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Slow strain waves from seismological and geophysical observations

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Slow strain waves are typically excited due to natural processes that occur within the crust and the lithosphere and are displayed in variations of seismicity and geophysical fields. The concept of strain waves generated in the Earth is based on the results of the study of earthquake distribution and slow tectonic deformation processes and the transfer of geophysical field anomalies.

The fast seismicity migration at velocities of 1-10 km/day is observed in various regions of the world (Barabanov et al., 1994; Hill et al., 1995). Strain waves along crustal faults at velocities of 1-10 km/day are inferred from radon, electrokinetic and hydrogeodynamic signals (Nikolaevskiy, 1998). Migration of episodic tremor and slow slip events along plate boundaries in subduction and transform fault zones occurs at a velocity of 10 km/day, on an average (Beroza and Ide, 2011).

We obtained complementary field data in support of migration of crustal deformations or strain waves migrating at a similar velocity. The subsequent recordings of displacements associated with magnetic and gravity anomalies were monitored near active tectonic structures on the meridional geodynamic polygon across the northern boundary of the Amurian plate. Monitoring was conducted by a permanent geophysical network of 11 observation sites. The sites for magnetometric and gravimetric observations were spaced at no more than 100 meters. In different observation series, we noticed a coincidence in the time of occurrence and the direction of displacement of the gravity and magnetic anomalies as well as their subsequent site-to-site moving at velocities from 200 to 1200 km/yr (0.7-4.0 km/day).

A remarkably good coincidence in magnetic and gravity anomaly displacement velocities may imply a single source of disturbance of the stress state of the crust, migrating at a similar velocity and initiating tectonomagnetic and gravity effects. This source may be the migration of crustal deformations in the form of slow waves.

The annual cycle seismicity migration initiated by the east-west propagation of a strain wave front at an average velocity of 1000 km/yr (2.7 km/day) is also observed along the northern margin of the Amurian plate (Trofimenko et al., 2016).

Our new data on the spatiotemporal variation pattern for the magnetic and gravity anomalies, and their velocity correlation with seismicity migration on the northern margin of the Amurian plate are consistent with the concepts on slow strain waves as the main source of disturbance of the stress state of the crust.

A coincidence of magnetic and gravity anomaly displacement velocities with the migration velocity of weak earthquakes (Barabanov et al., 1994; Hill et al., 1995; Trofimenko et al., 2016), creep velocity (King et al., 1973), and tremor and slow slip (ETS) migration velocity (Beroza and Ide, 2011) is of fundamental importance. Achieving a breakthrough in physics of earthquakes may be expected just in this direction.

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