Unlocking Potential:

A Strategic Showcase of a Multifunctional Clay Mineral for Sustainable Innovation

Demonstrating Cross-Sector Versatility from Construction to Cosmetics

May 2025

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Executive Summary

As industries worldwide accelerate the shift toward sustainable, high-performance materials, the demand for versatile, locally sourced minerals has never been greater. Our multifunctional clay mineral offers a unique solution, proven across sectors from low-carbon construction to animal feed safety and clean beauty, unlocking new possibilities for innovation and environmental impact.

Derived from a geologically stable deposit with a balanced mix of kaolinite, illite and quartz, this clay delivers strength, adsorption capacity and thermal stability. Independent research confirms its effectiveness as a supplementary cementitious material reducing CO_2 emissions, a mycotoxin binder enhancing animal feed safety, a rheology modifier improving industrial formulations and a natural ingredient aligning with clean cosmetic trends.

By bridging traditional uses with next generation demands, our clay supports circular economy goals, advances decarbonisation, and drives product differentiation. This paper invites you to explore its full potential and collaborate in scaling sustainable innovation across multiple industries.

This body of research underscores the clay's potential as a sustainable, high-performance additive, showcasing its versatility across diverse industries, reinforcing its role in advancing circular economy initiatives and reducing environmental impact.

Overview

Clay minerals are no longer just a background material, they are becoming central to industrial strategy across multiple sectors. In construction, clays are essential for cement, bricks and geotechnical works. In agriculture, they act as carriers and binders for fertilisers and pesticides and improve soil health. In cosmetics, pharmaceuticals and ceramics specific types like kaolinite and bentonite are prized for their unique chemical properties and in environmental protection they are used in pollution control.

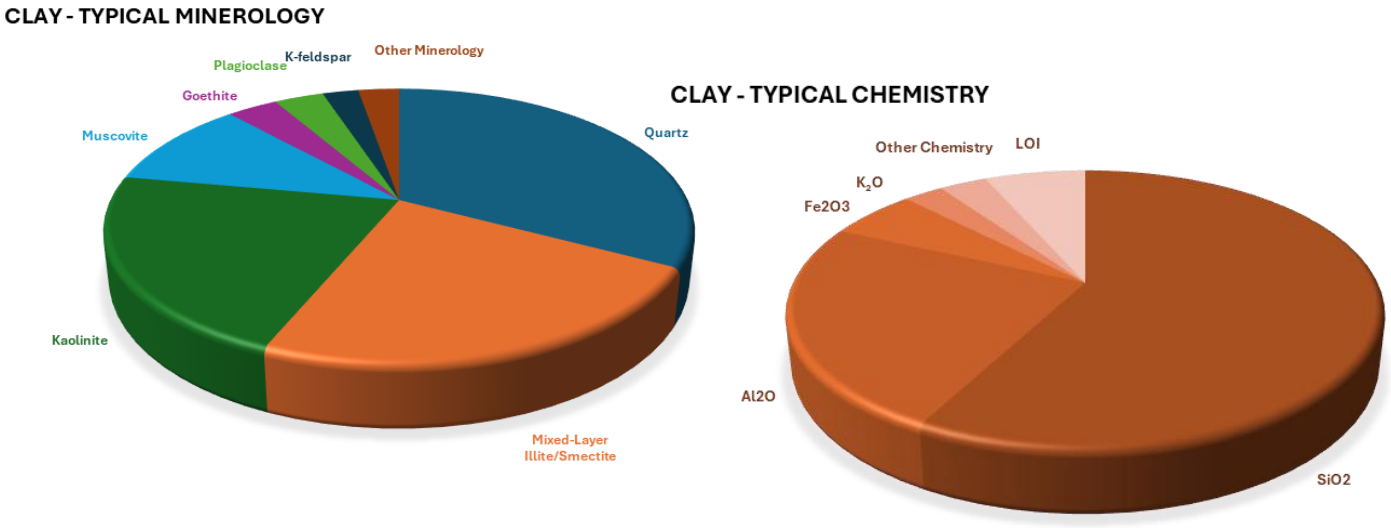
As industries shift toward sustainable and locally sourced materials, access to the right clay minerals with multifunctional capabilities is becoming of great strategic advantage.

Our Clay

This clay is a multifunctional material with a balanced mineralogy, offering strength, plasticity, adsorption and moderate cation exchange capacity. Its properties make it compatible with environmentally sensitive, thermally demanding and biologically active applications. It is ideal as a sustainable additive in construction, feed and advanced material formulations, supporting circular economy initiatives. The clay has a balanced mix of kaolinite, illite and quartz, along with iron oxides and feldspars, enhancing its suitability for construction materials, ceramics, industrial applications, cosmetic and environmental remediation. Its neutral pH and cation exchange capacity add versatility, with potential use in fired products providing good strength and colour properties.

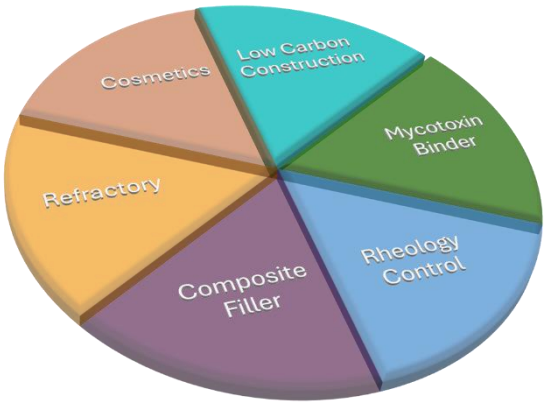
Geological Origin & Resource Security

The clay is sourced from glaciolacustrine deposits formed during the Last Glacial Maximum (26,000–15,000 years ago), when Lake Humber covered much of the region. These sediments settled in a calm, low-energy environment, creating fine, laminated layers of silts and clays with naturally low permeability. The material includes distinctive varved layers, seasonal bands of grey and darker clay reflecting rhythmic deposition over thousands of years. This geological history has produced a clay rich in illite, kaolinite, and smectite, offering consistent mineralogy with reliable performance characteristics across applications.



Research & Development

We commissioned research across several institutions to explore its performance in diverse applications and demonstrate the versatility of our multi-functional mineral. These included low carbon construction materials, mycotoxin binding in animal feed, rheology control in industrial formulation and a filler in industrial applications. Additionally, we reference refractory and cosmetic applications because of the inherent absorbent and structural properties. These studies highlight the mineral's broad potential as a multifunctional additive, supporting sustainable and high-performance solutions across multiple industries.



Low Carbon Construction

Research Partner: Kirton Concrete Services Ltd, a UKAS-accredited laboratory specialising in cementitious materials.

Purpose:
To evaluate the potential of our clay mineral as a supplementary cementitious material (SCM) aimed at reducing clinker content and associated CO_2 emissions in cement production.

Background:
The cement industry is a significant contributor to global greenhouse gas emissions, with clinker production accounting for most of the carbon footprint. Supplementary cementitious materials, such as calcined clays, are increasingly recognized for their ability to partially replace clinker while maintaining or enhancing concrete performance.

Findings:
Our clay, rich in mixed-layer Illite/Smectite minerals, demonstrates optimal pozzolanic reactivity when calcined at approximately 850°C. Testing showed that incorporating 15% calcined clay by weight into cement blends yielded the highest activity index and compressive strength across curing periods of 7, 28, and 90 days.

Calcination Temp°C	Inclusion Rate	Activity index @ Nr Days	2 Days	7 Days	28 Days	90 Days
800	15%	Activity Index	76%	80%	82%	83%
		Strength of OPC Control - Mpa	32.4	51.6	69.5	75.6
		Strength of Minore Sample - Mpa	24.5	41.2	57.2	62.8
	30%	Activity Index	53%	60%	60%	62%
		Strength of OPC Control - Mpa	32.4	51.6	69.5	75.6
		Strength of Minore Sample - Mpa	17.2	30.9	41.8	46.8
850	15%	Activity Index	82%	90%	87%	89%
		Strength of OPC Control - Mpa	32.4	51.6	69.5	75.6
		Strength of Minore Sample - Mpa	26.6	46.5	60.4	67.2
	30%	Activity Index	59%	87%	70%	72%
		Strength of OPC Control - Mpa	32.4	51.6	69.5	75.6
		Strength of Minore Sample - Mpa	19.2	34.2	48.8	54.2
930	15%	Activity Index	81%	83%	82%	82%
		Strength of OPC Control - Mpa	31.6	51.3	70.4	76.5
		Strength of Minore Sample - Mpa	25.6	42.7	57.4	62.5
	30%	Activity Index	62%	64%	67%	65%
		Strength of OPC Control - Mpa	31.6	51.3	70.4	76.5
		Strength of Minore Sample - Mpa	19.5	33.0	47.5	49.9

Key performance highlights include:

- Significant enhancement of early and long-term compressive strength compared to control mixes without SCM.
- Sustained mechanical integrity aligning with industry standards for structural applications.
- Reduced clinker demand contributing directly to lower CO_2 emissions per tonne of cement produced.

Implications:
The integration of this calcined clay as a SCM offers a practical pathway for cement manufacturers seeking to reduce their carbon footprint without compromising product quality. Its thermal stability and consistent mineralogy ensure reliable performance, supporting large-scale adoption in low-carbon construction initiatives.

Mycotoxin Binder/Adsorption Properties

Research Partner:
IBU-tec Advanced Materials AG, a German publicly listed company specialising in advanced materials development and thermal processing technologies. IBU-tec serves industries ranging from chemicals and pharmaceuticals to plastics, coatings and green technologies.

Application:
Use of clay minerals in animal feed as a mycotoxin binder, reducing the bioavailability of harmful contaminants such as Aflatoxin, Zearalenone and Ochratoxin. These toxins are a major risk to livestock health, reducing productivity and posing food chain safety concerns.

Performance:
Independent testing confirmed that our clay exhibits exceptionally high adsorption capacity for Aflatoxin (99% removal in virgin clay). Importantly, thermal treatment at low calcination temperatures (≤450 °C) further enhances binding of other critical mycotoxins such as Zearalenone and Ochratoxin.

Results suggest that a blended use of raw and low-temperature calcined clay offers the most effective broad-spectrum binding performance. This dual approach supports consistent mitigation of multiple toxin risks in feed supply chains.

The following table illustrates the adsorption efficiency of clay fired at different temperatures

	virgin	450 °C	600 °C	unit
Aflatoxin	99.0	43.8	42.9	%
Zearalenone	53.2	98.7	90.2	%
Ochratoxin A	29.7	98.3	89.0	%
T2-Toxin	17.6	92.4	92.4	%

Commercial Relevance:
- Provides a cost-effective, natural feed additive for toxin management
- Supports animal health, productivity and regulatory compliance
- Aligns with the growing demand for sustainable, mineral-based solutions in agriculture
- Demonstrates adsorption potential across other applications

By offering multi-toxin protection, our clay positions itself as a competitive additive for global feed markets facing tightening food safety standards.

Rheology Control Applications

Research Partner:
Centre for Process Innovation (CPI) – Part of the UK's High Value Manufacturing Catapult, CPI supports the development of advanced materials and formulated products across sectors such as adhesives, coatings, personal care and industrial chemicals.

Application:
Use of clay as a rheology modifier to control viscosity and flow behaviour in formulated products. Thixotropic agents are critical in applications where stable, shear-responsive flow is required such as in epoxy adhesives, resins, sealants, coatings and 3D printable pastes.

Performance:
Testing by CPI confirmed that our clay performs effectively as a thixotropic additive:

- Viscosity Control: When incorporated at 10–50 wt%, the clay significantly increased viscosity, introducing shear-thinning behaviour essential for applications where products need to be stable during storage but flow under application pressure.
- Processability: Maintained uniform dispersion without aggregation or sedimentation.
- Adhesion: No significant compromise in adhesion properties was detected in epoxy resin formulations, though further testing is recommended for specific substrate interactions.

Clay Addition (wt%)	Effect on Viscosity	Flow Behaviour
10%	Moderate increase	Shear-thinning
30%	High viscosity	Stable thixotropy
50%	Paste-like consistency	Strong shear-thinning

Commercial Relevance:

- Enables precise control of flow, spreadability, and stability in adhesives, coatings and sealants
- Reduces need for synthetic rheology agents, supporting natural formulation trends
- Supports cost-effective formulation by partially replacing higher-cost additives

This performance opens pathways for the clay to be used in industrial adhesives, epoxy flooring systems, 3D printing materials and personal care products where rheology control is critical.

Filler – Industrial Applications

Research Partner:
Centre for Process Innovation (CPI) – A leading UK technology centre supporting the development of advanced materials, including plastic composites, polymer blends and circular economy solutions.

Application:
Use of clay as a functional filler in recycled plastic composites, particularly polypropylene (PP). Fillers are added to plastics to improve mechanical properties, reduce costs and enhance processing performance, especially in mixed recycled streams where optical clarity is less critical but material performance matters.

Performance:
CPI testing validated the clay's suitability as a cost-effective filler in PP composites:

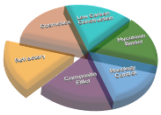
- Loading Rate: Successfully incorporated at up to 10 wt% with no adverse effects on melt behaviour or processability.
- Mechanical Enhancement: Increased material stiffness by up to 41% at 25°C, improving rigidity and dimensional stability.
- Dispersion: Uniform distribution throughout the polymer matrix, with no voiding or aggregation, ensuring consistent product quality.
- Surface Finish: Minor increase in surface roughness, acceptable for non-cosmetic applications such as automotive components, industrial casings, or packaging.

Filler Content (wt%)	Stiffness Increase	Processing Impact
5%	+20%	None
10%	+41%	None

Commercial Relevance:

- Adds value to recycled plastic streams by improving performance, not just acting as an inert filler
- Reduces reliance on virgin polymers while lowering production costs
- Supports circular economy objectives by improving the quality of recycled products

This makes the clay a viable additive for automotive plastics, construction components, electronic housings and recycled consumer products where mechanical reinforcement is needed without the high costs of engineered fillers.



Refractory Applications

Application Focus:
High-temperature industrial processes require materials that maintain structural integrity under extreme heat. Our clay's mineral composition makes it highly suitable for refractory products, materials designed to withstand repeated thermal cycling without degrading.

Material Advantages:

Property	Performance Benefit
High Alumina and Silica Content	Provides thermal stability and structural strength
Low Fluxing Agents (Na_2O, CaO)	Reduces risk of premature softening or deformation
Non-Swelling Kaolinite & Illite	Enhances resistance to thermal shock and shrinkage
Moderate Iron Oxide Content	Contributes to sintering strength and controlled coloration
Quartz Content	Acts as a structural filler, improving dimensional stability under heat

Potential Uses:

- Refractory Bricks – Linings for kilns, furnaces and incinerators
- Castables & Mortars – Pumpable or gunned applications for high-temperature installations
- Insulation Products – Lightweight thermal barriers with stable performance over time

Why This Matters:
Global demand for refractory materials is rising due to the growth of sectors like steel making, glass production, ceramics and waste-to-energy. However, supply chain risks, environmental regulations and rising costs of imported refractories are pushing industries to seek alternative local sources.

Commercial Opportunity:
Our clay provides a UK-based, low-carbon alternative to imported refractory materials, supporting:

- Domestic supply chain security
- Reduced embodied CO_2 compared to fully synthetic or imported options
- Customisable formulations for both dense and insulating refractories

Cosmetics

Application Focus:
As the cosmetics industry pivots toward natural, mineral-based ingredients, high-purity clays are increasingly in demand for their gentle absorbency, detoxifying properties and skin-friendly profiles. Our clay aligns with this trend, offering multifunctional benefits for skin care and cosmetic formulations.

Material Advantages:

Property	Cosmetic Benefit
High Kaolinite Content	Provides soft texture, mild absorbency, and skin detoxification
Near-Neutral pH (6–8)	Gentle on skin; maintains natural acid mantle
Fine Particle Size	Smooth skin feel; non-abrasive in masks and powders
Muscovite Presence	Adds natural slip and sheen for enhanced product aesthetics
Low Heavy Metal Content	Safe for topical applications; aligns with regulatory standards
Anatase (TiO_2 phase)	Potential for natural UV reflectivity and light-scattering

Potential Uses:

- Facial Masks & Clays – Detoxifying and mattifying formulations
- Powders & Foundations – Natural mattifying agents with smooth feel
- Cleansers & Scrubs – Mild exfoliation and oil absorption
- Sunscreen Enhancers – Light-reflective properties for mineral-based SPF products

Market Alignment:

- Clean Beauty Movement – Consumers demand transparent, naturally sourced ingredients with minimal processing.
- Sustainability Focus – Locally sourced minerals reduce supply chain emissions and environmental impact.
- Formulation Flexibility – Compatible with both water-based and oil-based systems.

Commercial Opportunity:
This clay offers cosmetic formulators a multifunctional, UK-sourced ingredient that enhances product performance while supporting “clean beauty” and eco-conscious branding.

Supply Chain Information

Our clay resource is abundant and well-positioned to support large-scale industrial demand. Current proven reserves total approximately 200,000 tonnes, with an estimated 90,000 tonnes in stock for immediate supply.

This secure and locally sourced supply ensures consistent availability, enabling reliable long-term partnerships and scalable production to meet growing market needs in construction, feed, cosmetics and industrial applications.

Conclusion

The evolving role of clay minerals in modern industry reflects a broader shift toward sustainable, high-performance materials that support circular economy goals. Our multifunctional clay, with its balanced mineralogy and adaptable properties, stands at the forefront of this transformation. From reducing carbon emissions in construction to enhancing animal feed safety, improving industrial formulations and enabling clean beauty innovations, the clay's versatility has been validated through rigorous cross-sector research.

Its geological origin, mineral composition and performance across diverse applications underscore its potential as a strategic resource. As industries increasingly prioritise local sourcing, environmental responsibility and material efficiency, this clay offers a compelling solution, bridging traditional uses with next generation demands. Continued development and collaboration will unlock even greater value, positioning this material as a cornerstone of sustainable innovation.

We are actively seeking partners to scale this material into commercial use across construction, feed, cosmetics, and beyond. Contact us to explore pilot projects, supply partnerships or joint R&D.