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New methodological aspects of using dendrochronological analysis for dating strong paleoearthquakes (by the example of SE Altai, Russia)

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Dendroseismology has a great potential in a paleoseismological investigation due to utmost precision of dating. Rings of trees – witnesses of seismic events contain both the evidence for the earthquake and its age. These evidences can be created by surface ruptures (sheared off tree roots and trunks, tilted and fallen trees etc.) or by earthquake induced geomorphic processes and/or seismic shaking (tree death or slower growth caused by lost of their crowns, tilted or buried trees caused by landsliding, as well as trees germination on bared surfaces) (McCalpin, 2009). Dendrogeomorphology (Stoffel, 2010) is another young and promising approach which among others studies different aspects of rock fall activity on the basis of wood penetrating injuries of trees. It should be underscored that both techniques are used most efficiently just on times that cover the life span of the last forest stand (about 300-500 years).

The main idea of our approach of using dendrochronological analysis for timing strong paleoearthquakes is analyzing of tree-ring anomalies caused by specifically seismically triggered rock falls during the prolonged time interval. SE part of Russian Altai, in this case, is a unique place: 1) seismically induced slope processes intrude into forest stand zone in an immediate vicinity with the modern upper timber limit (which is favorable for carrying out the dendrochronological analysis); 2) arid climate promotes good preservation of wood (up to two thousand years on stone surfaces); 3) 2367-years absolute tree-ring chronology “Mongun” has been developed for SE Altai and Tuva regions (Myglan et al., 2012).

We tested this approach during our paleoseismological investigations at the previously unknown complex of earthquake triggered landslides on the northern part of the Chagan-Uzun massif. The south fault boundary of this block was reactivated at the time of the 2003 Chuya earthquake (s=7.3). We developed 1153 years (856 -2009 AD) local tree ring chronology on Pinus sibirica for this area. In order to provide absolute dates of paleoearthquakes we analyzed the ages of penetrating tree injuries caused by rock falls. Simultaneity of these injuries sustained by trees which grew on different earthquake induced landslides was accepted as a criterion of their seismic origin. The accuracy of such an approach was supported by data obtained from analyzing injuries occurred on trees as a result of rock falls triggered by the 2003 Chuya earthquake.

In addition to estimating the upper possible date of creation of this complex of earthquake triggered landslides we have also established with the annual resolution the date of previously unknown strong medieval earthquake. This dendrochronologically obtained data has been independently verified by radiocarbon dating of seismically cut fossil soil overlapped by that undistorted. New data also allows us to specify the recurrence interval of strong earthquakes for SE Altai. Beside the obvious applied importance for local paleoseismological investigations the suggested approach can be used for timing strong paleoearthquakes for regions where instrumental seismic records or historical accounts are not available.