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Novel archive of ice cover and hydro-chemical conditions at the glacier bed in subglacial silica deposits, Mount Rainier, USA

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Subglacial deposits form as a result of mineral dissolution and subsequent precipitation from saturated waters under sliding glaciers. These deposits yield new insights into processes at the bed of glaciers that are elusive because direct observations are generally impossible as they occur in a microscopic film under massive sliding ice. These basal processes include pressure melting and refreezing (regelation) associated with glacier sliding, mechanical abrasion and comminution of rock fragments entrained in the ice where they contact the bed, as well as water transport, phase changes, and chemical exchange in the subglacial water film. Here we report new chemical and isotopic data of subglacial silica deposits collected at Mount Rainier, Washington, USA. These data reveal the timing of precipitation and variation in subglacial solute compositions, suggesting alternating hydro-chemical conditions at the glacier bed during the Last Glacial Maximum (LGM). Light color, millimeters-thick, layered deposits are found on the lee side of surface bumps on the glacially eroded, andesite bedrock. The deposits comprise 10's to 100's μm thick laminas that differ by color, amount of rock-fragment, and chemical composition of the precipitated matrix. Major element chemical analysis by electron microprobe (EMP) documents distinct compositional differences between laminas in the deposits and between them and the underlying bedrock, reflecting interaction between subglacial water and crushed minerals in the formation of deposits. The composition of the siliceous laminas can be divided into those with a matrix that is rich in silica or calcium. Isotopic analysis by secondary ion mass spectrometry (SIMS) reveals that homogenous, Ca-rich layers are sufficiently enriched in U (up to $\sim$100 ppm) to permit U-series isotopic analyses (230Th, 234U, 238U). The analysis yields ages between 10 and 30 ka, consistent with precipitation during the LGM. Our findings suggest that these deposits survived subsequent glacier over-riding during the late glaciation periods (e.g. the Little Ice Age), and limits the maximum amount of erosion during these periods. They also suggest that abrupt changes in the subglacial hydro-chemical conditions occurred during the LGM, and that they are chemically archived in considerable detail in the deposits.