Glacial landforms with dimensions smaller than the imaging capability of the first generation multibeam sonars will become a more frequent topic as high-resolution seafloor mapping technology advances. In Pine Island Bay (PIB) glacial trough, West Antarctica, small regular ridges, only a few metres high from trough to crest, were mapped in water depths around 700 m. The small size of these ridges is on the limit for what modern deep-water multibeam sonars are capable of mapping. They are interpreted to have been formed at the trailing end of mega-icebergs moving up and down in response to tides while ploughing the seafloor (Jakobsson et al. 2011). The mega-icebergs in PIB were produced by an ice shelf break-up and associated grounding-line retreat.

Description
The glacial trough in central PIB contains a suite of landforms indicative of fast-flowing ice streams and episodic ice-sheet retreat following the Last Glacial Maximum (Anderson et al. 2002; Graham et al. 2010; Jakobsson et al. 2011). The relatively flat 690 to 710 m deep central section of the PIB trough is dominated by linear to curvilinear sets of large furrows aligned parallel to the trough axis with a spacing of 150 m to >500 m (Fig. 1). These large furrows resemble mega-scale glacial lineations, although their more irregular alignment suggests formation from an armada of clustered icebergs rather than from a more intact fast-flowing ice stream (Jakobsson et al. 2011).

Within the large furrows, remarkably regular sets of smaller ridges occur oriented at close-to-right-angles to them (Fig. 1a, b). These ridges are separated by ~60–200 m, with spacing generally decreasing progressively in a seaward direction; ridge heights range from 1 to 2 m from trough to crest. The extremely regular appearance of these ridges makes the furrows look corrugated; hence the smaller ridges were named “corrugation ridges” by Jakobsson et al. (2011).

Similar landforms have been mapped in the eastern Weddell Sea in individual iceberg plough marks using side-scan sonar (Lien 1981; Barnes and Lien, 1988). Furthermore, features identical to the corrugation ridges of PIB have been mapped in large iceberg furrows in the northern part of Bjarneøyrena, Barents Sea (Andreassen et al. 2013), and within mega-scale glacial lineations in the central (Jakobsson et al. 2011) and western Ross Sea (Anderson, 1999).

Interpretation
Several formation mechanisms for corrugation ridges have been explored by Jakobsson et al. (2011) and Graham et al. (2013). Their extreme regularity excludes formation as recessional moraines formed near a grounding-line retreat. The corrugation ridges in PIB are interpreted to have been generated at the trailing edge of mega-icebergs that broke off at the grounding line of the former PIB ice stream and drifted seaward (Jakobsson et al. 2011). Each ridge is formed when an iceberg, or an armada of icebergs in the case of PIB, rhythmically settles to the sea floor under the influence of tidal motion and squeezes sediments into ridges that are preserved in the wake of the drifting icebergs (Fig. 1d). In PIB, where the corrugation ridges exist in large parallel furrows, the formation model calls for a rather uniformly thick iceberg armada just thick enough to keep the icebergs grounded on the gently upward-sloping glacial trough. This mélangé of ice would eventually disintegrate into individual icebergs that drifted away on their own; most of them were probably unstable and thus soon to rotate (Fig. 1d). In PIB, iceberg plough ridges were formed at the end of each large megaberg-induced furrow before the icebergs rotated (Fig. 1a). While corrugation ridges may form in slightly different glacial environments, i.e. behind icebergs or underneath a fractured ice stream, the vertical and rhythmic tidal motion is the common denominator for the formation process.

References

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Fig. 1. Multibeam bathymetry from Pine Island Bay (PIB), West Antarctica, collected during the Oden-Southern Ocean 2010 expedition (OSO0910) with Swedish icebreaker _Oden_. Acquisition system Kongsberg EM122. Frequency 12 kHz. Grid-cell size 30 m. (a) Examples of corrugation ridges in the central part of PIB located in large furrows with widths from about 150 m to >500 m. (b) Detail of corrugation ridges, white box in (a) shows the location. (c) Location of study area (red box; map from IBCSO v. 1.0) (d) Schematic model of stages of corrugation ridge formation.