KNOWLEDGE OF IMPACT GARDENING IS NECESSARY TO UNDERSTAND THE HISTORY OF LUNAR ICE. E. S. Costello[1] , P.G. Lucey[1], and R.R. Ghent[2], [1]University of Hawaii at Manoa, Honolulu, HI (ecostello@higp.hawaii.edu), [2] Planetary Science Institute, Tucson, Az.

Introduction: "Impact Gardening" in the context of planetary surfaces is the process by which impacts mechanically churn the uppermost regolith. The effects of gardening on Earth's Moon are apparent in the Apollo cores, which show the presence of surface-correlated space weathering products such as submicroscopic iron and cosmogenic radionuclides at depths well below the region where they could be produced on a static surface [e.g., 1]. Impacts have transported these space weathering products to and from depth, homogeneously distributing them in a reworking zone.

Gardening has been suggested as shield for ice via burial [e.g., 2] and a threat to ice via excavation [3]. By exploring the relative rates of excavation and burial in impact gardening, we are able to understand the depth to possible buried ice on the Moon and probe the evolution of the lunar regolith at large. To correctly interpret the distribution of ice present in future lunar cores, knowledge of the impact gardening history and context will be critical.

Model: To model the burial and excavation rate by impacts, we adopt and adapt the statistical treatment of impact effects from [3], and include a chronology function [4] to investigate gardening early in lunar history (>1 billion years ago). We calculate the depth of burial under ejecta as a function of distance from source craters to 10 crater radii, assuming exponential ejecta thickness as in [5].

Results: In presenting our gardening predictions, we carry over the definition of the "in-situ reworking zone" from Morris [1], who defined this zone as a region from the surface to some depth where surface-correlated space weathering products and cosmogenic radionuclides are homogeneously mixed. Gardening in the in-situ reworking zone fits observations of the thorough mixing of surface-correlated space weathering products in the Apollo cores.

We also define the "degradation zone." The degradation zone extends from the bottom of the in-situ reworking zone to a lower boundary defined by averaged model results for equilibrium burial and excavation. Our predictions for the extent and growth of the degradation zone with time fit the degradation rate implied by the disappearance of density-anomalous cold spots [6] and crater rays [7; Figure 1]. Material inside the degradation zone is broken up and mixed but not extensively reworked and exposed at the surface like material in the in-situ reworking zone.

Discussion: We can refer to gardening model results to understand the evolution of specific ice deposits. For example, let us imagine a 1 m thick ice deposit was emplaced 3 billion years ago. Using Figure 1b we can interpret the ice deposit's current state through assessment of the in-situ reworking and degradation zones (vertical line at 3 Ga). If the ice deposit was never buried by a large, rare, ejecta blanket [e.g., 8], it will have been completely pulverized between the time of its emplacement and the present. The top 2 m will be dry (in-situ reworking zone) and fragments of the ice deposit may reside between 2 - 20 m depths (degradation zone). If the deposit was located in a depositional environment such as the bottom of a crater and was subsequently buried under a 3 m thick blanket of regolith soon after being emplaced 3 billion years ago, then the in-situ reworking zone will remove ice from the uppermost 2 meters, including any ice brought up from below by larger, rarer, degradation zone impacts, but we could expect there to be a relatively high concentration of particulate ice between 3 - 20 m depths within the degradation zone. This example shows that knowledge of impact gardening will be necessary to interpret the history of lunar ice.

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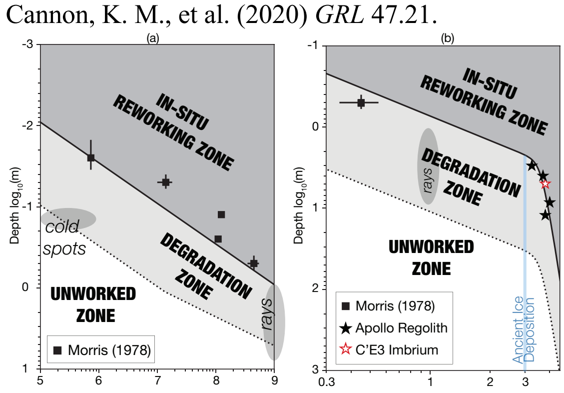

Figure 1: These plots show model results for the depth of impact gardening zones. Ice in the "in-situ reworking zone" is frequently destabilized. Ice in the "degradation zone" is patchy and broken up.