Journal of the Geological Society, London, Vol. **167**, 2010, pp. 539–553. doi: 10.1144/0016-76492009-015.

Holocene sediments from the Southern Chile Trench: a record of active margin magmatism, tectonics and palaeoseismicity

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Abstract: Sedimentology, petrography and the provenance of Holocene sediments from the Southern Chile Trench (36–47°S) were investigated in an integrated approach combining description of a collection of gravity cores, measurements of physical properties, quantitative X-ray petrography and modal analysis. The sediments studied were trench hemipelagic sediments, fan deposits, and more distal hemipelagic sediments from the Nazca Plate. The trench is mostly fed by multiple point sources via submarine canyons. Sandy turbidites show a southward increase in sediment maturity. Whereas volcanic lithic fragments and plagioclase represent the dominant fraction in the north, quartz content strongly increases in the southern part of the study area, in line with source lithologies. Further north, active volcanoes in the Main Cordillera represent almost the entire provenance signal as a result of a strong contribution of highly erodible volcanic rocks. Recurrence rates of sandy and silty turbidites in the trench fan sediments indicate a link to the palaeoseismic record on land. Our study documents the potential usefulness of proximal turbidites to reconstruct palaeoseismicity, even at a scale of single segments of the plate boundary.

Sedimentary fills of deep-sea trenches are sensitive recorders of long-term tectonics, shorter-term changes in surface processes, and even seismic cycles operating on very short (centennial) geological time scales at active plate margins. Whereas upper plate denudation, trenchward sediment transport, eventual subduction of sediments and involvement in generation of arc melts may be viewed as part of a more or less continuously operating cycle of solids and volatiles (e.g. Kilian & Behrmann 2003), the impacts of singular or cyclic events may also be documented in deep-sea trench sedimentation patterns and facies. This has been shown for cyclic changes of the global climate (e.g. Völker *et al*. 2006), regional climate (e.g. Lamy *et al*. 2001), deglaciation (e.g. Hebbeln *et al*. 2007) or even cycles of plate margin seismicity (e.g. Huh *et al*. 2004; Goldfinger *et al*. 2007). Mostly, this evidence has been collected from long-term stratigraphic records supported by one or a few drill-holes. We lack, however, more comprehensive investigations on the regional variations of sediment composition and dynamics within a single time slice in a deep-sea trench environment. Such studies would concern the character of the dispersed hemipelagic sedimentation, and would also refer to the turbidite record as a proxy for seismic activity, and to the provenance signal from the denudation area. Climate zones, large coseismic ruptures and major geological provinces on land are typically hundreds to about a thousand kilometres in size, and studies must, therefore, attempt to take this scale into account.

For a study of young sediments at this scale, we have chosen the Southern Chile Trench between 36° and 47°S latitude. In this paper we present a new set of sedimentological and petrographical data derived from the analysis of 16 gravity cores that were collected during R.V. *Sonne* expedition 181 (see Flüh & Grevemeyer 2005) from the Southern Chile Trench fill, from the hemipelagic sediments on the incoming Nazca Plate, and from trench fans formed at the mouths of submarine canyons seaward of major river systems on land. We specifically analysed grain-size distributions of the sediments, the mineralogy of fine-grained background sediments, the frequencies and petrography of the turbidites, and their provenance signal.

Plate-tectonic, oceanographic and climatic setting

The Southern Chile Trench relates to the subduction of the Nazca and Antarctic Plates beneath the South American Plate (Fig. 1). The most striking tectonic feature of the area is the subduction of an active spreading centre, the Chile Ridge, at about 46.4°S, 75.7°W (e.g. Behrmann *et al*. 1994), forming the Chile Triple Junction. Whereas the Nazca Plate is currently being subducted at about 6.6 cm a^{-1} (Angermann *et al*. 1999), faster rates prevailed over the past few million years, with maximum rates of up to 15 cm a^{-1} between 28 and 26 Ma (e.g. Angermann *et al*. 1999; Kendrick *et al*. 2003). The Antarctic Plate is subducted much more slowly at about 1.8 cm a^{-1} (DeMets *et al*. 1990). The oceanic crust that is currently subducted becomes progressively older northward and southward of the Chile Triple Junction. At the Nazca–South American plate boundary crustal ages range from zero to 33 Ma at about 36°S (e.g. Tebbens & Cande 1997). As a result, the thermal state varies and leads to a latitudinally different buoyancy of the subducted Nazca Plate, which contributes, along with the decreasing sediment input at lower latitudes, to the northward increasing water depth at the trench axis. Values range from *c*. 8200 mbsl (metres below sea