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Chemical weathering of serpentinite rocks and implications for atmospheric CO2 carbonation

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Chemical Weathering of Serpentinite Rocks and Implications for Atmospheric CO_2 Carbonation

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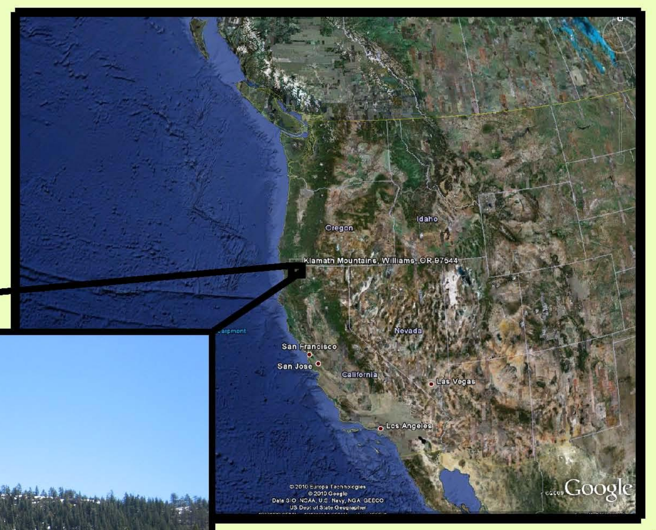
I. INTRODUCTION

Concerns regarding global climate change have arisen as CO_2 emissions steadily increase at rates much larger than the consumption rates of CO_2 in nature (Kerrick et al., 1995). Chemical dissolution of weathering serpentinite soils, coincident with the formation of carbonate minerals, is a method by which carbon dioxide waste is sequestered naturally. In this study we will conduct mineralogical and chemical analyses to examine natural weathering of serpentinite soils. Quantifying dissolution rates of serpentine minerals could contribute to an understanding of weathering processes and the potential to accelerate them in industrial mineral carbonation. Although ultramafic rocks occur throughout the world, one locality, the Klamath Mountains in California, contain extensive serpentine deposits. A better understanding of serpentine mineral dissolution limits may have important implications for their use in mineral carbonation and their contributions to the carbon cycle.

II. FIELD AREA AND SAMPLE COLLECTION



(Klamath Mountains, California picture by Julie Baumeister)

(Profile of serpentinite soil, Klamath Mountains, CA. Picture by J. Baumeister.)

(Parent Rock collected from serpentinite profile. Pencil for scale.)

Samples were collected from a vegetated serpentine soil at 41° 05′ 08 N, 122° 39′ 54 W with augered samples from a depth of 0 to 40cm. Samples of rock from road cuts beneath profile were also collected.

III. METHODS

Samples were prepared and analyzed for:

SEM (Scanning Electron Microscopy)

Samples were embedded in epoxy, polished and images were captured.

EDS (Energy Dispersive X-ray Spectroscopy)

Epoxy samples were analyzed for chemical composition.

XRD (X-ray Diffraction)

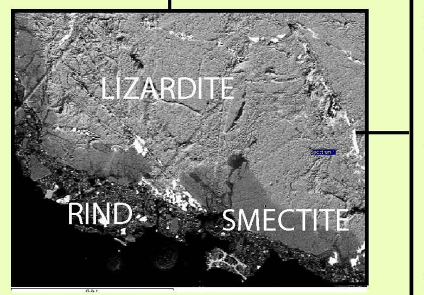
Samples were powdered and analyzed.

XRF (X-ray Fluorescence)

Samples were powdered, heated and analyzed.

IV. RESULTS

SEM/EDS



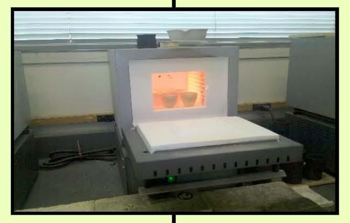
(SEM image of serpentinite grain with weathering rind)

SEM images of polished weathered rock suggest the formation of Al-bearing secondary minerals on the surface.

XRD (X-ray Diffraction)

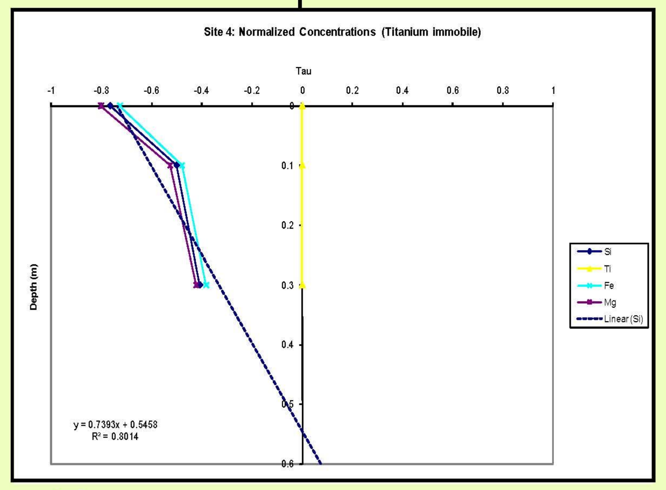
Preliminary results suggest the presence of Lizardite, smectites, and Fe oxides in the parent material and weathered soils.

XRF (X-ray Fluorescence)



Bulk chemistry of the soils were normalized to parent material to calculate the dimensionless mass transfer coefficient tau (τ)*.

Depth vs. Tau Plot



$$\tau_{i,j} = \frac{C_{j,w}}{C_{j,p}}\frac{C_{i,p}}{C_{i,w}} - 1$$

- $\tau_{i,j}$ normalized concentration of the immobile or mobile element
- $C_{j,w}$ concentration of the mobile element in weathered material
- $C_{j,p}$ concentration of the mobile element in parent material
- $C_{i,p}$ concentration of immobile element in parent material
- $C_{i,w}$ concentration of immobile element in weathered material

When:

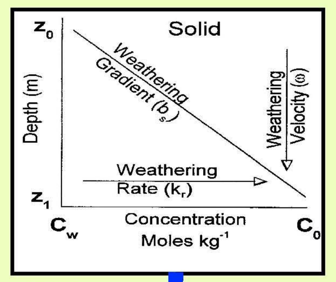
$\tau = 0$, normalized concentration is equal to parent rock.

$\tau < 0$, normalized concentration is depleted.

$\tau > 0$, normalized concentration is enriched.

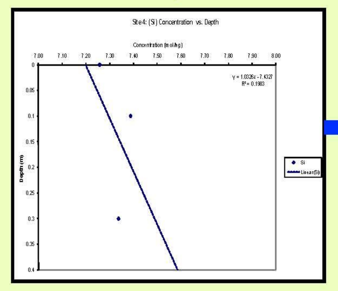
V. DISCUSSION

Calculation of Serpentinite Dissolution Rate



(White, 2002)

Serpentine mineral dissolution rates are an important factor in natural CO_2 sequestration but remain poorly understood. Rates have been calculated from the weathering velocity and the weathering gradient using the method of (White 2002).



$$R_s = 1000\frac{\rho_w}{S\beta}\left(\frac{\omega}{b_s}\right)$$

- R_s surface-area normalized weathering rate
- 1000 density conversion factor
- ρ_w density of the weathered material
- S reactive surface-area
- β stoichiometric coefficient
- weathering advance rate
- ω weathering gradient
- b_s

VI. CONCLUSIONS

- Natural weathering rate: 5.76064×10^{-17} mol/m^{2}s
- Lizardite appears to be altering to smectite.
- Chemical weathering appears to be occurring below the point of refusal.

VII. FUTURE WORK

We are continuing to analyze XRD results, constrain variables and characterize weathering in this environment to better interpret implications for atmospheric CO_2.

VIII. ACKNOWLEDGEMENTS

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