Is ice mechanical heterogeneity controlling the stability of the Larsen C ice shelf?

Bernd Kulessa[1], Edward King[2], Brian Barrett[3], Daniela Jansen[1], Adrian Luckman[1], Peter Sammonds[4], Matt King[5]

[1]Swansea Glaciology Group, School of the Environment and Society, Swansea University, SA2 8PP, UK, b.kulessa@swansea.ac.uk
[2]Physical Sciences Division, British Antarctic Survey, Cambridge, CB3 0ET, UK
[3]Zetica Ltd, Long Hanborough, UK
[4]Department of Earth Sciences, University College London, WC1E 6BT, UK
[5]School of Civil Engineering and Geosciences, Newcastle University, UK

We want to understand why rift tips align along certain flowstripes on many Antarctic ice shelves, and what implications this has for ice-shelf stability. Such flowstripes were noted in several publications over the last three decades, and several speculative inferences regarding their origin and potential implications for ice-shelf mechanics have been brought forward. The southeastern sector of the Larsen C ice shelf is a prominent example of frequent rift generation at the Kenyon Peninsula, and subsequent rapid northward propagation (up to ~ 23 km/yr). Propagation halts abruptly when the rift tip encounters a thin flowstripe that originates downflow of the Joerg Peninsula, separating two glaciers discharging into the ice shelf. Modelling experiments of Holland et al (2009) were consistent with oceanic freezing in this area, suggesting that mechanically softer ice could make up significant proportion of the flowstripe, reducing stress intensities along it and ultimately acting to halt rift propagation in the ice-shelf's south-eastern sector. Notwithstanding, Holland et al. (2009) could not exclude the possibility that mechanisms other than oceanic freezing generated the flowstripe mechanical anomaly.

We have collected a range of seismic and ground-penetrating radar (GPR) data in both flowstripe and surrounding glacier-derived ice in this sector. These include multi-component, azimuthal common-midpoint (CMP) seismic reflection, azimuthal CMP and skidoo-towed constant-offset (CO) GPR data at 50 MHz. These data confirm that anomalous ice is indeed present in the lower half of the flowstripe, appearing geometrically as two 'lobes', as predicted by Holland et al.'s (2009) model. The interface between the overlying meteoric ice and this anomalous ice appears 'fuzzy' in the CO-GPR data, and creates distinct reflections in our seismic data. In this presentation we analyse these GPR and seismic signals in detail, and suggest possible physical origins and implications for the formation of this anomalous ice. We present detailed seismic and GPR azimuthal velocity-depth profiles through the firn, meteoric ice and the anomalous ice, and interpret these data in terms of ice anisotropy and density. We further comment on the possibility of deriving ice-shelf temperature profiles from joint seismic and GR derived velocity profiles. Indeed, we find that GPR and seismically derived density profiles for the firn layer (with a firn-ice transition at ~ 45 m) are distinctly different, which had previously been noted at other Antarctic survey sites. We revisit Doake's (1984) joint GPR and seismic analyses of average ice-shelf densities to understand the origin, and the glaciological and mechanical implications, of these differences. Finally, we synthesize all available information and attempt to answer the question in the title of this presentation.

Doake, C. S. M. (1984), Ice shelf densities from a comparison of radio echo and seismic soundings, *Annals of Glaciology*, *5*, 47-50.

Holland, P. R., et al. (2009), Marine ice in Larsen Ice Shelf, *Geophysical Research Letters*, *36*, doi:10.1029/2009GL038162.