LKAB Minerals

HMH - A NATURAL SOLUTION TO YOUR BURNING ISSUES

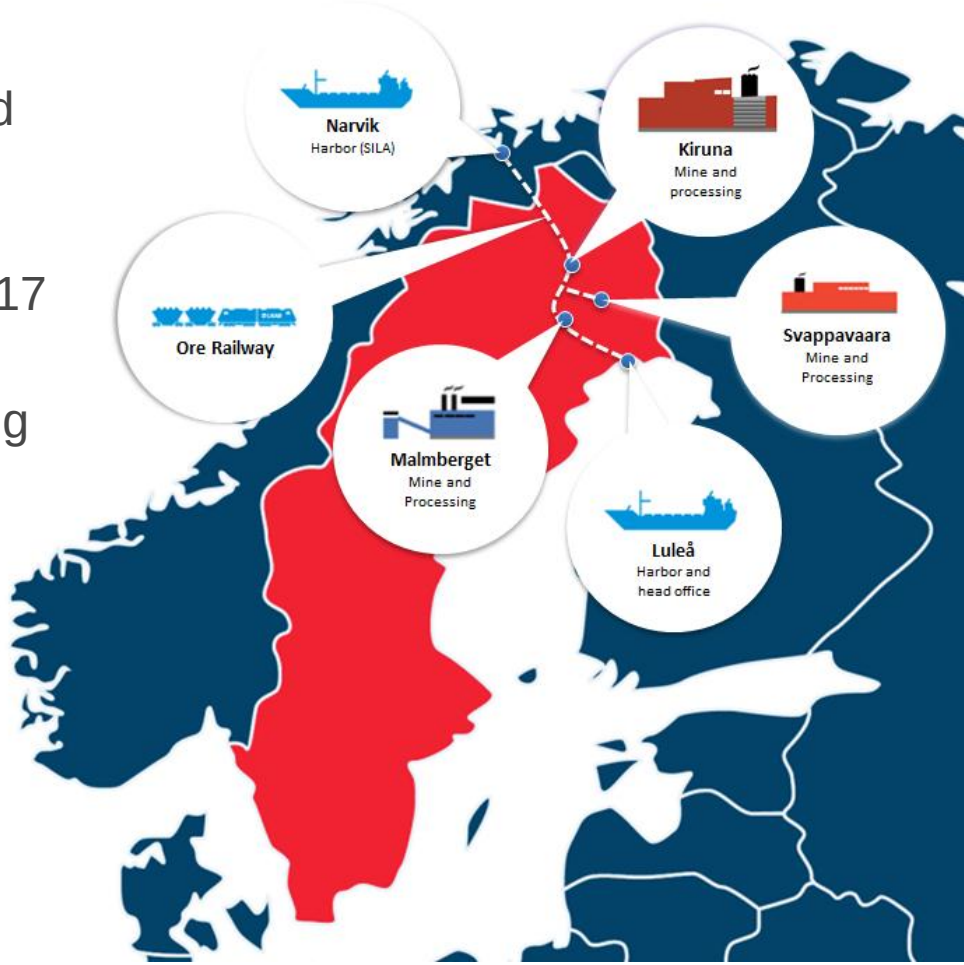
Dr. Chris DeArmitt FRSC

- HMH work by Stefan Viering

MINERAL SOLUTIONS FOR OUR WORLD

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 by 2017
- 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: SEK 23.65 Billion



FOCUS CREATES SPECIALISATION

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

ROTARY KILN

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

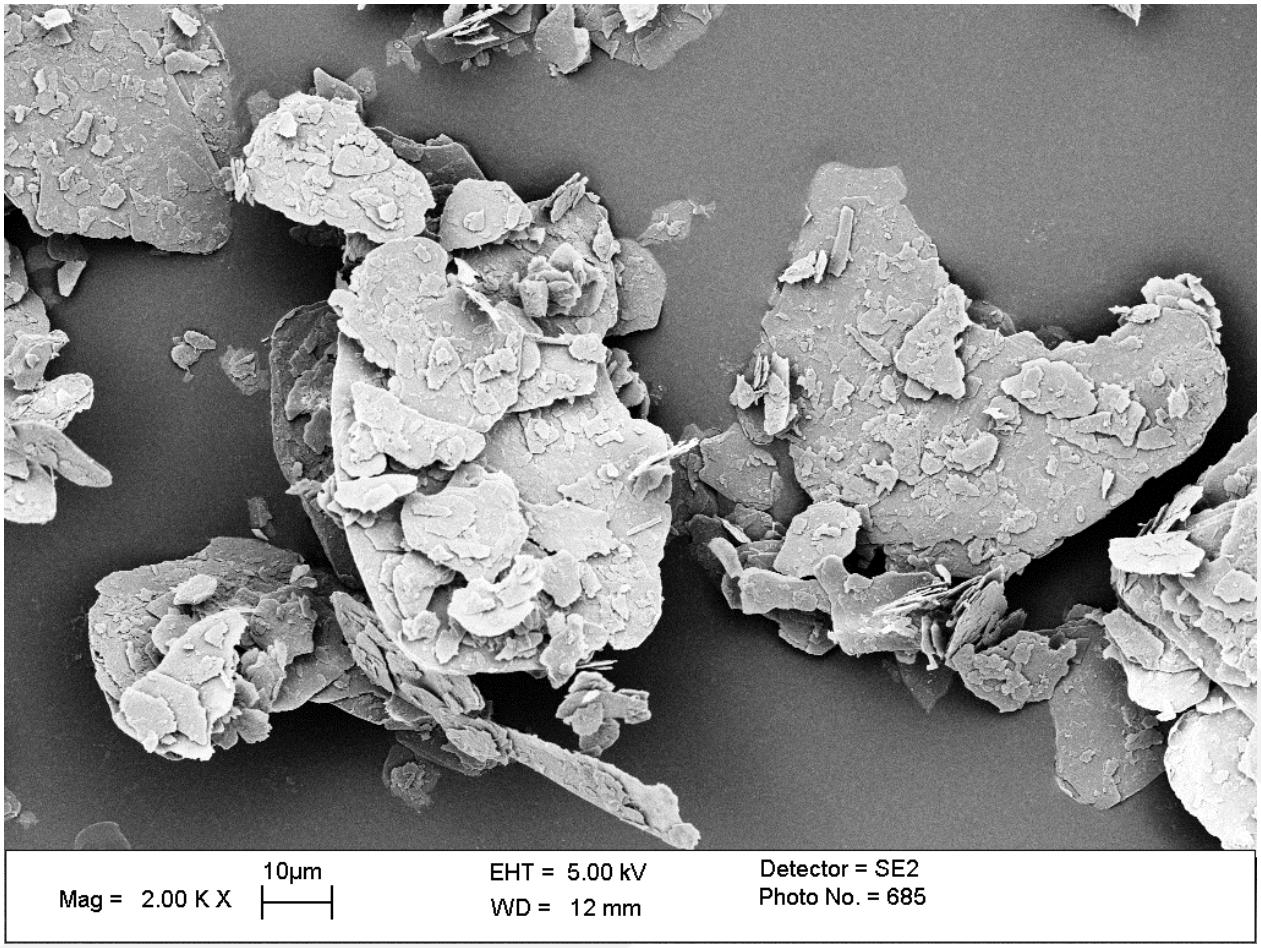
1. Sound deadening, weights
2. Solid surfaces
3. Anti-static, shielding, induction & microwave heatable
4. Lowers cycle time
5. Heat storage
6. Food contact approved

PHLOGOPITE MICA – VHAR REINFORCEMENT

MINERAL REINFORCEMENTS COMPARED

Particle Dimensions (Malvern)	Talc	Calcined Clay	Wollastonite	Phlogopite Mica PW80
D_{50}	12	3	3.5	37
D_{90}	40	10	13	95
Aspect Ratio	High	High	High	Very High

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

LKAB Minerals data from accredited external laboratory

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

LKAB Minerals data from accredited external laboratory

ULTRACARB – NATURE'S OWN FLAME RETARDANT

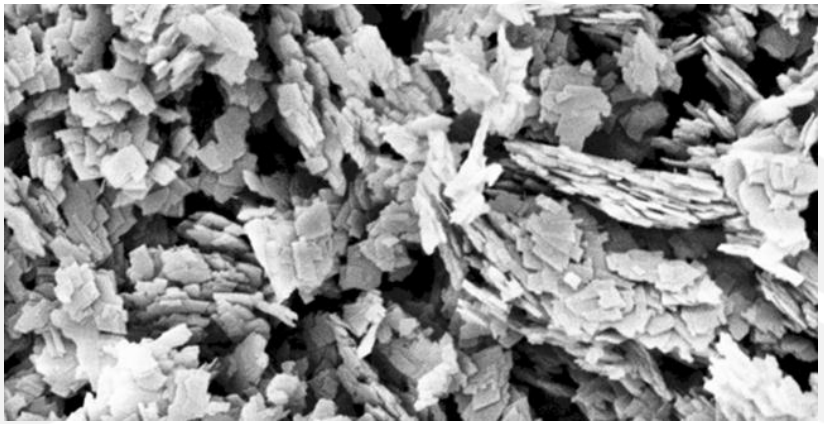
HMH: A BLEND OF TWO MINERALS

huntite:
magnesium calcium carbonate

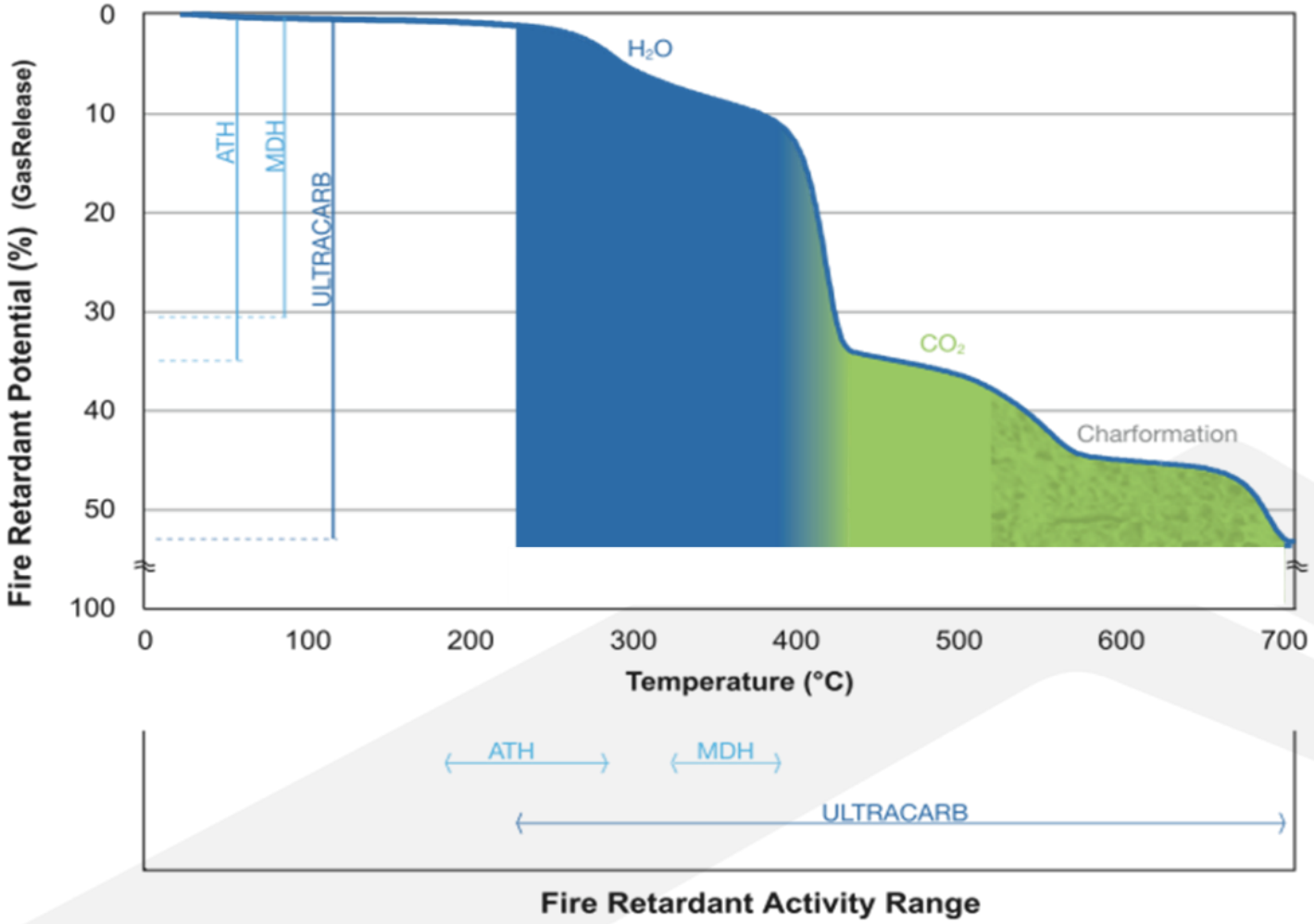
$Mg_3Ca(CO_3)_4$ + 1 kJ/g
→ 3MgO + CaO + $4CO_2$

hydromagnesite:
hydrated magnesium carbonate

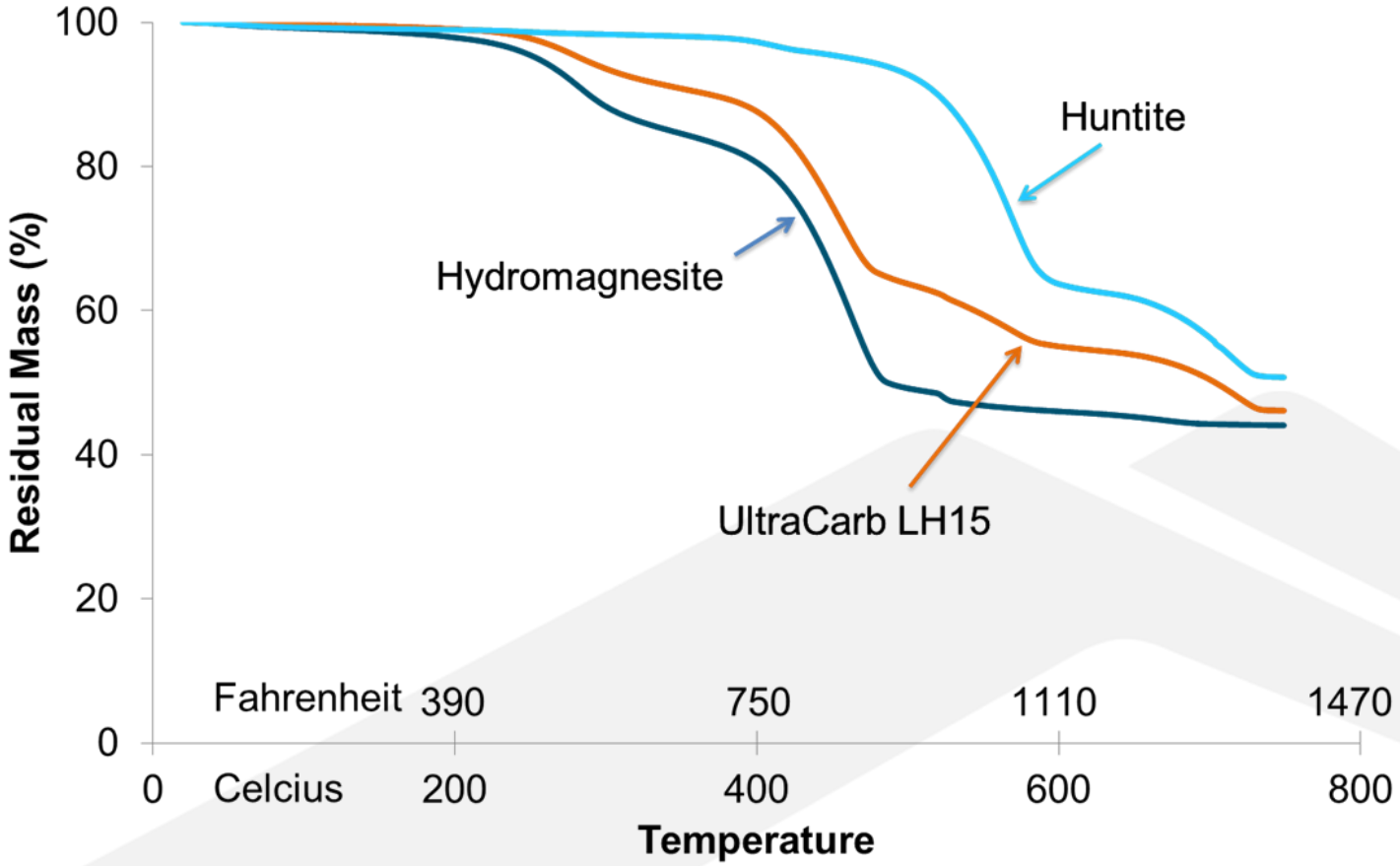
$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$ + 1 kJ/g
→ 5MgO + $4CO_2$ + $5H_2O$



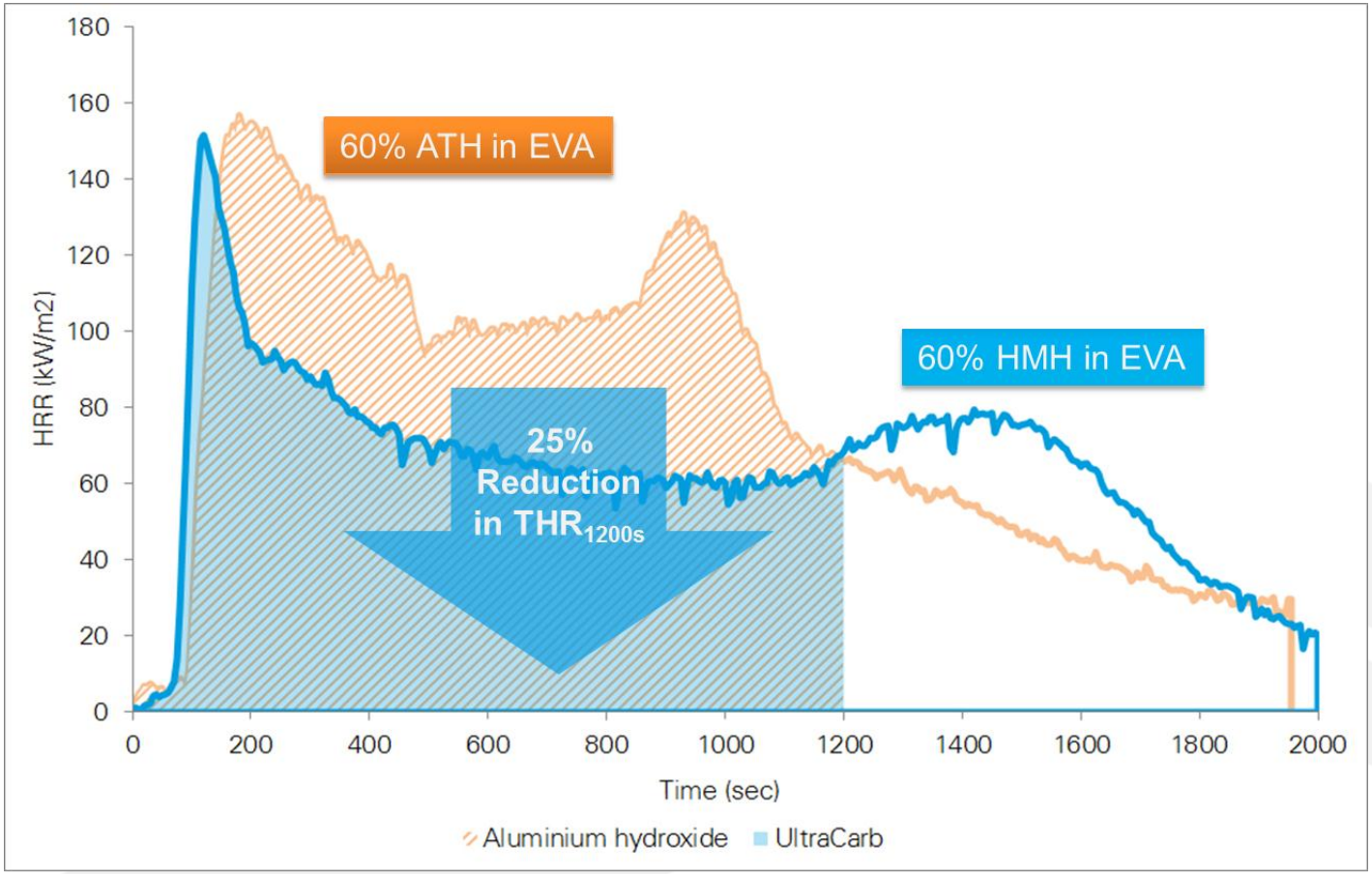
THE THREE STAGE FR MECHANISM OF HMH



HYDROMAGNESITE & HUNTITE DECOMPOSITION

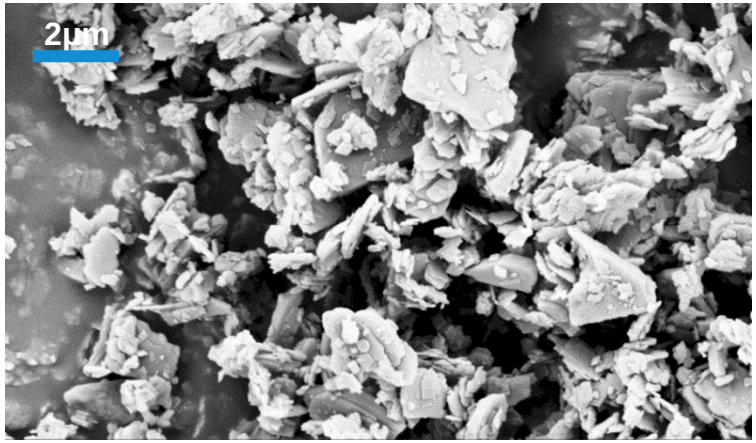


TOTAL HEAT RELEASE OF HMH AND ATH

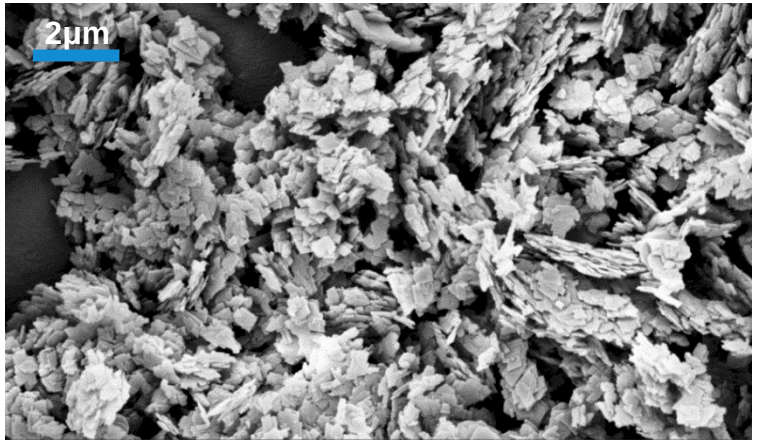


Data retrieved from 50kW cone calorimeter

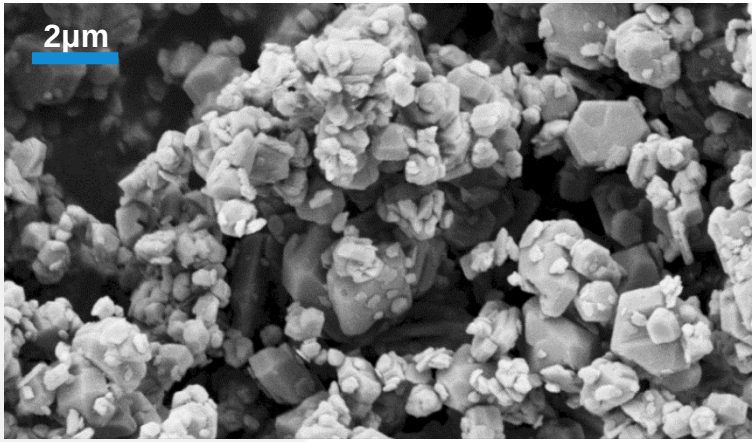
PARTICLE MORPHOLOGY



HMH



Huntite

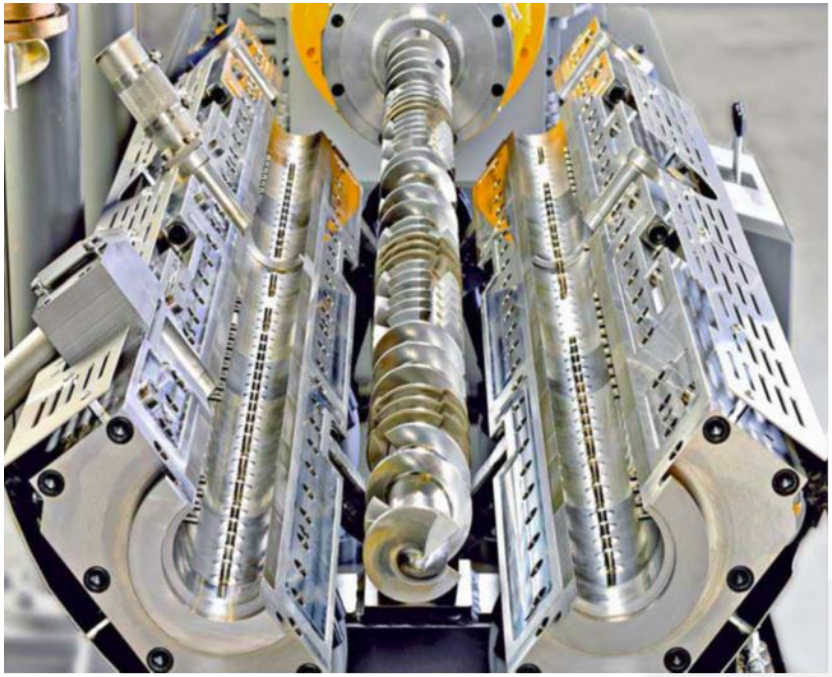


ATH

NATURAL HMH VERSUS SYNTHETIC ATH

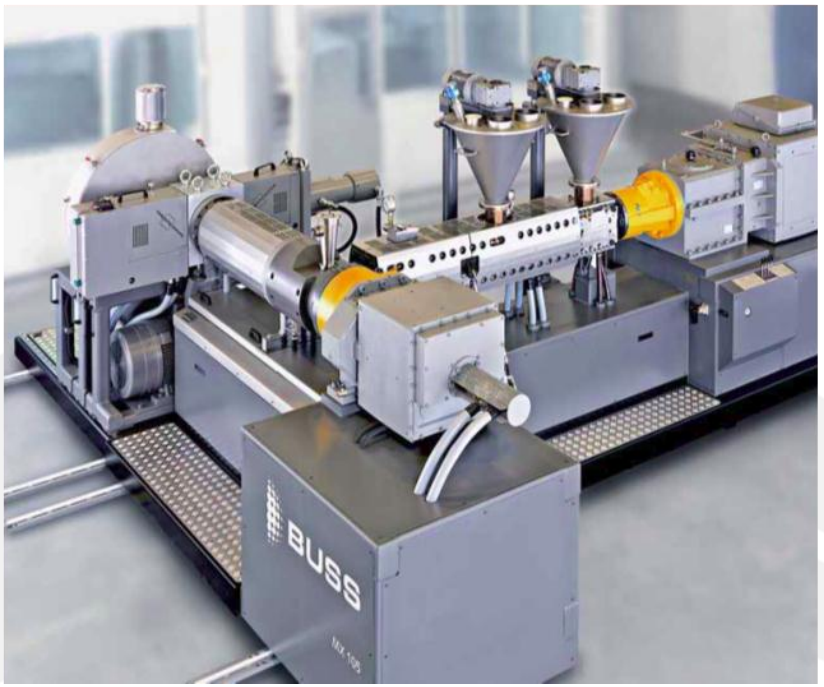
	HMH	ATH
Shape	Platy	Spherical
FR activity range	220°C – 700°C	180°C – 280°C
Evaporation enthalpy	-1000 kJ/kg	-1000 kJ/kg
Water release	>220°C	>180°C
Cementicious char	Yes	No
Bulk density (at feeding)	0.3g/cm³ (0.3g/cm³)	0.6 g/cm³ (0.4g/cm³)
BET surface	10m²/g (15m²/g)	4m²/g (7m²/g)
Processing temperature	<220°C @ 1 bar	<180°C
High shear kneading	**Yes**	**No**

THE FOUR-FLIGHTED BUSS KNEADER

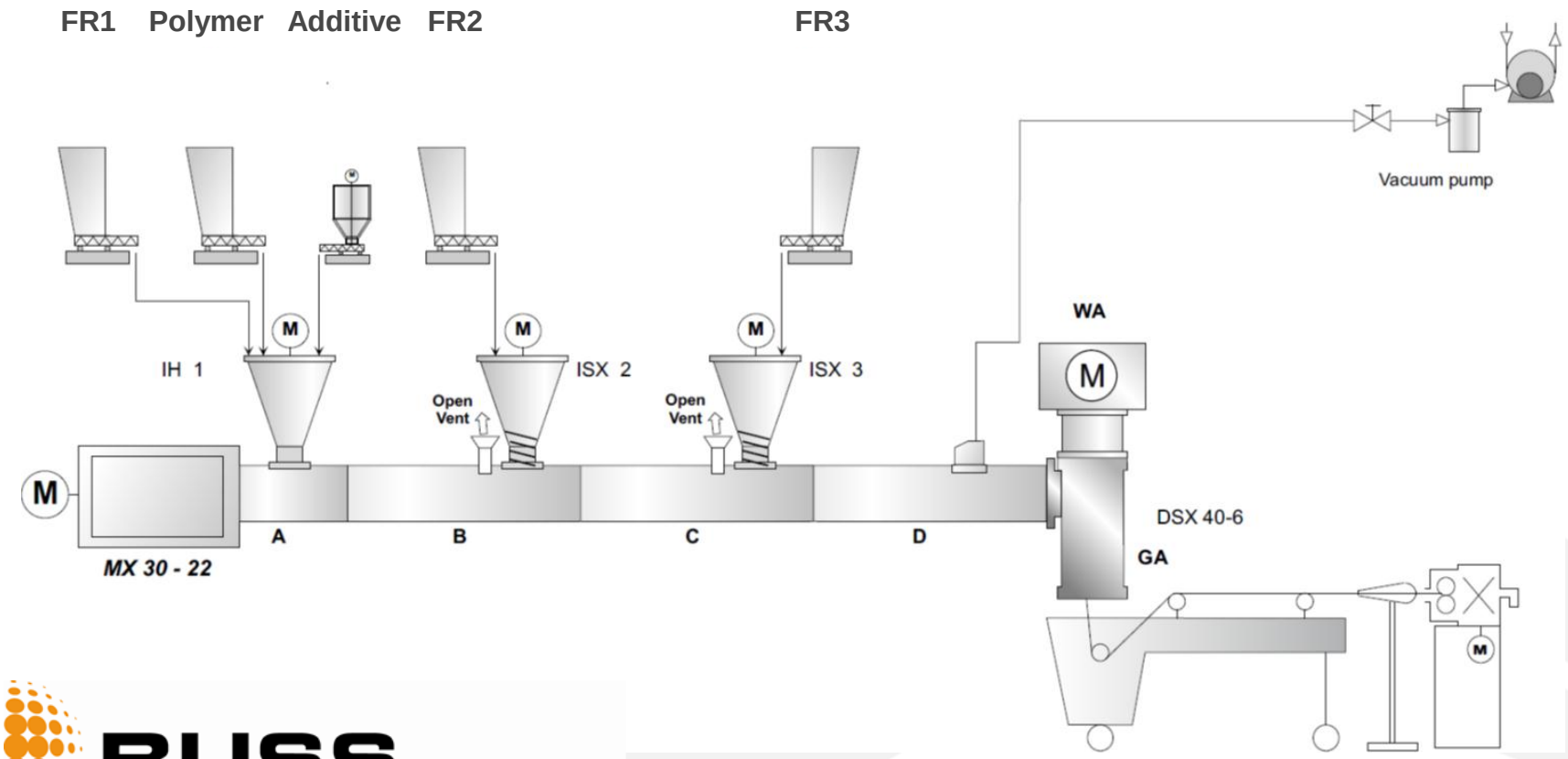


BUSS
excellence in compounding

BUSS
MX-Series



MX-30 SETUP

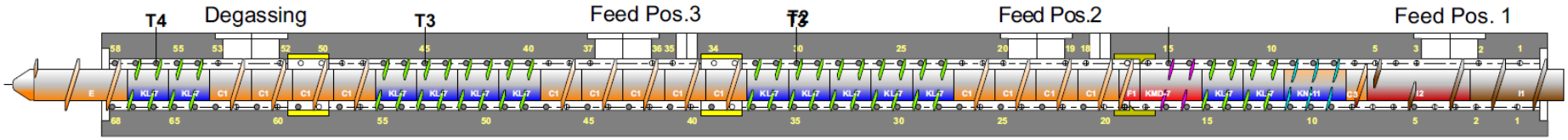


BUSS
excellence in compounding

KNEADER CONFIGURATION

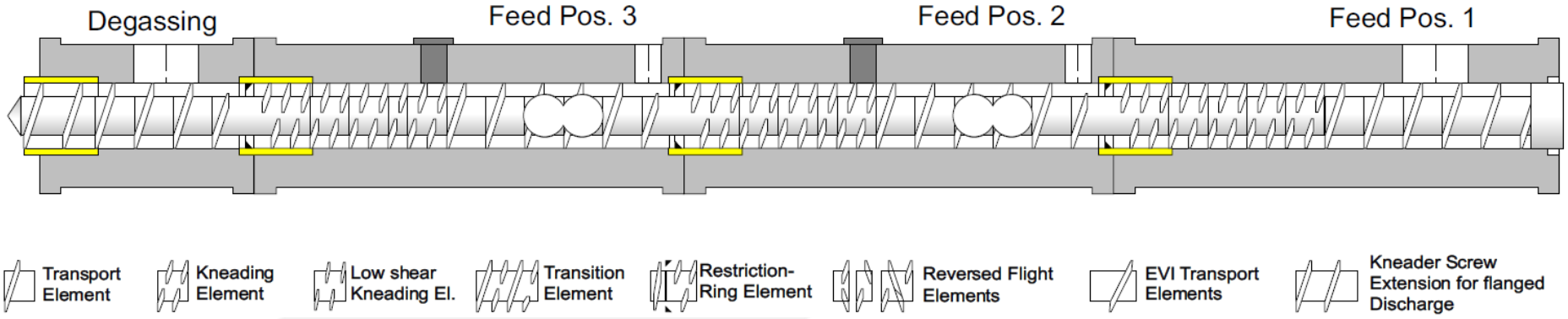
Screw MX 30 l/d=22

Four-flighted



Screw MKS 30 l/d=20

Three-flighted



EVA + ULTRACARB LH3 + PATH

Ingredients

26.5% Elvax 265 A (EVA)

3.75% Compoline CO/LL (MAH)

6.5% Eltex PF6130 AA (LLDPE)

1.5% Silmaprocess AL 1142A (Processing aid)

0.75% Silmastab AE 1527 (Stabilizer)

30.5% UltraCarb LH3 (oil abs. 25 ml/100g)

30.5% fine pATH (oil abs. 30 ml/100g)

Tensile Strength:	11 MPa
Elongation @ Break:	230%
Dispersion:	very good
LOI:	35.5

Instructions

Feed polymers, additives and processing aids in the first hopper of a Buss Co-Kneader MX-30, feed the UltraCarb LH3 in port 2, and the ATH in port 3.
Let it run at 600 rpm and 15kg/h.

EVA + ULTRACARB LH3

Ingredients

26.5% Elvax 265 A (EVA)

3.75% Compoline CO/LL (MAH)

6.5% Eltex PF6130 AA (LLDPE)

1.5% Silmaprocess AL 1142A (Processing aid)

0.75% Silmastab AE 1527 (Stabilizer)

61.00% UltraCarb LH3

Tensile Strength:	13 MPa
Elongation @ Break:	186%
Dispersion:	very good
LOI:	34.5

Instructions

Feed polymers, additives and processing aids in the first hopper of a Buss Co-Kneader MX-30 and split feed the UltraCarb LH3 in port 1+2 and let it run at 600 rpm and 15kg/h. Do not exceed 260°C (750rpm) as the EVA may start to degrade.

EVA + ULTRACARB LH3 + PLASTOMER

Ingredients

20.0% Elvax 265 A (EVA)

6.5% Lucene LC180 (Plastomer)

3.75% Compoline CO/LL (MAH)

6.5% Eltex PF6130 AA (LLDPE)

1.5% Silmaprocess AL 1142A (Processing aid)

0.75% Silmastab AE 1527 (Stabilizer)

61.00% UltraCarb LH3

Tensile Strength:	15 MPa
Elongation @ Break:	276%
Dispersion:	very good
LOI:	32.5

Instructions

Feed polymers, additives and processing aids in the first hopper of a Buss Co-Kneader MX-30 and split feed the UltraCarb LH3 in port 1+2 and let it run at 600rpm and 15kg/h.

CONCLUSIONS

- Natural mixtures of hydromagnesite and huntite are effective fire retardants
- Hydromagnesite is more active in the early stages of the fire providing an endothermic release of gas similar to ATH
- Huntite provides additional fire retardant activity not seen with ATH
- Varying the ratio of minerals allows tuning
- With proper processing, excellent FR and mechanical performance are possible in EBA, conventional EVA based cables or PVC
- Natural Mixtures of hydromagnesite and huntite offer much more than simply ATH replacement
- They are fully natural, non-synthetic, products

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?