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Ground penetrating radar evidence of refrozen meltwater in the firn column of Larsen C Ice Shelf

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Firn densification has been strongly implicated in ice shelf collapse, and can occur rapidly by the percolation and refreezing of surface meltwater. By reducing the permeability of the firn column, this process potentially establishes a positive feedback between densification and surface meltwater ponding, and may ultimately facilitate hydrofractures associated with shelf collapse. Meltwater ponds on Larsen C's Cabinet (CI) and Whirlwind (WI) inlets form where foehn winds reach and influence the shelf surface. While associated zones of refrozen meltwater are strongly evidenced in borehole optical televiewing (OPTV) and seismic refraction data, the spatial sparsity of these observations limits insight into the dimensions of these zones. Here, we present highlights from an 800-km archive of ground-penetrating radar (GPR) profiles acquired in CI and WI during November-December 2015.

In the upstream reaches of CI and WI, stratified firn layers are abruptly truncated by extensive zones of diminished GPR reflectivity, consistent with a homogenised firn layer. The zones originate ~ 5 m beneath the surface and extend to a depth of ~ 30 m; their volume appears to exceed 6 km^3 (CI) and 1 km^3 (WI), although this is a minimum estimate since volumetrics can only be established where there is GPR control. The horizontal distribution of these zones correlates with the pattern of reduced backscatter in SAR images, supporting their association with meltwater ponds. GPR reflectivity models, derived from OPTV density trends, suggest reduced GPR wavespeeds and dielectric contrasts, consistent with firn that is both homogenised *and* densified. A firn density model supports the ability of meltwater ponds to form periodically in Cabinet Inlet and subsequently homogenise the density of the firn column.