Submarine landslides on the upper southeast Australian passive continental margin - preliminary findings

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Abstract

The southeast Australian passive continental margin is narrow, steep and sediment-deficient, and characterized by relatively low rates of modern sedimentation. Upper slope (<1200m) sediments comprise mixtures of calcareous and terrigenous sand and mud. Three of twelve sediment cores recovered from geologically-recent, submarine landslides located offshore New South Wales/Queensland (NSW/QLD) are interpreted to have sampled failure surfaces at depths of between 85 cm and 220 cm below the present-day seabed. Differences in sediment physical properties are recorded above and below the three slide-plane boundaries. Sediment taken directly above the inferred submarine landslide failure surfaces and presumed to be post-landslide, returned radiocarbon ages of 15.8 ka, 20.7 ka and 20.1 ka. The last two ages correspond to adjacent slide features, which are inferred to be consistent with their being triggered by a single event such as an earthquake. Slope stability models based on classical soil mechanics and measured sediment shear-strengths indicate that the upper slope sediments should be stable. However, multibeam sonar data reveal that many upper slope landslides occur across the margin and that submarine landsliding is a common process. We infer from these results that: a) an unidentified mechanism regularly acts to reduce the shear resistance of these sediments to the very low values required to enable slope failure, and/or b) the margin experiences seismic events that act to destabilise the slope sediments.

Keywords: Mass-failure, multibeam, seafloor geomorphology, continental slope.

Project Details

The aim of this project is to determine the timing and improve our understanding of the causes of several recent examples of large number of submarine landslides that present on the entire length of the continental slope of the southeastern (SE) Australian margin. The research aims to: (1) define the age, morphology, composition and origin of particular submarine landslides on the SE Australian upper continental margin recently discovered offshore New South Wales/Queensland (NSW/QLD); (2) investigate, for the first time, the mechanical characteristics of sediments from the upper SE Australian continental slope; (3) answer the two important questions, when and why have slope failures occurred; (4) improve risk assessment and understanding of the tsunami hazard along this margin.

Submarine mass failures have been common throughout geological history; particularly on inclined seafloor slopes, areas where sedimentation rates are high, sediments are fine-grained, or seafloor rocks are weakened by fractures. Failures are thought to be triggered by a variety of stressors that dramatically reduce

sediment shear strength and include: earthquakes, sea level fluctuations, tectonic events, gas hydrate dissociation, storms waves, and sedimentation. Individual failures can involve the movement of volumes of material reported to be as large as 20,000 km^3 over distances of more than 140 km (Hampton et al. 1996).

Despite extensive literature on the nature and causes of submarine landslide, their dynamics and triggering processes are not well understood (Locat and Lee 2002; Bardet et al. 2003; Mosher et al. 2010). This lack of understanding partly results from the limited data on the physical and mechanical properties of sediments from the slide plane, as these materials are not usually collected.

In the Australian context, only a few studies have investigated submarine landslides on the Australian continental slopes. While evidence of submarine landslides on the southeastern (SE) Australian margin was first reported by Jenkins and Keene (1992), it was not until high resolution, multibeam bathymetric data became available (Glenn et al. 2008; Boyd et al. 2009) that the extent and ubiquity of these slides has been established. The preliminary investigations arising from the RV *Southern Surveyor* research cruise (*SS12/2008*) established that some, if not many, of the large submarine landslides located on the eastern Australian coastal margin offshore the Byron Bay area are geologically young (Boyd et al. 2009, 2010; Clarke et al. 2011).

This project addresses fundamental questions about the timing and mechanisms responsible for submarine landslides along Australia's SE continental margin, based on a unique data set collected on the *RV Southern Surveyor* research cruise (*SS12/2008*) (Boyd et al. 2009, 2010). The study area is located along the SE Australian continental margin off northern New South Wales and southern Queensland (Fig. 1). To date, preliminary work has shown that the upper slope sediments are comprised of mixtures of calcareous and terrigenous sand and mud. Three of twelve cores collected during the *Southern Surveyor* cruise at separate sites located offshore NSW/QLD probably penetrated large, geologically-recent, submarine landslide failure surfaces at depths of between 60 cm and 200 cm below the present-day seabed (Fig. 2). Distinct differences in sediment physical properties have been determined for material immediately above and below the three slide-plane boundaries. Three preliminary ^{14}C ages from sediment presumed to be post-slide yield dates of 15.8 ka, 20.7 ka and 20.1 ka directly above the inferred submarine landslide failure surfaces. The last two ages were determined for adjacent but distinct slide features, which is consistent with their being triggered by a single event such as an earthquake.

Slope stability models based on classical soil mechanics and measured sediment shear-strengths indicate that the upper slope sediments should be stable. However, the ubiquity of upper slope slides across the margin indicates that their occurrence is a relatively common event; and that submarine sliding is a frequent process on this margin. While this presents something of an interpretational paradox, it nevertheless indicates that either a) an unidentified mechanism regularly acts to reduce the shear resistance of these sediments to the very low values required to enable slope failure or b) the margin experiences earthquakes large enough to destabilise the slope sediments relatively frequently.

Detailed characterization of the slope sediment provides essential information needed to explain the timing and occurrence of the large submarine landslides on the SE Australian upper continental slope. While

the tsunamigenic potential of these submarine landslides is unknown, they are certainly volumetrically large enough and occur at shallow enough water depths (< 1200 m) to have the potential to generate substantial tsunamis that could cause widespread damage on the SE Australian coast and threaten coastal communities.

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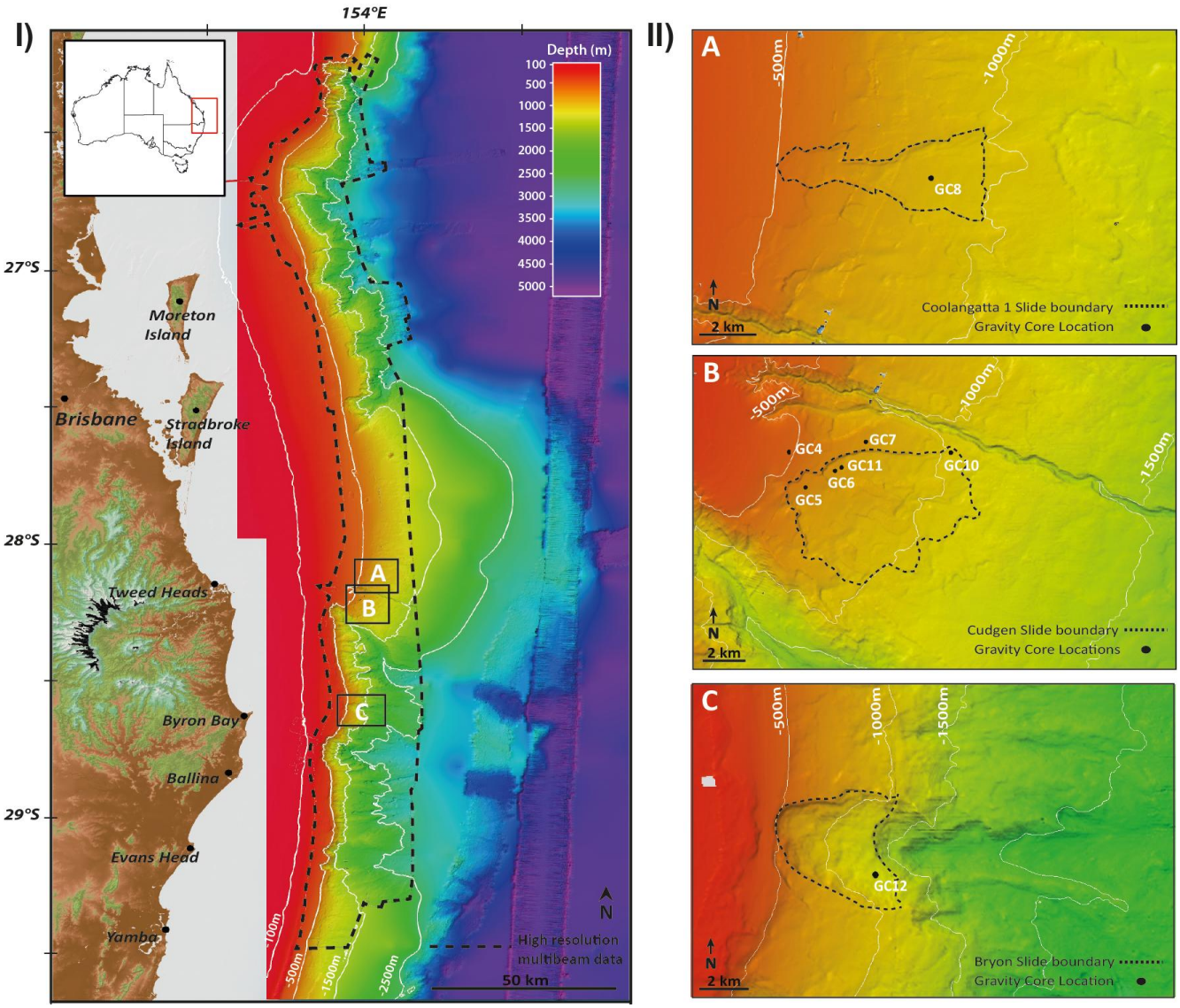

Figure 1 I) Location map of the southern Queensland to northern New South Wales coastline and bathymetry, showing the location of the study area (dashed line). Insets mark the three slides sites (north to south): (A) Coolangatta 1 Slide, (B) Cudgen Slide, (C) Byron Slide. II) The three slide sites showing the locations of 8 gravity cores (GC) collected on the RV *Southern Surveyor* (SS2008/12) voyage.

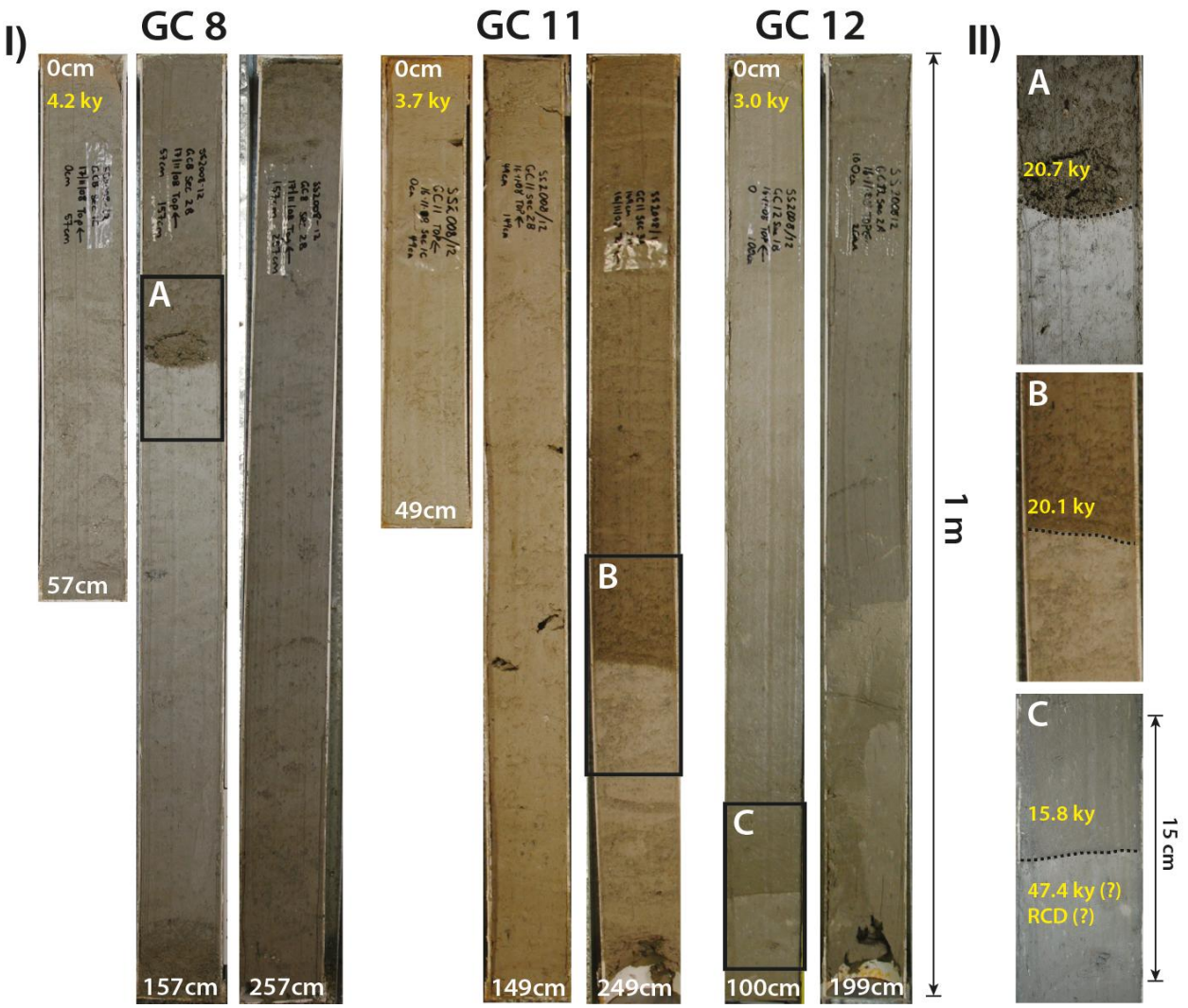

Figure 2 I) Images of the three gravity cores (GC) that present boundary features: GC8, GC11 and GC12. See Figure 1 for the locations of the gravity cores. II) Close up of the boundary feature in each core. The inferred slide plane is indicated with a dashed black line. Bulk radiocarbon ages for each core are also shown in yellow (ky = thousand years before present, RCD = radiocarbon dead).