**Estimating Historic Weathering Rates in Western Oregon from Tombstone Morphology –
Part 1 Data Collection**

Introduction

Rock weathering at the Earth's surface forms the basis for regolith production and is a fundamental process that shapes the landscape over time. Rates and degrees of rock weathering at any given location are controlled by climate (aspect, temperature, precipitation), rock types (composition and texture), organic activity (moss and lichen growth), and style of chemical/physical weathering processes (e.g. freeze thaw, hydrolosis, etc.).

Objective

The objective of this lab is to use tombstone morphology in the Monmouth area to estimate historic weathering rates in the region. Tombstones represent important historic weathering indicators as they provide data on known exposure ages and rock composition, two important variables necessary for understanding weathering conditions at the Earth's surface.

Methodology

The class will visit the local Monmouth cemetery south of town and collect the following data on Table 1:

Observation Date (todays date)
Date of Death (from tombstone)
Exposure Time (yrs) (observation date – Death date)
Rock Type (igneous = granite, basalt, andesite; sedimentary = sandstone, limestone, metamorphic (marble, gneiss)
Crystal / grain size (mm) (size of mineral grains / textural characteristics)
Mineral composition (quartz, feldspar, plagioclase, hornblende, calcite)
Surface Roughness to Touch (1 = smooth, 2= slightly rough, 3 = moderately rough, 4 = highly rough)
Polish Condition (1= highly polished, 2= moderately polished, 3 = poorly polished, 4 = unpolished)
Epitaph Inscription Quality Rating (1-11) (observed from 50 cm viewing distance; see attached sheets)
0 – recent sharp-edge inscriptions; 1- roughened polish; 2 – roughened surface to touch, but perfectly legible; 9 – inscription barely readable; 10 – inscription barely seen; 11 – inscription totally removed
Inscription Aspect Azimuth (azimuth direction the inscription of the tombstone faces)
Inscription height above ground surface (cm)
Top Stone Thickness - right (mm) (measured using meter stick / calipers)
Top Stone Thickness - left (mm)
Top Stone Thickness - middle (mm)
     Average Top Stone Thickness (mm)
Basal Stone Thickness – right (mm) (measured using meter stick / calipers)
Basal Stone Thickness – left (mm)
     Average Basal Stone Thickness (mm)
Weathering Loss (Avg. bottom thickness – Avg. top thickness) (mm)
Lichen / Moss Cover?
     Lichen Diameter (mm)
     Percent cover

Fig. 1. Photographic comparison scale of inscription legibility states (0–10) on Vermont marble tombstones at various North American locations. No photo is available for state 11 (no visible trace remaining of original inscription).

ES322 Tombstone Weathering Data Sheet   **Location:**   **Survey Team Members:**

Rock Type = granite, gabbro, marble, limestone, sandstone, gneiss   Surface Roughness: 1=smooth, 2 = slightly rough, 3 = moderately rough, 4 = highly rough

Minerals = calcite, quartz, potassium feldspar, plagioclase feldspar, amphibole, biotite   Polish Condition: 1 = highly polished, 2 = moderately polished, 3= poorly polished, 4 = unpolished

Observation Date	Death Date (Oldest Listed)	Exposure Time (yrs)	Rock Type	Avg. Crystal/ Grain Size (mm)	Mineral Composition (List)	Surface Roughness	Polish Condition	Inscription Rating (0 = new; 11 = oliterated)	Inscription Aspect (Azimuth)	Top Stone Thickness-Right (cm)	Top Stone Thickness-Middle (cm)	Top Stone Thickness-Left (cm)	Avg. Top Thickness (cm)	Basal Stone Thickness-Right (cm)	Basal Stone Thickness-Left (cm)	Avg. Basal Thickness (cm)	Stone Recession (Bottom - Top) (cm)	%Lichen/ Moss Cover	Avg. Lichen Diameter (mm)	Comments

ES322 Geomorphology
Tombstone Weathering Exercise – Task List and Instruction Sheet

Task 1. Take a class field trip to the Monmouth Cemetary, make observations and collect data on tombstone ages, lithology and characteristics.

Task 2. In teams of 2-3 collect data on data table, compile observations in a MS Excel spreadsheet (posted on class web site) and send to student team leader for group compilation.

Task 3. Combine this year's tombstone observations / spreadsheets, with previous year's data (on class web site) to increase the total number of sample observations and increase the veracity of the statistical analysis.

Task 4. Using Excel or graph paper, plot the follow tombstone weathering relationships:

A. Provide a tabled summary of your total observations, the number of samples according to tombstone lithology.
B. Inscription Rating Graph (one graph, two lithologies with different symbols)
   a. Inscription Rating (Y Axis) vs. Exposure Age (X Axis) for granite lithology
   b. Inscription Rating (Y Axis) vs. Exposure Age (X Axis) for limestone/calcareous sandstone/marble lithology
C. Surface Roughness Graph (one graph, two lithologies with different symbols)
   a. Surface Roughness (Y Axis) vs. Exposure Age (X Axis) for granite lithology
   b. Surface Roughness (Y Axis) vs. Exposure Age (X Axis) for limestone/calcareous sandstone/marble lithology
D. Using Excel or visual inspection, draw a best-fit regression line to each of the plots on your graphs in 4 A and 4 B above.

Task 5. Using MS word, write a 2 page lab report with your findings, address the following questions:

A. Describe / discuss your observations of tombstone Inscription Rating and Surface Roughness in the context of exposure age. Do either one of these weathering metrics effectively correlate with time since tombstone exposure?
B. Describe and discuss the differences in relative rock strength and resistance to weathering, as related to tombstone lithology. How to the granite and limestone lithologies hold up to weathering over time? Are they the same or different? Present your discussion and refer to your results in Task 4 above.
C. List and discuss the implicit assumptions and sources of error that could be associated with your observations in items 5A and 5B.
D. Discuss any other aspects of tombstone weathering or favorite concepts related to the ES322 field trip to the cemetery.