

EXCITING FUNCTIONAL FILLERS THAT YOU MAY NOT HAVE TRIED

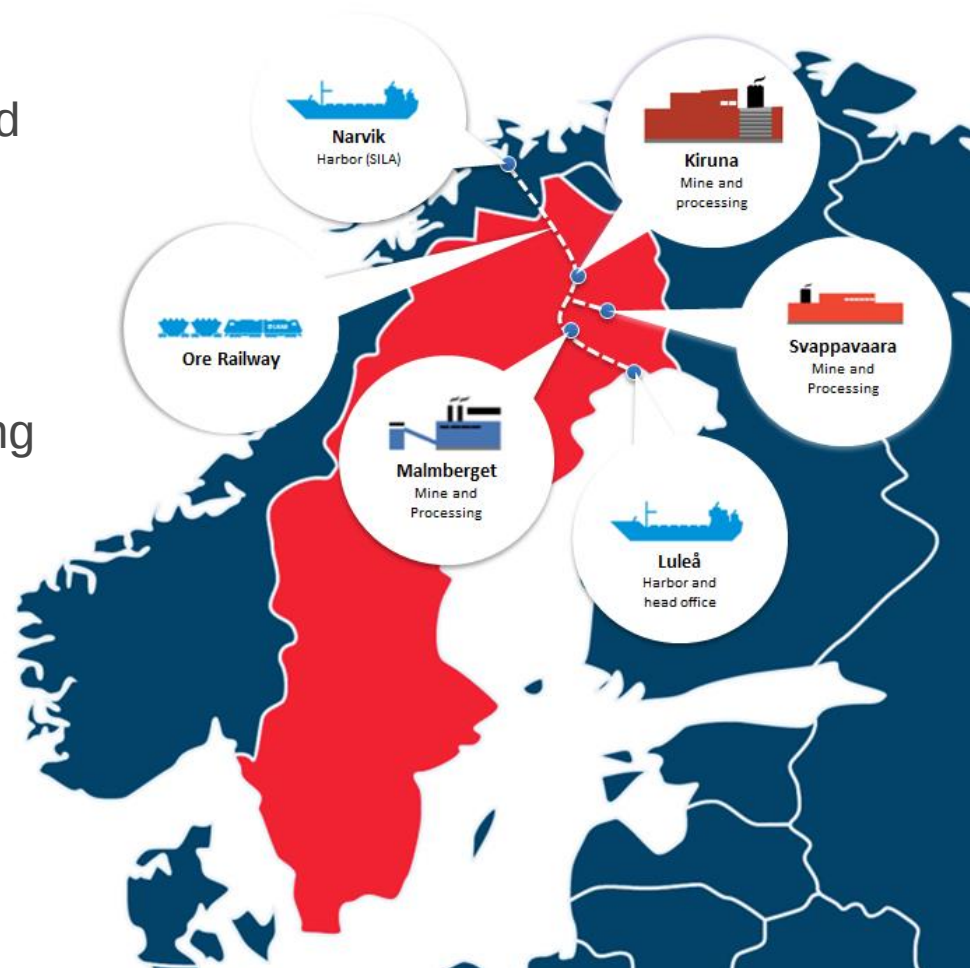
Dr. Chris DeArmitt FRSC

OUTLINE

- Introduction to LKAB Minerals (formerly Minelco)
- Magnetite – a multi-functional specialty filler
- Phlogopite mica – PW80 a new breakthrough grade
- HyperCarb – pure Huntite, a new functional filler
- Conclusions

THE LKAB GROUP IN BRIEF

- World leading producer of upgraded iron ore
- Delivered 25.5 Million MT in 2013, plan to grow to 37 Million MT
- Two underground mines in Kiruna and Malmberget and open pit mining in Svappavaara
- Producer of 90% of EU's iron ore
- ~4,400 employees
- 30 companies in 15 countries
 - E.g. Drilling, Concrete, Explosives, Railway, Harbour, Construction.
- Turnover 2013: USD 3.2 Billion



BROAD APPLICABILITY

We focus our R&D resources on mineral and application development in the areas of:

Civil Engineering and Construction



Polymers and Coatings



Refractory and Foundry



MAGNIF – HIGH PURITY MAGNETITE

MAGNETITE PROCESSING



MAGNETITE ORE



1. Density 5.2 gcm^{-3}
2. Moh Hardness ~ 6
3. Semi-conductive
4. Thermally conductive
5. High specific heat capacity
6. Extremely pure



1. Sound deadening, weights
2. Solid surfaces
3. Anti-static, shielding, induction & microwave heatable, tracer
4. Improved productivity
5. Heat storage
6. Food contact approved

MAGNETITE IN USE



PHLOGOPITE MICA – VHAR REINFORCEMENT

MINERAL REINFORCEMENTS COMPARED

Particle Dimensions (Malvern)	Calcined Clay	Wollastonite	Talc	Phlogopite Mica PW80
D ₅₀	3	3.5	12	37
D ₉₀	10	13	40	95
Aspect Ratio	Medium	Medium	High	Very High
Reinforces in	2 directions	1 direction	2 directions	2 directions

PHLOGOPITE MICA

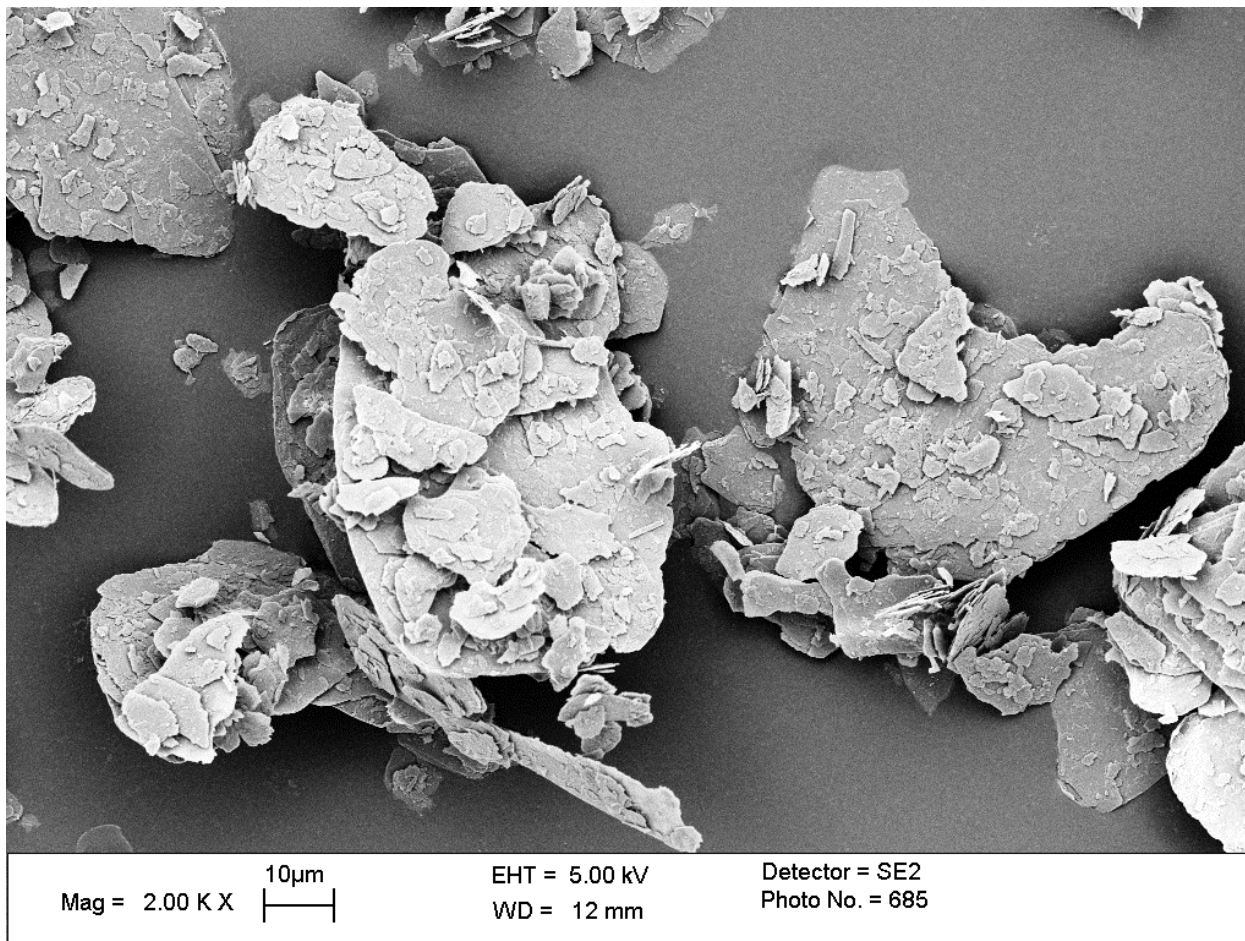


1. Chemically inert
2. Electrical insulator
3. Bronze colored
4. Stable to 900°C
5. Platy shape
6. Extremely pure (low quartz)



1. Barrier
2. Dielectric
3. Pigment
4. FR applications
5. Reinforces in two directions, sound deadening
6. Food contact approved

SEM OF PHLOGOPITE MICA PW80



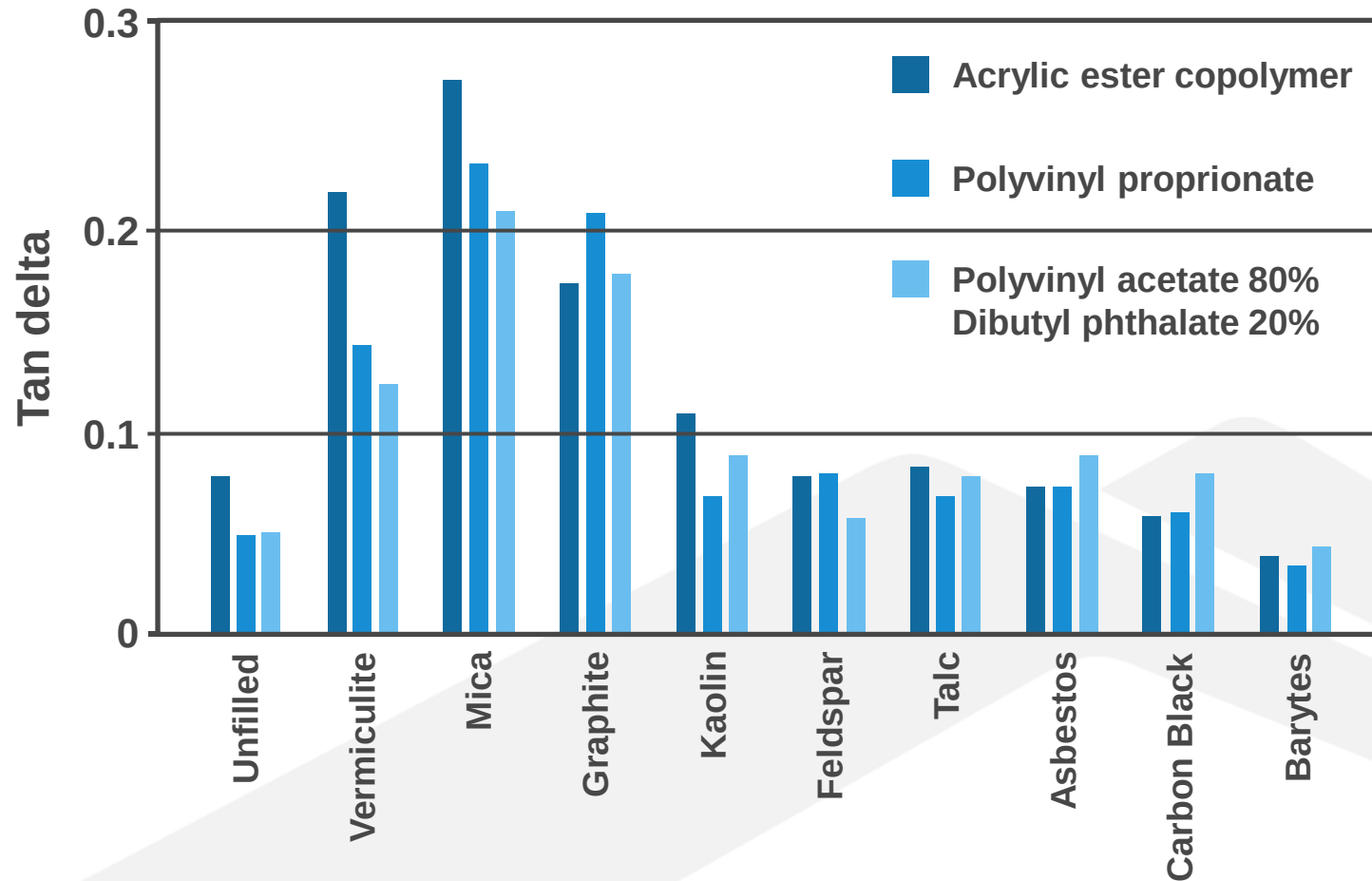
REINFORCEMENT COMPARISON IN PA6

Property	Talc 40%	Calcined Clay 40%	Wollastonite 40%	Phlogopite Mica 40%	GF 40%
Flexural Modulus (MPa)	7400	6120	5514	10370	11980
Flexural Strength (MPa)	120	150	135	155	290
Tensile Modulus (MPa)	7470	6313	5450	11160	13215
Break Stress (MPa)	74	87	83	95	195
Break Strain (%)	2.8	6.4	8.4	1.7	2.6
Unnotched Charpy (kJm ⁻²)	28.5	80	No Break	29	79
Notched Charpy (kJm ⁻²)	3.5	6.4	6.4	4.0	12.8
Shrinkage = (%)	0.65	1.31	1.06	0.58	0.1
Shrinkage (%)	0.97	1.66	1.64	0.87	0.98
Warpage (%)	0.32	0.35	0.58	0.29	0.88

REINFORCEMENT COMPARISON IN PA6

Property	GF25% Talc15%	GF 25% Clay 15%	GF 25% Wollastonite 15%	GF 25% Phlogopite Mica 15%	GF 40%
Flexural Modulus (MPa)	9843	9350	9080	10550	11980
Flexural Strength (MPa)	210	213	226	231	290
Tensile Modulus (MPa)	11400	9950	10100	12200	13215
Break Stress (MPa)	140	144	144	165	195
Break Strain (%)	2.4	3.4	2.6	2.4	2.6
Unnotched Charpy (kJm ⁻²)	52.3	43.6	50.3	60	79
Notched Charpy (kJm ⁻²)	7.4	5.6	6.9	8.6	12.8
Shrinkage = (%)	0.22	0.26	0.23	0.22	0.1
Shrinkage (%)	0.91	0.99	1.04	0.81	0.98
Warpage (%)	0.69	0.73	0.81	0.59	0.88

SOUND DAMPING - VHAR MICA VS OTHER MINERALS



Influence of Fillers on Damping Efficiency, Kunststoffe, 50 (11): 606-612 (1960).

CUSTOMER FEEDBACK ON PW80

“It’s magic”

high performance coatings company

“It blew everything else out of the water”

leading plastics manufacturer

“significantly better than everything else”

Fortune 500 company

VHAR PHLOGOPITE MICA

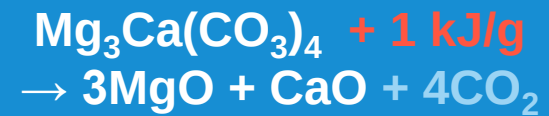
- High purity Phlogopite Mica as starting material
- State of the art wet grinding and classification for optimal aspect ratio and particle size control
- Excellent reinforcement alone or in combination with glass fiber
- The best solution for nylon, PP and other engineering thermoplastics, comparable to double the amount of talc
- Warpage control, superb electrical properties and sound damping are other key advantages

HYPERCARB – PURE HUNTITE

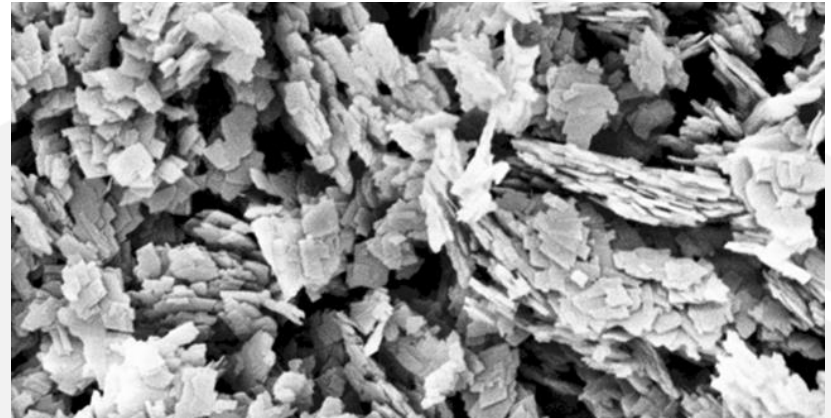
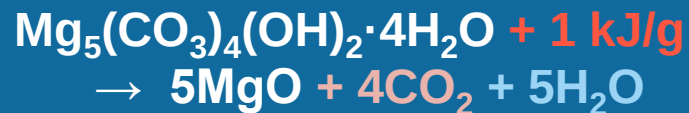
HMH: A BLEND OF TWO MINERALS



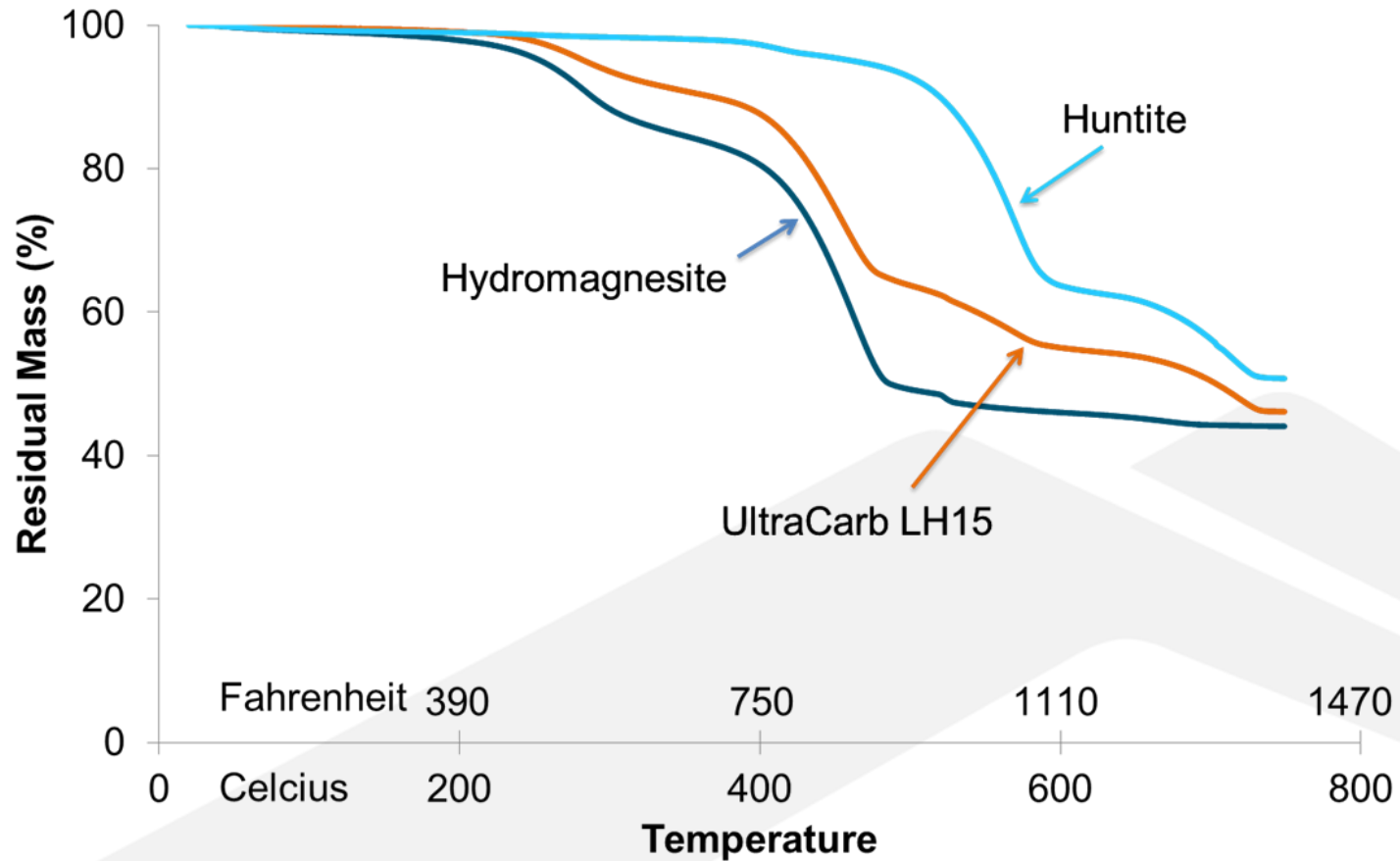
huntite:
magnesium calcium carbonate



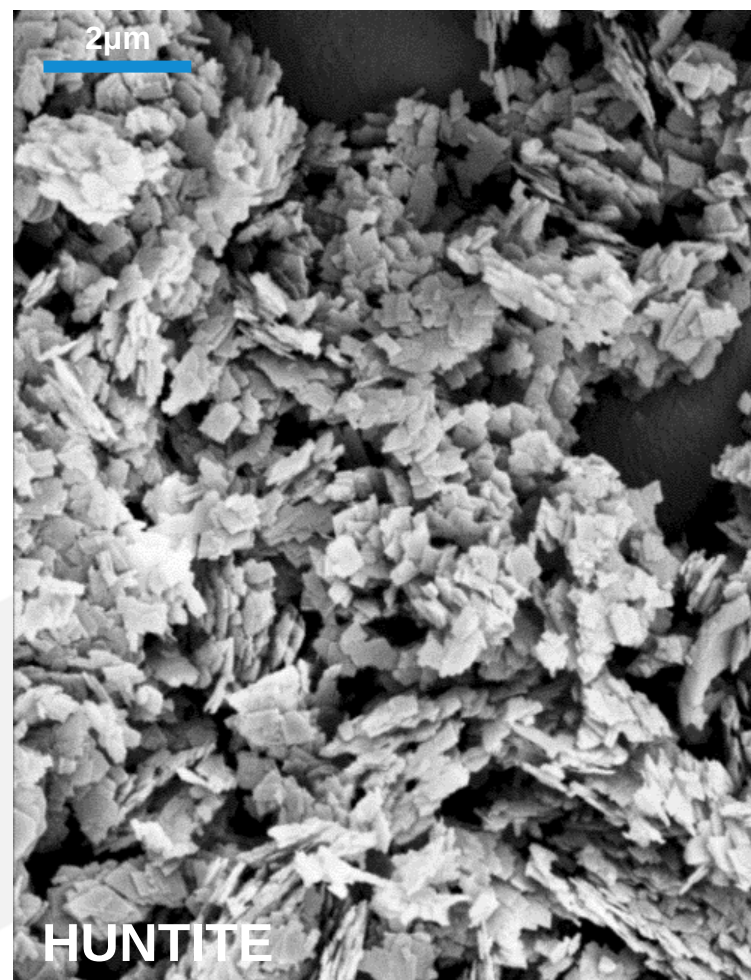
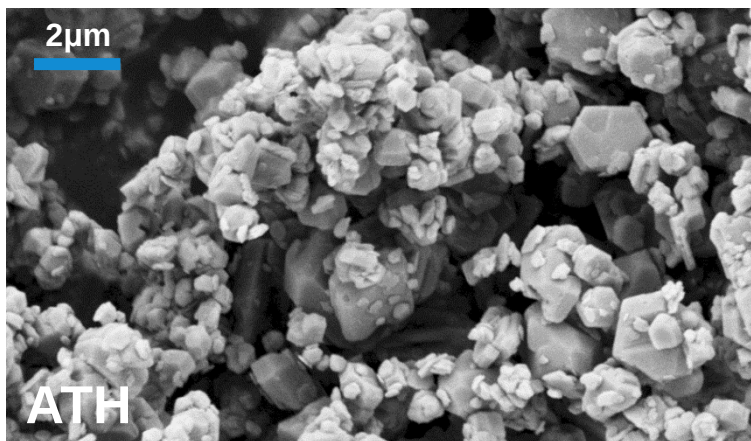
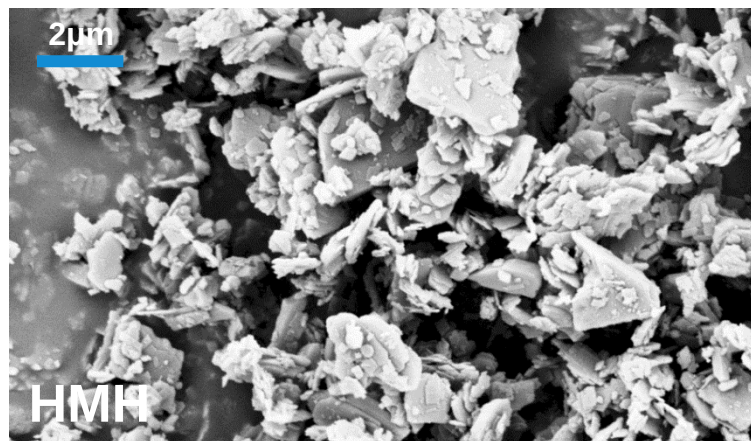
hydromagnesite:
hydrated magnesium carbonate



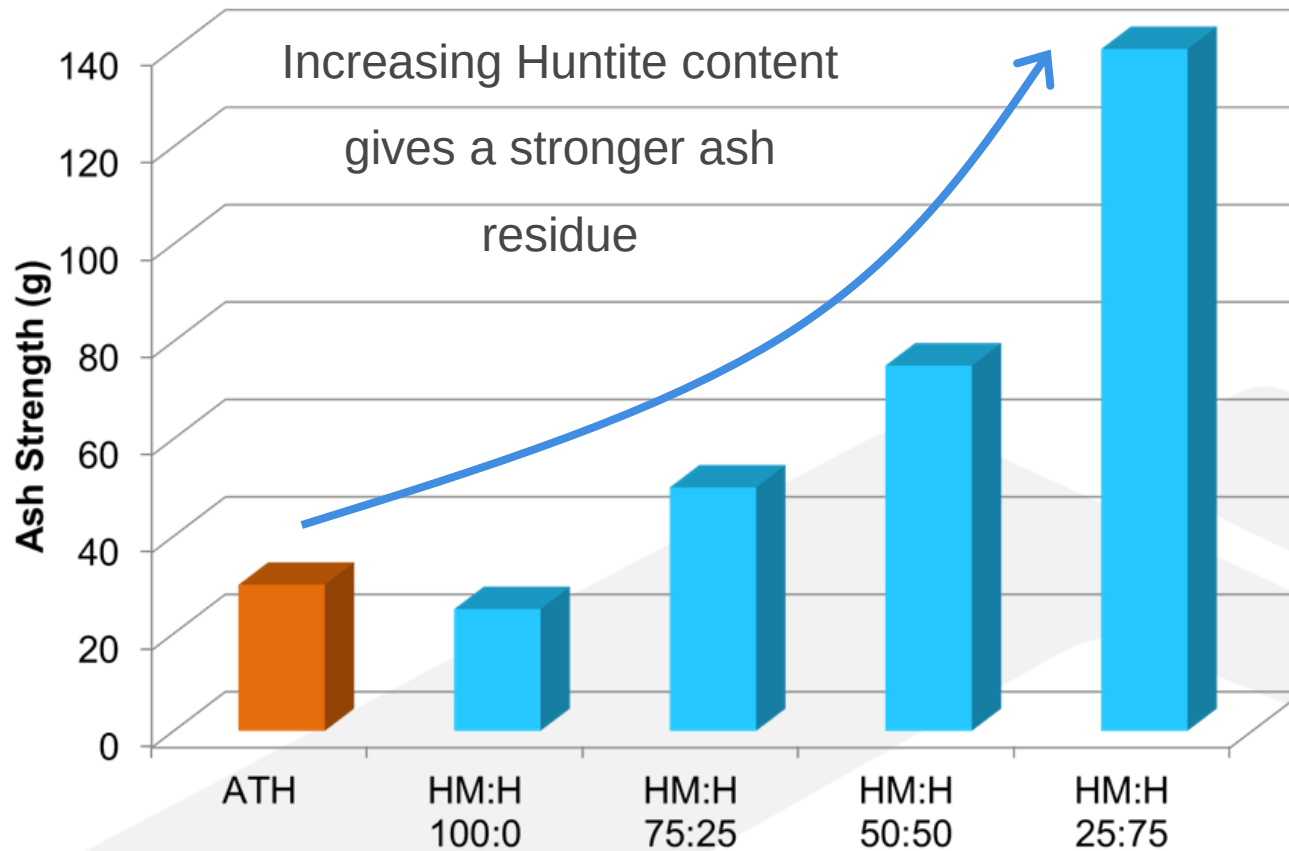
HYDROMAGNESITE & HUNTITE DECOMPOSITION



PLATY MORPHOLOGY



ANALYSIS OF THE ASH RESIDUE



HUNTITE



1. Calcium magnesium carbonate
2. High surface area
3. High refractive index and small
4. Alkaline
5. Platy shape
6. Extremely pure



1. Acid scavenger, chemical & physical blowing agent, dissolvable
2. Foam nucleation, rheology
3. Partial TiO_2 replacement
4. Allows unimpeded cure
5. Reinforces in two directions
6. Food contact approved

CONCLUSIONS

- Specialty minerals allow new levels of performance
- Established minerals like mica can still be innovative
- Magnetite has been used for decades but its full potential has not yet been tapped
- HyperCarb, pure Huntite is a new functional filler with unique properties that gives new opportunities

Information herein is intended for guidance only and given in good faith but without guarantee. LKAB Minerals is not responsible for the product's suitability for a particular purpose. The only warranty LKAB Minerals makes is the express written warranty extended on the sale of its products.

THANK YOU! – QUESTIONS?