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A New Low to Ultrahigh-Velocity Hydrothermal Friction Apparatus for Studying the Effects of Fluids on Rock Friction

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Recent development in high-velocity friction (frictional properties of faults at high velocities and large displacements during seismogenic fault motion) clearly brought about a need for a wide slip-rate hydrothermal friction apparatus. There are cases for natural faults where frictional melting does not occur, but thermal pressurization is less effective. In such cases, chemical tribology (enhanced interfacial reaction fostered by frictional heating) can be an alternative mechanism for dramatic slip weakening at high velocities. No mechanical data have been collected on such effects on rock friction although tribochemistry is already an established filed in tribology.

Another need for such an apparatus is to study rock friction at intermediate velocities. Old laboratory data on halite shear zone (Shimamoto, 1986) indicate that velocity weakening behavior changes to velocity strengthening at slip rates on the order of a few tenths of mm/s. Such velocity strengthening will definitely stabilizes fault motion and may counteract against the onset of a large earthquake immediately after earthquake c\nucleation along a fault. This point has been confirmed by simulation of fault motion. However, there is a gap in slip rate of a mm to about a hundred mm between conventional apparatus and our high-velocity frictional apparatus, and intermediate slip-rate regime is a totally unexplored filed.

A new friction apparatus was developed in Kyoto to cover wide slip rates, from 3 mm/yr to about 10 m/s, by using four sets of gear arrangements. An ultrahigh velocity arrangement using two sets of belts increases rate of revolution by nine times and allows to produce such a high slip rate. Pressure vessel made of stainless steel can hold water pressure up to about 50 MPa, by using a 6 sets of high-velocity seals across which water pressure is reduced in a stepwise manner to keep pressure difference across each seal below about 10 MPa. Since hollow-cylindrical specimens are used without jackets, water pressure in the vessel acts as pore pressure and normal stress to fault is applied with a hydraulic press. An external furnace will produce temperature to around 400 degrees Celsius, thereby producing supercritical condition. Constitution of machine together with preliminary results will be presented.