Assessing the carbon dioxide sequestration potential of ultramafic rocks in British Columbia as a climate change mitigation strategy

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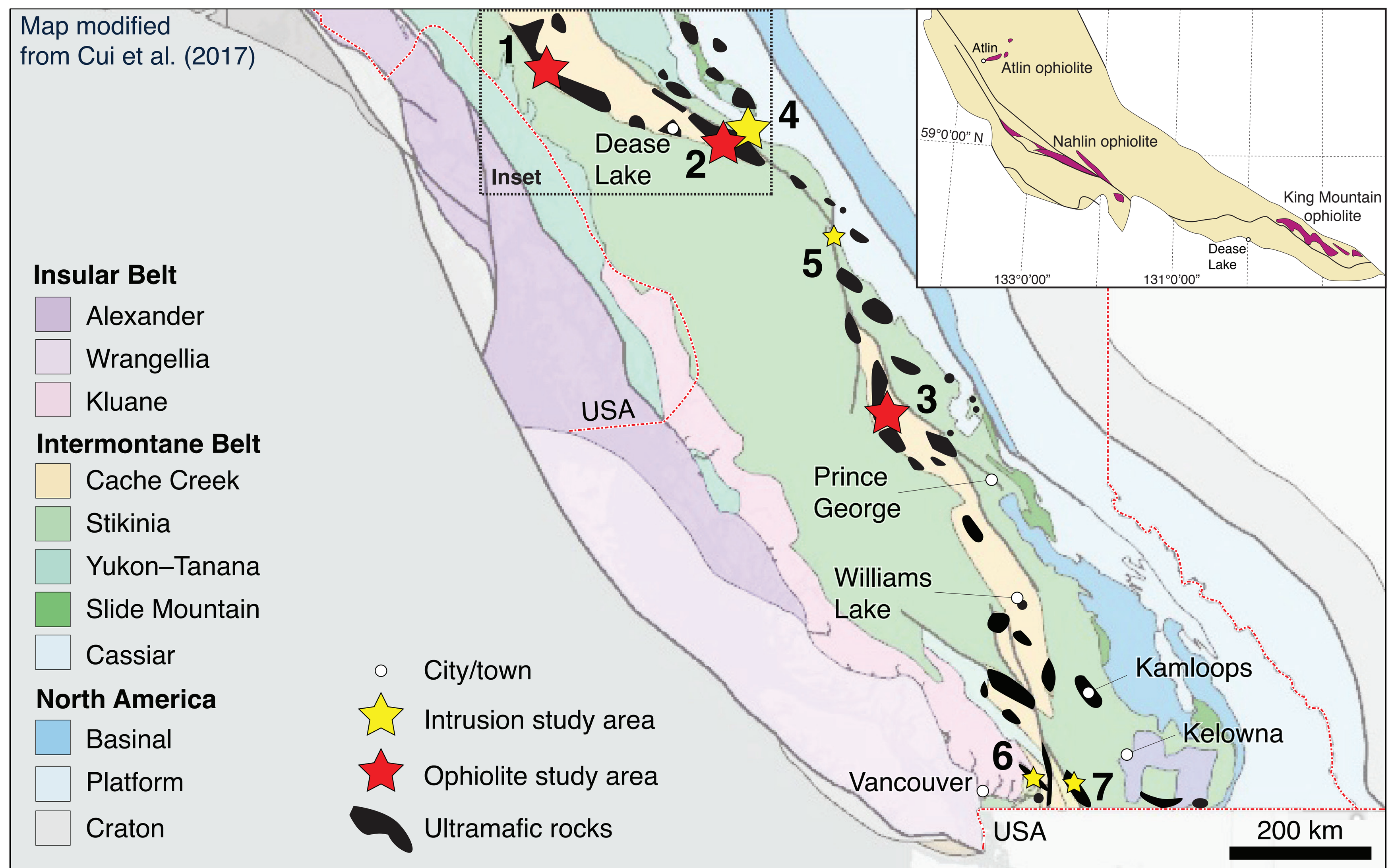
1 - INTRODUCTION

Ultramafic rocks and their serpentinite products are commonly associated with Ni±Fe-Cu-Co-PGE mineralization and can be used to permanently sequester carbon dioxide (CO_2) as newly-formed minerals. Given the abundance of ultramafic rocks in British Columbia and the CO_2 emissions related to resource extraction, the current government carbon offset schemes provide companies mining ultramafic rocks with economic incentive for carbonating mine tailings. Serpentinization involves the hydration of Mg-rich silicate minerals and carbonation involves the reaction of serpentinization-related minerals with CO_2 and the formation of Mg-carbonate minerals; **highly-serpentinized rocks have the greatest potential for CO_2 sequestration**. Alteration is commonly associated with changes in the physical properties of the rocks. This study aims to constrain and quantify the changes in physical properties during alteration of ultramafic rocks in four key localities in British Columbia. These relationships will be used to inform geophysical inversions with the goal of calibrating remote sensing techniques for assessing the potential of given ultramafic rocks to sequester CO_2.

2 - STUDY SITES

Ultramafic rocks in British Columbia occur mainly as ophiolite massifs (e.g., Zagorevski et al., 2017) and as intrusive complexes (e.g., Nixon et al., 2015). Samples from four primary localities (large stars below) that span the range of serpentinized and carbonated ultramafic rocks are the focus of this study. These include the Atlin (1), King Mountain (2), and Decar areas, which are ophiolitic rocks, and the Turnagain intrusion (4); the Atlin area contains the Atlin and Nahlin ophiolites (inset in figure below). Secondary study sites (small stars below) include the Polaris (5), Giant Mascot (6), and Tulameen (7) intrusions.



3 - PHYSICAL PROPERTIES OF ALTERED ULTRAMAFIC ROCKS

Serpentinization is a net volume-increasing reaction and involves the production of magnetite. **Serpentinized rocks should be more magnetic and less dense than their un-serpentinized protoliths**

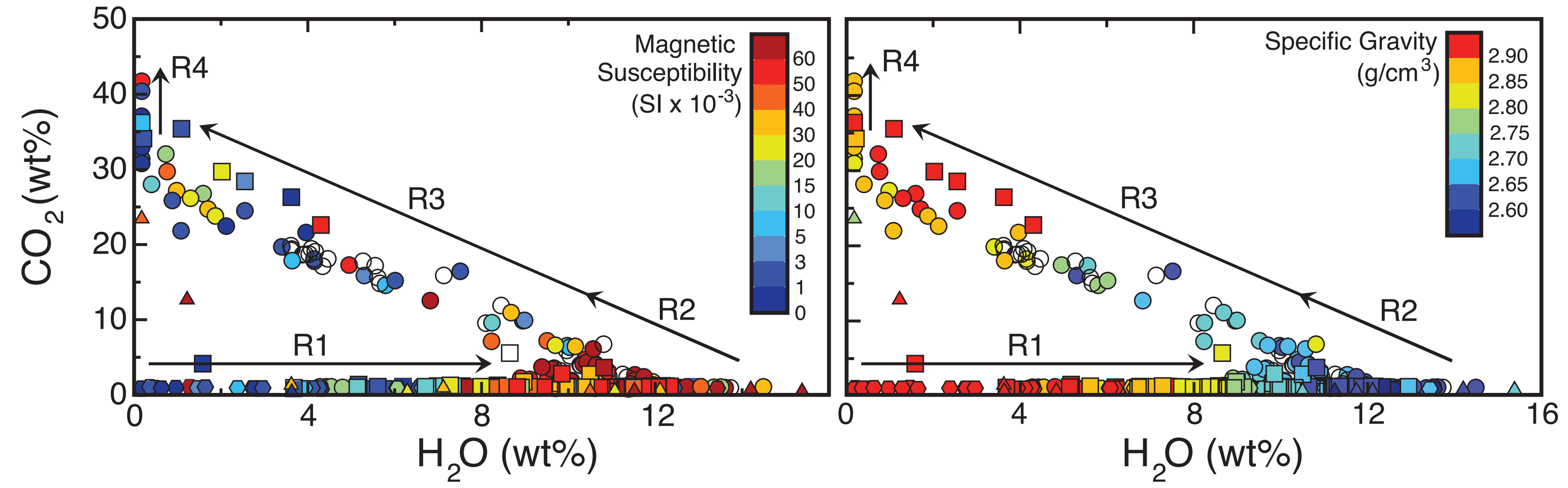
R1: olivine + orthopyroxene + **H_2O** ⟶ serpentine + brucite + **magnetite** +/- awaruite

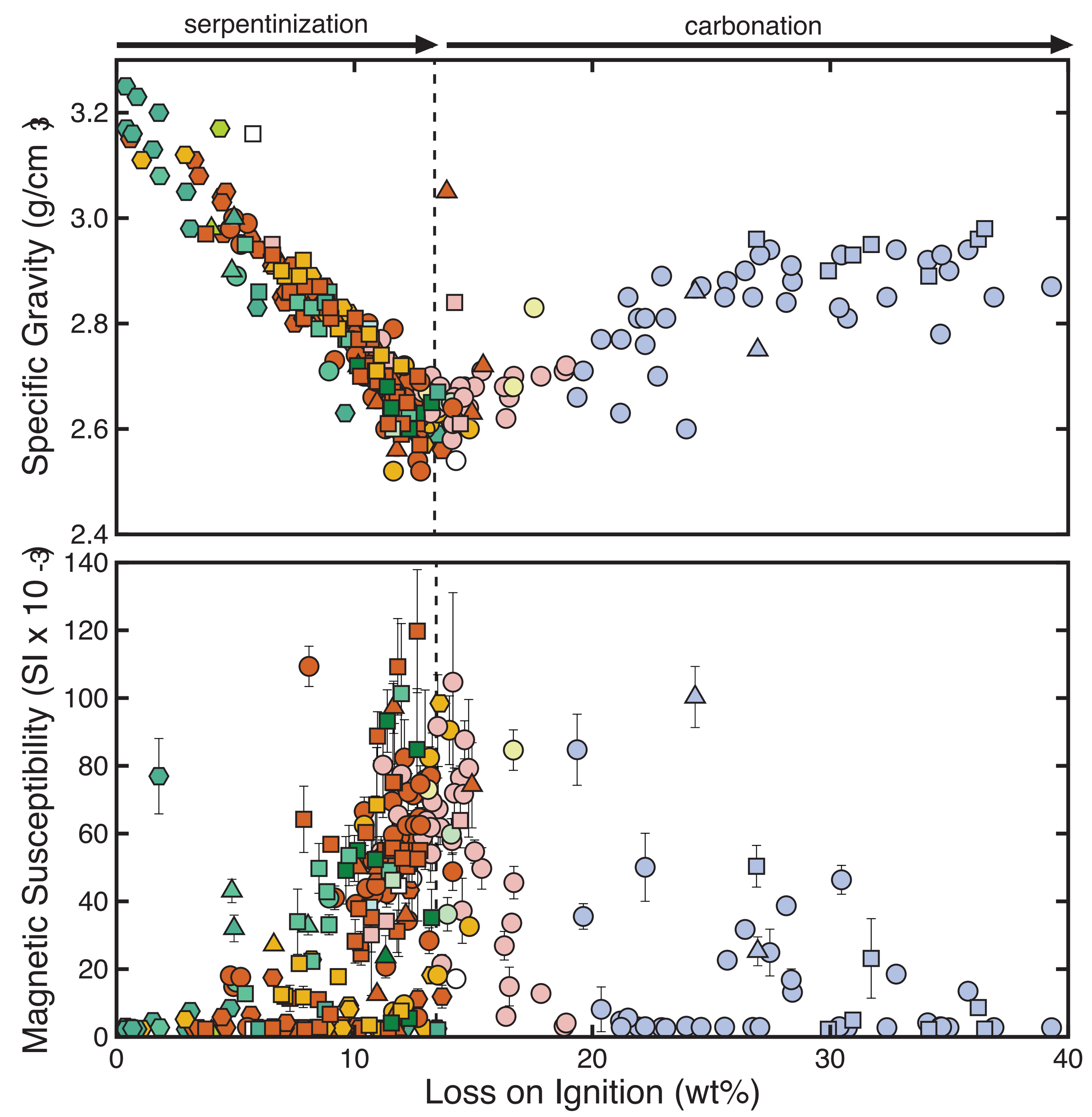
Carbonation fills any pore space and consumes magnetite, brucite, and alloys. **Carbonated serpentinites should be denser and less magnetic than their un-carbonated equivalents.**

R2: olivine + brucite + **CO_2** ⟶ serpentine + (ferro-)magnesite + **H_2O**

R3: serpentine + magnetite + **CO_2** ⟶ (ferro-)magnesite + talc/minnesotaite + **H_2O**

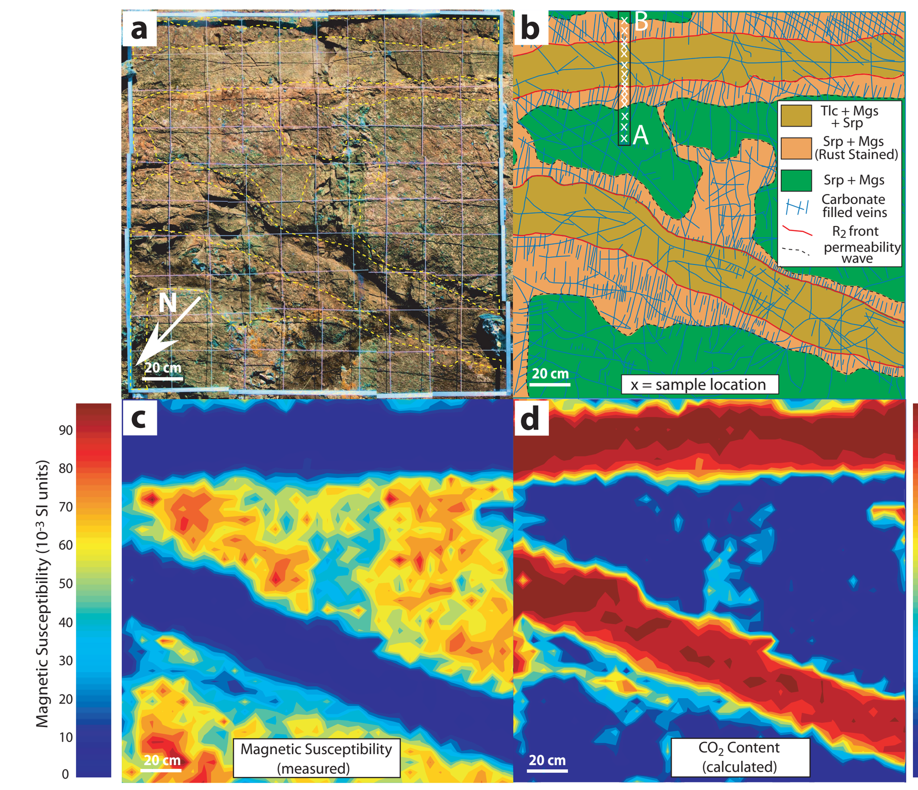
R4: talc/minnesotaite + **CO_2** ⟶ (ferro-)magnesite + quartz

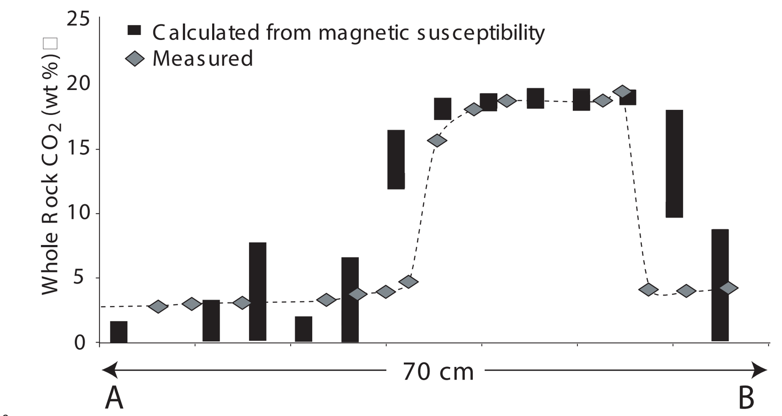




For ophiolitic ultramafic rocks in BC, specific gravity (density) consistently decreases with progressive serpentinization and increases with carbonation. In general, the opposite is true for magnetic susceptibility; however, it also may vary as a function of the protolith (see Steinthorsdottir et al. poster).

4 - IMPLICATIONS AND NEXT STEPS





(Left) a) photograph showing lithologic contacts, b) mineral assemblage map, c) magnetic susceptibility map, and d) calculated CO_2 content map (from Hansen et al. 2005).

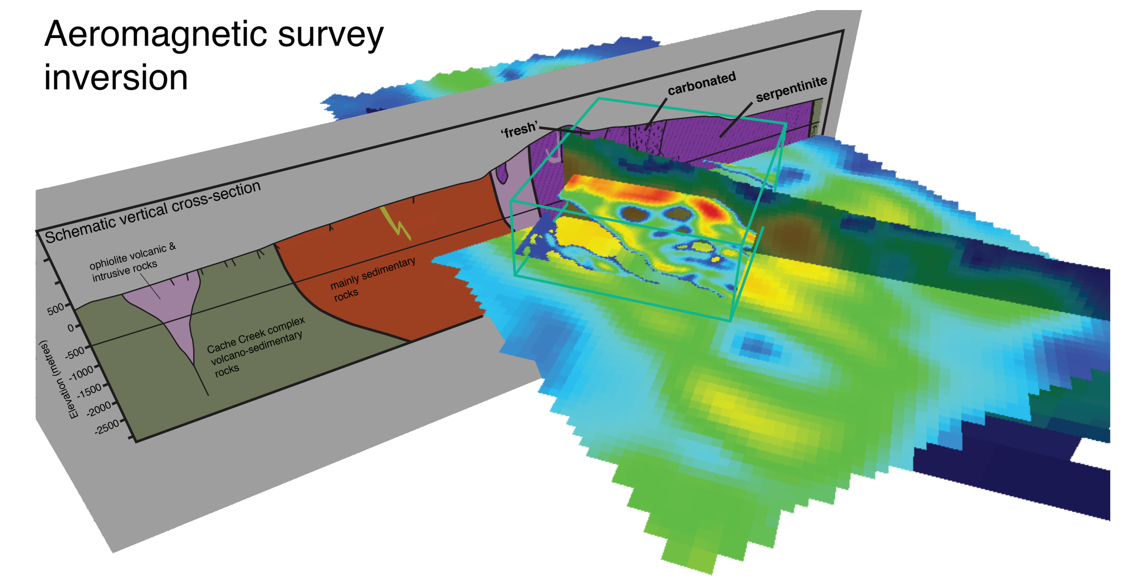
(above) Transect across a carbonated vein showing measured CO_2 content campared to predictions predicted based on magnetic susceptibility (from Hansen et al. 2005).

Carbonate alteration of ultramafic rocks can be clearly mapped in detail at the outcrop-scale using magnetic susceptibility

Can magnetic susceptibility and density or aero-magnetic and gravity surveys be used to map out the degree of serpentinization and carbonation at the outcrop-, deposit-, and regional-scale?

Do the physical properties of rocks from ultramafic intrusions behave in a similar way to those from ophiolites?

Aeromagnetic survey inversion



5 - KEY TAKEAWAY POINTS

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1. Serpentinite has value as feedstock for carbon capture and storage, whereas fresh and carbonated ultramafic rocks do not.

2. Serpentinites are less dense and have higher magnetic susceptibility than their ultramafic protoliths, whereas carbonated rocks are more dense and have lower magnetic susceptibility than their serpentinite pre-cursors.

3. The relationships between alteration and physical properties will be used to formulate a carbon sequestration potential index to be used both on a regional-scale to characterize prospective sequestration tarets AND at the mine-scale to identify and classify tailings .

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