A Holocene volcanic knoll within a glacial trough, Antarctic Sound, northern Antarctic Peninsula

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Jaegyu Knoll is located in Antarctic Sound, between Trinity Peninsula and islands of the Joinville Island Group, on the northern Antarctic Peninsula (Fig. 1a). Jaegyu Knoll is interpreted as a Holocene submarine intraplate volcano based on its morphology, *in situ* observations such as bottom videos and high-resolution photographs (Quinones *et al.* 2005), a rock dredge that recovered fresh volcanic rock (Hatfield *et al.* 2004) and a measured geothermal anomaly (Hatfield *et al.* 2004). All aspects of the knoll are consistent with recent volcanic activity, which appears to have been persistent in the northern Antarctic Peninsula region from Mesozoic times to the present (e.g. Baker *et al.* 1973; González-Ferrán 1991; Gracia *et al.* 1997). The knoll, and at least two other smaller volcanic features in Antarctic Sound (Fig. 1a), lie within an overdeepened glacial trough that was presumably sculpted by ice during the Last Glacial Maximum (LGM; 23–19 ka BP).

Description

Jaegyu Knoll has an elliptical elongate shape in planform, is orientated NNW–SSE and has a relatively flat crest (Fig. 1b). It stands about 650 m above the seafloor of Antarctic Sound with its summit at a depth of 255 m. It is 3 km long and 2 km wide at its base, and 750 m long and 110 m wide at its summit which covers <1 km^2. The flanks of the knoll have slope gradients averaging 20–30° and some display small-scale gullies (Fig. 1c).

Acoustic profiler images return high-amplitude reflections and no signal penetration, suggesting that volcanic basement is exposed at the knoll surface where significant sediment cover is lacking. Bottom imagery was acquired via a scud video camera survey in 2004 (Quinones *et al.* 2005), and ROV video records and high-definition bottom photographs in 2010 (Fig. 1d). The imagery reveals that the knoll flanks have been densely colonized by macrobenthic organisms. In contrast, barren patches of volcanic cobbles and pebbles and coarse-grained sediment cover the crest, probably a result of volcanism, iceberg scouring and strong bottom currents. A rock dredge on the crest recovered over 80% fresh alkali-basalt with the remainder comprising ice-rafted debris from Trinity Peninsula Group meta-sediments (Hatfield *et al.* 2004).

Jaegyu Knoll lies in an overdeepened glacial trough 19 km long by 10 km wide, carved out by ice streaming activity that reached over 1000 m deep. The main ice flow within Antarctic Sound was fed by a series of tributary systems now marked by hanging submarine valleys found to the north and from channels surrounding Joinville Island (Fig. 1a). A set of elongate streamlined ridges parallel to the axis of the trough (mega-scale glacial lineations or MSGLs) and drumlinized bedforms delineate past ice-flow directions southwards out to the Erebus and Terror Gulf system (Lavoie *et al.* 2015). The MSGLs have a vertical relief of 10–25 m, are 100–150 m wide and 8–12 km long, with crest-to-crest spacing averaging 210 m. They are approximately parallel to each other with a general trend to the SE followed by a SW direction as they pass the narrowest portion of the sound (Fig. 1b). The drumlinized bedforms are asymmetrical in long profile with a measured mean elongation ratio of 5:1.

Interpretation

The geomorphological records of Antarctic Sound provide information on past ice-sheet dynamics and changes in dominant processes shaping the seafloor during the Holocene. A distinctive assemblage of preserved glacial bedforms suggests LGM grounded ice and ice-streaming activity parallel to the Antarctic Sound axis. Bedforms show that ice-stream flow was through the sound, indicating topographic control on this tributary of the Antarctic Peninsula Ice Sheet (Lavoie *et al.* 2015). Decoupling of the glacial system from deep portions of Antarctic Sound must have involved a rapid flotation mechanism as there is no evidence for grounding-zone systems which might indicate a punctuated retreat. Further, there is no direct age control on the deglacial timing within Antarctic Sound proper.

Jaegyu Knoll interrupts the glacial sculpting of the Antarctic Sound seafloor by overprinting the streamlined seabed, indicating that volcanic activity post-dates the latest ice-stream flow in Antarctic Sound. By contrast, in Bransfield Strait (a product of back-arc extension), a chain of submerged volcanic features (e.g. González-Ferrán 1991; Gracia *et al.* 1997) has no glacial imprint as water depth is too large (>2000 m) for LGM ice to have been grounded. The morphology and setting of Jaegyu Knoll make it a unique submarine volcanic feature on the seabed of the northern Antarctic Peninsula.

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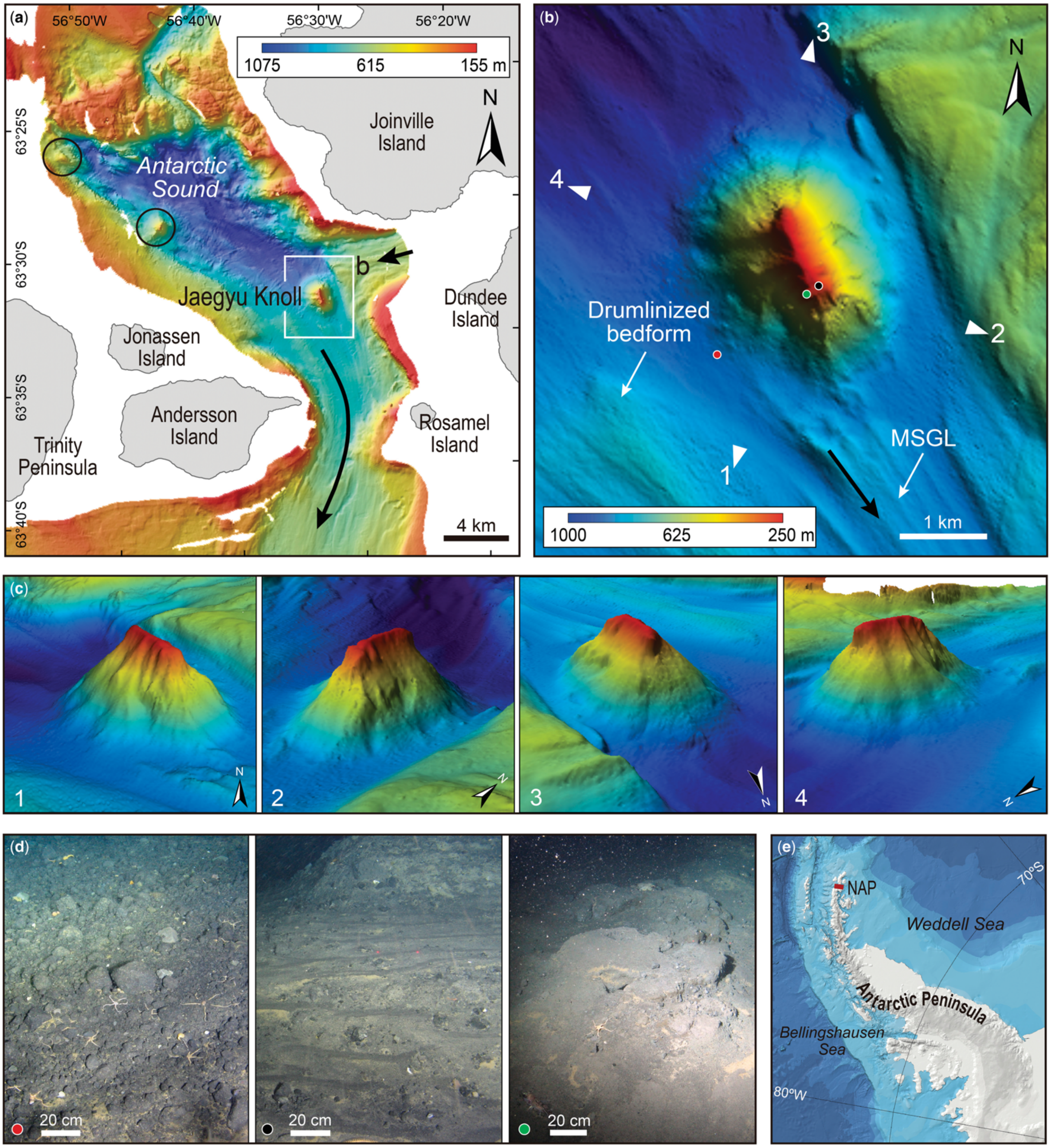

Fig. 1. Jaegyu Knoll (63° 29′ 45″ S, 56° 26′ 45″ W) located on the seafloor of the Antarctic Sound glacial trough, northern Antarctic Peninsula. Jaegyu Knoll was discovered and mapped for the first time in 2001 and named in honour of the young Korean scientist Mr Jun Jaegyu who succumbed to hypothermia after he participated in a sea rescue attempt of another person in Maxwell Bay in 2003. (**a**) Colour-shaded swath-bathymetric image showing the Antarctic Sound seafloor. Acquisition systems Seabeam 2100 and Kongsberg EM 120. Frequency 12 kHz. Grid-cell size 30 m. Black circles locate two other volcanic features. Black arrow denotes former ice-flow direction. (**b**) Detailed multibeam image of Jaegyu Knoll indicating the location of the orientated views (1 to 4) of the 3D swath-bathymetric images in (c). Colour dots locate remotely operated vehicle (ROV) photographs. VE × 3. (**c**) 3D shaded relief swath-bathymetric images of the knoll from viewpoints 1 to 4 in (b). (**d**) Bottom high-definition photographs. ROV system from Renard Centre for Marine Geology showing: (left, red dot in (b)) typical rubble bottom with >90% volcanic cobbles and pebbles, and lack of significant benthic colonization by epifaunal and or sessile organisms; (centre, black dot in (b)) current-swept rubble field with sorted sand waves and scattered ice-rafted debris (note large diamicton or agglomerate mound in background and the lack of appreciable benthic colonization); and (right, green dot in (b)) atypical ‘mesa-like’ table-top features consisting of coarse volcanic rubble and crevasses that separate individual flat-topped ‘tables’ (note surrounding sorted fines, sand and local patches of diamict or agglomerate). (**e**) Location of study area (red box; map from IBCSO v. 1.0). NAP, northern Antarctic Peninsula.