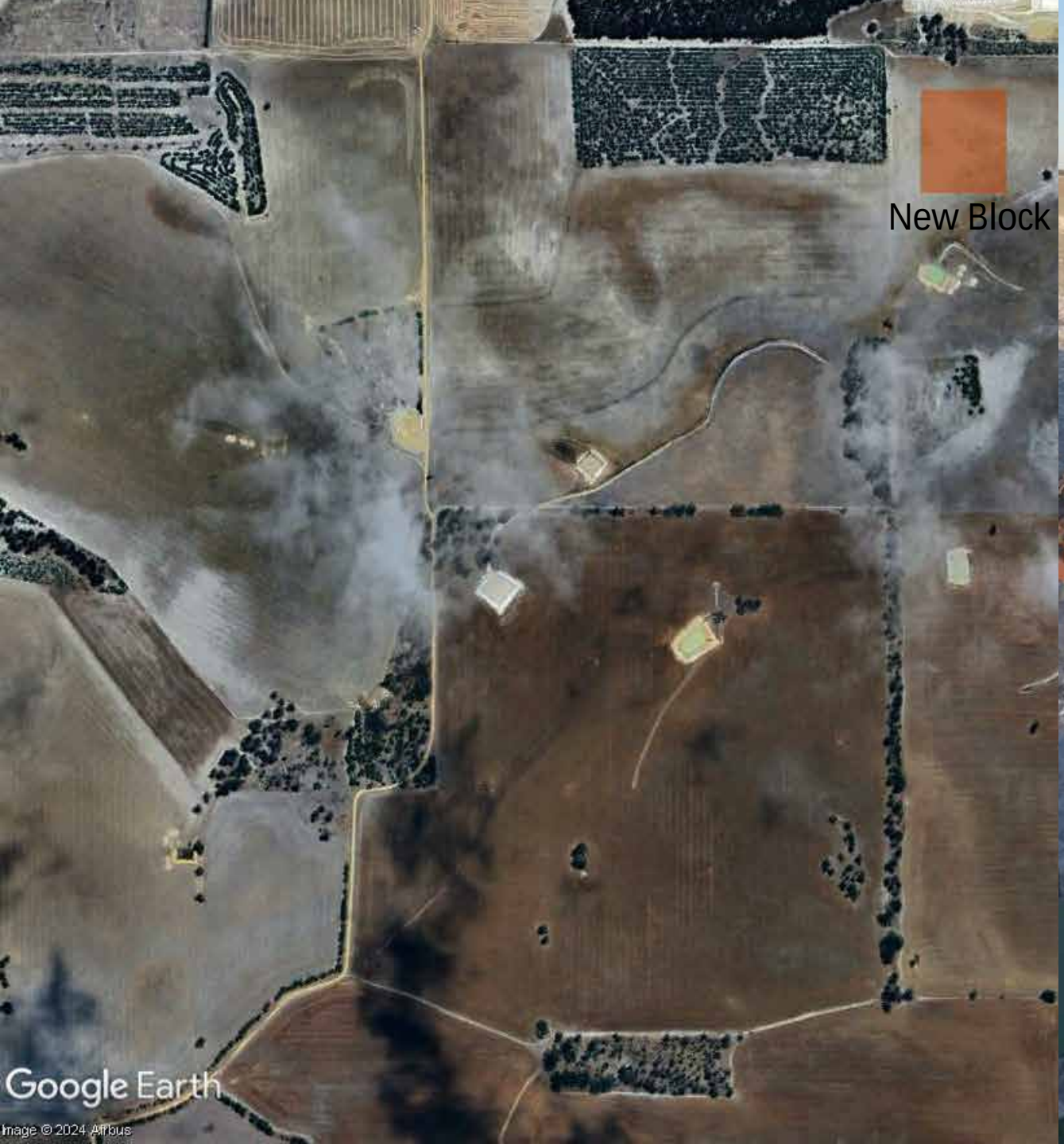


DOC



Humic Acid




New Block
Google Earth
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Thank you

Acknowledgements

WA Kaolin

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