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EXPLORATION OUTLOOK IN QUEBEC FOR A NEGLECTED COMMODITY

5th Strategic Diversification Newsletter

March 2004

Ressources naturelles, Faune et Parcs

Québec

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- Business opportunity and potential in Quebec

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Strategic Diversification Newsletter
SIDEX - MRNFP

SIDEX is using the Exhibitor's Innovation Forum to present its 5th "Strategic Diversification Newsletter".

The newsletter has been prepared with Ministère des Ressources naturelles, de la Faune et des Parcs du Québec (MNRFP) - Mines Sector.

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SIDEX is the:

Diversification of Exploration Investment Partnership (SIDEX Limited Partnership).

It was established in 2001 by the Government of Quebec and the Solidarity Fund QFL (*Quebec Federation of Labour*).

SIDEX (Société d'investissement dans la diversification de l'exploration)

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SIDEX's mission is to:

- invest in the equity of companies...
- engaged in mineral exploration...
- in Quebec, in order to...
- diversify Quebec's mineral base for commodities with attractive market or discovery potential.

The theme of Newsletter # 5 is ...

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Newsletter # 5

Magnesite
(& brucite)

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Minerals

Magnesite ($MgCO_3$ - 28,8% Mg) is the main mineral of interest, since:

- **it is used in large quantities in Quebec for the extraction of magnesium metal; and**
- **it can readily be transformed into the main magnesium commodity, which is magnesia (MgO - 60,3% Mg).**

Brucite ($Mg(OH)_2$ - 41,7%Mg) could be of interest for both types of applications.

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Market outlook

- Commercial products
- Uses and specifications
- Market supply

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Commercial products

Magnesia (MgO) is the main commercial magnesium compound.

Except for one important case in Quebec *, magnesite is not a direct consumer commodity on world markets.

*** Norsk Hydro Canada's plant in Becancour (QC) is currently the only plant in the world using magnesite for the extraction of magnesium.**
(*http://www.hydromagnesium.com*)

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Commercial products

"Natural" magnesia can be derived from magnesite (or brucite) by calcination:

Magnesite:

$MgCO_3$ + heat $\rightarrow$ MgO + CO_2(gas)

Brucite:

$2Mg(OH)_2$ + heat $\rightarrow$ $2MgO + 2H_2O$(vapour).

Most of the world's production (> 80%) is sourced from magnesite; natural magnesia is generally less expensive.

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Commercial products

"Synthetic" magnesia can be obtained by calcining the hydroxide form resulting from the conversion of magnesium chloride from seawater or brines:

Most of the US magnesia production is from such sources. Synthetic magnesia tends to be more expensive than the "natural" form from magnesite.

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Commercial magnesia

Magnesia is produced in different grades controlled by the calcination temperature:

- **dead-burned** or **refractory** magnesia, used for the production of basic refractories; ± 60% of production;

- **caustic** magnesia which is the **reactive form** of magnesia used in chemical transformation, environmental applications (water treatment & gas scrubbing), agriculture and several other applications; ± 35% of production;

- **fused** or electrofused magnesia, used for specialty refractories and electrical insulation.

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Market outlook

- Commercial products
- Specifications & prices
- Market supply

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General specifications

	MgO %
Extraction of Mg	46
(Eq. $MgCO_3$)	± 96 %
Caustic MgO	80 - 90+
Refractory MgO	90-98 (> 96 typ.)
Fused MgO	96 - 99+

High grade required

Say 95% + purity in the mineral form

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Prices

Very wide variations… orders of magnitude...

Magnesite:	**< $US 60 /t**
Caustic magnesia:	**$US 100 – $US 400 /t**
Refractory magnesia:	**$US 100 – $US 400 /t**
Fused magnesia:	**$US 250 – $US 900 /t**
Hydroxide:	**$US 225 – $US750 /t**

Increasing purity

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Market outlook

- Commercial products
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Market supply

Canada and the USA have to import* most of their needs for magnesite and magnesia because...

**** Canadian imports (MgCO3 + MgO): ± 50 M$CA/a***

US imports (MgO): ± 100 M$US/a

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1- North America, a major market for magnesium compounds, is deficient in exploited mineral sources.

World capacity (2002)

('000 t/a - Equivalent MgO)	Raw material: Magnesite-brucite	Raw material: Brines	Total	
North America	329	880	1 209	11%
	27%	73%	100%	
Rest of the world	8 666	1 055	9 721	89%
	89%	11%	100%	
	8 995	1 935	10 930	

2- North American production is mostly the more expensive synthetic variety of magnesia.

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Market supply

USA

Salient facts

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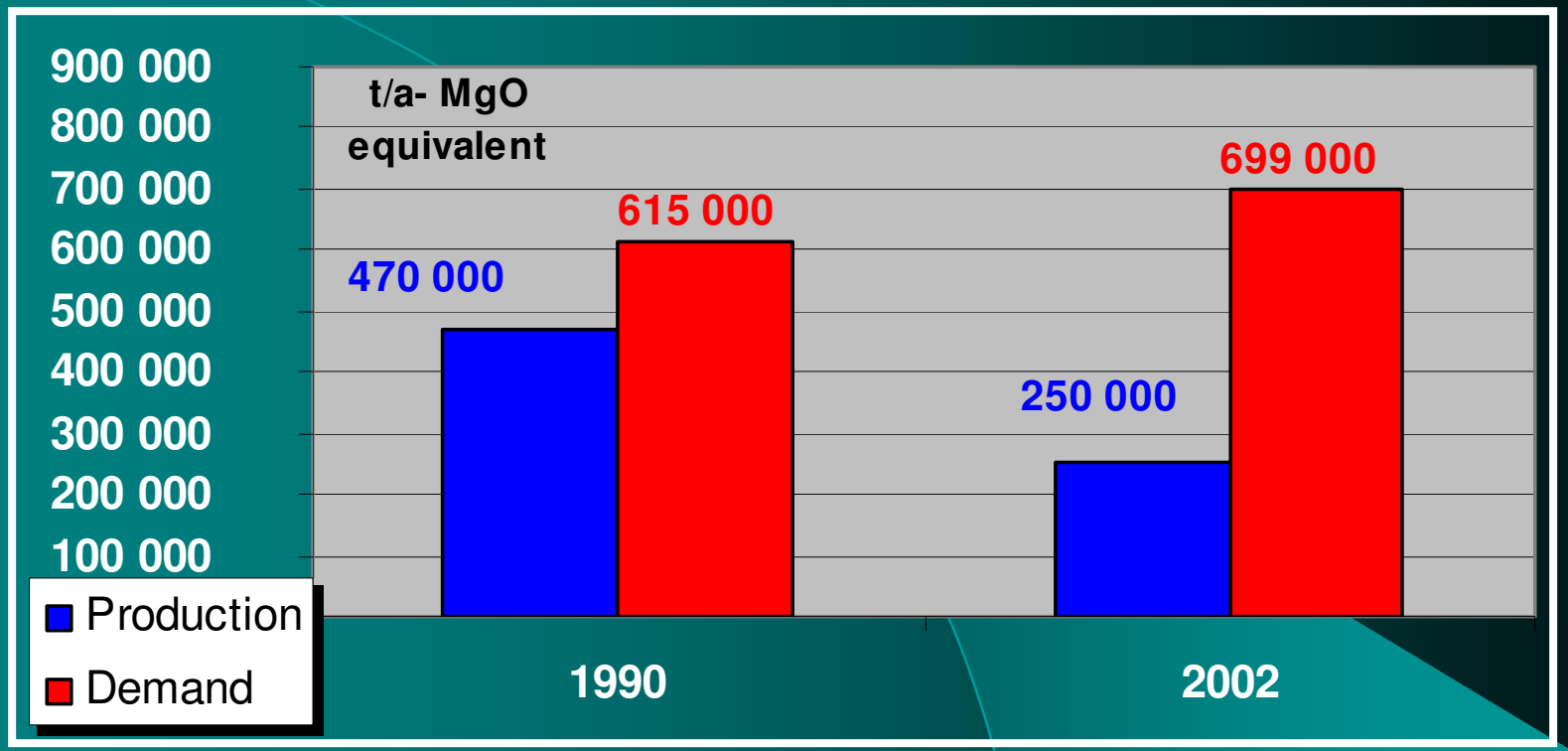
Opportunity for exploration

US production of magnesium compounds is declining, while demand is increasing:



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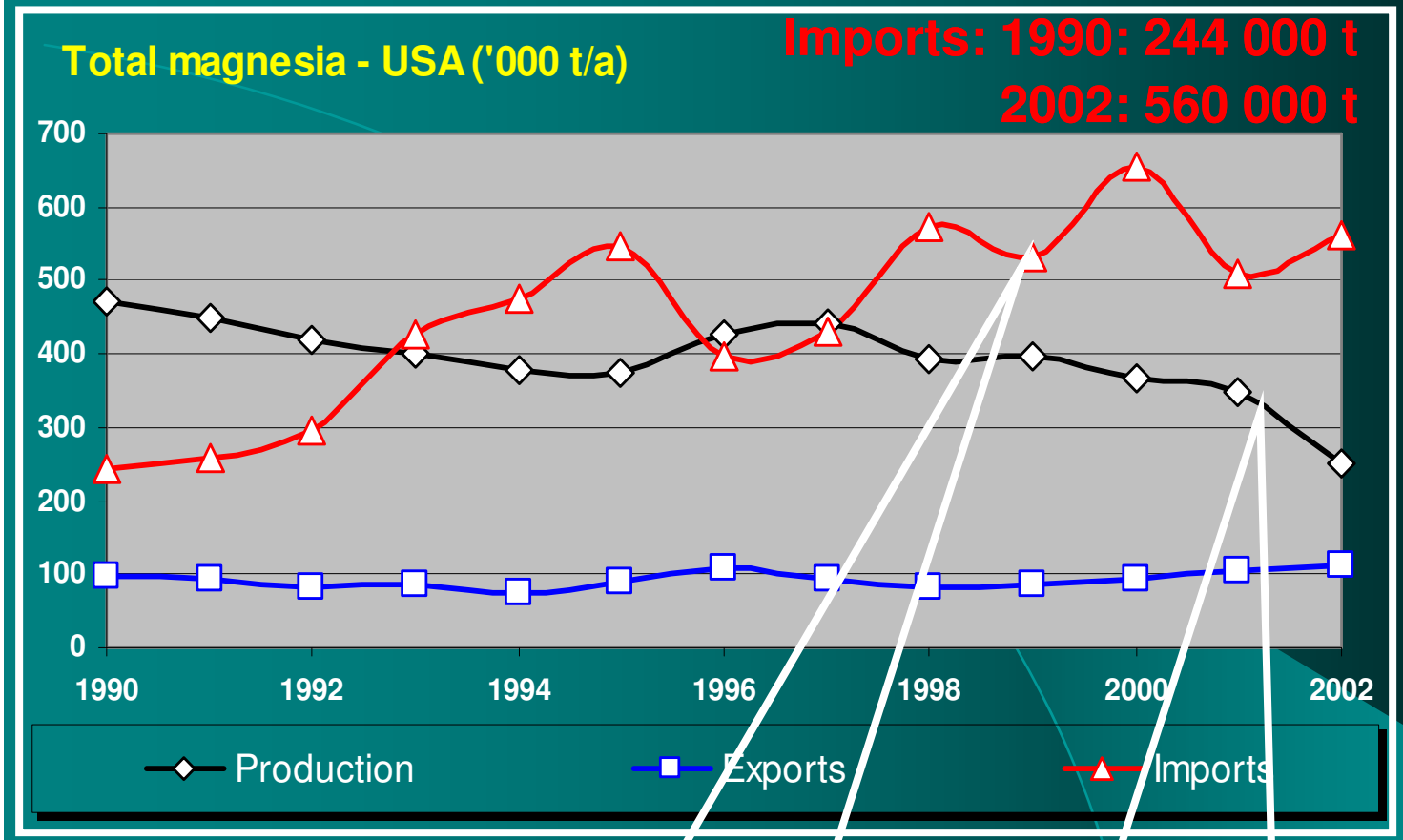
USA Total magnesia supply



Imports (2002)

- 80% of total demand (560 000 t)
- 65% of caustic demand (166 000 t)
- 89% of refractory demand (394 000 t)

Increasing imports > 100 M$US/a

Declining production

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USA Total magnesia supply

Important note: more than 90% of total magnesia imports by the USA are from countries supplying natural magnesia.

Main recent suppliers are China (66%), Australia (10%) and Canada (9%).

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Market supply

Canada

Salient facts

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Market supply - Canada

One Canadian producer:

- Baymag inc. (*www.baymag.com*).
- Mine in Southern British Columbia.
- Calcination and fusion plants near Calgary.
- Estimated capacity:
  - 80 000 - 100 000 t/a caustic magnesia plus some fused magnesia.
- Does not sell magnesite (except maybe sales to Norsk Hydro Canada in 1999-2001).

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Market supply - Canada

(www.baymag.com)

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Market supply - Canada

Baymag's magnesia grades

- **MgO:** 96,5 to 97,3%
- CaO: 1,7 to 2,5%
- Fe_2O_3: 0,4 to 0,7%
- Al_2O_3: 0,1 to 0,3%
- SiO_2: 0,2 to 0,4%

Source: Industrial Minerals, April 1996, p. 135

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Market supply

Canadian market for magnesite is supplied by imports

Main suppliers:

- China - 80%
- Australia - 10%
- Spain - 5%
- (Several others)

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Magnesite imports - Canada

Canadian imports of magnesite 1989-2002:

- **1,5 M tons cumulative; 80% from China.**
- **One customer in Bécancour (Québec) - 95% of total import value.**
- **Annual demand ± 185 000 t.**
- **"Resistance price" ± $80/t.**

http://www.hydro.com/search

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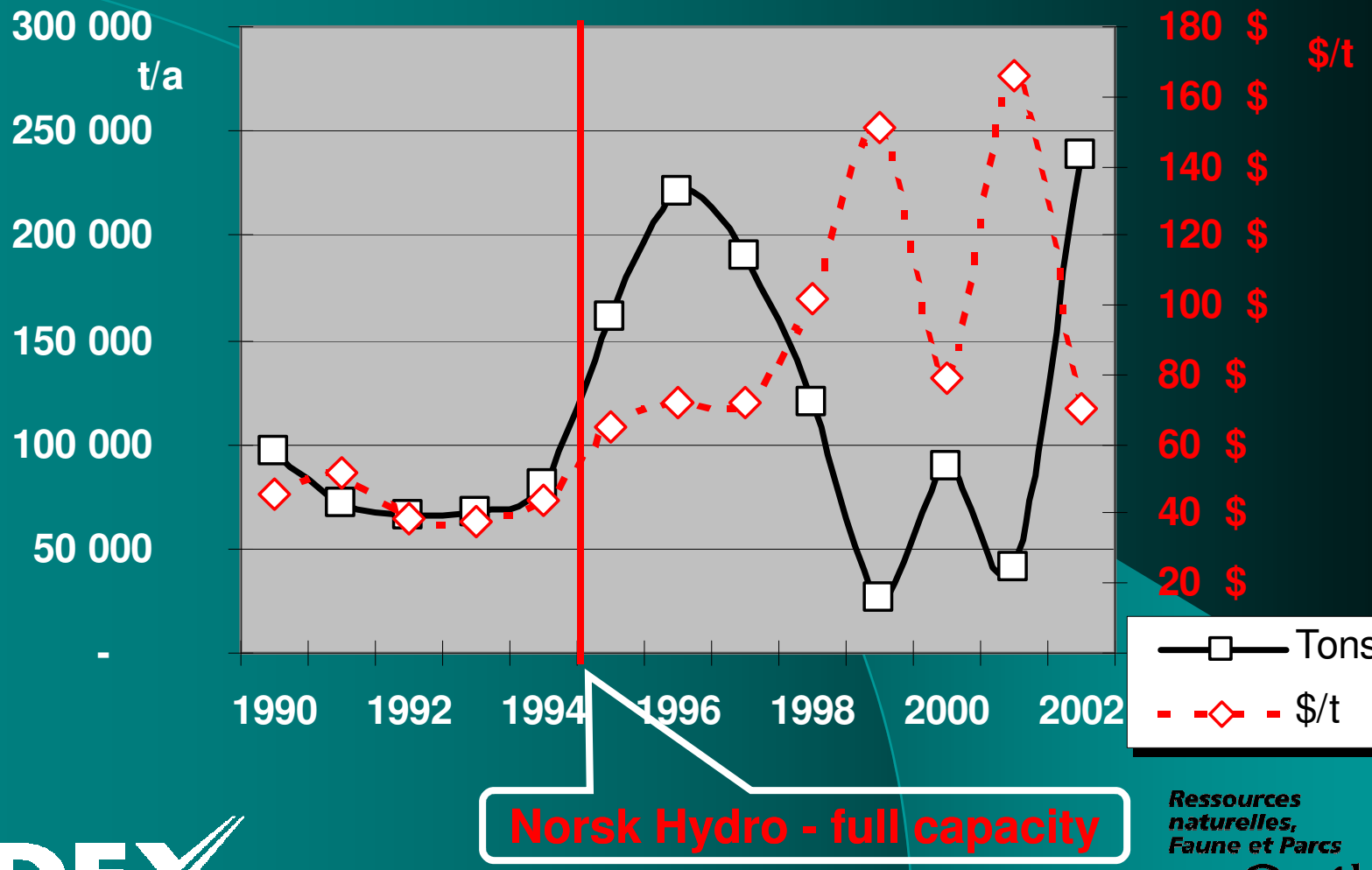
Magnesite imports - Canada

Canadian imports of magnesite 1990-2002 (Tons and unit value)



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Market supply

Canada also imports large quantities of magnesia

Main suppliers:

- USA (> 50%)
- China (30-35%)
- Austria (5%)

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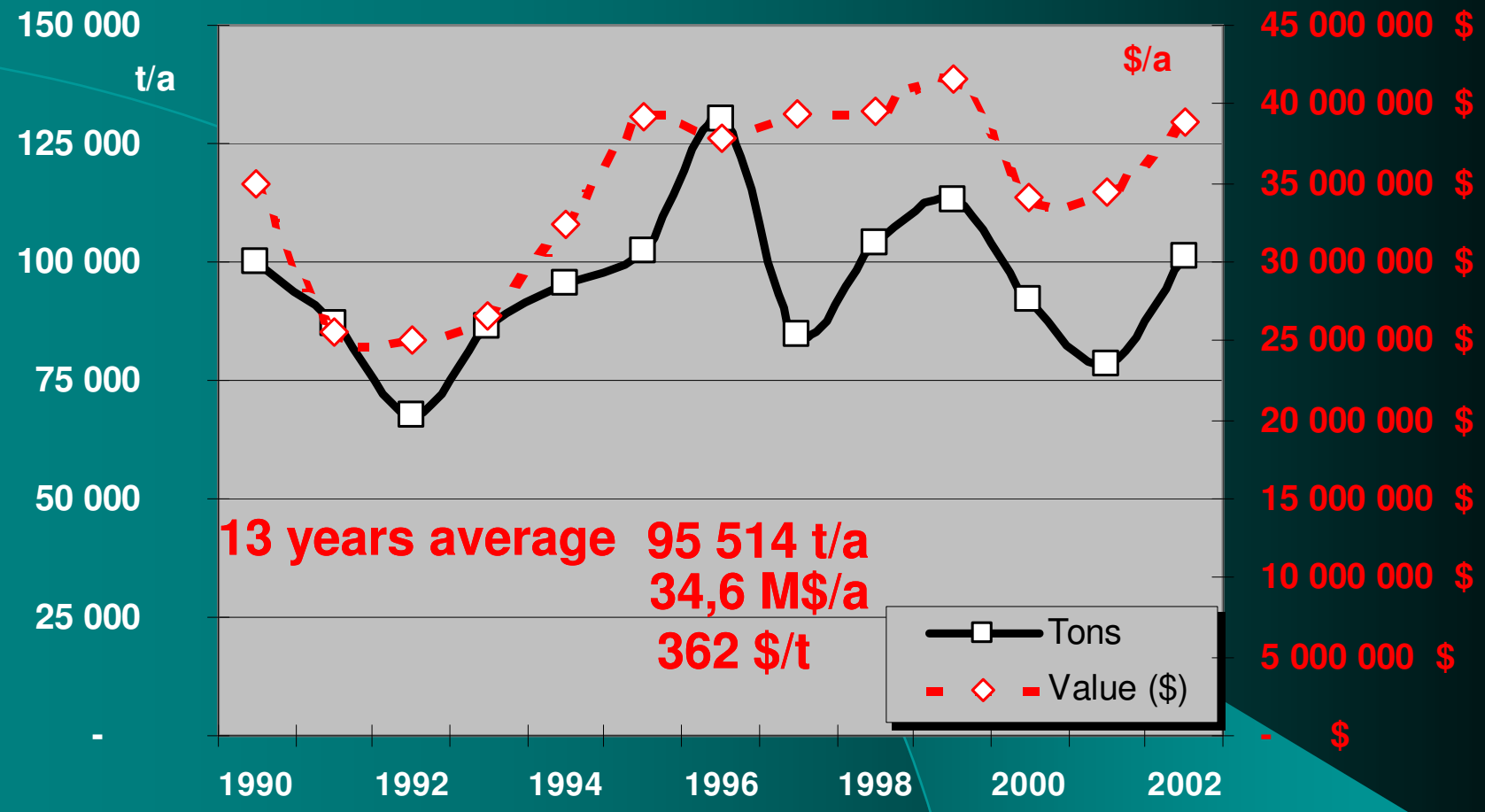
Magnesia imports - Canada



± 60% is refractory grade

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Market supply

Part of these magnesia imports is so-called "*cheap*" material from China, but...

competition from these "cheap" imports may be easing...

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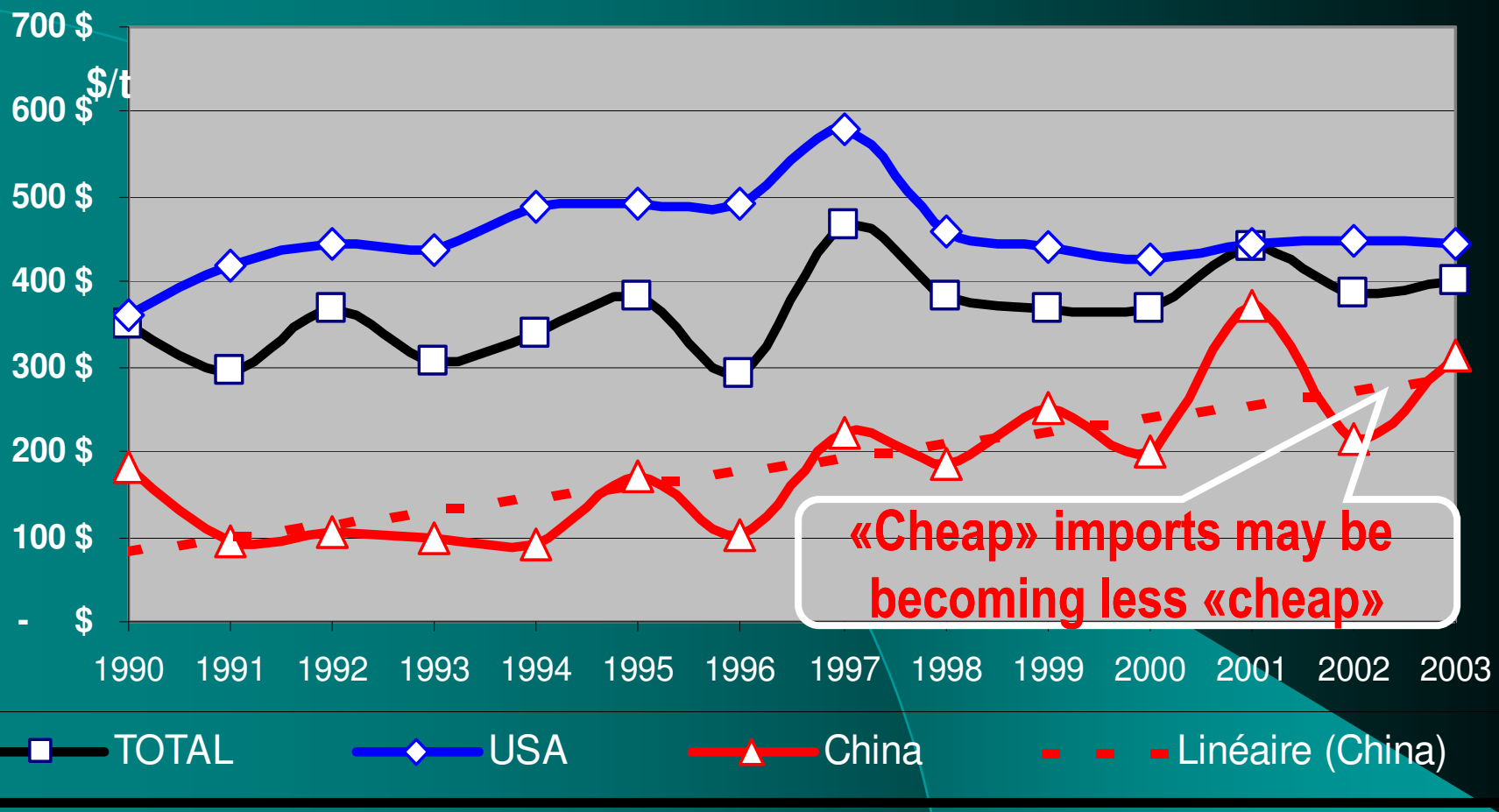
Magnesia imports - Canada

Canadian imports of magnesia 1990-2002 (Unit value)



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Magnesia imports - Canada

Canadian imports of magnesia 1998-2002 (by province)

Annual average 1998-2002

To…	Quebec	Ontario	Others	Total
$M/a	21,09	15,06	1,56	37,71
± t/a	54 000	40 000	3 600	97 600
%	56%	40%	4%	

Quebec is the main destination of magnesia imports.

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Geology and metallogeny

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Magnesite genesis

Magnesite can be found as:

- **Replacement mineral in carbonate rocks (the most common commercial form).**
- **Hydrothermal alteration of ultramafic rocks (second most frequent occurrence).**
- **Others** ***(not commercially significant)***
  - ***Vein-filling.***
  - ***Sedimentary rock.***

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Magnesite - Hydrothermal replacement in carbonate rocks

- The most important form of occurrence of commercial deposits (size and purity); 80% of world production.
- Purity may exceed 95% $MgCO_3$ - crystalline material.
- Dolomite, limestone or siliceous shales are infiltrated and altered by magnesium-rich fluids.

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Magnesite - Hydrothermal replacement in carbonate rocks

- Transition zones of dolomite always present when limestone is the host rock; contacts are gradational from magnesite to limestone.
- Completeness of replacement is variable, with replacement dolomite generally more common than magnesite.
- *Ex.: USA (NV) - Brazil - Spain - Austria - Slovakia - Canada (BC)*

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Magnesite - Hydrothermal alteration of ultramafic rocks

- Deposits generally of smaller size and lesser grade.
- Grade typically less than 50%-80% $MgCO_3$ (often < 20% $MgCO_3$) - iron levels often high (breunerite - Fe-rich magnesite).
  - Alteration of serpentine by CO_2-rich fluids; or
  - Serpentinization of ultramafics (exsolution of hydrothermal magnesite under low pressure and temperature).

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Magnesite - Hydrothermal alteration of ultramafic rocks

- Alteration may be progressive, with intermediate talc-magnesite and quartz-magnesite stages.
- Magnesite is generally cryptocrystalline (amorphous).
- *Ex.: Canada (QC) - Austria - Australia - Greece - Turkey - China - Russia*

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Brucite genesis

- Secondary origin, often associated with other magnesium minerals (serpentinites - carbonates).

- Contact metamorphism between granitic intrusions and magnesium-rich limestone or dolomite, which are dedolomitised (separation of the Ca and Mg species) followed by the hydration of the periclase form (MgO).

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Exploration

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Exploration

Target areas

- In sedimentary rocks: focus on areas where limestone or dolomite has been affected by folding or magmatic activity.

- In ultramafics: focus on serpentinized zones, in proximity to faults, or areas that may have been hydrothermally altered.

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Elements of opportunity for exploration in Quebec

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Opportunity for exploration

1- North America is deficient in exploited mineral resources of magnesium minerals.

2- A large proportion of canadian demand is satisfied by imports: ± 35 $M/a by Quebec alone.

3- A very large proportion of US demand is satisfied by imports: > 500 000 t/a, > 100 $USM/a, mostly for natural magnesia.

4- US production of magnesium compounds is declining, while demand is increasing.

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Potential in Quebec

(See Newsletter for more details)

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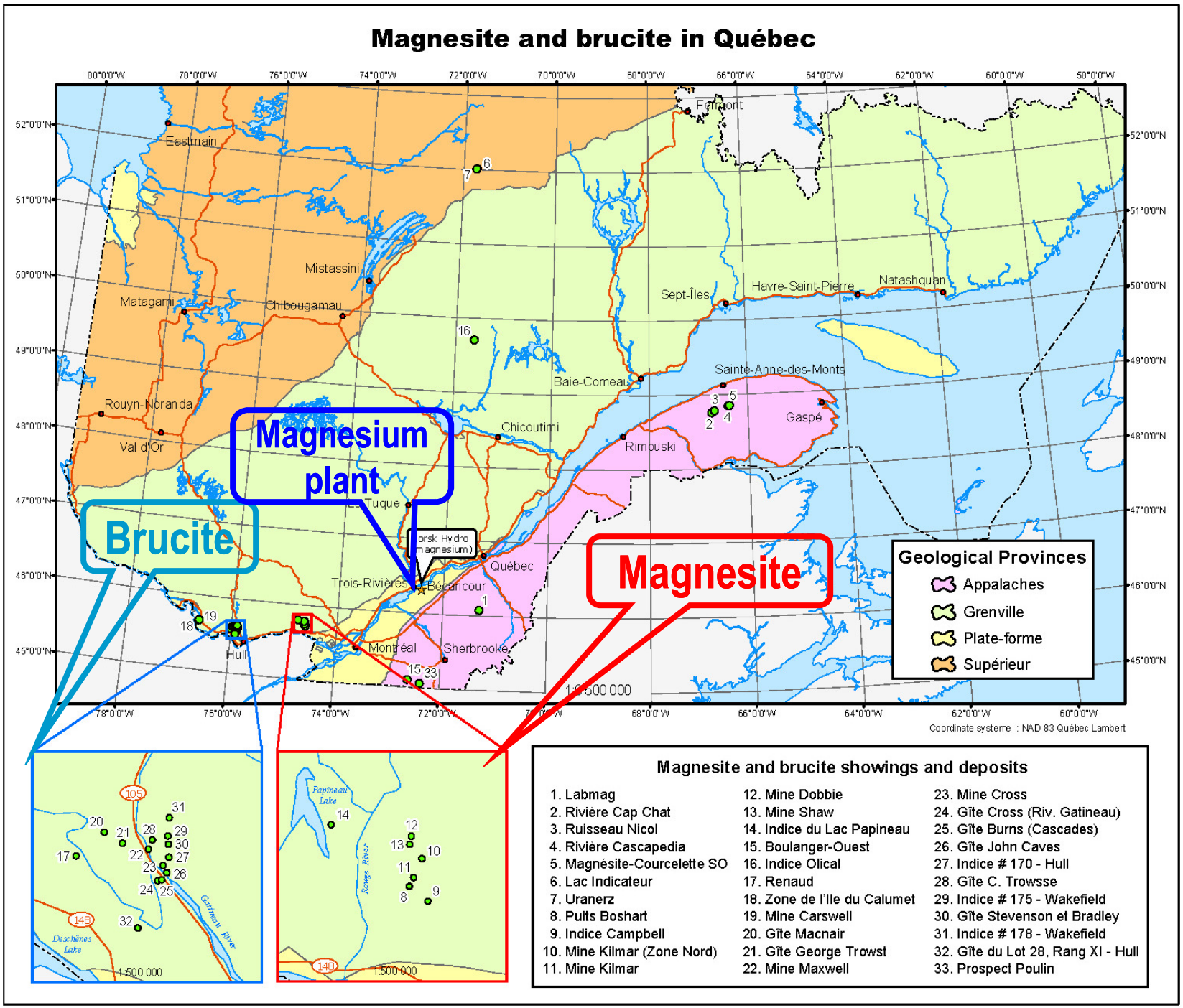
Magnesite and brucite in Québec



Potential in Quebec - Magnesite

- Grenville Province
  - Kilmar area - North of the Ottawa River
  - Dolomitic marbles of the Grenville Supergroup, between alumina-rich gneisses and quartzite
  - Generally lenticular masses
  - ***Most favourable area***

- *Otish Mountains North of Lake Mistassini*
  - *Sedimentary origin (carbonate complex)*
  - ***Too remote***
- *Thetford-Mines area*
  - *Altered serpentine (altered peridotite)*
  - ***High levels of iron, quartz and talc***

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Potential in Quebec - Brucite

- Grenville Supergroup
  - Several deposits in marbles north of the Ottawa River.
  - Most near the Gatineau River.

- *One occurrence north of Lac-St-Jean (low grade calcitic marble).*

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Basic economic criteria

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Basic economic criteria

- High grade deposit required (stringent specifications):
  - Min 95% - 96% MgO in calcined product.
  - Min 45% - 46% MgO in magnesite *(Min 95% - 96% $MgCO_3$)*
  - Min 65% - 66% MgO in brucite *(Min 95% - 96% $Mg(OH)_2$)*

- Need for open-pit operation (lower capital + operation costs to compete against imports).

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Basic economic criteria

Kunwarara deposit - Australia

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Basic economic criteria

- No beneficiation possible for magnesite, except selective mining. May be possible for brucite.
- Not too remote (land transportation cost).
- Large size: few million tons, re:
  - Unit infrastructure cost
  - Unit development cost
  - Probably no interest from customers for small tonnages.

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Access to the Newsletter

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Newsletter

Websites

- **Long version - Ministère des Ressources naturelles, de la Faune et des Parcs**
  http://www.mern.gouv.qc.ca/mines/industrie/mineraux/mineraux-proprietes.jsp

- **Short version - SIDEX**
  www.sidex.ca

Paper copy

- **Conference room exit**
- **MRNFP Booth # 225**

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