Decameter-scale, flow-parallel ridges in a submarine megaslide: Tampen Slide, North Sea

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Submarine landslides can be orders of magnitude larger than their terrestrial counterparts and pose a significant hazard to offshore infrastructure and coastal communities. Elongated ridges within landslide debris provide important information about the kinematics of failure. For subaqueous landslides, these ridges are typically perpendicular to the flow direction and confined to the head and toe regions of the slide, where they are associated with extension and compression, respectively. Any ridges present within the central, translational region of the slide debris tend to be localized, <1 m high, and result from the diversion of evacuated debris around topographic features. Here, we use high-resolution 3D seismic data from the headwall region of the Tampen Slide to characterize the ridges present within the slide debris. The 3D seismic data were acquired by TGS in 2017 and cover approximately 16,000 km^2 with vertical and horizontal resolutions of ~2 m and ~10 m, respectively. We extracted the upper and lower surfaces of the Tampen Slide through dense horizon picking at up-to-150 m increments, and performed geomorphological and statistical analysis on the time and amplitude surfaces. The upper surface of the up-to-180 m thick Tampen Slide is irregular and can be divided into distinct morphological categories that correspond with variations in the internal deformation of the slide. Contrastingly, the Tampen Slide's basal glide plane is smooth and laterally continuous, and consists of a variable amplitude positive reflection overlain by a very high amplitude negative reflection. We identify elongated ridges within the Tampen Slide debris that are parallel to the flow direction, up-to-40-m higher than the surrounding slide material, unrelated to variations in topography of the basal plane, and geomorphically distinct from extensional and compressional ridges. Flow-parallel, elongated ridges, such as we find within the translational region of the Tampen Slide, are frequently found in terrestrial and volcanic settings; however, this is the first time that ridges of this nature have been identified in a deep marine setting. This poses questions about the substrate conditions and failure mechanism required for the formation of such longitudinally orientated ridges, as well as their prevalence in the deep marine environment. Based on our characterization of the deposits, we provide a new three-stage model for the emplacement of the Tampen Slide: an initial, translational failure (>720 km^3) was followed by extensional spreading along the side- and headwalls, and several smaller volume (<40 km^3) retrogressive debris flows or collapses.