Geophysical Research Abstracts
Vol. 19, EGU2017-15141, 2017
EGU General Assembly 2017

Interpreting the Cenozoic initiation and evolution of the North America-Eurasia transform plate boundary system by analysing local unconformities

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The plate boundary system between the Eurasian and North American plates (EUR-NAM) is multi-stranded and mostly aseismic, except in its southernmost 1,000 km, which runs north-south through the island of Sakhalin, on the west side of the Sea of Okhotsk. This dextral transform system has several inactive and two active strands, which have slip rates of 0.86 mm a–1and 1.09 mm a–1 over the past 3.6 Ma. The island is in a state of transpression and recent seismic activity includes the 7.6 magnitude Neftegorsk earthquake (1995).

In the Mesozoic, Sakhalin was part of the Eurasian plate and formed the forearc to the Sikhote Al'in arc (K2-Pg), the latest of three Mesozoic arcs accreted to east Asia. Subduction of Pacific crust under Sakhalin shut down by southward migration of an arc-arc cusp from a position north of Sakhalin in the latest Cretaceous to its present position in Hokkaido, leaving Sakhalin isolated in a retro-arc position. Over this interval, the old forearc of Sakhalin was covered by a thick sedimentary cover of locally sourced terrestrial conglomerates and sandstones, marine mudrocks and diatomites, and clean, well-sorted sands deposited in the giant palaeo-Amur delta. Timing of initiation of the NAM-EUR plate boundary in east Asia is debated but is generally thought to be Miocene, coincident with formation of the Kuril Arc. It is also suggested that the Sakhalin portion of the plate boundary system propagated northwards from Hokkaido though the Neogene.

However, in this paper we present new evidence to suggest that the present plate configuration dates from the Oligocene and that the whole length of the Sakhalin segment of the plate boundary came into existence at the same time. We show that tectonism in Sakhalin focused on three discontinuities in the former forearc: (a) the arc-forearc boundary; (b) the axis of the forearc basin (west Sakhalin); and (c) the boundary between forearc basin and accretionary complex (east Sakhalin). The Neogene succession is deformed into neotectonic anticlines centred on, and slightly oblique to, the active faults; hills are 25 km long on average (range 6-35 km) with a constant 3.5:1 length:width ratio and are 1-200 m above the regional surface. Structural hydrocarbon traps offshore Sakhalin are the same scale. The stratigraphy of Sakhalin is interrupted by numerous local unconformities, averaging 25 km long and removing 100-200 m of stratigraphy. These are absent from Paleocene and Eocene strata but occur throughout the Oligocene and Neogene; the earliest are coeval across the whole island. We hypothesise that these unconformities were formed by the removal of transient topography equivalent to the present-day neotectonic anticlines and record contemporaneous Oligocene onset of the NAM-EUR plate boundary in Sakhalin.