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Research paper

Conduits, timing and processes of sediment delivery across a high-relief continental margin: Continental shelf to basin in Late Quaternary, Gulf of Papua

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A B S T R A C T

The Gulf of Papua (GoP), between Australia and Papua New Guinea, is the receiving basin for multiple substantial rivers draining southern Papua New Guinea with collective sediment discharge >> 220 million metric tons (Mt) per year, comparable to a continental-scale river, but draining a combined catchment area of only ~160,000 km^2. This study of the deepest marginal basins in the Gulf of Papua was undertaken to build a regional late Quaternary lithofacies and stratigraphic framework to better understand processes, timing, and conduits of sediment delivery from terrestrial and shelf settings to deep marginal basins, using the GoP as a natural laboratory. Methods include observations of sediment-core stratigraphy and physical properties, accelerometer mass spectrometry (AMS) C-14 dates, core x-radiographs and thin sections.

Six lithofacies across the deep water Gulf of Papua (GoP) are identified based on core visual and textural observation. Chronological constraints permit an assessment of changes in sediment supply and depositional environments across time and space, from marine isotope stage (MIS) -3 to -1, or in the last 40 cal ka. The sediment delivery to the deep water GoP is dominated by two mechanisms, gravity-driven flows down slopes and into deep sea basin primarily during lowstands in the western portions of the study area, and hemipelagic sediment accumulation during transgression and highstand. Although the sediment flux appears to be overall dominated by sediment-gravity flows, hemipelagic sediment delivery is widespread during periods of sea level highstand. In the eastern portions of the study area, off-shelf sediment delivery continued into the Holocene in sufficient local volumes to produce turbidity currents. This late, localized sediment delivery appears to have been facilitated by oceanographic processes that allowed seaward sediment transport after flooding of the shelf.

A simple sediment budget comparing basinal sediment accumulation to modern estimated river-sediment discharge indicates that peak sediment accumulation in proximal basins occurred during MIS-2; and declined thereafter, generally shifting to upper slope locations, except for the eastern margin of Moresby Trough. There, turbidite deposition continued until 7.4 cal ka, well after drowning of the shelf edge. This continued Holocene deep-sea sediment delivery is likely explained by the local narrow shelf width, and the presence of oceanographic processes capable of transporting sediments from shore to shelf edge.

1. Introduction

The Gulf of Papua (GoP) deep-sea basins are the ultimate sink for sediment from the southern margin of the Papuan mainland and peninsula, and contains a valuable chronological record of the spatial and temporal variations in regional sedimentation rates and

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dispersal patterns. This region was selected by the US National Science Foundation MARGINS-Source-to-Sink Program (S2S) as a focus area for study of continental margin sedimentation and stratigraphy, because of the high rates of sediment transfer from land to coastal sea to marine basins, and because of relatively modest anthropogenic alteration of both terrestrial and marine portions of the sediment dispersal system; The GoP was the location of numerous S2S research cruises in 2003–2005 to study a passive margin evolution (NSF MARGINS, 2004; NSF MARGINS, 2009; Dickens et al., 2006). This modern sedimentary basin has formed within a continental-margin salient characterized by gradients in morphology and sediment supply, with mature rivers feeding a wide shelf margin in the southwest area, and steep slope, small mountain-fed rivers and narrow shelf margin in the southeast peninsular area (Fig. 1). Numerous studies have been published evaluating geological processes and products including local geological processes through time (e.g., Howell et al., 2014), and modern regional seabed morphology (Francis et al., 2008), but the regional geological evolution of the deepest basins remains underexplored, particularly with respect to changes in sediment flux and sources over time.

The objectives of this chapter are to build a regional Late Quaternary lithofacies and stratigraphic framework for the study area by combining observations of sediment-core stratigraphy and physical properties, accelerometer mass spectrometry (AMS) C-14 dates, core x-radiographs and thin sections. Data sets used to evaluate the study area are derived from analysis of multi-cores and jumbo piston cores collected during the PANASH cruise of the R/V Melville cruise in 2004 (Dickens et al., 2006). In the present study, this framework will be used to determine depositional frequency and timing for turbidite delivery into the basin, and to evaluate regional lithofacies variability, as influenced by glacio-eustatic, climatic and oceanographic forcing. In Septama (2015), this framework forms the basis for additional studies of seabed geomorphology and sediment provenance (Septama and Bentley, 2016a, 2016b). The maximum absolute age obtained for most cores is approximately 40 cal ka, equivalent to a time frame for these studies that encompasses part of marine isotope stages (MIS) 3, a complete MIS-2 and MIS-1 (ICS, 2010).

2. Geological background

The island of Papua is one component of a complex convergent plate boundary formed as a result of the collision between the Indo-Australian Plate and the Southwest Pacific Plate (Fig. 1) (Pigram and Davies, 1987). The study area in the GoP is an example of an active developing foreland basin which receives intense terrigenous sediment influx from the surrounding river systems (Slingerland et al., 2008).

The Pandora and Moresby Troughs are the foredeep of the Papuan Orogen which are originally part of the inactive Aure Trough (Cloos et al., 2005), which has risen since the Late Cretaceous (ca. 65 Ma) (Fig. 1). These foreland basins began receiving terrigenous sediment in the proximal area as early as Eocene (55.8–33.9 Ma) and reached peak depositional rates through the entire basin during the Pliocene–Holocene (<5 Ma) when uplift in the orogenic belt intensified, in particular middle Pliocene interval (1–2 my duration) during which the monsoon intensified and the shelf prograded to 80 percent of its modern extent (Tcherepanov et al., 2008, 2010). The uplift along the collision margin has produced >4000 m relief which, combined with high precipitation rate (2–10 m/yr), produces runoff that delivers abundant sediment downstream (approximately 365 million t/yr; Milliman, 1995). The best documented influxes come from the Fly, Kikori and Purari

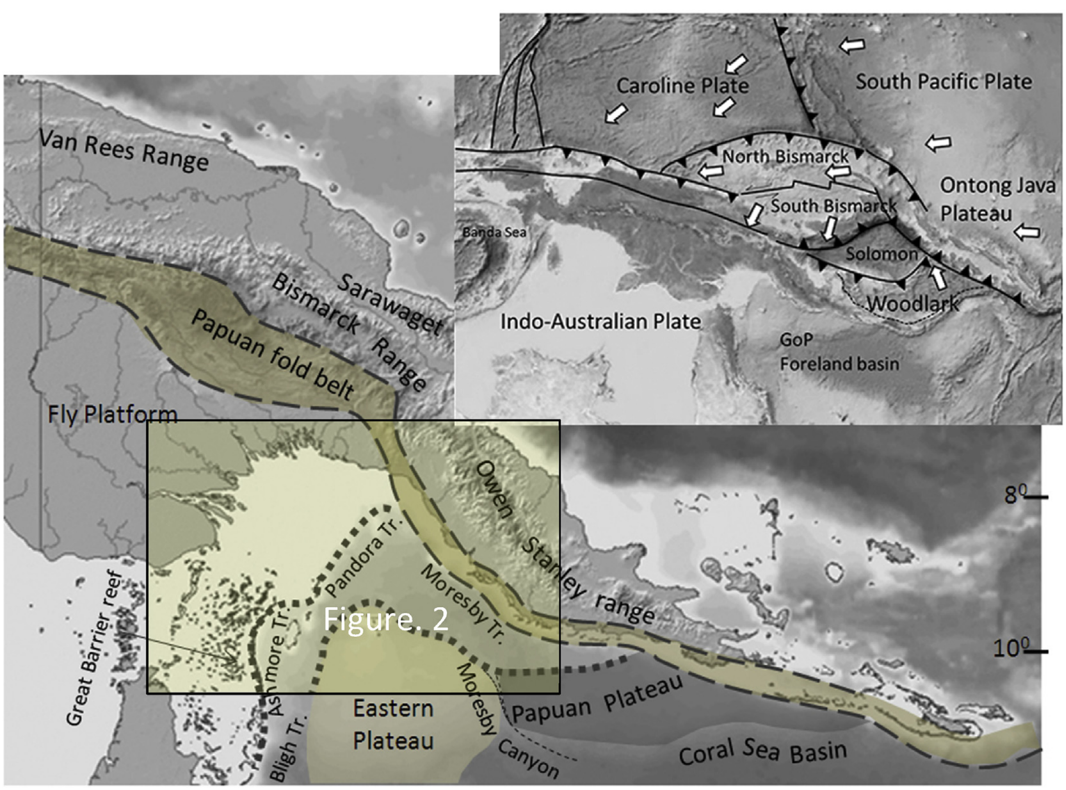

Fig. 1. Modern physiographic and tectonic elements of the Gulf of Papua (modified after Pigram and Davies, 1987; the inactive Aure trough was re-drawn based on Cloos et al., 2005); the inset tectonic map is modified after Hamilton, 1979 overlayed on Google Earth imagery.