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Influence of intensive parameters and assemblies on friction evolution during piston-cylinder experiments

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Abstract

Piston-cylinder assemblies exhibit inhomogeneous pressure distributions and biases compared to the theoretical pressure applied to the hydraulic press because of the thermal and mechanical properties of the assembly components. Whereas these effects can partially be corrected by conventional calibration, systematic quantification of friction values remain very sparse and results vary greatly among previous studies. We performed an experimental study to investigate the behavior of the most common cell assemblies, i.e., talc [$Mg_3Si_4O_{10}(OH)_2$], NaCl, and $BaCO_3$, during piston-cylinder experiments to estimate the effects of pressure, temperature, run duration, assembly size, and assembly materials on friction values. Our study demonstrates that friction decreases with time and also partially depends on temperature but does not depend on pressure. We determined that friction decreases from 24 to 17% as temperature increases from 900 to 1300 °C when using talc cells, indicating a friction decrease of ~2% per 100 °C increase for 24 h experiments. In contrast, friction becomes independent of time above 1300 °C. Moreover, at a fixed temperature of 900 °C, friction decreases from 29% in 6 h runs to 21% in 48 h runs, corresponding to a decrease of friction of 0.2% per hour. Similar results obtained with NaCl cell assemblies suggest that friction is constant within error, from 8% in 9 h runs to 5% in 24 h runs. At 900 °C, possible steady-state friction values are only reached after at least 48 h, indicating that friction should be considered a variable for shorter experiments. We establish that assembly materials (and their associated thermomechanical properties) influence the friction correction more than the dimensions of the assembly parts. Finally, we show that the use of polytetrafluoroethylene film instead of conventional Pb foil does not modify friction but significantly reduces the force required for sample extraction, thus increasing the lifetime of the carbide core, which in turn enhances experimental reproducibility.

Keywords: Experimental petrology, piston-cylinder, friction, assembly, calibration