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Thermo-chemical structure of northeastern North American craton from Rayleigh wave phase velocities

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Background

- **Thermal and compositional structure** of lithospheric keels underlying the **Precambrian cores of continents** may shed light on their **evolution and long-term stability**
- Several seismic studies have found **significant 3D seismic heterogeneity** in cratonic lithosphere, which is enigmatic because temperature variations in old shields are expected to be small and seismic sensitivity to major-element compositional variations is limited. Metasomatic alteration has been proposed to play a role in average 1-D structures (Eeken et al., EPSL 2018) and mid-lithospheric discontinuities.

Method

Rayleigh wave phase velocities are from: Foster et al (Gondw. Res. 2020) for the Superior south of Hudson Bay and adjacent Proterozoic belts (**region A**, Fig. 2), Petrescu et al (JGR, 2017) for the eastern-most Superior and adjacent Grenville (**region B**) . Only the isotropic component is analysed here.

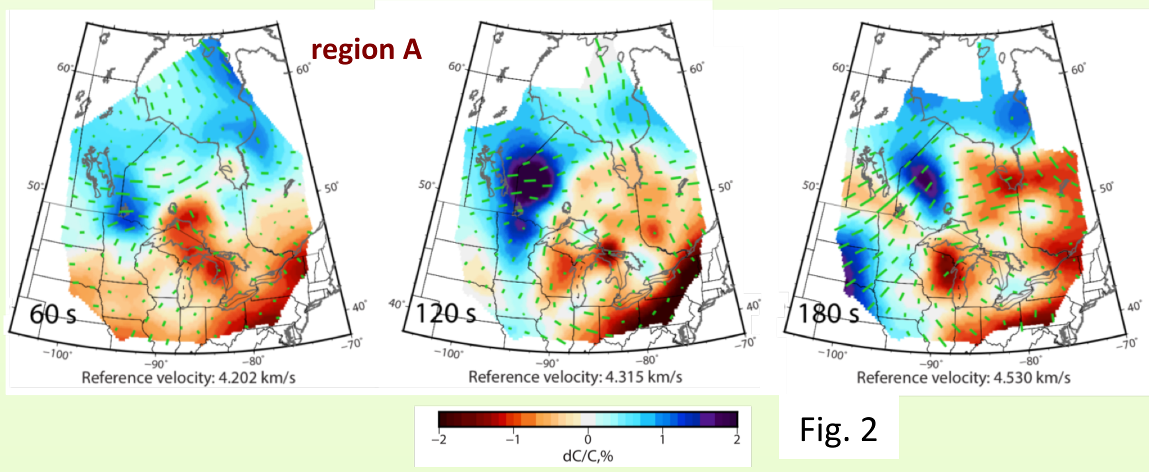

Fig. 2

Regions of distinct phase velocities are derived by k-means **cluster analysis**. Clusters are further subdivided if crustal structures (based on receiver functions, refraction profiles) are different. This yields 10 subregions for region A and 9 for region B.

For each region, a **grid-search** is performed for thermo-chemical structures that fit the data within their uncertainties, as detailed in Fig. 3.

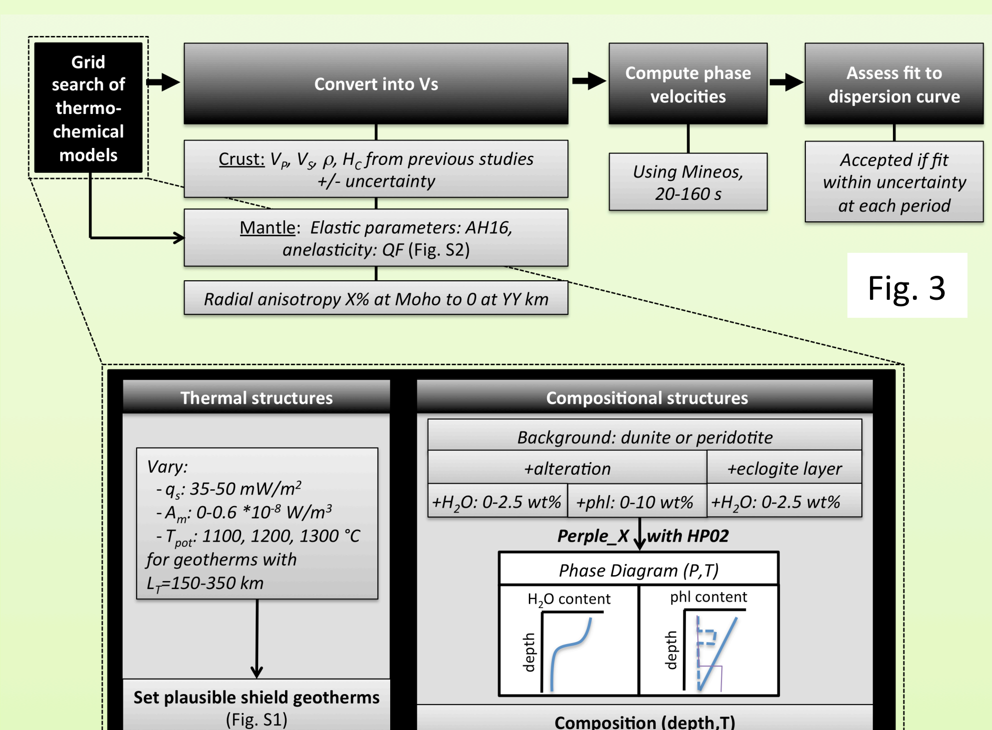

Fig. 3

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Aim

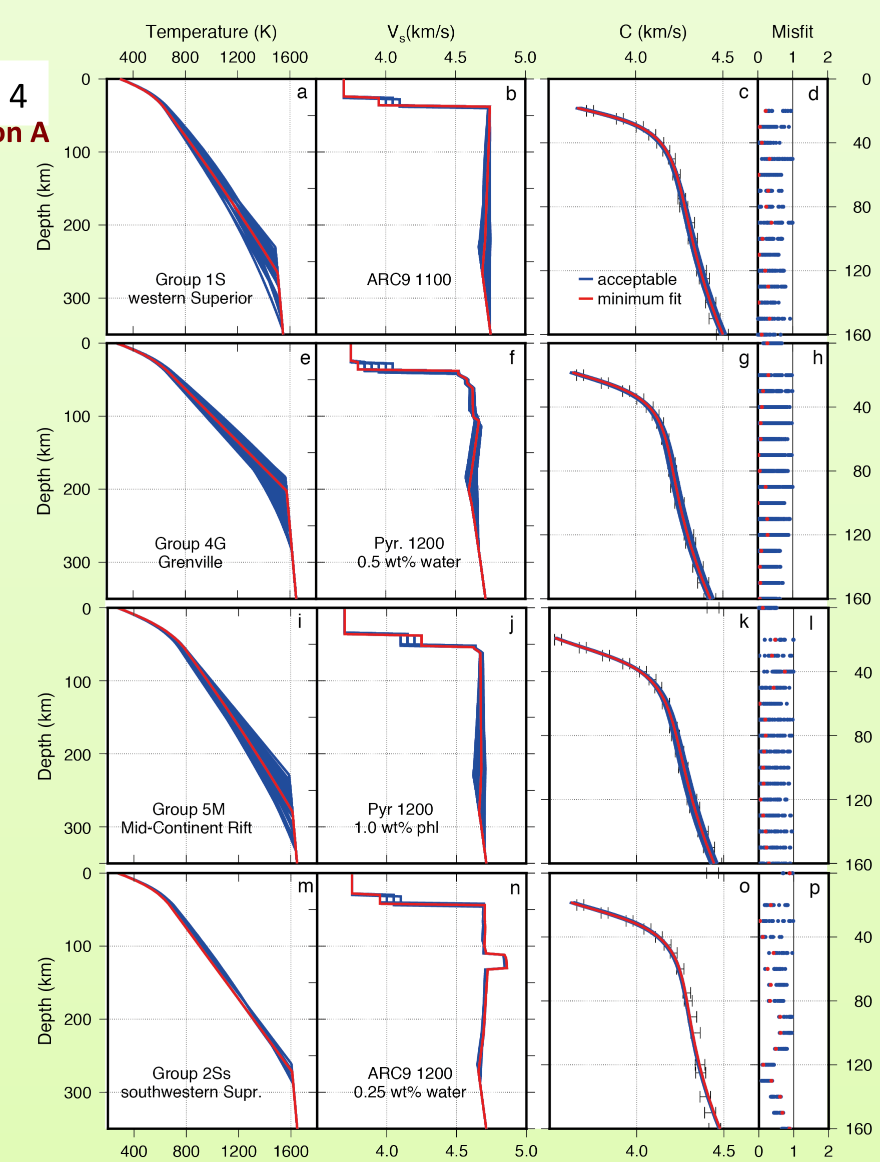
Model **Rayleigh wave phase velocities** between 20 and 160 s for two regions (Fig. 1) in the **northeastern** part of **North America** comprising the Superior craton, the largest Archean craton in the world, and surrounding Proterozoic belts using a grid search for **thermo-chemical structures** including metasomatic compositions.

Example Solutions

We find four types of distinct compositional structures are required to match the long-period phase velocities. Examples for region A e are shown in Fig. 4:

i. The **unaltered** oldest cores of the Superior,
ii. Archean and Proterozoic lithosphere **modified throughout** by rifting and/or plume activity, and two distinct types of subduction signatures:
iii. An Archean/Paleo-Proterozoic signature that includes a **high-velocity eclogite layer** in the mid-lithosphere and
iv. A post Paleo-Proterozoic signature characterised by strongly **altered shallow mantle lithosphere**.

Fig. 4
region A



- Eeken, Goes, Pedersen, Arndt, Bouilhol, EPSL 2018;
- Eeken, Goes, Petrescu. Altoe, JGR, in press;
- Altoe, Eeken, Goes, Foster, Darbyshire, EPSL, in revision

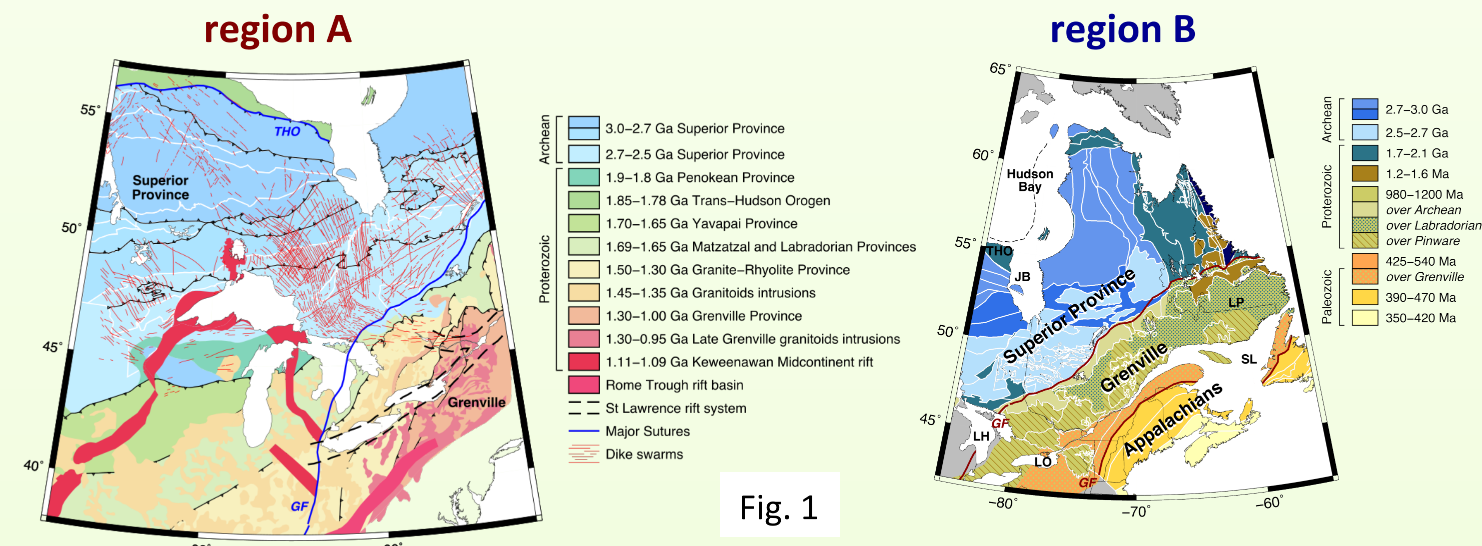


Fig. 1

Conclusions

- Smooth variations in **thermal structure** that include variations in thermal thickness within the Superior and decreasing thickness towards the edges of the shield
- Four types of distinct **compositional structures** are required to match the long-period phase velocities, reflecting tectonic evolution of the cratonic lithosphere.
- Processes that have affected the formation and modification of cratonic lithosphere and were previously recognised in xenoliths and crustal geology appear to have also left **large-scale imprints in seismic structure** of the lithosphere.

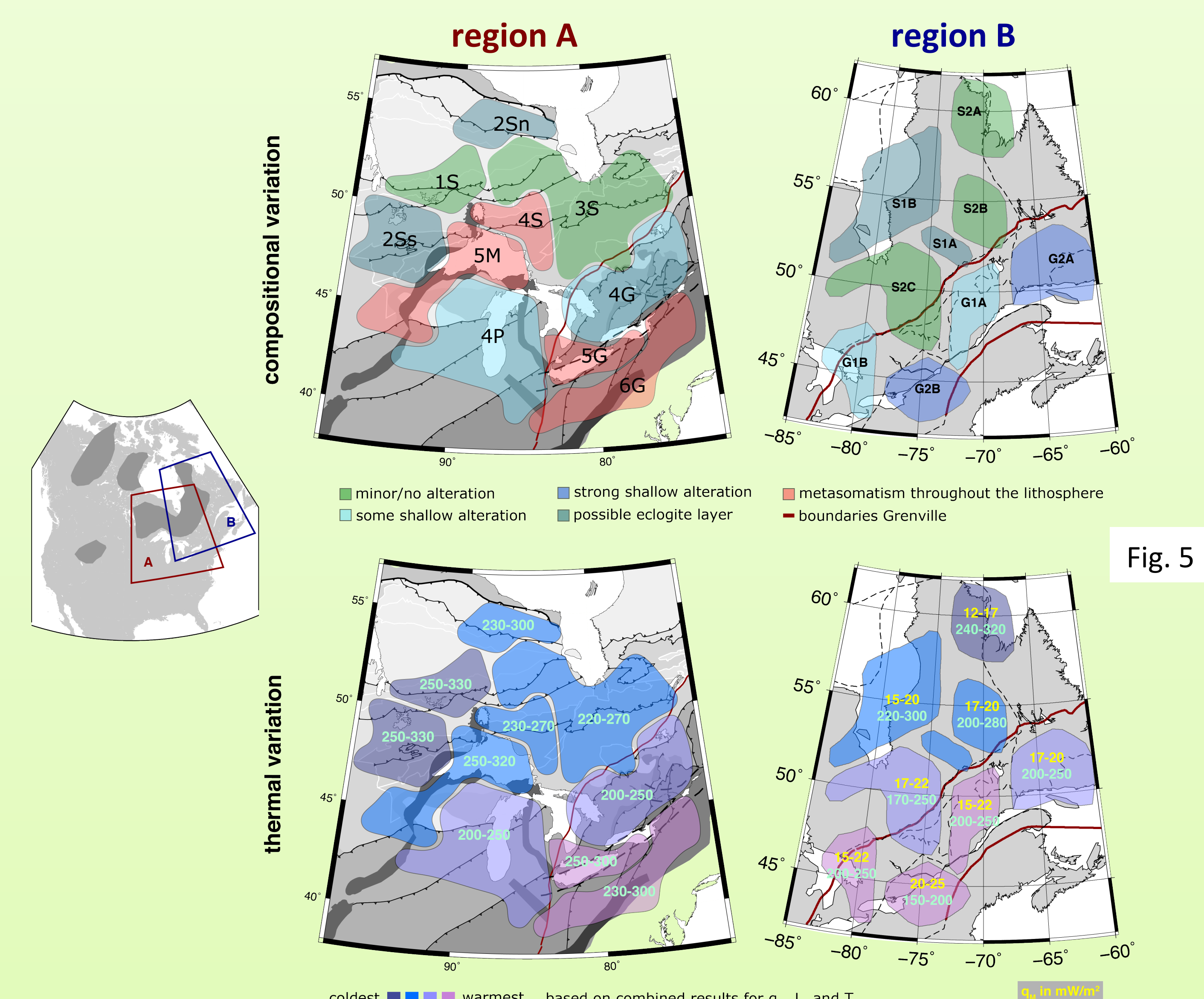


Fig. 5

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