SURFACE DEFORMATIONS IN SAKHALIN FROM GPS DATA

N.F. Vasilenko¹, A.I. Ivaschenko¹, A.S. Prytkov¹, G.M. Steblov², D.I. Frolov³, M.G. Kogan⁴, M. Kasahara⁵, and H. Takahashi⁵

¹ Institute of Marine Geology and Geophysics FED RAS, Yuzhno-Sakhalinsk, Russia
² Geophysical Service RAS, Obninsk, Kaluga Region, Russia
³ Ioffe Institute of Physics and Technology RAS, St. Petersburg, Russia
⁴ Lamont-Doherty Earth Observatory of Columbia University, NY, USA
⁵ Institute of Seismology and Volcanology, Hokkaido University, Sapporo, Japan

In the framework of global plate tectonics, a system of major north-south trending faults in Sakhalin is regarded as the Eurasia - North America tectonic plate boundary [1]. According to continuous GPS measurements performed since 1995 at reference stations in the north, middle, and south of the island, Sakhalin moves at a speed of 3 – 4 mm/yr to the west relative to Eurasia and at a speed of 3 – 5 mm/yr to the east relative to North America [2]. The sense of motion agrees with convergence of these plates at Sakhalin and the velocity is about 50 –100% of the velocity of convergence [3].

Survey-mode GPS observations carried out in 2000 and 2002 at six stations along a profile traversing the island at 50⁰N showed that current horizontal deformation in middle Sakhalin combines compression and right-lateral strike slip. The rate of total deformation is 3 – 4 mm/yr, or about half of the convergence rate of the Eurasian and the North American plates in this region [2].

Horizontal GPS velocities at all survey-mode stations in south Sakhalin reoccupied in 1999, 2002, and 2003 are shown in Figure 1. A predominant mode of deformation in this part of the island is the east-west compression at ~ 7 mm/yr (velocities of stations not observed in 1999 should be considered with caution). This allows us to conclude that the east-west trending deformations resulting from convergence of two plates mostly occur within the landmass of Sakhalin. They are so rapid that not much deformation happens in the neighboring regions of the Sea of Japan and Sea of Okhotsk, although at middle Sakhalin deformation in both seas perhaps absorbs 50% of the total plate convergence.

At south Sakhalin, the plate boundary can be identified with the regional shear zone between Aprelovsky and Tym-Poronaisky faults. The Tym-Poronaisky fault has been inactive in the late Pleistocene – Holocene while the Aprelovsky fault is definitely active at the present time. According to the paleoseismic studies of M.I. Streltsov and A.I. Kozhurin, the most recent $M_w \geq 7.5$ earthquake within this fault occurred about 800 yrs ago.

Judging from geology, the right-lateral strike-slip deformation is persistent, including the Holocene, in the western part of the island and in the above mentioned shear zone. However, it follows from GPS that such deformation with an amplitude of 2 mm/yr is only observed in the west but not within the Aprelovsky fault.

The regional shear zone is now seismically active. A recent crustal seismicity and the highest gradient of elastic stresses are mostly associated with it [4]. In June-October 2001, a swarm of shallow events occurred within the zone. The N-S nodal plane of the $M_w = 5.3$ main shock has a significant right-lateral component.

We conclude that the repeated GPS observations provide evidence for a rapid strain rate accumulation in the southern part of the island. Absence of significant current deformation within the Aprelovsky fault can be considered as a warning of a big earthquake in the future.
Fig. 1. Horizontal GPS velocities in south Sakhalin from repeated observations in 1999-2003.

The velocities are estimated with respect to reference station YSSK. Velocities of stations observed within the total 4-year time span are accurate to 1 mm/yr (1-σ); velocities of stations observed in 2002 and 2003 are accurate to 2 mm/yr (URYM, SVOB, NOVI, and EVST).


References