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Aleutian basin oceanic crust

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ABSTRACT

We present two-dimensional P-wave velocity structure along two wide-angle ocean bottom seismometer profiles from the Aleutian basin in the Bering Sea. The basement here is commonly considered to be trapped oceanic crust, yet there is a change in orientation of magnetic lineations and gravity features within the basin that might reflect later processes. Line 1 extends ∼225 km from southwest to northeast, while Line 2 extends ∼225 km from northwest to southeast and crosses the observed change in magnetic lineation orientation. Velocities of the sediment layer increase from 2.0 km/s at the seafloor to 3.0–3.4 km/s just above basement, crustal velocities increase from 5.1–5.6 km/s at the top of basement to 7.0–7.1 km/s at the base of the crust, and upper mantle velocities are 8.1–8.2 km/s. Average sediment thickness is 3.8–3.9 km for both profiles. Crustal thickness varies from 6.2 to 9.6 km, with average thickness of 7.2 km on Line 1 and 8.8 km on Line 2. There is no clear change in crustal structure associated with a change in orientation of magnetic lineations and gravity features. The velocity structure is consistent with that of normal or thickened oceanic crust. The observed increase in crustal thickness from west to east is interpreted as reflecting an increase in melt supply during crustal formation.

1. Introduction

The northern and northwest Pacific is rimmed by marginal basins, most of which formed by backarc spreading behind island arcs [e.g., Karig, 1970; Packham and Falvey, 1971; Xu et al., 2014]. In contrast, the Aleutian basin (Fig. 1) is commonly modeled as oceanic crust, trapped ∼55–50 Ma when subduction moved from the Beringian margin to its current location beneath the Aleutian ridge [Scholl et al., 1975; Cooper et al., 1976b, 1987; Worrall, 1991; Cooper et al., 1992]. Little is known about the deep structure of the Aleutian basin, except that early seismic refraction profiles suggest a velocity structure consistent with oceanic crust [Shor, 1964; Ludwig et al., 1971; Cooper et al., 1979].

Magnetic studies initially identified north-south trending magnetic lineations in the Aleutian basin that supported the hypothesis that the basin crust was trapped oceanic crust formerly part of the Mesozoic Pacific basin [Cooper et al., 1976a]. However, a later magnetic compilation mapped more complex anomalies in the basin that follow trends observed in gravity data (Fig. 1); these anomalies cannot be reliably correlated with the geomagnetic reversal time scale and thus spreading rates at which this crust accreted are unknown [Cooper et al., 1992]. Cooper et al. (1992) suggest that northeast-southwest oriented magnetic lineations are associated with early Cenozoic back-arc extension that took place after entrapment of Pacific basin oceanic crust. The proposed region of extension is located on the 100–200 km wide Vitus arch (Fig. 1), which is characterized by northeast-southwest trending basement horsts and grabens [Cooper et al., 1992]. An alternate model has the Vitus arch associated with a push-up structure along a strike-slip fault zone active in the middle Eocene [Chekhovich et al., 2012; Chekhovich and Sheremet, 2013].

Recent seismic reflection profiles over the Vitus arch image thick, flat-lying sediments overlying a rough basement, but do not constrain crustal thickness because Moho is not clearly imaged (Fig. 2). In this study we present new seismic refraction profiles that characterize the crust in the region of complex magnetic lineations on the Vitus arch (Fig. 1). These new data are consistent with thickened oceanic crust, with no clear change in structure associated with the prominent change in magnetic anomaly trend on the northwestern flank of Vitus arch.

2. Seismic data, analysis, and results

2.1. Data acquisition and processing

Cruise MGL1111 acquired seismic refraction and reflection data in the Aleutian basin during August 2011 using the R/V *Marcus*

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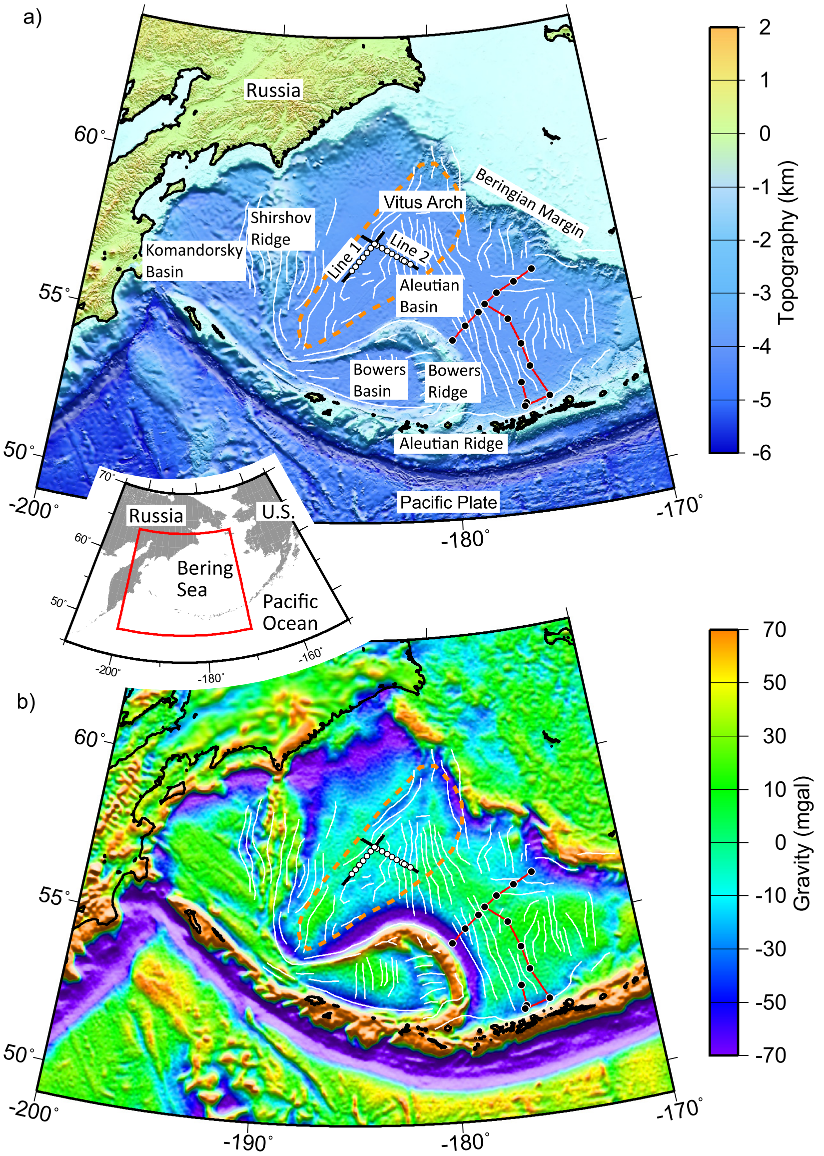

Fig. 1. Location maps of the study region displaying a) Seafloor bathymetry [Smith and Sandwell, 1997] and onshore topography (GTOPO30 from USGS); b) Gravity anomaly [Sandwell and Smith, 2009]. Black lines show wide-angle profiles presented in this paper, with OBS positions displayed by white circles. Red lines and black circles show seismic refraction profiles and stations of Shor (1964) and Ludwig et al. (1971). White lines and orange dashed line mark magnetic lineations and Vitus arch, respectively, as defined by Cooper et al. (1992). Inset displays the larger setting. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

G. Langseth. The source for seismic data acquisition was a 36-airgun 4-string array towed at a depth of 9 m, with a total volume of 6600 cubic inches and a pressure of 2000 psi. Seismic refraction profiles had a shot interval of 150 m, and were recorded by ocean bottom seismometers (OBSs) positioned at a seafloor spacing 20 km on Line 1 and 5–20 km on Line 2 (Fig. 3). The OBSs included a vertical, hydrophone, and two horizontal channels, and used a sample interval of 4 ms. Coincident multichannel seismic reflection profiles were acquired with the same source array, with a shot interval of 50 m, and were recorded by an 8-km-long solid streamer with 636 channels at 12.5 m spacing towed at a depth of 9 m. Seismic reflection record length is 16 s with an original sample interval of 2 ms.

Initial processing of the OBS data included applying a correction for clock drift during deployment and inverting the direct water-wave arrivals for instrument location. Instrument location errors are small in the along-track direction but much larger in the cross-track direction; maximum instrument location errors are estimated to be 200 m. Further processing consisted of applying a Butterworth filter with a low cut of 3 Hz, a high cut of 15 Hz, and a 48 dB/octave rolloff. Seismic reflection data processing included trace regularization, bandpass filtering, velocity analysis, normal move-out correction, muting, multiple suppression, stacking, and f-k migration.

2.2. OBS data analysis

Representative OBS record sections are displayed in Fig. 4, and show phases typical of sedimented oceanic crust. At offsets of ∼7–12 km, refracted arrivals through the sediment (*Psed*) are observed as first arrivals with apparent velocities of ∼2.5–3.0 km/s. The *Pg* phase (crustal refraction) exhibits a change in slope, with apparent velocities increasing from ∼5–5.5 km/s to ∼6.5–7 km/s, while the *Pn* phase (mantle refraction) has apparent velocities of ∼8–8.5 km/s. A basement reflection (*Pbase*) is observed at near offsets, while a prominent mantle reflection (*PmP*) is observed as a triplication behind the *Pg* and *Pn* phases. The *Pn* arrival is observed to longer offsets on Line 1 (Fig. 4a–b) than on Line 2 (Fig. 4c–d), while the opposite is true of the *PmP* phase.