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The origin of ice shelf channels at Institute and Möller ice stream grounding zones, West Antarctica

HAFEEZ JEOFRY[1,2,*], NEIL ROSS[3], JILU LI[4], PRASAD GOGINENI[5], MARTIN J. SIEGERT[6]

[1] Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, Kuala Nerus, 21300 Terengganu, Malaysia
[2] Institute of Oceanography and Environment, Universiti Malaysia Terengganu, Kuala Nerus, 21300 Terengganu, Malaysia
[3] School of Geography, Politics and Sociology, Newcastle University, Newcastle upon Tyne NE1 7RU, UK
[4] Center for the Remote Sensing of Ice Sheets, University of Kansas, Lawrence 66045 Kansas, USA
[5] ECE and AEM Departments, The University of Alabama, Tuscaloosa, AL 35487, USA
[6] Grantham Institute and Department of Earth Science and Engineering, Imperial College London, London SW7 2AZ
* Corresponding author email address: hafeez.jeofry@umt.edu.my

Abstract: Moderate Resolution Imaging Spectroradiometer (MODIS) imagery reveals meandering channels on the surface of ice shelves, 10s of km in length and 2-3 km wide, originating from the grounding lines of fast-flowing ice streams, referred to as 'M' channels, they form as a consequence of a locally thinner ice associated with selective

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upwards erosion beneath the ice shelf. Focused, linear basal melt forms 'U' channels, 1-300 m high concave channels carved into the base of the ice shelf; the M channels develop due to the relative difference in surface elevation between thicker versus thinner floating ice. The association between M channels and ice stream grounding line points to subglacial water as the agent of basal ice-shelf melt. Such systems have been shown to be associated with both soft- and hard-bedded landforms, which act to route basal water. Both the Möller and Institute ice streams in the Weddell Sea sector of West Antarctica are associated with ice-shelf channels. Here, using radio-echo sounding data collected by the British Antarctic Survey in the austral summer of 2008/09 and 2011/12 and the Center for Remote Sensing of Ice Sheets during the airborne geophysical surveys in 2012, 2014 and 2016, we investigate how these channels are formed by upstream subglacial conditions. For the Institute Ice Stream, we find that the hard-bedded landform explanation holds, where basal water is channelled beside the landform and, when mixed with cavity water, flows upwards into the corrugation developed by upstream ice flow around it. For the Moller Ice Stream, however, we propose an alternative mechanism for ice-shelf channelling. Subglacial water flows in a well-organised manner along the base of a deep but otherwise smooth basal trough. This trough also moulds the ice sheet base, such that at the point of flotation it is characterised by a notable convex profile. When the water exits the ice sheet, after mixing with ice shelf water it flows upwards beside lower elevation convex feature and etches an ice-shelf channel offset laterally from the axis of the upstream basal tough. These results demonstrate that while ice-shelf channels are associated with basal landforms at the grounding line, there are at least three ways in which they can be generated.

Keywords: MODIS, West Antarctica, ice shelves, ice stream