Using meteoric ^{10}Be to constrain the age and structure of the frontal wedge at the Japan Trench

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Abstract

We present new meteoric ^{10}Be concentration data from marine sediments recovered during International Ocean Drilling Program (IODP) Exp. 343 that help constrain the age and internal structure of the frontal prism at the Japan trench in the vicinity of the 2011 Tohoku-oki M9 earthquake rupture. Exp. 343 recovered sediments from an ~200 m interval of the frontal wedge at site C0019. Core and log observations identify the plate boundary décollement at ~820 mbsf, which separates a deformed sedimentary wedge from relatively undeformed underthrust sediments. However, reconstructions of the structural evolution of the wedge are difficult because of similarity in lithology between sediments from the incoming and overriding plate, and the chaotic character of seismic reflectors in the frontal wedge. We utilize the radiogenic decay of ^{10}Be ($t_{1/2}$ =1.36 Ma) in marine sediments to constrain variations in sediment age with depth in core C0019. Meteoric ^{10}Be was isolated from marine sediments at the University of Vermont using total fusion and ^{10}Be/^{9}Be ratios were measured at the Scottish Universities Environmental Research Centre. Concentrations of meteoric ^{10}Be in core C0019 range from 1.7x10^{7} to 2.1x10^{9} atm/g and are consistent with ^{10}Be concentrations at nearby DSDP sites 436 and 434. We calculate ^{10}Be sediment ages for analyzed samples assuming a range of initial ^{10}Be concentrations from 1.6 to 2.1x10^{9} atm/g. These concentrations are constrained by a ^{10}Be sample co-located with a radiolarian micropaleontology sample at 780 mbsf that yields a Quaternary age, and from previously reported ^{10}Be concentrations for Quaternary sediments in nearby DSDP cores. ^{10}Be and radiolarian micropaleontology samples from similar depths yield consistent ages for late Miocene to Quaternary sediments (R^2 = 0.89).

Calculated ^{10}Be ages range from 0-10 Ma, with ~50% of analyzed samples yielding ages <2 Ma. Repetition and inversion of high (10^9 atm/g) and low (10^7 atm/g) concentration sediments with depth in the core indicate at least three significant stratigraphic inversions within the recovered section between cores 1 and 2 (180 - 650 mbsf) cores 3 and 4 (655-690 mbsf), and cores 15 and 16 (817-819 mbsf). These inversions correspond to emplacement of late Miocene over Quaternary sediments and suggest thrust repetition of wedge sediments. A two-order-of-magnitude decrease in ^{10}Be concentrations (10^9 to 10^7 atm/g) occurs across the plate boundary décollement between cores 16 and 18, with an increase in ^{10}Be age from <1 Ma immediately above the décollement (819 mbsf) to 8-9 Ma below the décollement (825 mbsf). Sediments below the décollement are comparable in age to the basal 100m of the incoming Pacific sediment section at site 436. Increases in ^{10}Be concentration with depth at multiple intervals between 690-815 mbsf in C0019 suggest the potential for small-scale (<10m) stratigraphic disruption and overturned stratigraphic sections. These analyses show that meteoric ^{10}Be in deep marine sediments can be a viable tool to delineate the age and structure of marine forearc sediments and constrain the structural history of frontal prisms.

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