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Supplementary Materials for
**Dust Record from Allan Hills Blue Ice: Towards Extending the Archive
to 4000 ka**

Alissa Choi *et al.*,

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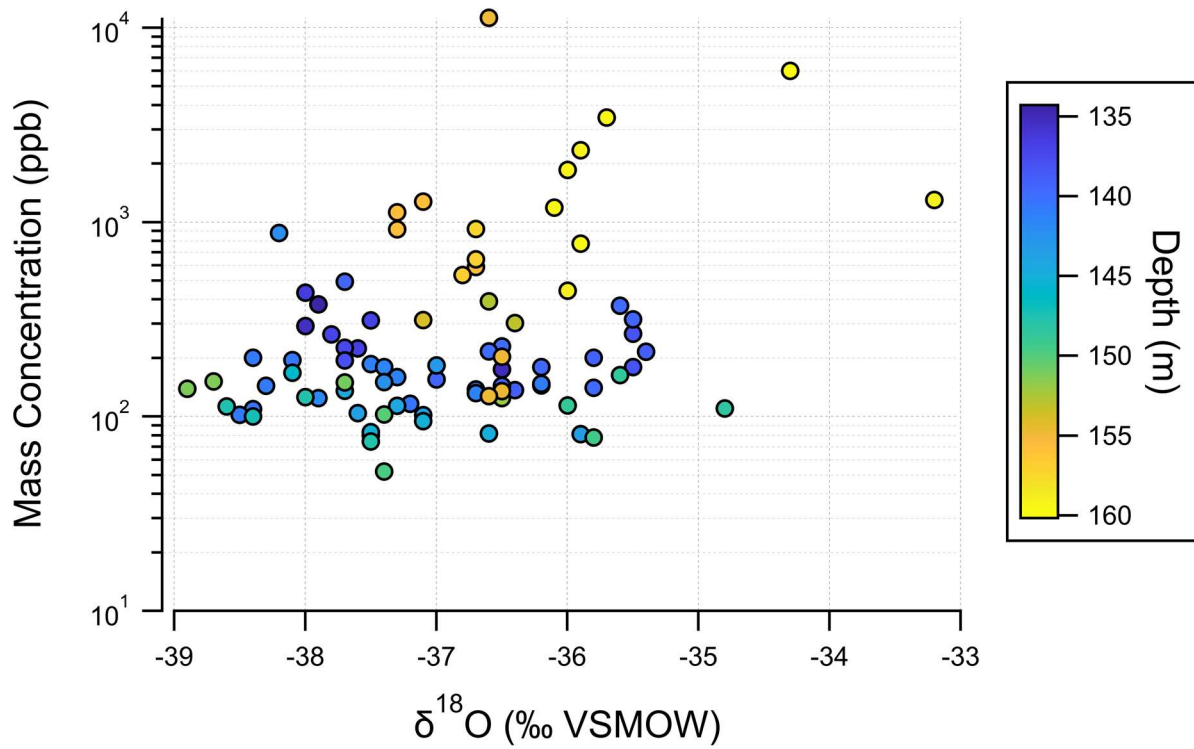
Corresponding author(s) emails: ac6202@columbia.edu, ac2889@princeton.edu

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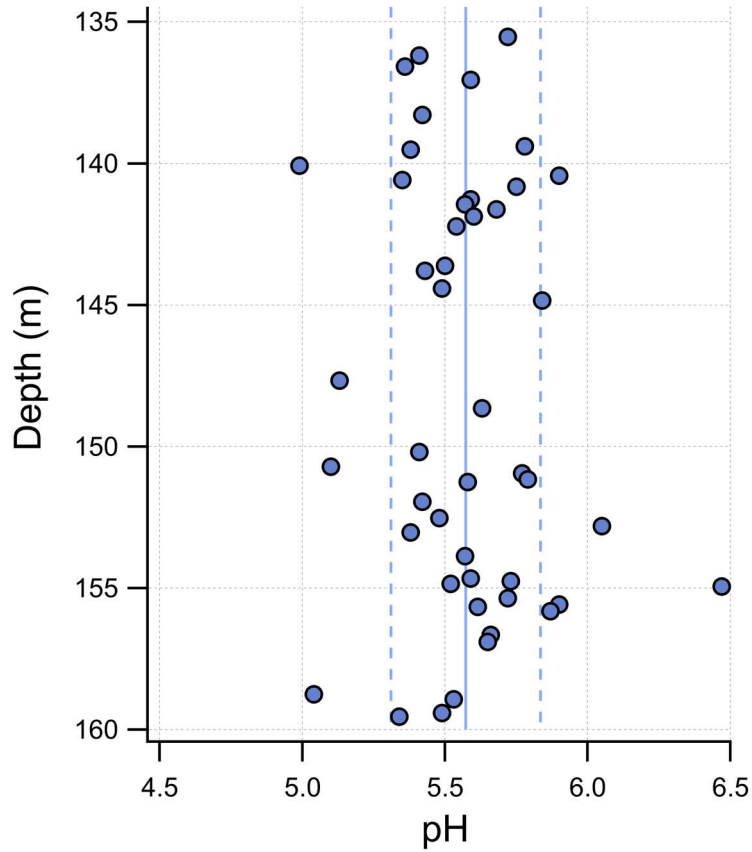
Supplementary Figs. 1 to 5

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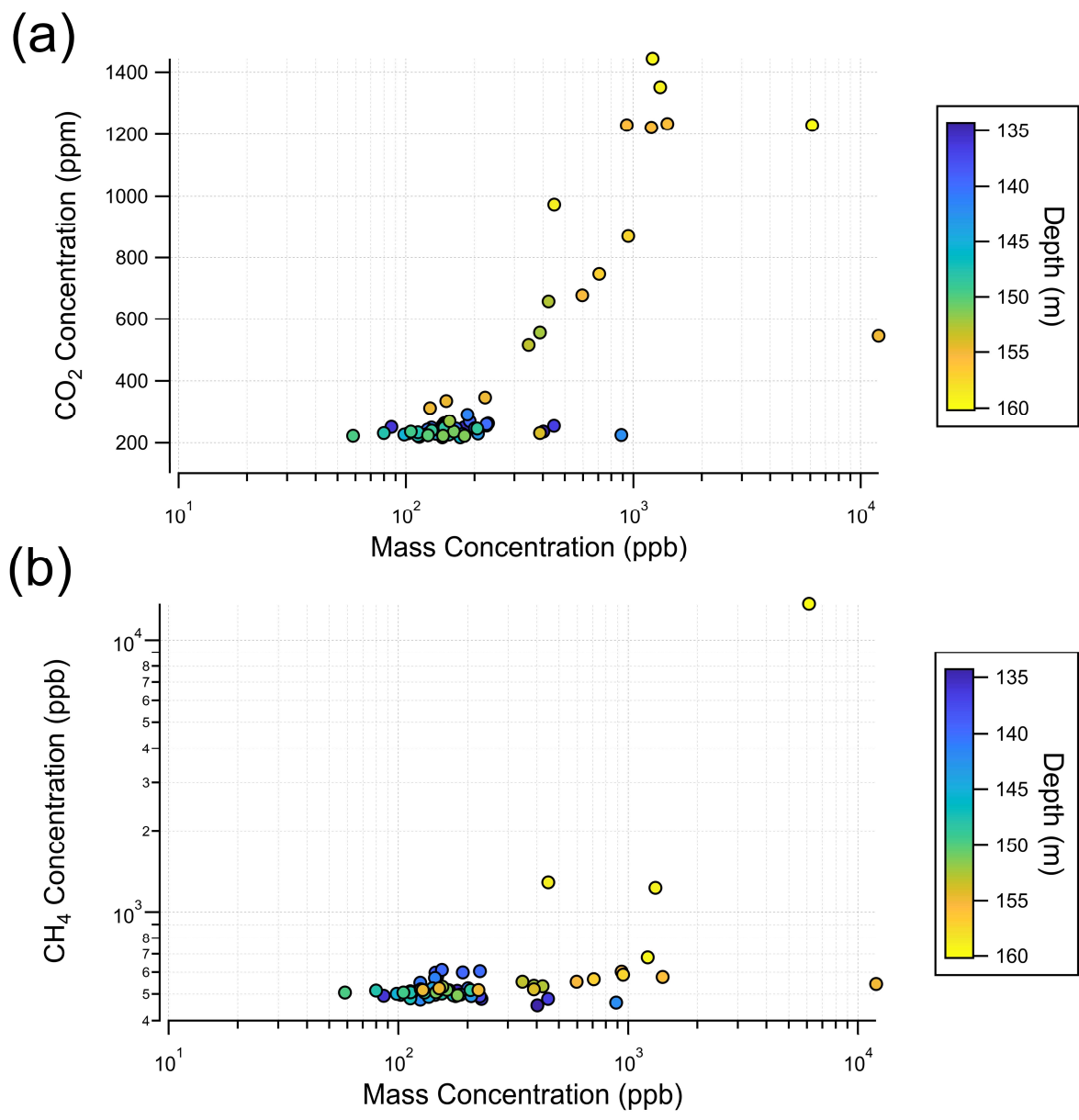
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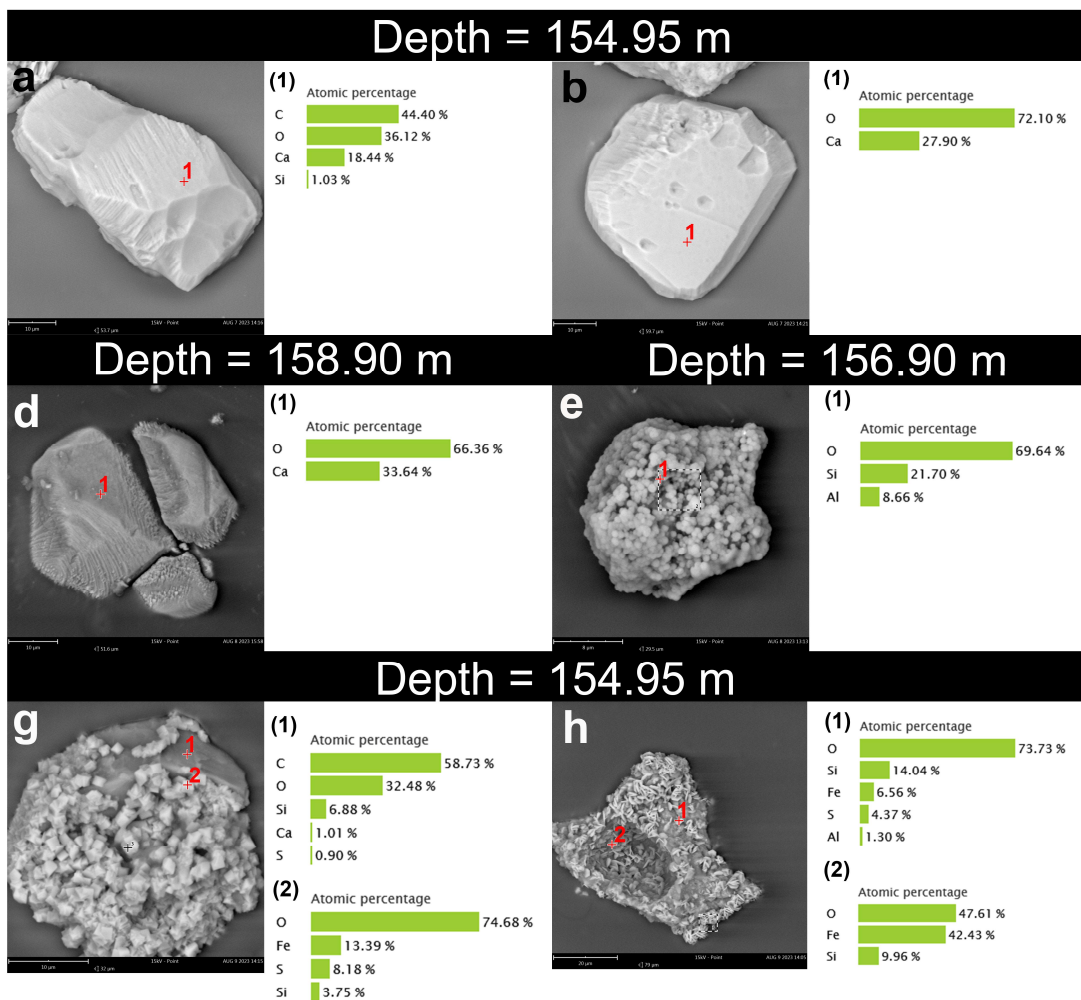
Supplementary Figure 1. Particle mass concentrations (ppb) in the 1-20 μm diameter size fraction compared with δ¹⁸O of sample meltwater measured at University of Washington and University of Maine (Shackleton et al., 2025).



30 **Supplementary Figure 2.** Measurements of pH in a subset of meltwater samples from ALHIC1901 at a depth range from 135 to 158 meters. Solid blue line denotes average pH of 5.58 and dashed blue line denotes standard deviation of ± 0.26 .

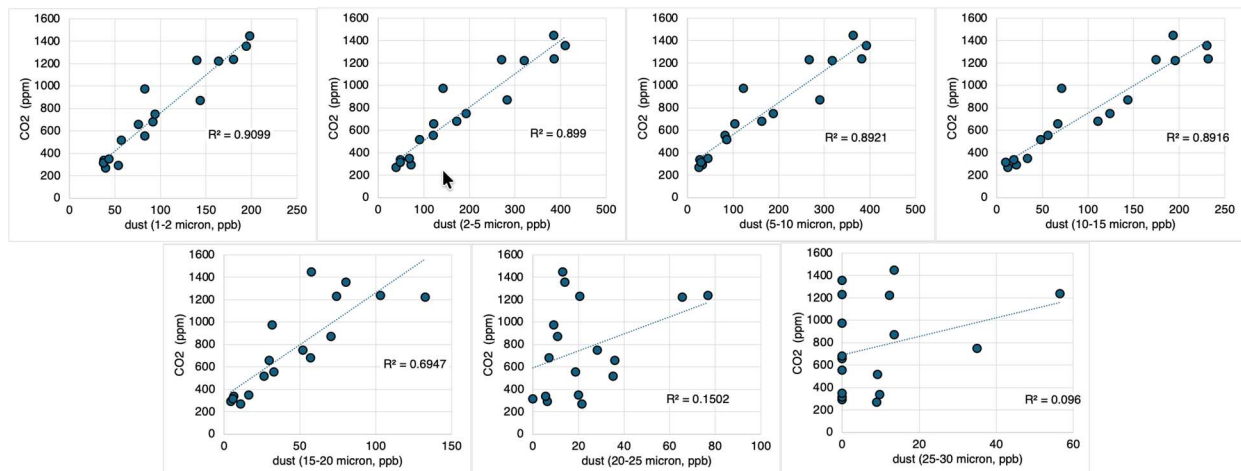


35 **Supplementary Figure 3.** Total particle mass concentration (1-30 μm) compared with CO₂ concentration and CH₄ concentration measured at Oregon State University (Marks-Peterson et al., 2026).



Supplementary Figure 4. Subset of EDS elemental data of particulate matter imaged in Figure 6. Elemental compositions of a, b, and c suggest a calcium carbonate dominant mineralogy. EDS spots of e, g, h allow for the potential identification of iron sulfide and aluminosilicate secondary minerals. Note the resin matrix of which particulate matter was mounted in is organic and may skew atomic percentages of carbon and oxygen. For certain samples (b, d, e, and h), carbon detection was turned off to avoid excess noise.

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Supplementary Figure 5. Discrete size bin relationships between dust mass concentrations and altered CO₂ concentrations. Individual panels show the relationship (or lack thereof) between dust mass concentration in each size fraction and concentrations of altered CO₂ (Marks-Peterson et al., 2026) measured on the same ice core samples. The correlation observed in finer fractions dissipates for particles >15 μm in diameter, which justifies the use of 1–15 μm cumulative size fraction shown in Figure 7.

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