

Que peuvent nous apprendre les isotopes du strontium (Sr) sur l'origine du sirop d'érable?

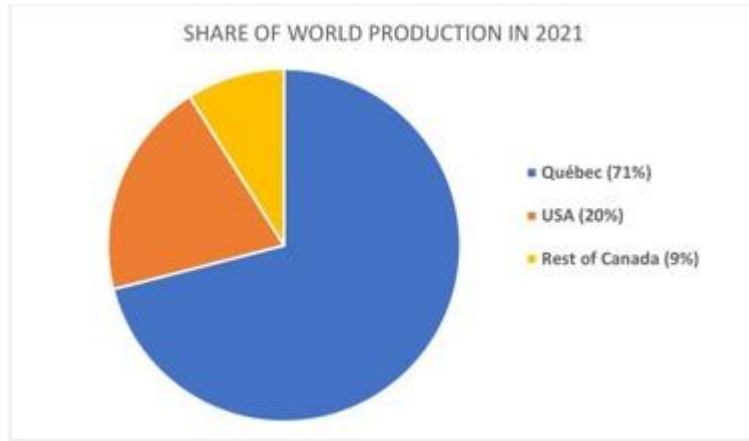
The origin of maple syrup: what can we learn from strontium (Sr) isotopes?

David Widory, Bruna Saar de Almeida, Ross Stevenson,
Mustapha Sadiki, Luc Lagace, Martin Pelletier

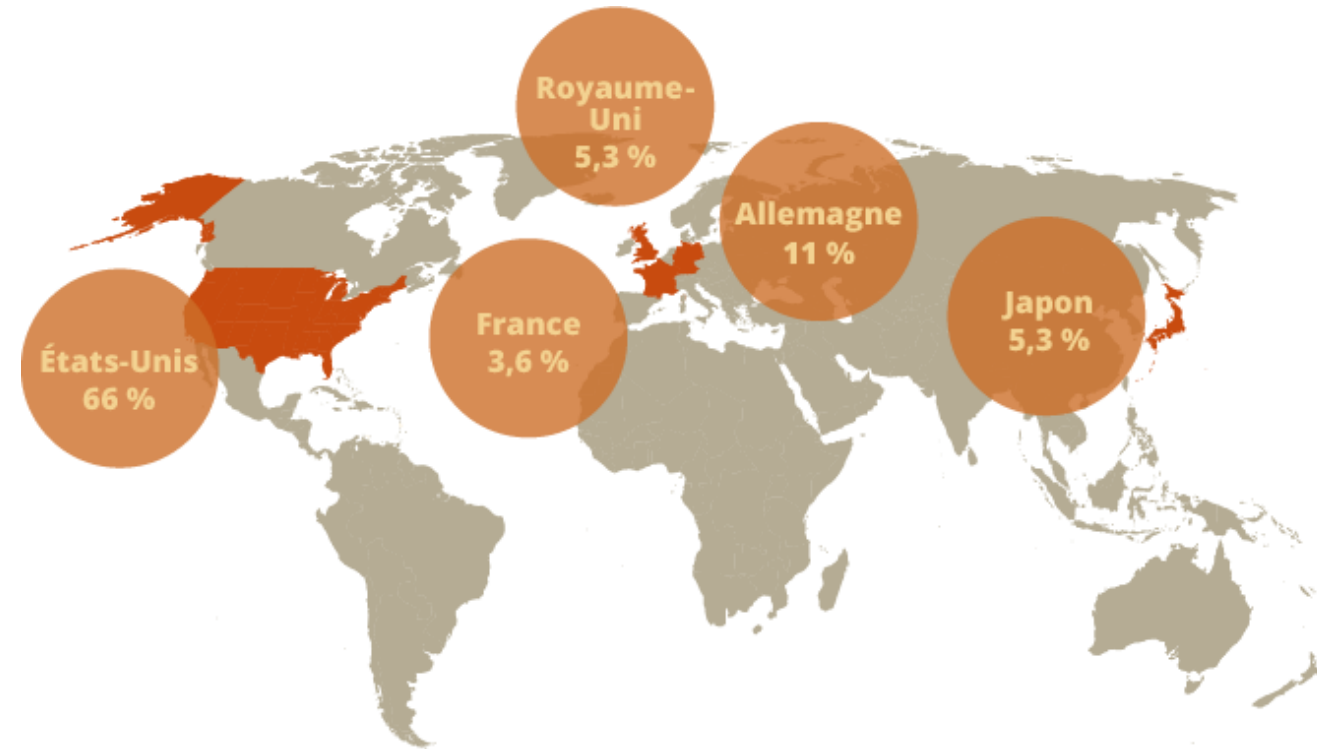
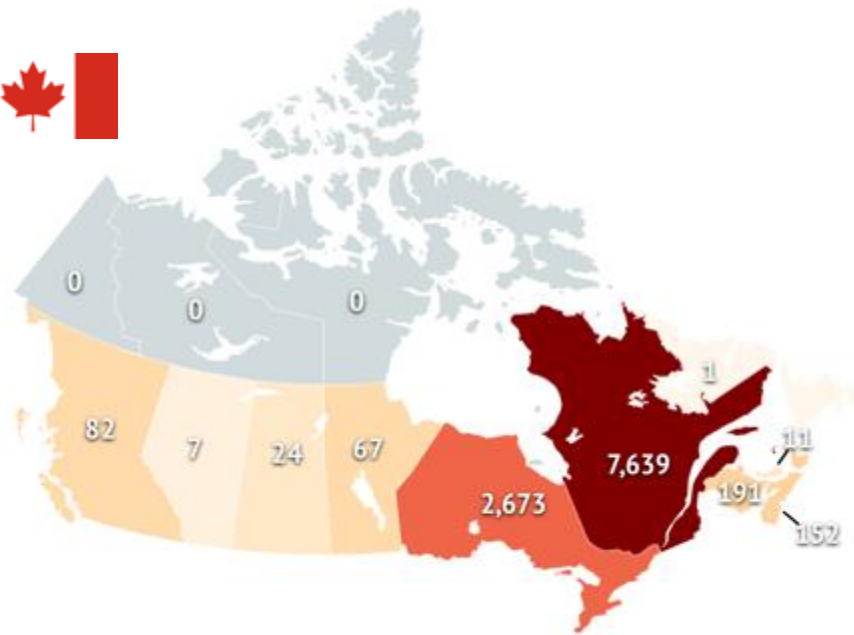




Production and export buyers



Source : PPAQ, AGÉCO, Statistics Canada, USDA



Source: Statistics Canada



Multi-step production



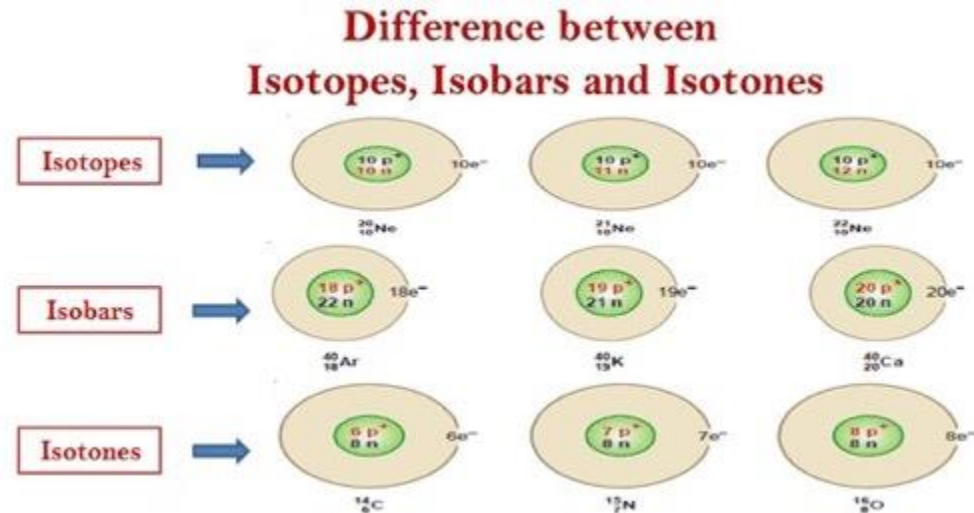
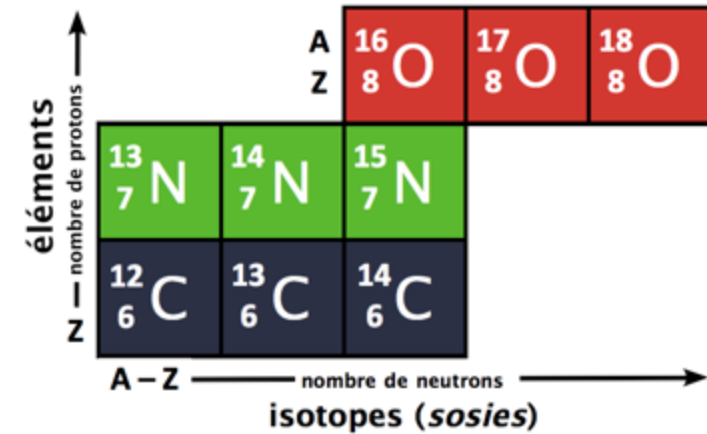
Atoms

- From the ancient Greek *ατομος* [atomos], “which cannot be divided”.
- Smallest part of a simple body.
- Contains a nucleus located at its center and electrons that revolve around it.
- The nucleus contains protons and neutrons.
- Electrons have a negative electric charge.
- Protons have a positive electric charge.
- Neutrons are neutral.

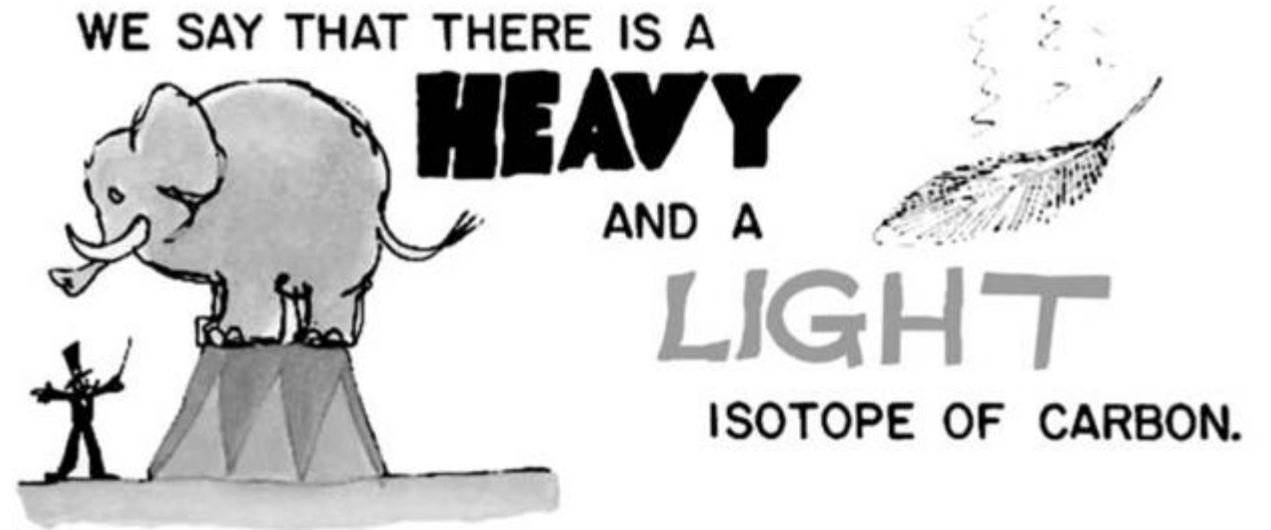
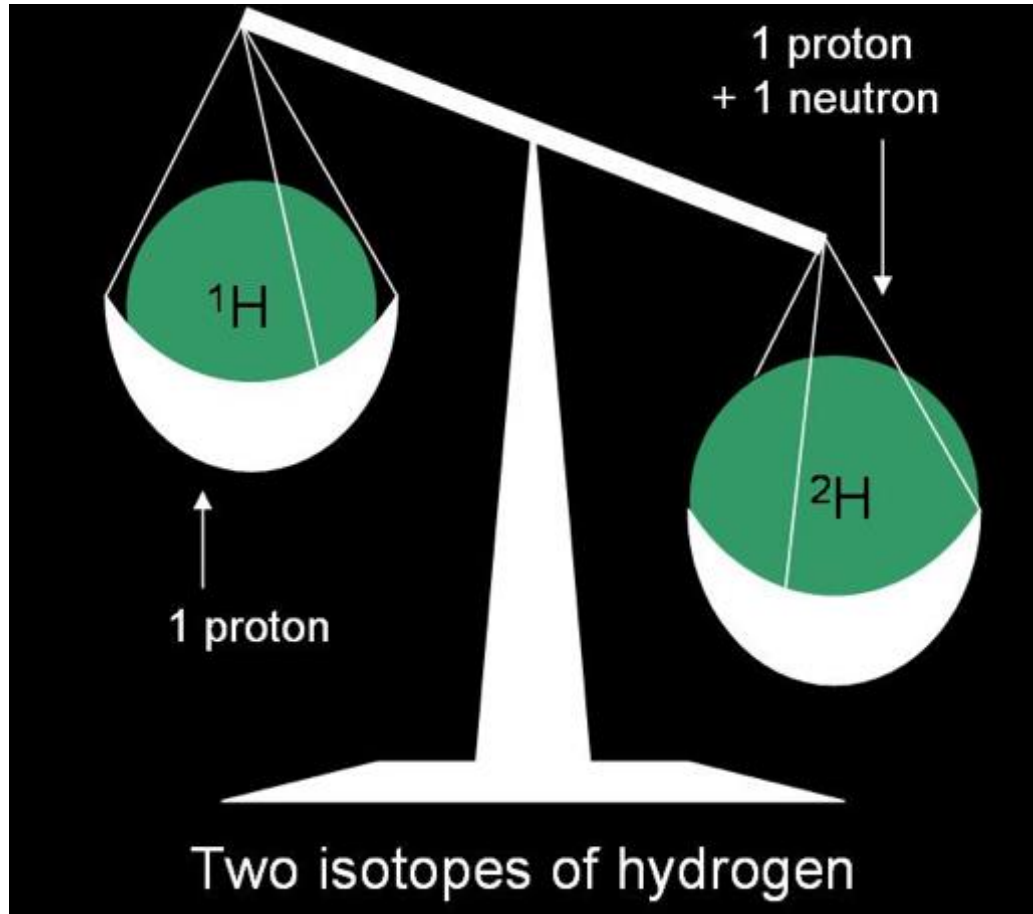


Elements all have isotopes

- Each element in the periodic table possesses multiple isotopes.
- Isotopes: atoms with the **same number of protons** and **electrons** BUT **different numbers of neutrons**.



What do different numbers of neutrons mean?



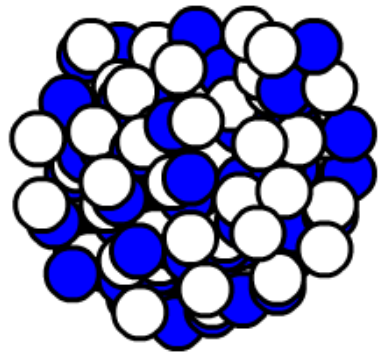
^{13}C CARBON HAS ONE
MORE NEUTRON THAN
 ^{12}C CARBON IN ITS NUCLEUS.



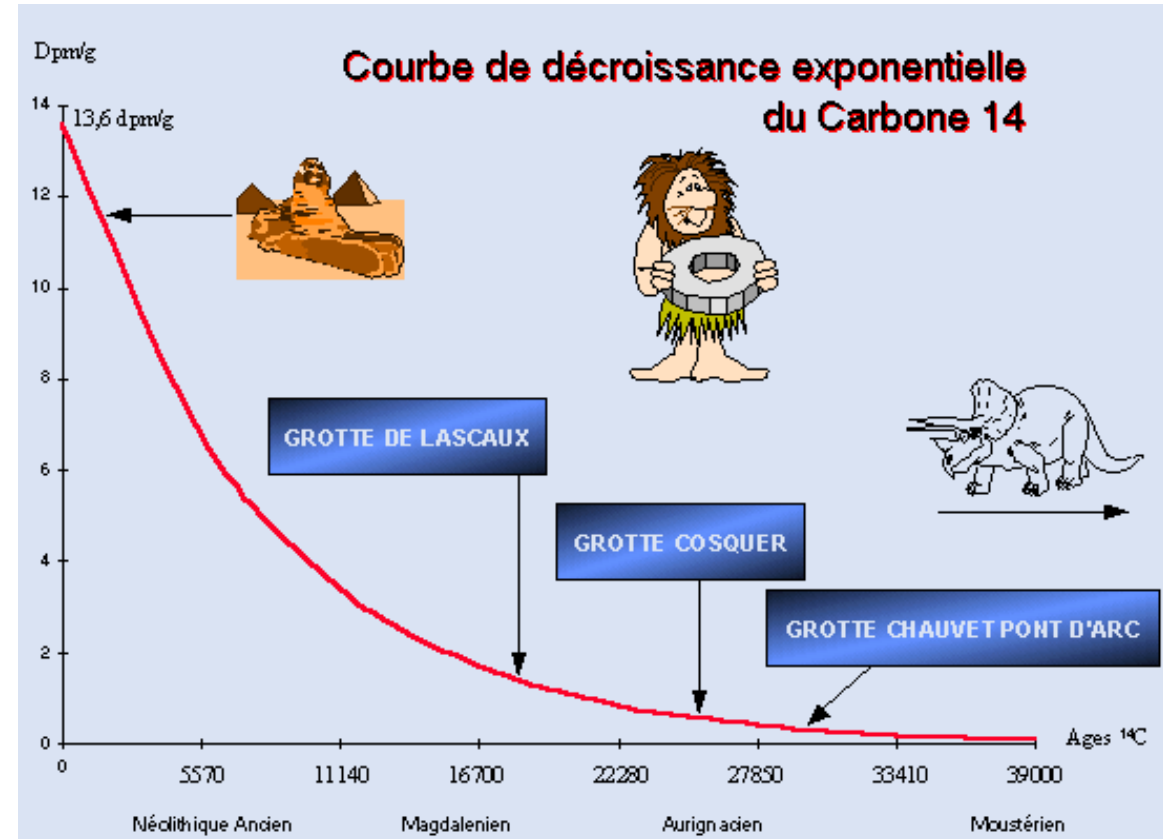
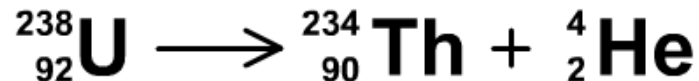
There are radioactive isotopes

- These will decay over time
- Mainly used to produce energy.....or nukes...
- But geoscientists use them for dating.

Alpha Decay of U-238

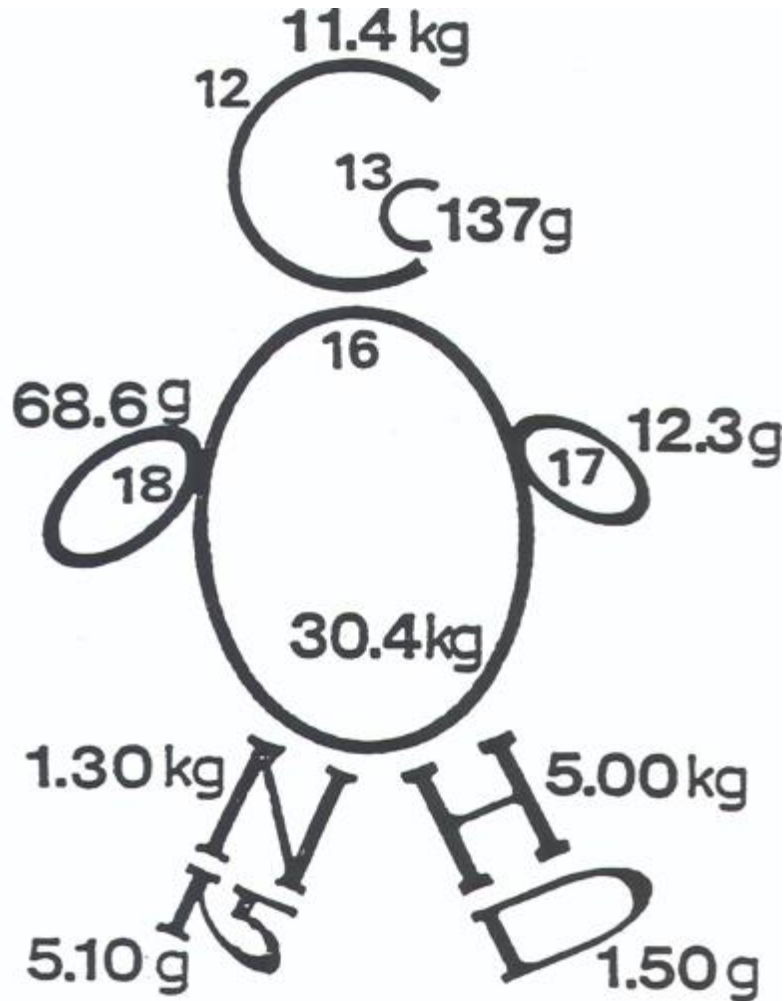


$^{238}_{92}\text{U}$



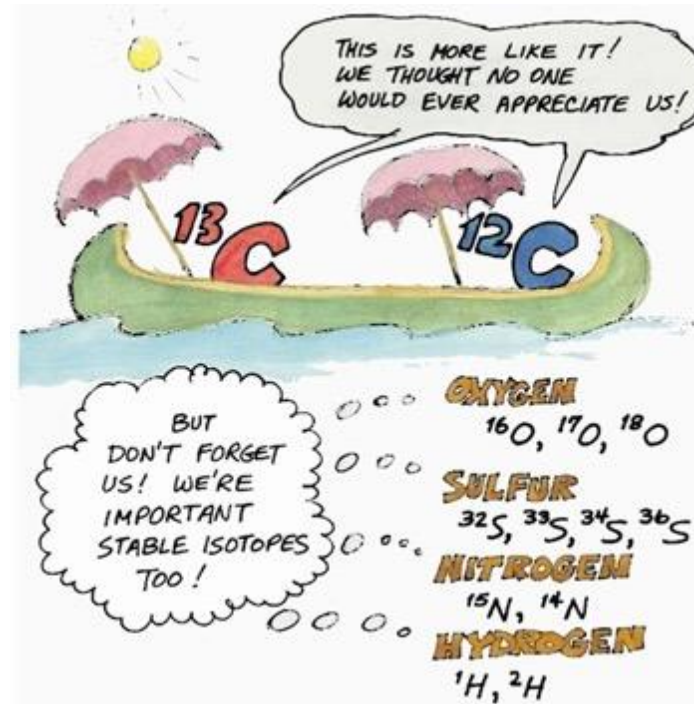
...but there are also stable isotopes!

- No radioactive decay.
- However, the distribution of these isotopes can be modified by certain processes.



Le corps humain contient des quantités appréciables d'isotopes stables, comme le montre ce dessin. Un individu de 50 kg renferme 225 grammes d'isotopes lourds, tels l'hydrogène 2, le carbone 13, l'azote 15, l'oxygène 17 et l'oxygène 18. (Photo: Wada/Mitsubishi-Kasai)

Fry (2008)

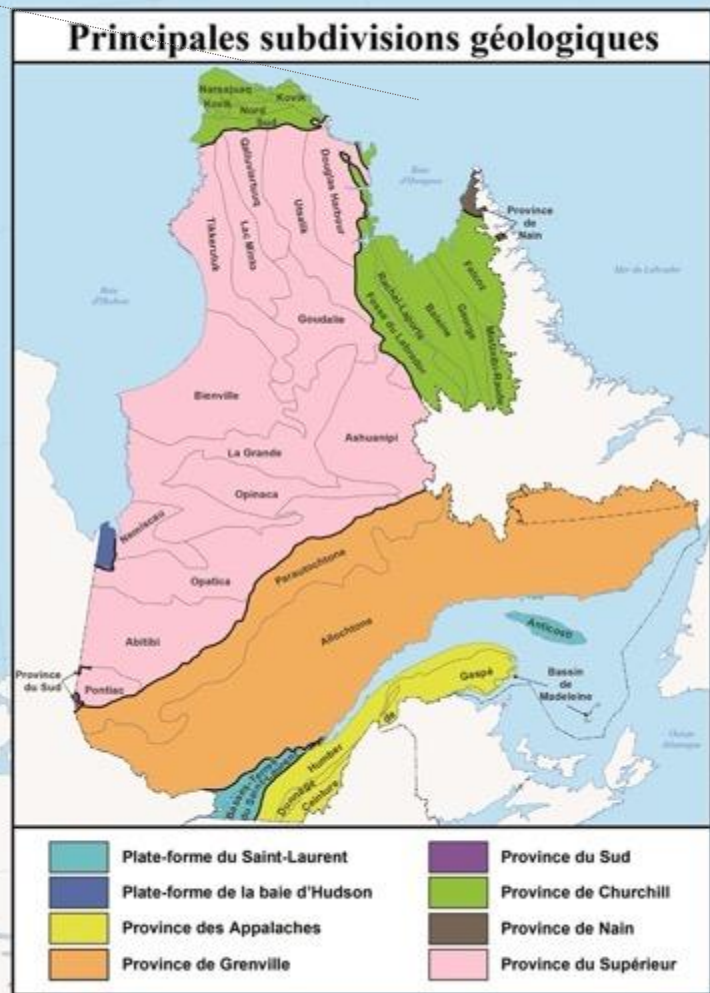


Fry (2008)

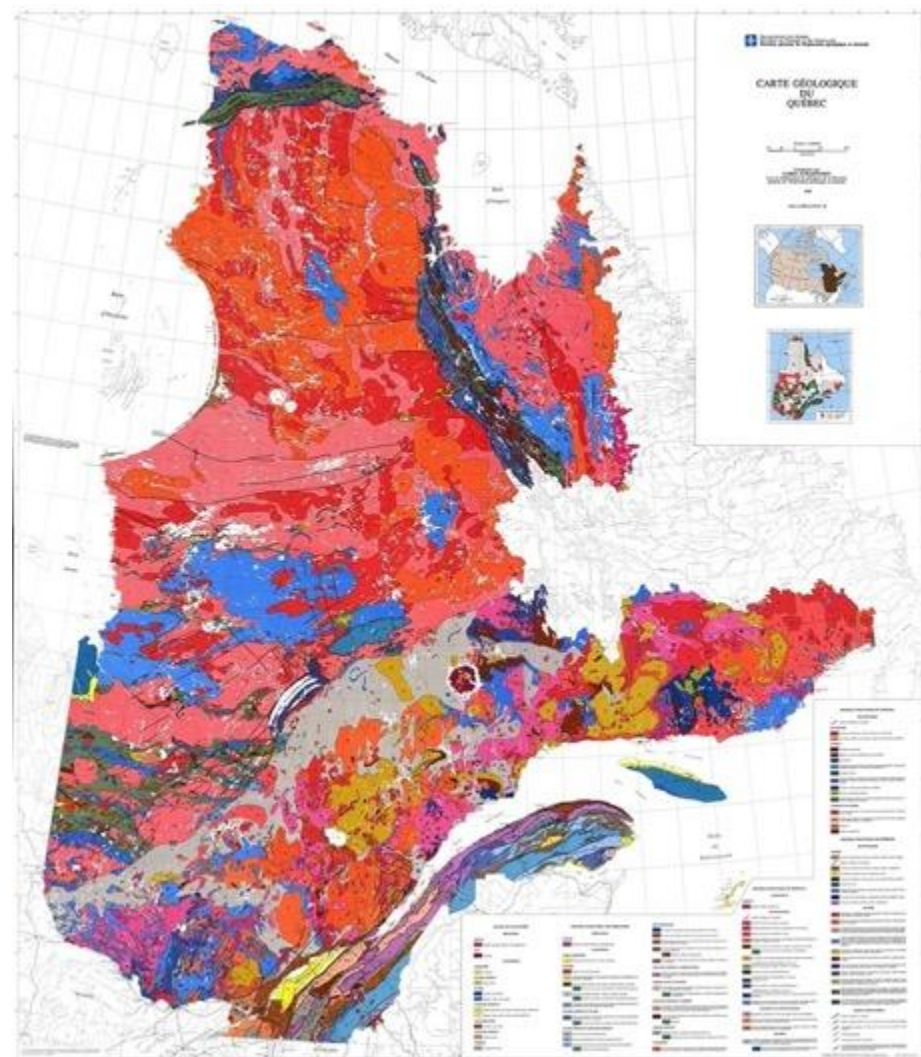


Geology

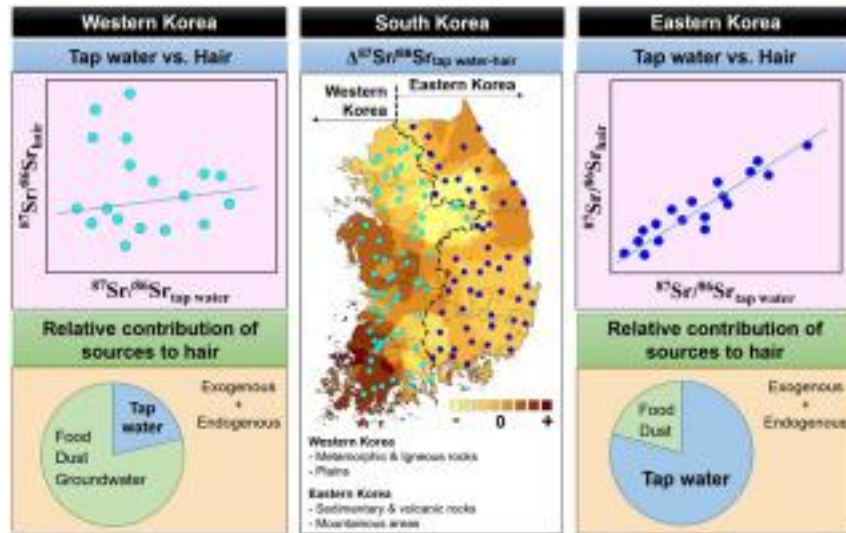
Geological Provinces of Quebec



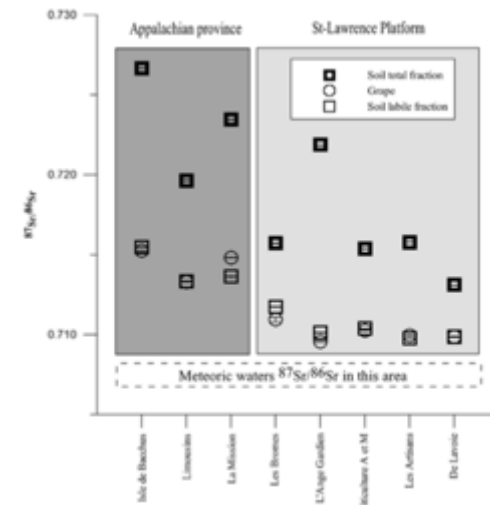
Geological Map of Quebec



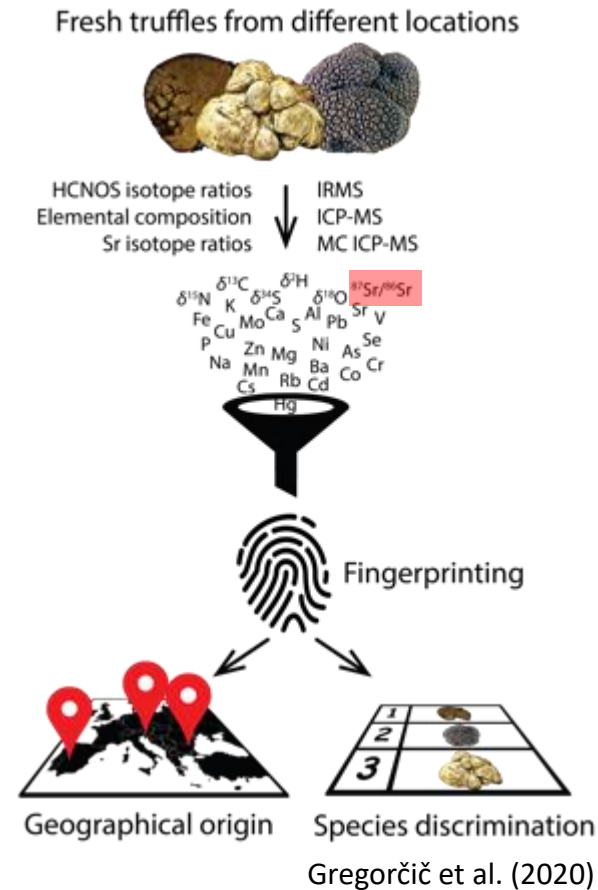
Why strontium (Sr) isotopes: $^{87}\text{Sr}/^{86}\text{Sr}$?



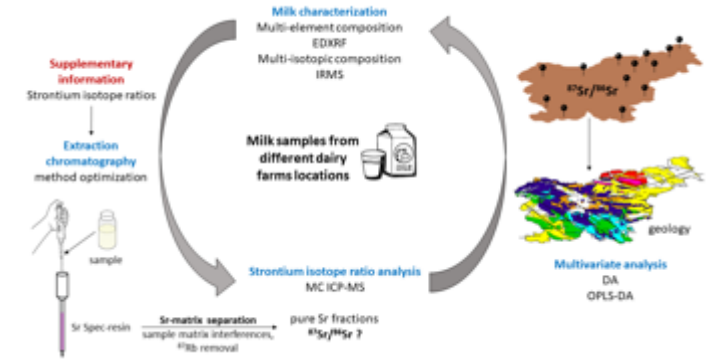
Shin et al. (2022)



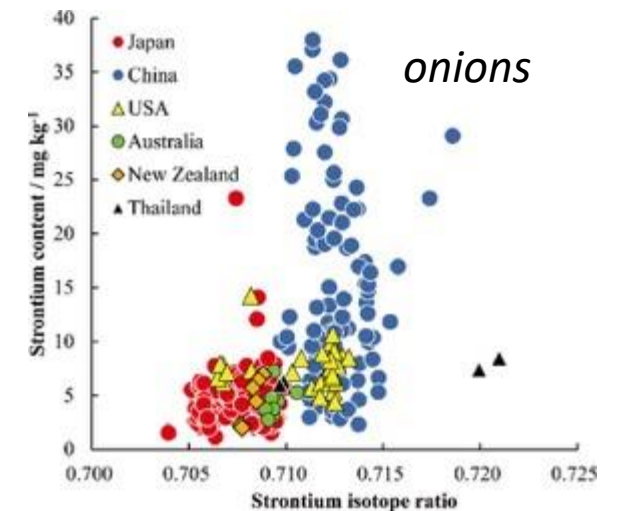
Vinciguerra et al. (2022)



Gregorčič et al. (2020)



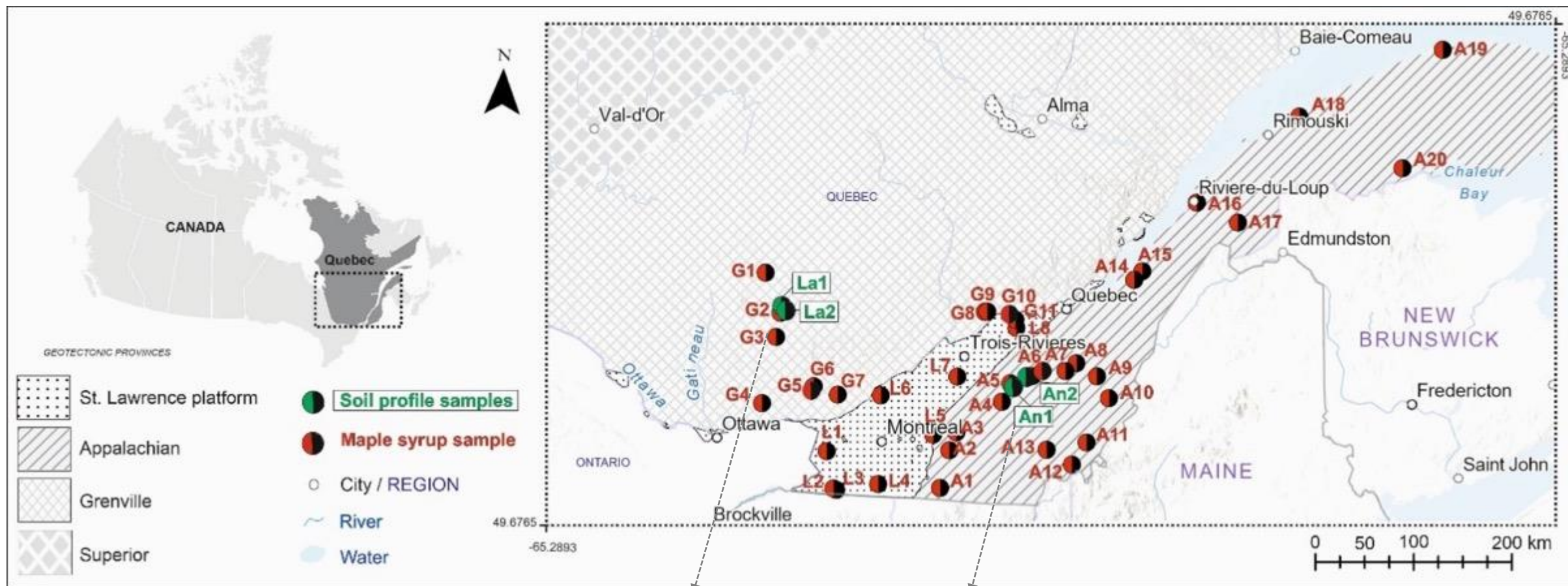
Gregorčič et al. (2021)



Hisaaki et al. (2016)



Sampling strategy

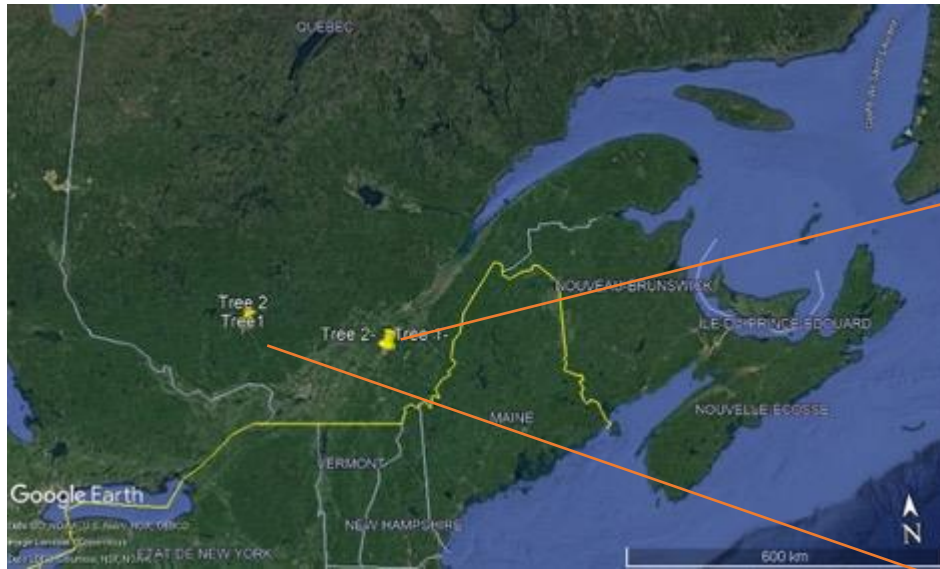


Age	Paléoprotérozoïque et Mésoprotérozoïque
Periode	
Strati	Suite magmatique de Lacoste
Code	geo338
Descript	Gneiss tonalitique et trondhyémitique; présence commune de tonalite

Age	Paléozoïque
Periode	Ordovicien à Silurien Inférieur
Strati	Formations de Bulstrode et de Melbourne
Code	geo173
Descript	Calcaire argileux, ardoise, mudrock, grès et conglomérat



Soil profiles



Saint-Norbert-d'Arthabaska (Samples 'AN')



Tree 1 (AN1)

Tree 2 (AN2)

Nominingue-Laurentides (Samples 'LA')



Tree 1 (LA1)

Tree 2 (LA2)

85 TOTAL SAMPLES

Soils: 20

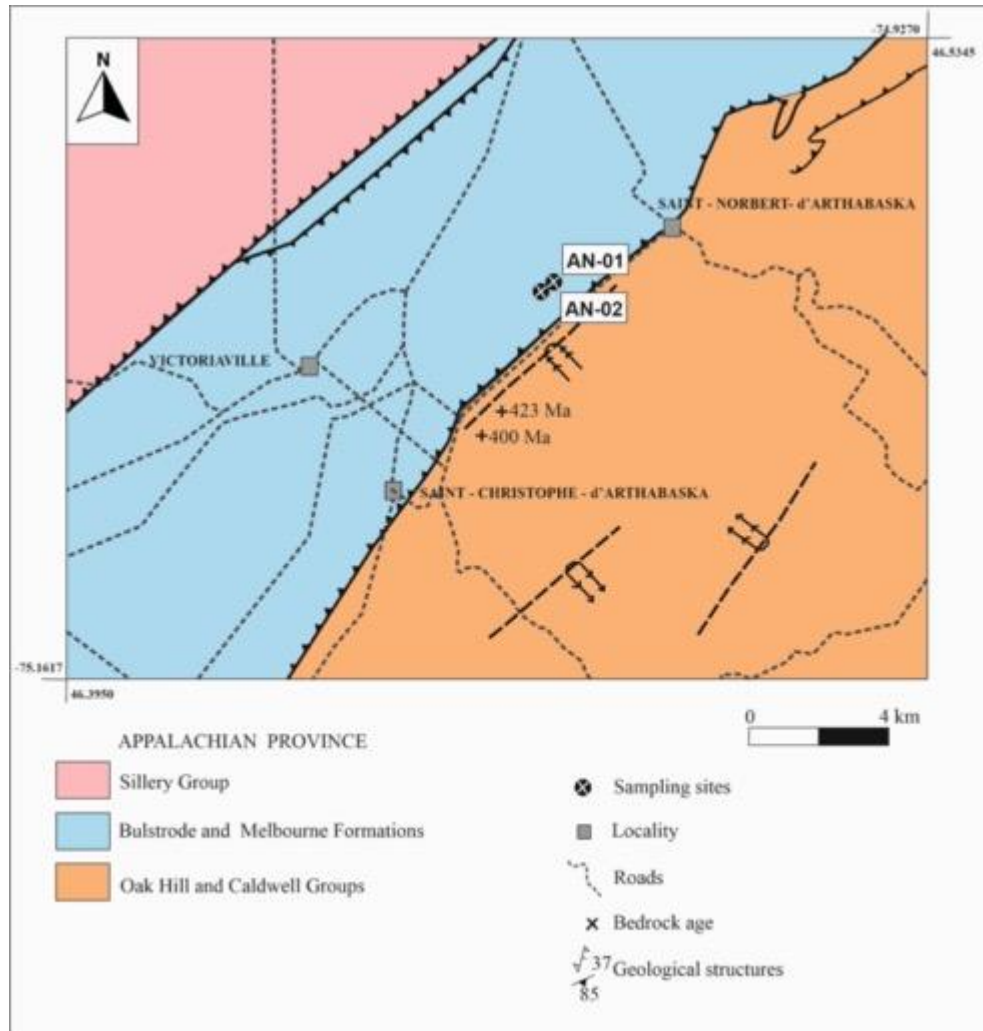
Maple tree: 16

Maple syrup: 30

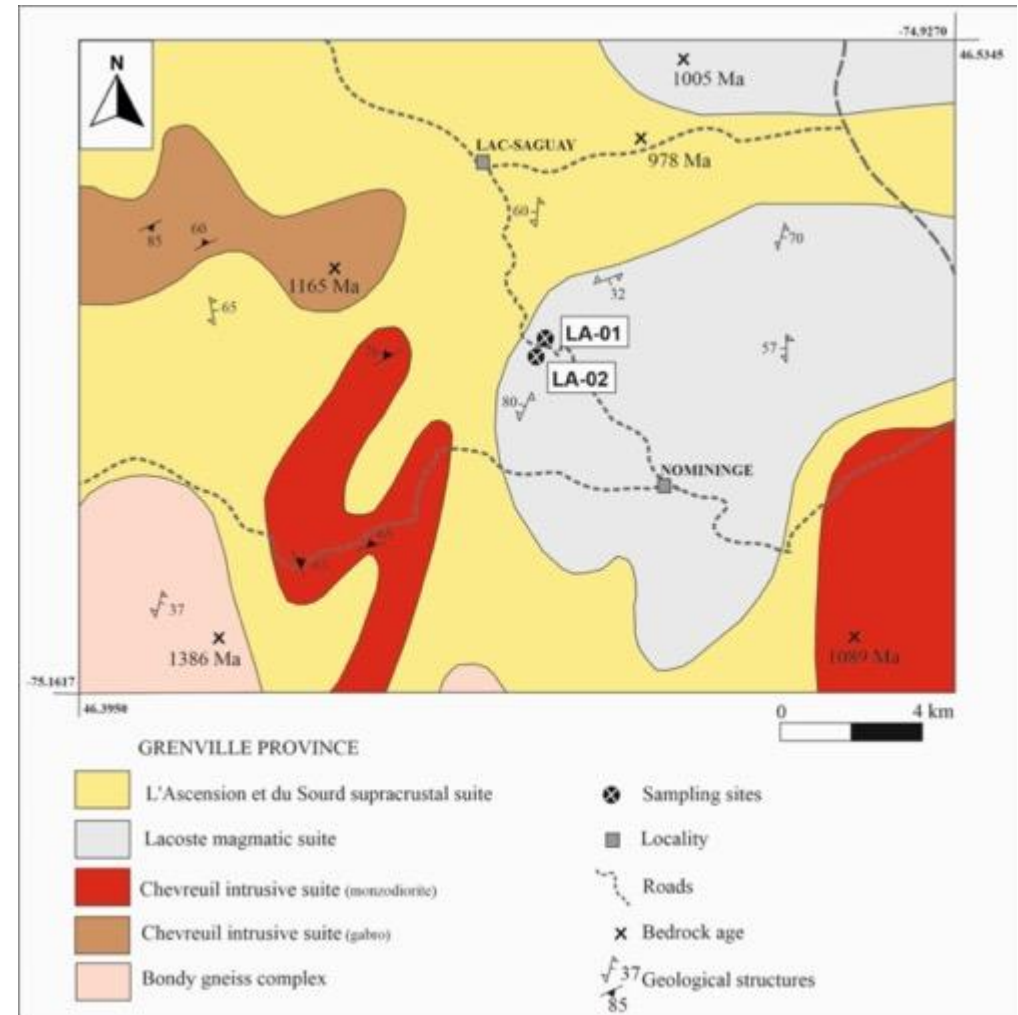


Soil profiles

Saint-Norbert-d'Arthabaska



Laurentides





Soils



Each soil profile:

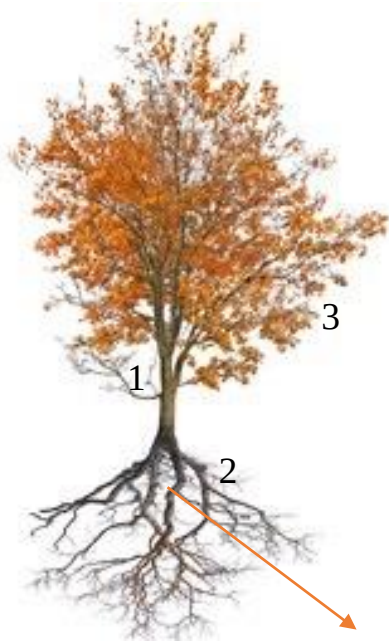
- | | |
|-----------|---------|
| Sample 1: | 0-10cm |
| Sample 2: | 10-20cm |
| Sample 3: | 20-30cm |
| Sample 4: | 30-40cm |
| Sample 5: | 40-50cm |



20 Soil samples
5 soil samples taken close to the roots
each 10cm



Maples



16 maple tree samples:
trunk, coarse roots, fine roots, leaves and
leaf litter

Trunk¹



Coarse roots²



Leaves³



Leaf litter⁴





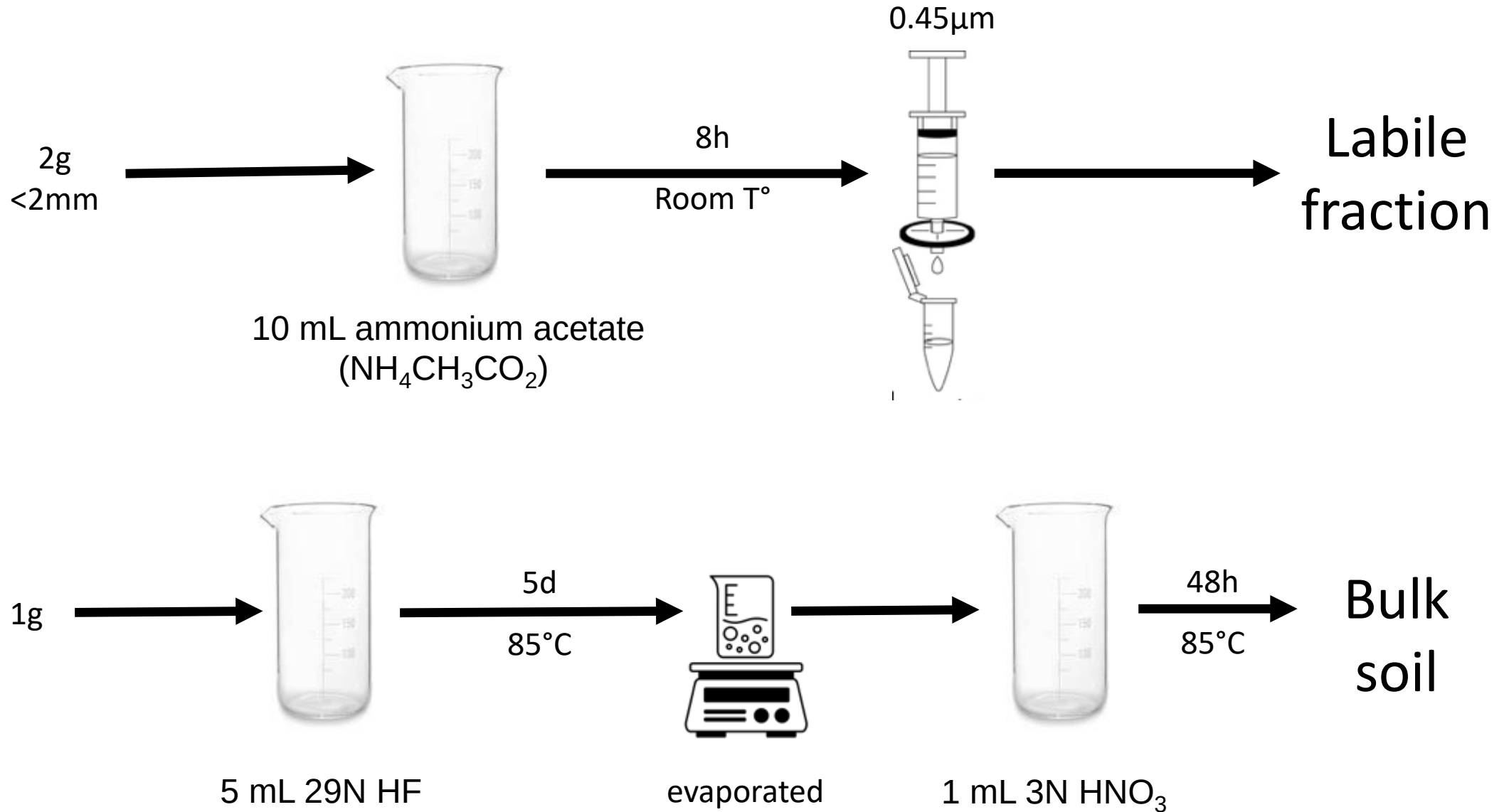
Maple sap products

- Sap
- Concentrate
- Syrup
- early season
- ¼ season
- middle season
- ¾ season
- late season

(30 samples)



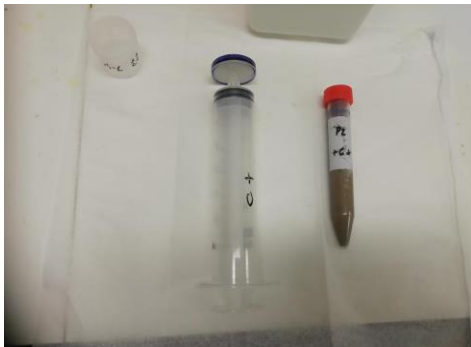
Bulk soil vs. labile fraction



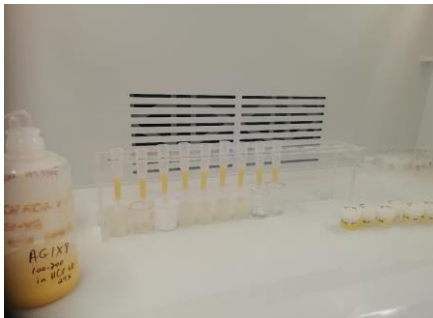


Sample preparation

Soil and tree components



Maple syrup samples

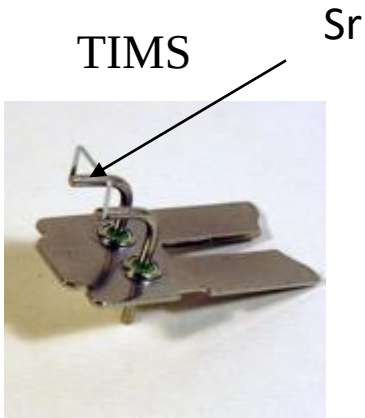


1	2	3	4	5
Resin loading	Resin washing	Sample loading	Rinsing	Sr recovery
2mL of AG50X-8 resin	10mL 6N HCl Qtx (x2)	2mL of sample (x5)	10 mL 1N HCl (x3)	10mL 6 N HCl (x2)
	10mL 1N HCl (2x)			

All samples



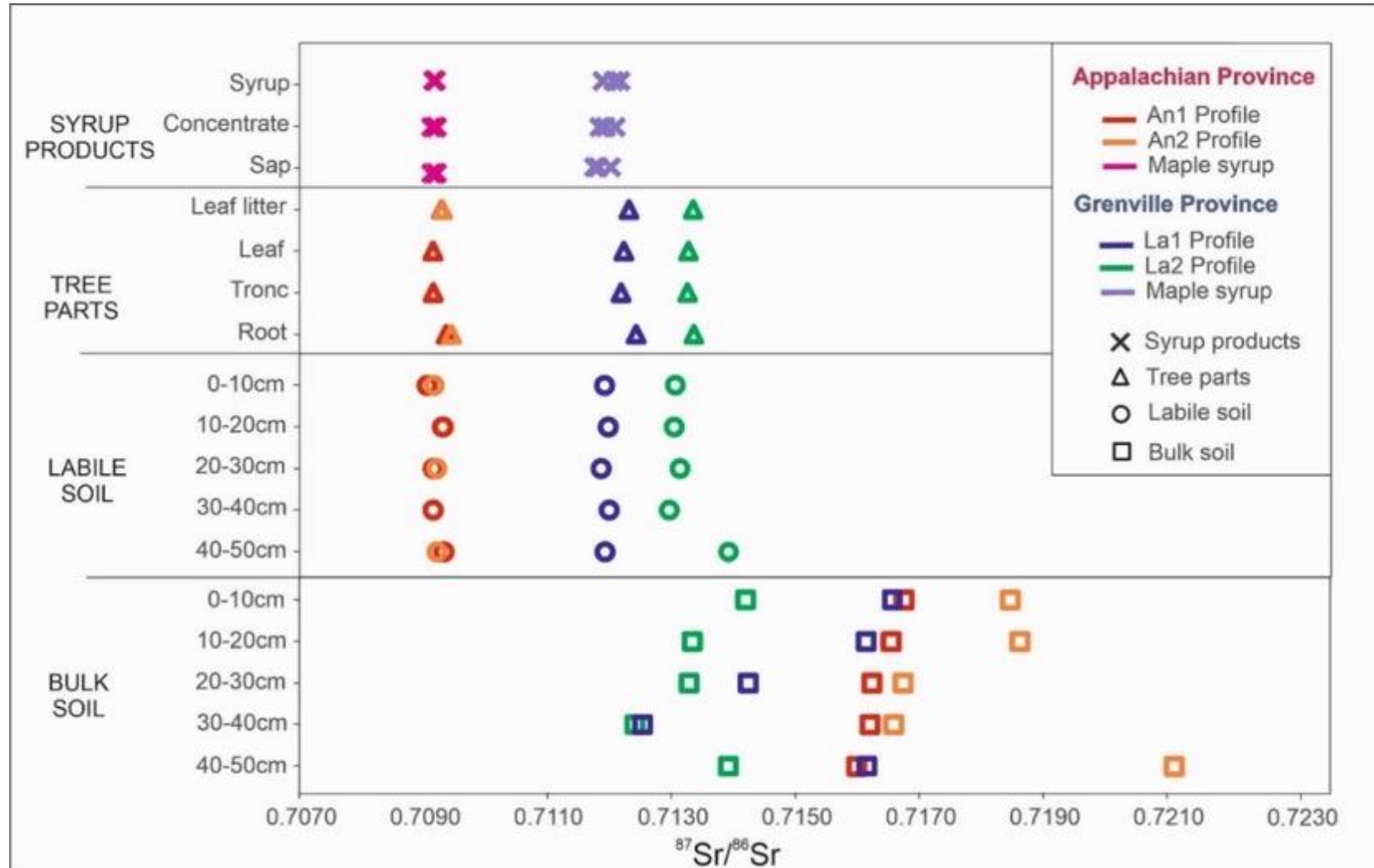
1	2	3	4	5
Resin loading	Resin washing	Sample loading	Rinsing	Sr recovery
0.25mL of Sr spec	2mL Mill-Q H ₂ O	0.25mL of sample (x4)	0.5mL 3N HNO ₃ (x6)	0.25mL 0.05N HNO ₃ (x5)
	2mL 3N HNO ₃ (x3)			



= ⁸⁷Sr/⁸⁶Sr



RESULTS - Bulk and labile soil fractions, maple tree components



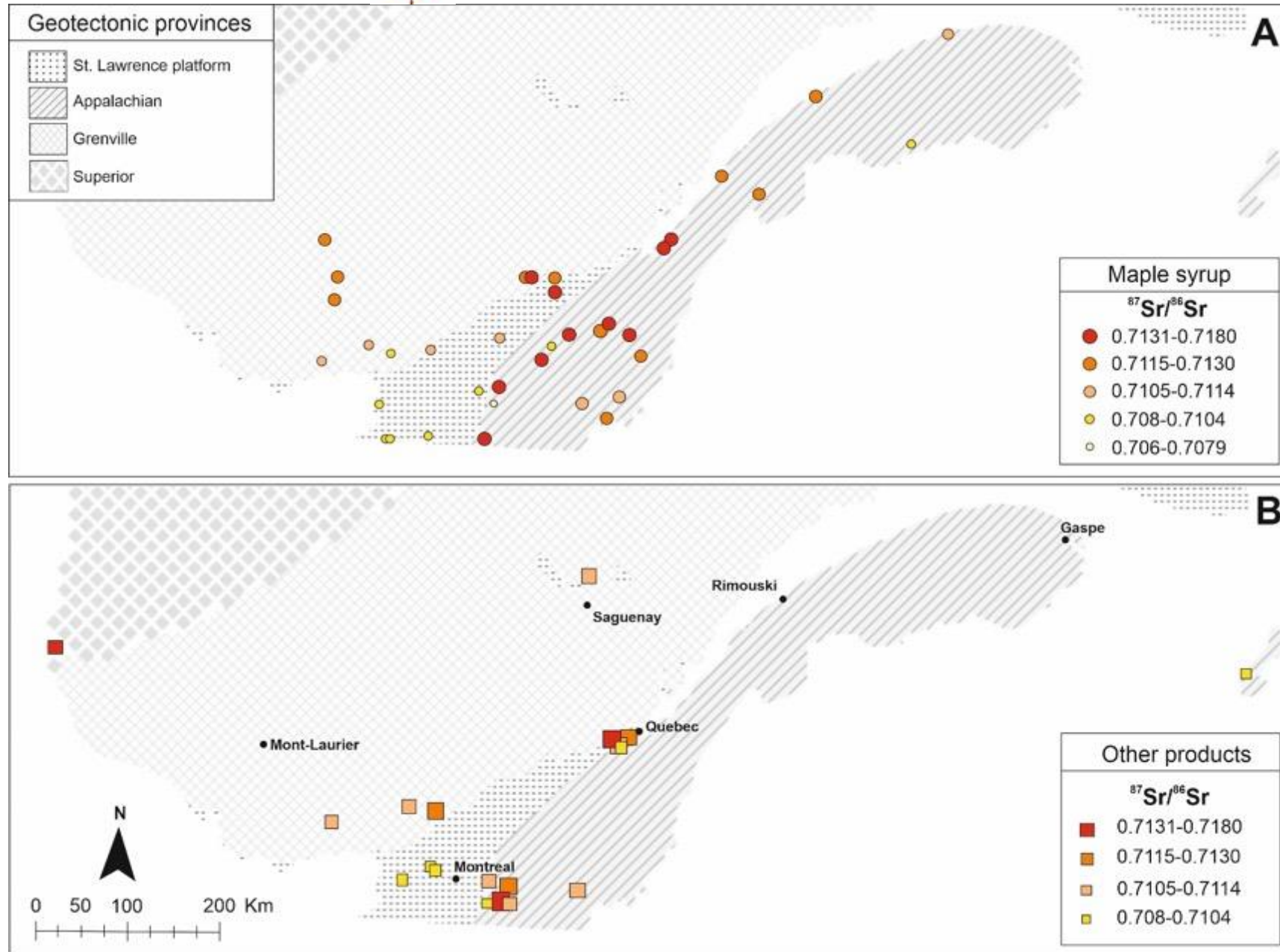


RESULTS

Province	Sample	Location	Region	⁸⁷ Sr/ ⁸⁶ Sr	2s
St. Lawrence platform	L01	Vaudreuil-Soulanges	Montérégie	0,7094	0,000007
	L02	Haut St-Laurent	Montérégie	0,7102	0,000008
	L03	Hinchinbrooke	Hinchinbrooke	0,7102	0,000011
	L04	Les Jardins-de-Napierville	Montérégie	0,7099	0,000007
	L05	Les Maskoutains	Montérégie	0,7098	0,000017
	L06	St-Alexis-De-Montcalm	St-Alexis-De-Montcalm	0,7092	0,000007
	L07	Nicolet-Yamaska	Centre-du-Québec	0,7110	0,000007
	L08	Lotbinière	Chaudière-Appalaches	0,7161	0,000010
Appalachian	A01	Brome-Missisquoi	Estrie	0,7168	0,000006
	A02	Roxton-Pond	Roxton-Pond	0,7069	0,000012
	A03	Acton	Montérégie	0,7152	0,000007
	A04	d'Arthabaska	Centre-du-Québec	0,7177	0,000008
	A05	Saint Norbert d'Arthabaska	Centre-du-Québec	0,7091	0,000008
	A06	de L'Érable	Centre-du-Québec	0,7168	0,000010
	A07	St-Pierre-De-Broughton	St-Pierre-De-Broughton	0,7143	0,000009
	A08	St-Severin-De-Beauce	St-Severin-De-Beauce	0,7159	0,000006
	A09	Robert-Cliche	Chaudière-Appalaches	0,7170	0,000008
	A10	Beauce-Sartigan	Chaudière-Appalaches	0,7119	0,000009
	A11	du Granit	Estrie	0,7121	0,000007
	A12	Notre-Dame-Des-Bois	Notre-Dame-Des-Bois	0,7127	0,000008
	A13	Haut-Saint-François	Estrie	0,7111	0,000006
	A14	L'Islet	Chaudière-Appalaches	0,7174	0,000006
	A15	St-Auber	St-Auber	0,7171	0,000007
	A16	Rivière-du-Loup	Bas-Saint-Laurent	0,7107	0,000007
	A17	Témiscouata	Bas-Saint-Laurent	0,7120	0,000009
	A18	La Mitis	Bas-Saint-Laurent	0,7124	0,000008
	A19	Marsoui	Marsoui	0,7102	0,000007
	A20	d'Avignon	Gaspésie-Îles-de-la-Madeleine	0,7098	0,000007
Grenville	G01	Antoine-Labelle	Laurentides	0,7121	0,000007
	G02	Laurentides	Laurentides	0,7121	0,000008
	G03	Nominingue	Nominingue	0,7124	0,000011
	G04	Papineau	l'Outaouais	0,7105	0,000008
	G05	Montcalm	Lanaudière	0,7102	0,000008
	G06	Montcalm	Lanaudière	0,7092	0,000007
	G07	Pays-d'en-Haut	Laurentides	0,7085	0,000007
	G08	L'avenir	L'avenir	0,7116	0,000008
	G09	St-Ubalde	St-Ubalde	0,7149	0,000011
	G10	Portneuf	Capitale-Nationale	0,7102	0,000007
	G11	Portneuf	Capitale-Nationale	0,7111	0,000009



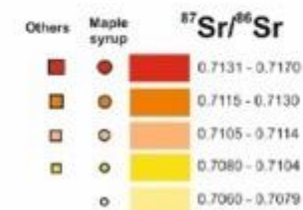
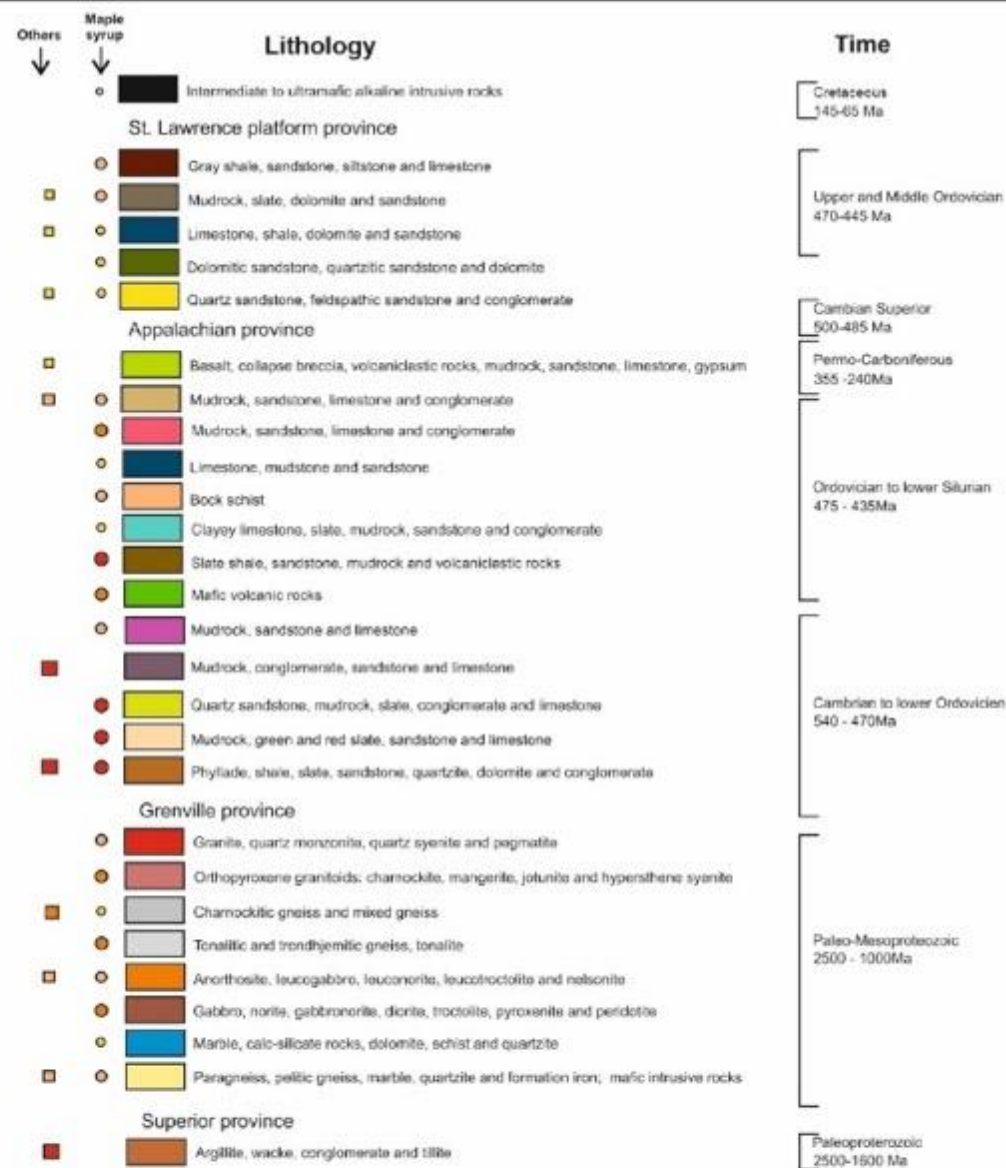
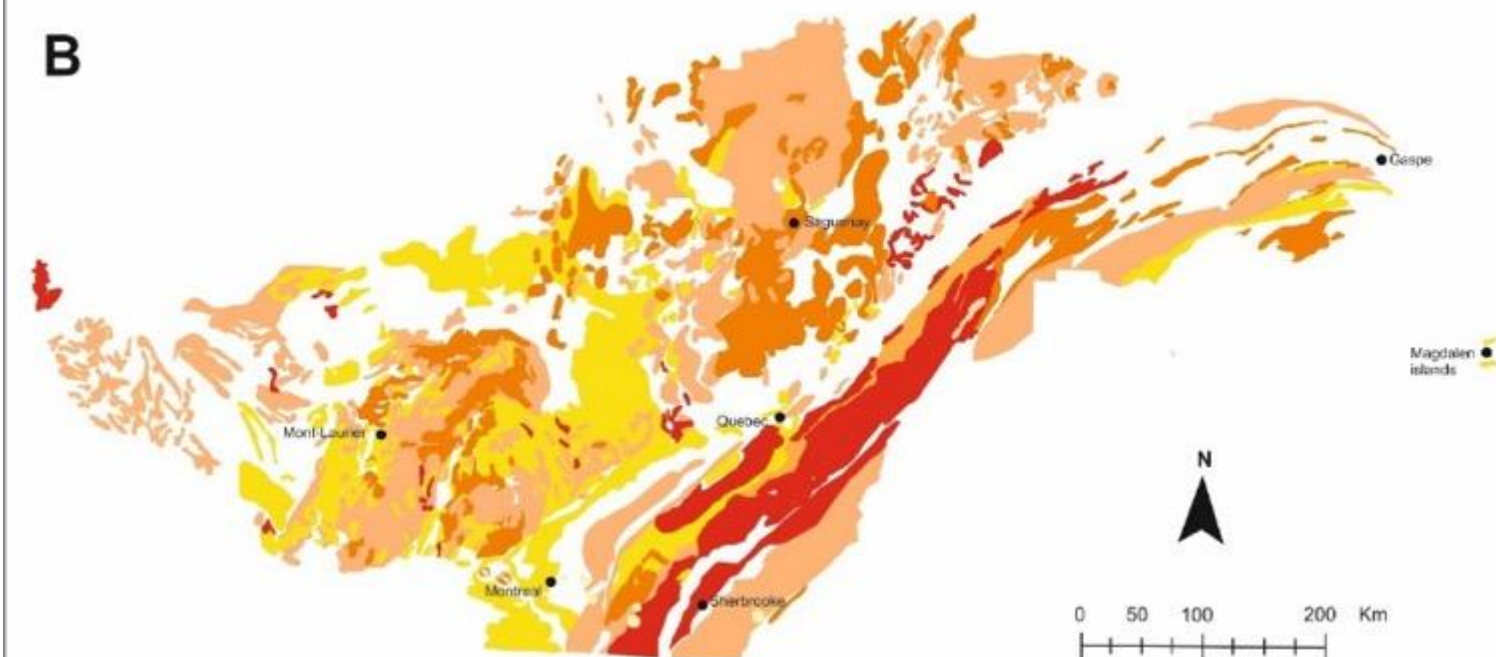
RESULTS



A



B



Conclusions

- There is no Sr isotope difference between the labile fraction of the soil, the maple tree parts and all the by-products of maple sap (sap, concentrate and maple syrup).
- The different evaporation phases during the production of maple syrup do not modify the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio.
- Underlying geology controls the $^{87}\text{Sr}/^{86}\text{Sr}$ ratio.
- The first Quebec isoscape map created for agri-food products is promising.
- Still, the size of the Sr isotope database needs to be incremented.

Thank you!!
Merci!!

