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# Seismotectonics and recent evolution of the Eurasia-North America Plate Boundary in Northeastern Russia

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In contrast to oceanic plate boundaries which are usually well defined by earthquake locations and magnetic anomalies, the present and past kinematics of plate boundaries in the continents remains problematic in many settings. One particularly vexing such boundary is the one that separates Eurasia from North America in Northeast Russia. In the earliest plate models it was evident that the mid-Atlantic spreading ridge continues in the Arctic as the Gakkel ridge which then runs almost perpendicularly into the continental shelf of Russia in the Laptev sea. On the shelf, and further south on land, the narrow belt of seismicity that is found along the Gakkel ridge broadens into a diffuse swath of earthquakes which is in places more than 800 km wide and extends along the Chersky Range towards the coast of the Okhotsk sea and northern Kamchatka The fact that the Okhotsk sea is aseismic but is surrounded by seismic belts has to lead the interpretation that it is an independent microplate that lies between the Eurasian, North American, Pacific and Amur plates (Cook et al.,
1986).Unravelling the kinematics of the Eurasia-Okhotsk-North America Plate boundaries has proven difficult. This is in part due to the paucity of geological and geophysical data from this remote region, and to the fact that the Eurasia-North America pole of rotation lies in close vicinity to the plate boundary itself. Cook et al. (1986), using earthquake slip vectors, placed the current pole of rotation near the Lena river delta, that is, in the area where Eurasia-North America plate boundary comes on shore ). As a consequence, spreading along the Gakkel ridge north of the pole of rotation, should change into convergence or strike-slip to the south depending on the orientation of the boundary. Making specific predictions for fault kinematics in the area has been hampered by the fact that different geophysical and geodetic data-sets have yielded different locations for the Eurasia-North America pole of rotation (Cook et al. 1986; Rowley and Lottes, 1988; De Mets, 1990; Imaev et al., 2000; Kogan et al., 2000). Focal mechanism solutions are predominantly left-lateral and thrust along the Chersky seismic belt, that is, the northern boundary of the Okhotsk plate and right-lateral along its western boundary leading Riegel et al.(1993) to the conclusion that the Okhotsk plate is being extruded to the south.

Furthermore, it has been shown on the basis of North Atlantic magnetic and gravity data, that the position of the Eurasia-North America pole of rotation moved significantly over that last 60 my so that the portion of the plate boundary in Northeast Russia changed from predominantly convergent until the Late Cretaceous to divergent until the Early Eocene, followed by various degrees of transpression during the rest of the Cenozoic (Gaina et al., 2002).On the shelf of the Laptev Sea, the Gakkel Ridge gives way to four major continental rift branches with up to 10 km of sedimentary fill spanning from the Late Cretaceous to Recent (Drachev, 1999). Earthquakes are most numerous along the southern margin of the rift system in the Lena delta region and have normal and strike-slip focal mechanism solutions (Imaev et al., 2000). On land, several branches of the rift system overprint the northern termination of the Mesozoic Verkhoyansk fold-and-thrust belt and the accreted arc terranes which are found in its hinterland (Parfenov et al., 1995). Focal mechanism solutions in this area shift from extentional to the north to compressional and strike-slip to the south. The plate boundary continues to the southeast across the Omoloi depression and then follows the trend of major mountain ranges and intermontane basins in the area: the Chersky and Moma ranges and the Moma basin.

The Chersky Range, which has the highest topographic elevations in Northeast Russia (3947 m), has a complex history of Mesozoic and Cenozoic deformation (Parfenov and Gaiduk, 2001). The highest peaks are underlain by late Jurassic granite batholiths. Late Oligocene-Miocene deposits along the middle Indigirka river are tightly

folded and thrust faulted (Imaev et al, 2000). Fragments of an elevated Early Pleistocene erosion surface, which was deformed in the Middle Pleistocene, have also been recognized (Parfenov and Gaiduk, 2001) attesting to recent tectonism. Several northwest-trending active left-lateral strike-slip faults, which extend the length of the Chersky range and continue to the southeast, have been identified in satellite imagery and topographic maps, and can be traced in the gravity and magnetic fields also (Imaev et al., 1990, McClean et al., 2000) and by dislocations of recent geomorphic features. The most important one is the Ulakhan fault which extends for 1500 km and is thought to accommodate a major part of the displacement between North America and the Okhotsk plate (McClean et al, 2000). Several elongated Neogene basins exist along the Ulakhan and neighboring faults. Some of these are interpreted as pull-apart basins, while others are attributed to extension related to the Moma rift . The Bugchan basin is an example of a pull-apart which is filled with variably deformed Miocene-Pliocene deposits cut by NW-striking faults. Another example is the Pereprava basin located further south along the Omulevka river which contains steeply-dipping Middle to Late Miocene lake deposits .The largest depression along the Ulakhan fault is the Seimchan-Buyunda basin filled with Paleogene and Neogene rocks . To the southeast of the Seimchan-Buyunda basin the Ulakhan fault becomes less distinct within the Okhotsk-Chukotka volcanic belt (McClean et al., 2000), although Late Cenozoic alkali lavas found in the Viliga river region are believed to have been extruded along the southern extension of the Ulakhan fault (Leonova, V.V. et al., 2005).It is apparent in satellite images of the southeastern portion of the Ulakhan fault that stream beds are systematically offset to the left up to 24 km. Other important left-lateral faults in the region are the Iren'ya-In'alin fault which splays off the Ulakhan fault, and the Chay-Yureya fault which lies to the south in the Chersky Range and generated the 1971 Artyk event (M6.8), and the Darpir fault which links with the Ulakhan fault from the southeast..

The Moma basin is an elongated depression located north of the Chersky range. It is filled with Paleogene to Neogene deposits unconformably overlain by Pleistocene sediments. The nature of the basin-bounding faults is complex. Parfenov et al., (2001) state that listric normal faults separate the Moma basin from adjacent Chersky and Moma ranges, while Imaev et.al. (1990) portray the Moma basin as being bounded by high-angle reverse faults. Perhaps the confusion arises from the shifting nature of the plate boundary interaction due to changes in location of the Eurasia-North America pole of rotation through the Cenozoic, or alternatively the Moma basin is a transtensional feature associated with left lateral strike-slip along the plate boundary. Earthquakes in this region include strike-slip, overthrust, and normal fault solutions . It is also worth noting that in the Moma basin there are two alkali basalt cones (Balagan-Tas and Serdtse-Kamen') dated at 300 ka (Layer et al. 1993). This volcanic activity is probably related to extension, or transtension, across the plate boundary.

In the northeast flank of the Moma Range there is a northeast-vergent fold and thrust belt which places Jurassic rocks over Neogene sediments of the Zyryanka basin. So,the nature of recent seismotectonical deformations and it places, shows difficult evolution this segment of intracontinental boundary.