colloque TAARMAQ 1RE ÉDITION

TRANSITION APPUYÉE ET ACCEPTABLE
POUR LES RÉSIDUS MINIERS AMIANTÉS AU QUÉBEC

Valorisation des RMA

Défis et opportunités

Louis-César Pasquier
Colloque TAARMAQ - 28 mars 2024

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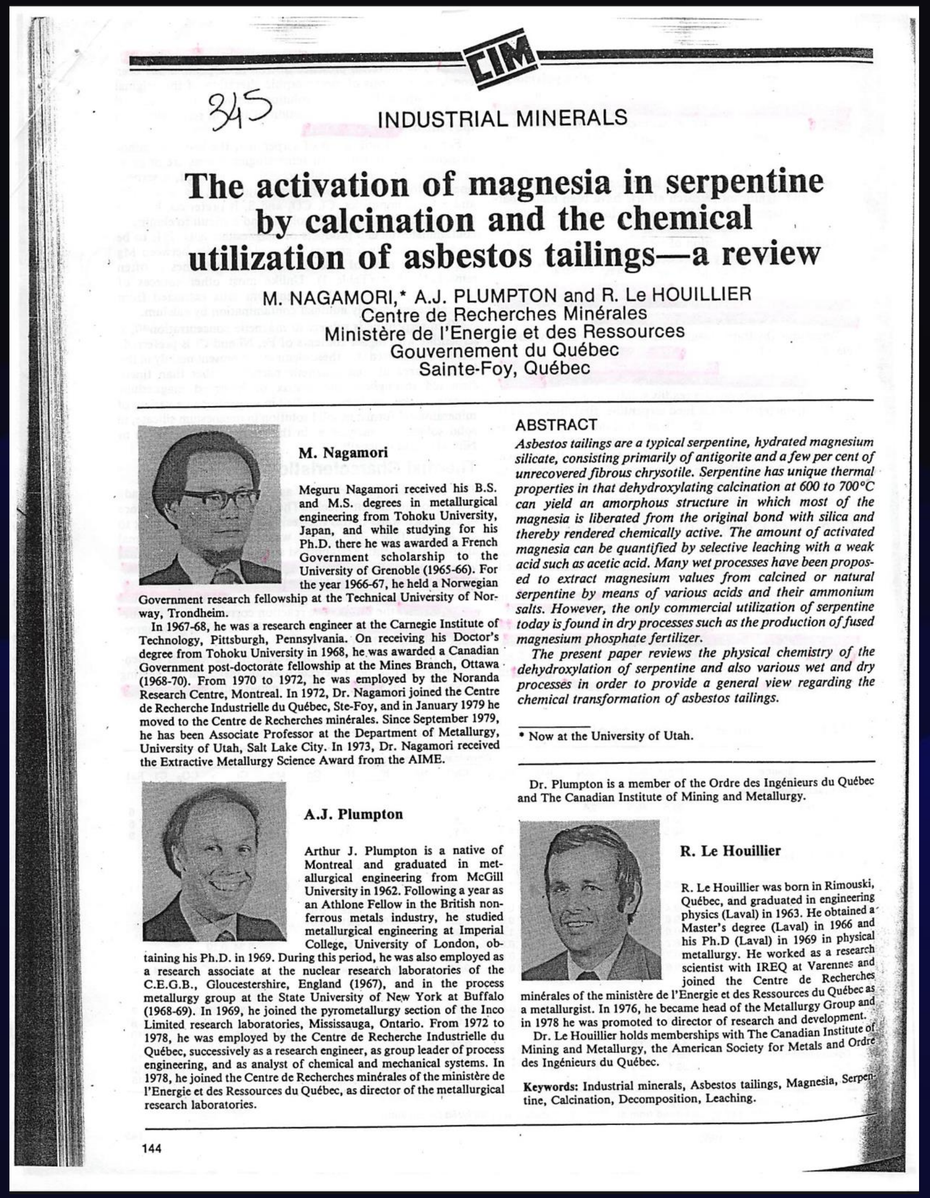

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INDUSTRIAL MINERALS

The activation of magnesia in serpentine by calcination and the chemical utilization of asbestos tailings—a review

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ABSTRACT

Asbestos tailings are a typical serpentine, hydrated magnesium silicate, consisting primarily of antigorite and a few per cent of unrecovered fibrous chrysotile. Serpentine has unique thermal properties in that dehydroxylating calcination at 600 to 700°C can yield an amorphous structure in which most of the magnesia is liberated from the original bond with silica and thereby rendered chemically active. The amount of activated magnesia can be quantified by selective leaching with a weak acid such as acetic acid. Many wet processes have been proposed to extract magnesium values from calcined or natural serpentine by means of various acids and their ammonium salts. However, the only commercial utilization of serpentine today is found in dry processes such as the production of fused magnesium phosphate fertilizer.

The present paper reviews the physical chemistry of the dehydroxylation of serpentine and also various wet and dry processes in order to provide a general view regarding the chemical transformation of asbestos tailings.

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M. Nagamori

Meguru Nagamori received his B.S. and M.S. degrees in metallurgical engineering from Tohoku University, Japan, and while studying for his Ph.D. there he was awarded a French Government scholarship to the University of Grenoble (1965-66). For the year 1966-67, he held a Norwegian Government research fellowship at the Technical University of Norway, Trondheim.

In 1967-68, he was a research engineer at the Carnegie Institute of Technology, Pittsburgh, Pennsylvania. On receiving his Doctor's degree from Tohoku University in 1968, he was awarded a Canadian Government post-doctorate fellowship at the Mines Branch, Ottawa (1968-70). From 1970 to 1972, he was employed by the Noranda Research Centre, Montreal. In 1972, Dr. Nagamori joined the Centre de Recherche Industrielle du Québec, Ste-Foy, and in January 1979 he moved to the Centre de Recherches minérales. Since September 1979, he has been Associate Professor at the Department of Metallurgy, University of Utah, Salt Lake City. In 1973, Dr. Nagamori received the Extractive Metallurgy Science Award from the AIME.

A.J. Plumpton

Arthur J. Plumpton is a native of Montreal and graduated in metallurgical engineering from McGill University in 1962. Following a year as an Athlone Fellow in the British non-ferrous metals industry, he studied metallurgical engineering at Imperial College, University of London, obtaining his Ph.D. in 1969. During this period, he was also employed as a research associate at the nuclear research laboratories of the C.E.G.B., Gloucestershire, England (1967), and in the process metallurgy group at the State University of New York at Buffalo (1968-69). In 1969, he joined the pyrometallurgy section of the Inco Limited research laboratories, Mississauga, Ontario. From 1972 to 1978, he was employed by the Centre de Recherche Industrielle du Québec, successively as a research engineer, as group leader of process engineering, and as analyst of chemical and mechanical systems. In 1978, he joined the Centre de Recherches minérales of the ministère de l'Energie et des Ressources du Québec, as director of the metallurgical research laboratories.

Dr. Plumpton is a member of the Ordre des Ingénieurs du Québec and The Canadian Institute of Mining and Metallurgy.

R. Le Houillier

R. Le Houillier was born in Rimouski, Québec, and graduated in engineering physics (Laval) in 1963. He obtained a Master's degree (Laval) in 1966 and his Ph.D (Laval) in 1969 in physical metallurgy. He worked as a research scientist with IREQ at Varennes and joined the Centre de Recherches minérales of the ministère de l'Energie et des Ressources du Québec as a metallurgist. In 1976, he became head of the Metallurgy Group and in 1978 he was promoted to director of research and development.

Dr. Le Houillier holds memberships with The Canadian Institute of Mining and Metallurgy, the American Society for Metals and Ordre des Ingénieurs du Québec.

Keywords: Industrial minerals, Asbestos tailings, Magnesia, Serpentine, Calcination, Decomposition, Leaching.

Avant toutes choses…

…ne réinventons pas la roue!

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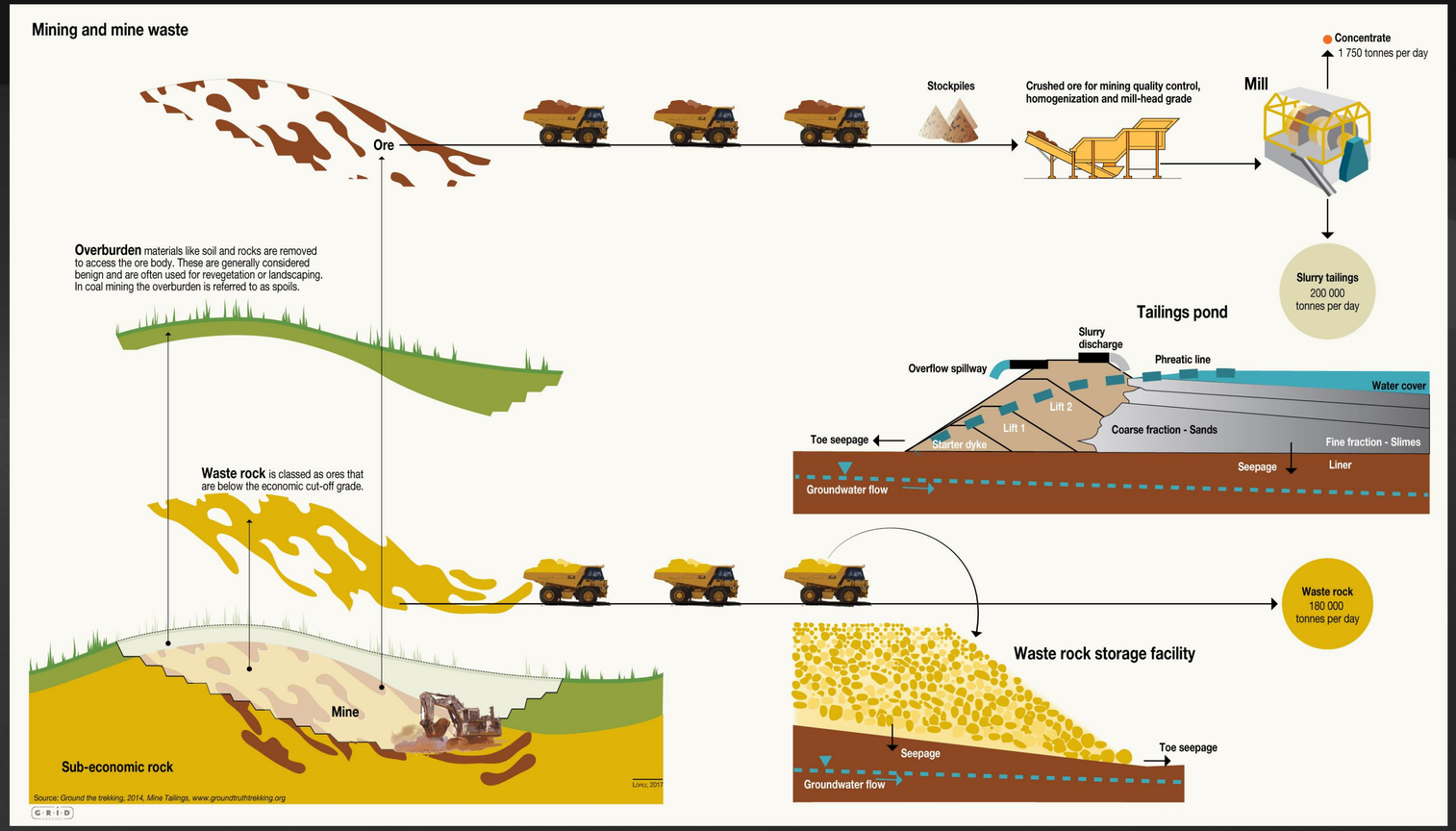
Qu’est ce que les RMA?

Quelques définitions

- Minerai : ce que l’on veut - chrysotile
- Stériles : ce qui est au dessus et autours - mort terrain
- Résidus miniers : ce qui est autours du minerai et n’est pas vendu

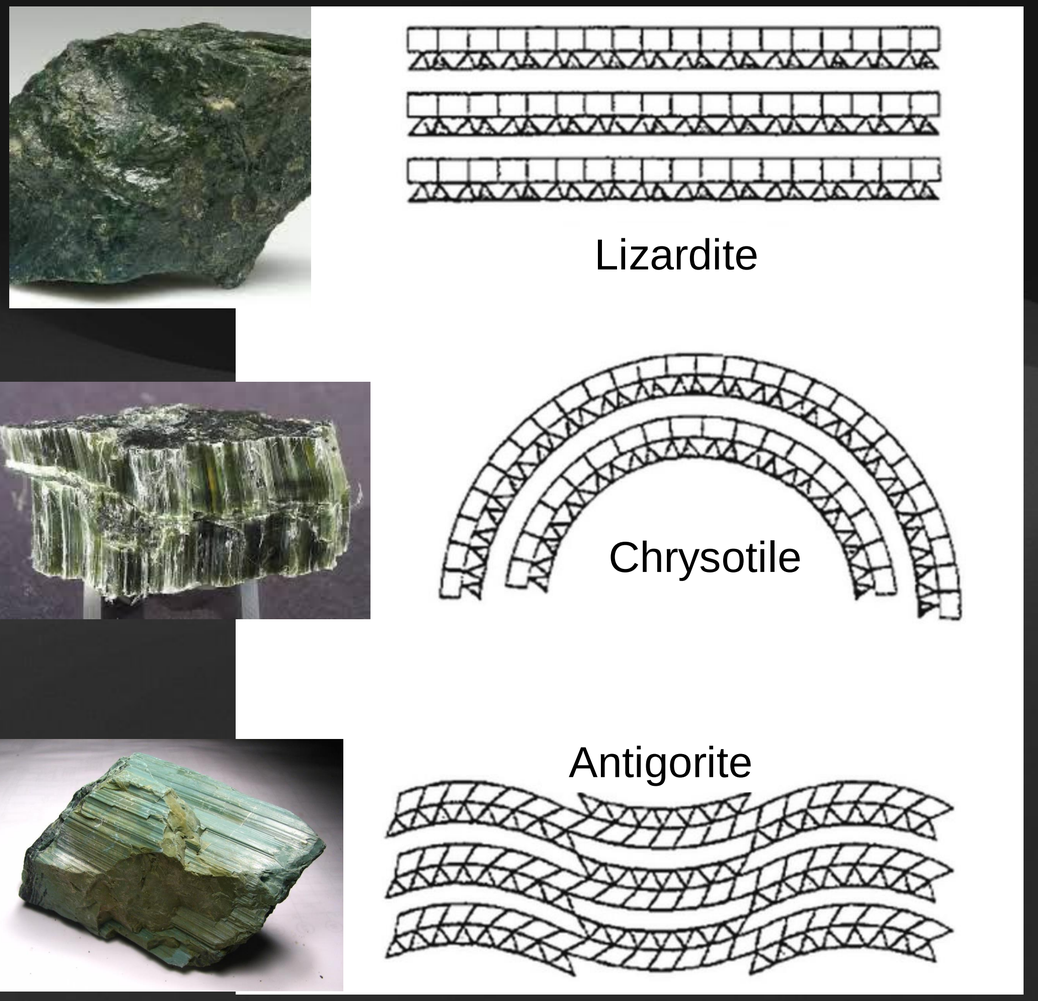


https://www.grida.no/resources/11415

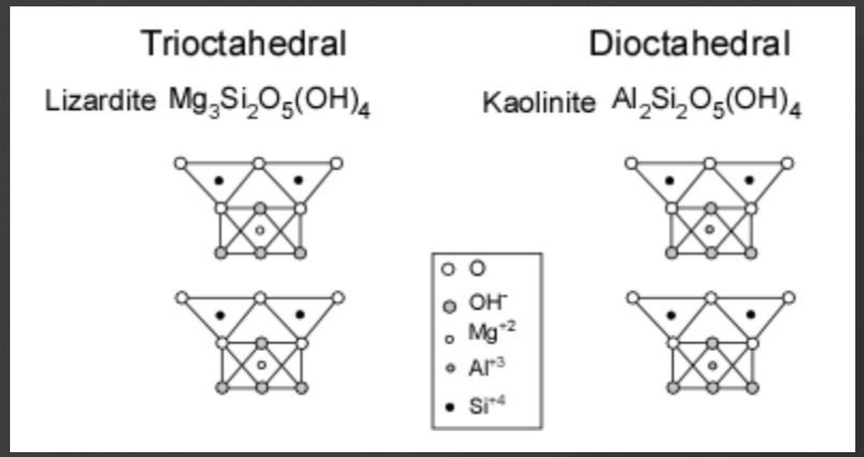
Serpentine?

Sous les pavés la plage…

- Iapetus se referme = obduction
- Phyllosilicates
- Famille de minéraux (3 polymorphes)

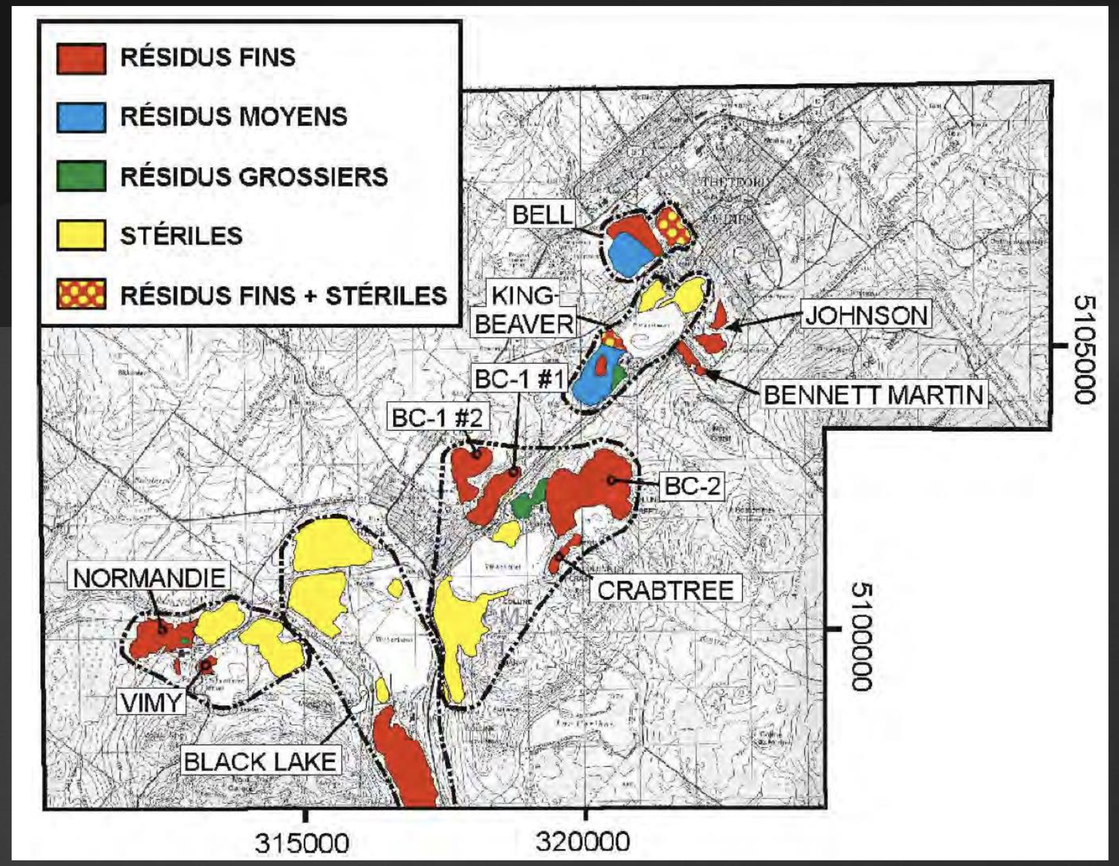


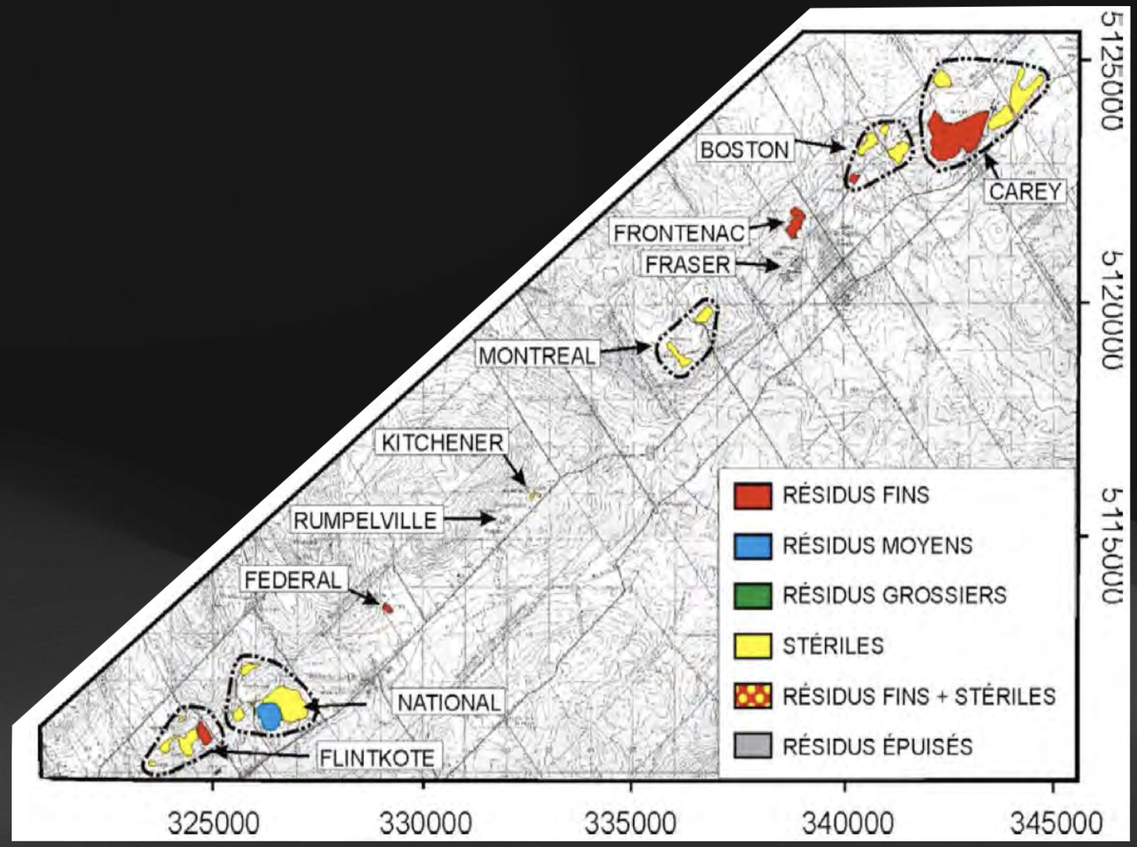
Lacinska AM, Styles MT, Bateman K, Wagner D, Hall MR, Gowing C, Brown PD (2016) Acid-dissolution of antigorite, chrysotile and lizardite for ex situ carbon capture and storage by mineralisation. *Chemical Geology* 437:153-169.



https://www2.tulane.edu/~sanelson/eens211/phyllosilicates.htm

Les anciennes mines et leurs particularités





Les RMA restent hétérogènes

Villeneuve, 2013. Rapport de caractérisation de caractérisation des résidus miniers Région de Thetford Mines. MDDEFP

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Composition chimiques des RMA

- Entre 15 et 20% de Mg
- Même ordre de grandeur pour Si
- Fer : 4,4 - 2,6%
- Nickel : 0,18 - 0,06%
- Traces de Cr, Mn

Mine	Nom d'échantillon	% Chrysotile
Flintkote	FL-HA-01	15-20
	FL-HA-02	15-20
	FL-HA-03	15-20
	DO-HA-03*	15-20
	FL-HA-04	10-15
	FL-ST-01	15-20
National	NA-HA-01	25-30
	NA-HA-02	15-20
	NA-HA-03	25-30
	NA-HA-04	30-35
	NA-HA-05	20-25
	NA-HA-06	10-15
	NA-HA-07	01-05
	NINA-CA-01	30-35
	NINA-PO-01	05-10
Federal	FE-HA-01	10-15
	FE-HA-02*	10-15
Carey	CA-HA-01	15-20
	CA-HA-02*	15-20
Bell	BE-HA-01	15-20
	BE-HA-02*	15-20
	NIBE-CA-01	30-35
	NIBE-PO-01	01-05
	NIBE-CA-02	35-40
	NIBE-PO-02	05-10
	NIBE-CA-03	30-35
	NIBE-PO-03	05-10

* Duplicata

Mine	Nom d'échantillon	% Chrysotile
King-Beaver	KB-HA-01	20-25
	KB-HA-02	20-25
	KB-HA-03	20-25
	KB-HA-04	20-25
	KB-HA-05	20-25
	KB-HA-06	20-25
	KB-HA-07	15-20
	KB-HA-08	15-20
	KB-HA-09	15-20
	KB-HA-10	05-10
Ville de Thetford	VT-HA-01	15-20
	VT-HA-02	15-20
	VT-GR-01	15-20
	VT-GR-02	10-15
	VT-GR-03	10-15
	VT-GR-04	15-20
Lac d'Amiante	LA-HA-01	30-35
	NILA-CA-01	35-40
	NILA-PO-01	05-10
Normandie	VI-HA-01	25-30
	NINO-CA-01	25-30
	NINO-PO-01	10-15
	NINO-CA-02	25-30
	NINO-PO-02	10-15
	NINO-CA-03	25-30
	NINO-PO-03	05-10
British-Canadian	BC-HA-01	15-20
	BC-HA-02*	30-35
Blanc de méthode	VT-HA-03	0

Villeneuve, 2013. Rapport de caractérisation de caractérisation des résidus miniers Région de Thetford Mines. MDDEFP

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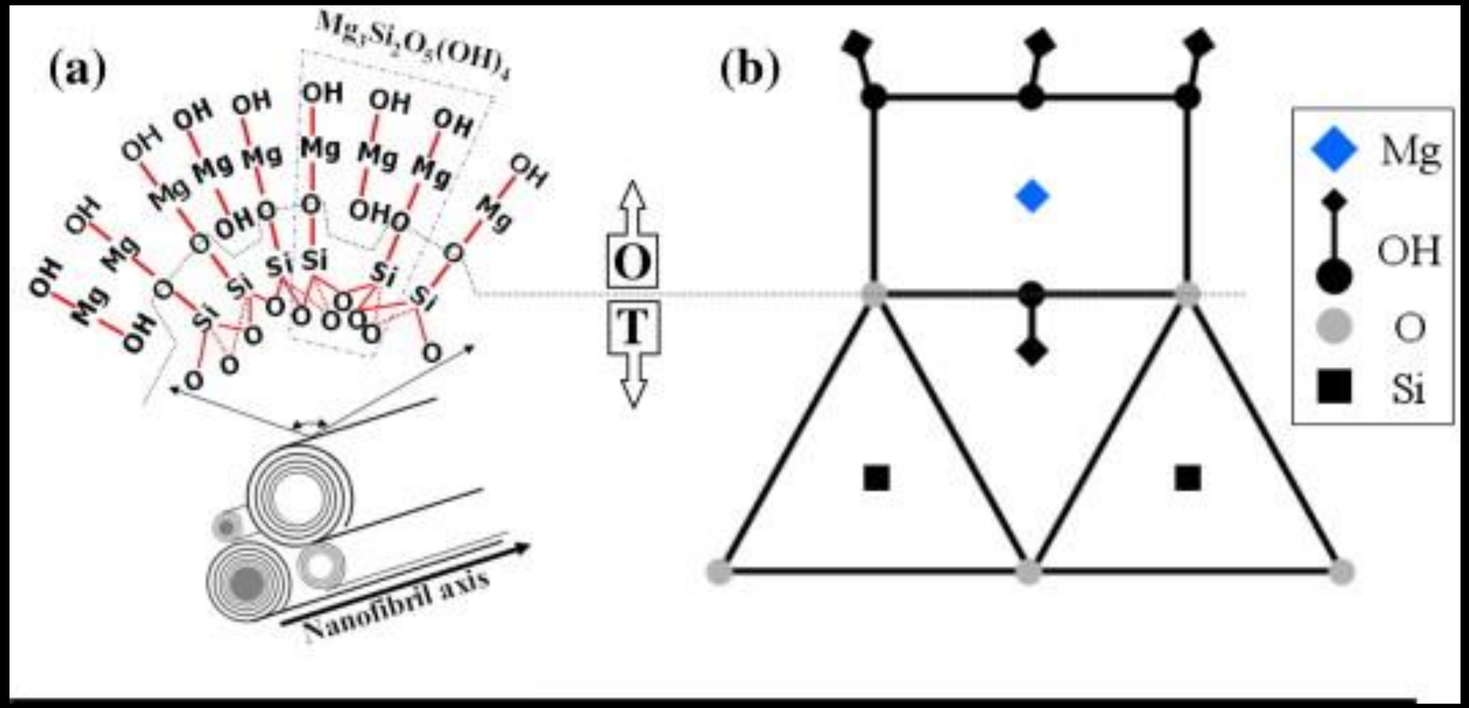
Comment les valoriser?



Larachi F, Daldoul I, Beaudoin G (2010) Fixation of CO2 by chrysotile in low-pressure dry and moist carbonation: Ex-situ and in-situ characterizations. *Geochimica Et Cosmochimica Acta* 74(11):3051-3075.

2 approches

Energie thermique et/ou chimique

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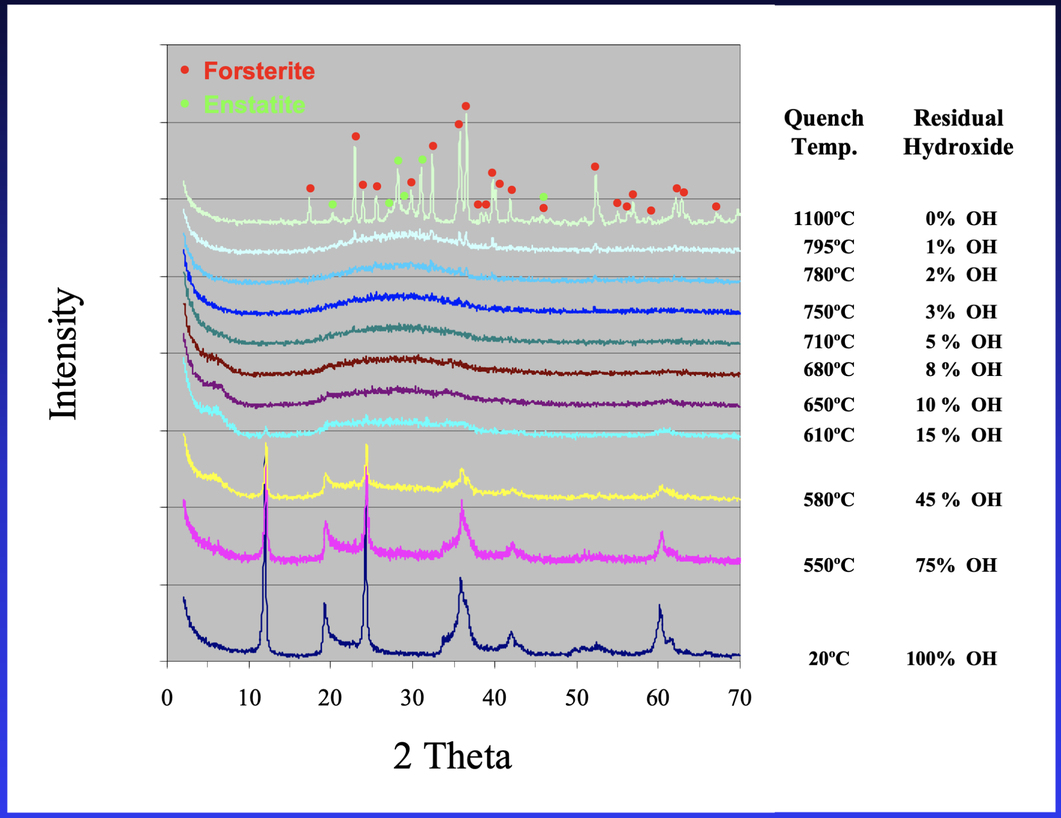
Activation thermique

Retour aux origines!

- Dehydroxylation de la serpentine observée entre 550 et 1100°C
- Entre 650 et 750°C, matériel amorphe (plus réactif)
- Au-delà, recristallisation de la forsterite et enstatite (stabilité)

X-RAY POWDER DIFFRACTION PROVIDES STRUCTURAL INSIGHT INTO THE REACTIVE META-SERPENTINE MATERIALS THAT FORM*



Quench Temp.	Residual Hydroxide
1100°C	0% OH
795°C	1% OH
780°C	2% OH
750°C	3% OH
710°C	5 % OH
680°C	8 % OH
650°C	10 % OH
610°C	15 % OH
580°C	45 % OH
550°C	75% OH
20°C	100% OH

*** XPD patterns shown are for heat-activated lizardite.**

McKelvy M, Chizmeshya A, Bearat H, Sharma R, Carpenter R (2001) Developing mechanistic understanding of CO2 mineral sequestration reaction processes. p 5-8.

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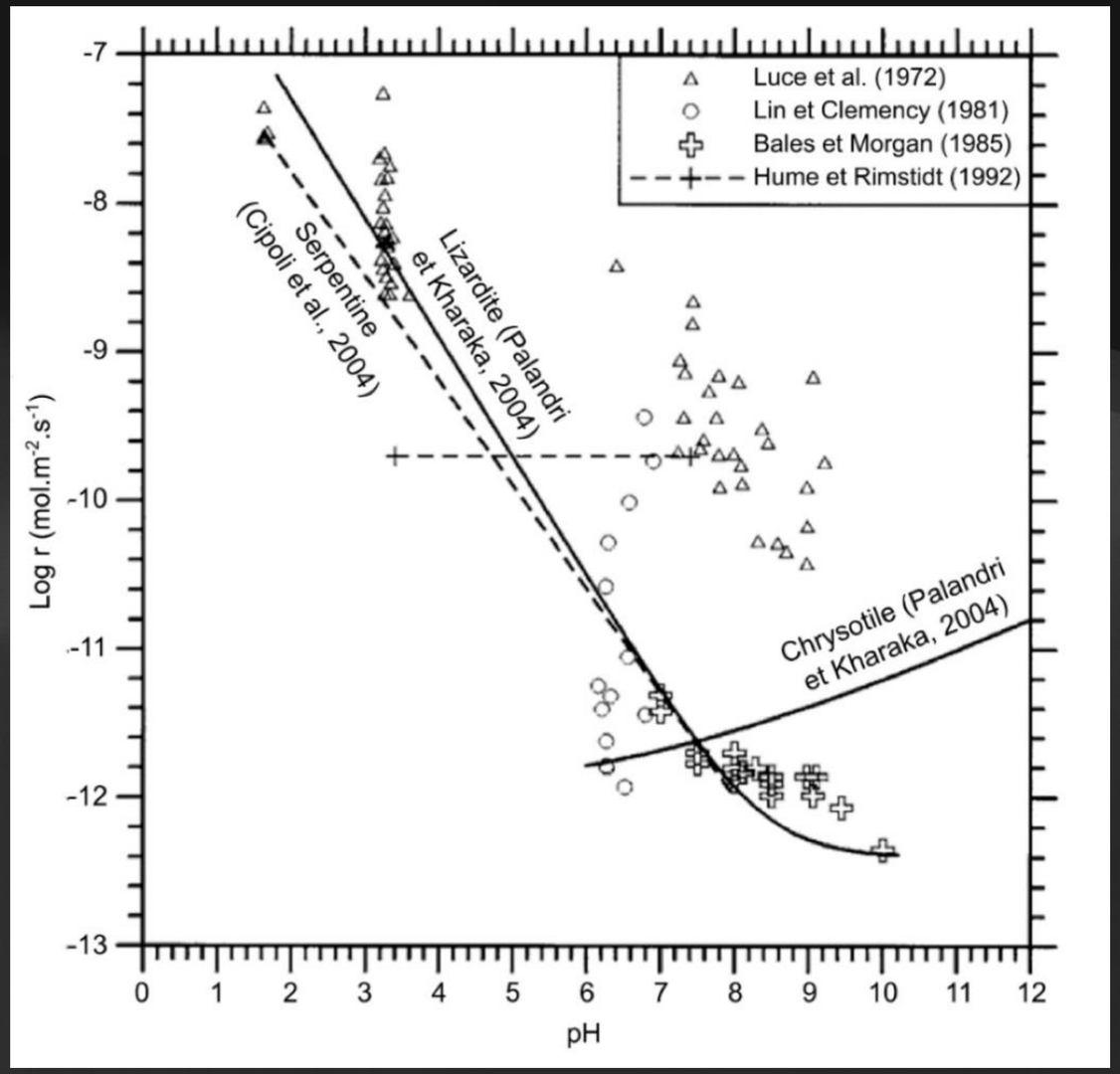
Dissolution des serpentines
L’importance du pH

- Acides:
  - Acide Chlorhydrique (HCl)
  - Acide Sulfurique (H_2SO_4)
  - CO_2
- Bases:
  - Hydroxide de Sodium (NaOH)
- Sels d’ammoniums
  - NH_4HSO_4



Pourquoi les valoriser?

Composés de Magnésium

Magnésium métal:

Nombreuses applications dans des alliages.
Leger et robuste

Sulfate ($MgSO_4$):

Engrais, industrie, médecine

Hydroxyde $Mg(OH)_2$:

traitement de l’eau, antiacide, agroalimentaire etc.

Chlorure ($MgCl_2$):

déglaçant, contrôle de poussières, supplement nutritif

Oxydes (MgO):

réfractaires, anti-feu etc.

Carbonates ($MgCO_3$):

desiccant pour les mains, séquestration du carbone

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Silice

- Métallurgie
- Ciment
- Verre
- Fonderies
- Industrie chimique

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Nickel

- Acier inoxydable
- Piles et batteries
- Alliages de métaux non ferreux
- Electroplaquage

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Voie de valorisation

Les sables Olimag Inc.

Fabrication de sables d’olivine (traitement thermique)

Les Sables OLIMAG Inc.

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Des expériences plus ou moins fructueuses…

Victimes de facteurs externes

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Quel futur?

Un nouvel essor?

- PEVCA
- CCTT (COALIA, KEMITEK)
- CIMMS
- Universités
- ONA

Conclusions

Simplicité

Efficacité

Sécurité

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Merci de votre attention!
Questions? Discussions!

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