Supplemental Material for "Velocity-Independent Dry Friction on Mica: Realization of Ideal Amontons-Coulomb Friction"

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This file includes supplemental materials for the detail in experimental conditions, relationship between shear stress and normal stress, friction coefficients of mica at 65 and 100ºC, the results of slide-hold-slide tests at 22 and 200ºC, available temperature dependence of the "*a*" parameter for various materials, and the detail in molecular dynamics simulations.

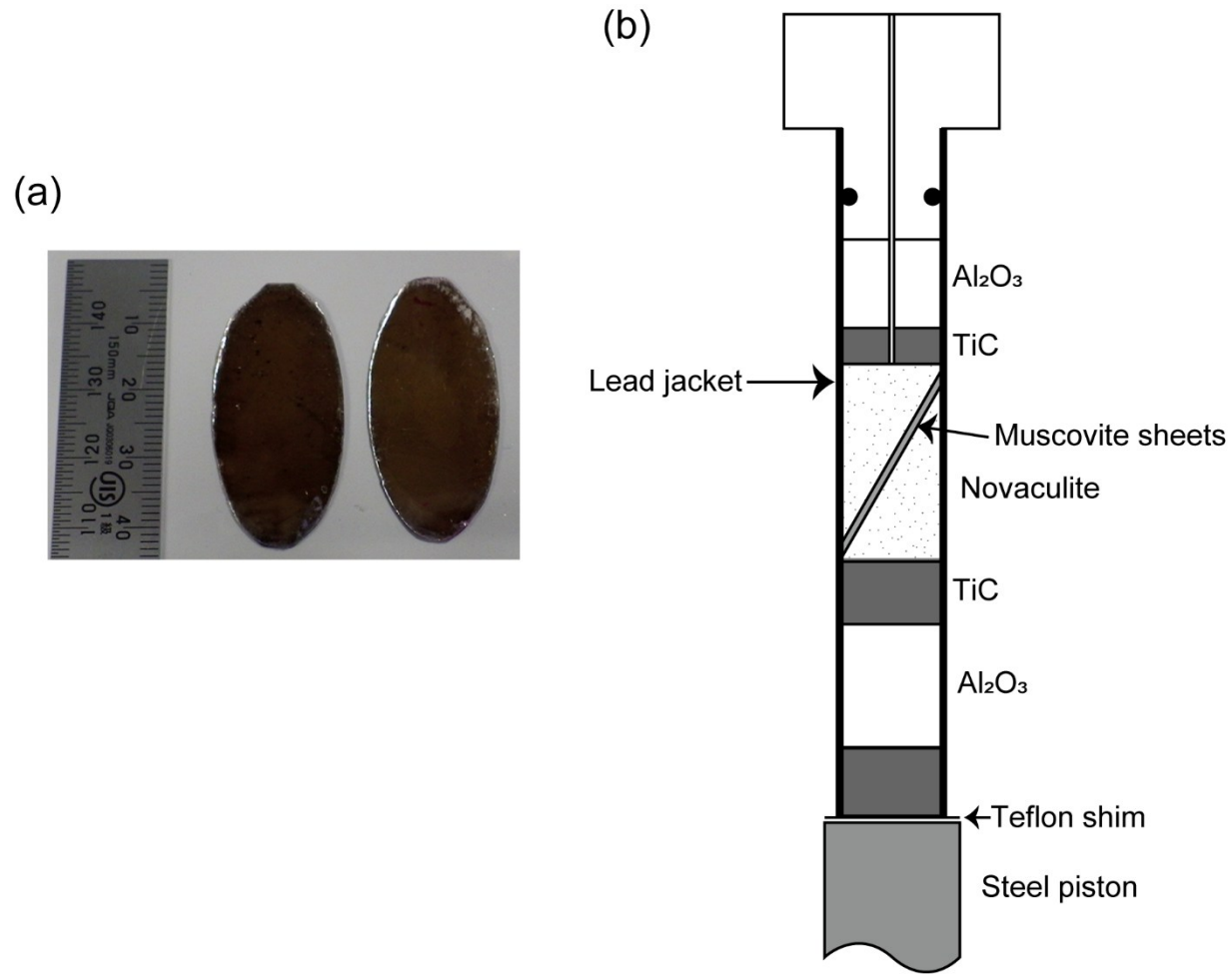

FIG S1. (a) Single-crystal mica sheets. (b) Cross section of the sample assembly with mica sheets between 30º sawcut novaculite driving blocks. During the experiments, the sample column was continuously evacuated through a 1.6 mm-diameter axial hole that extends to the upper porous novaculite driving block.

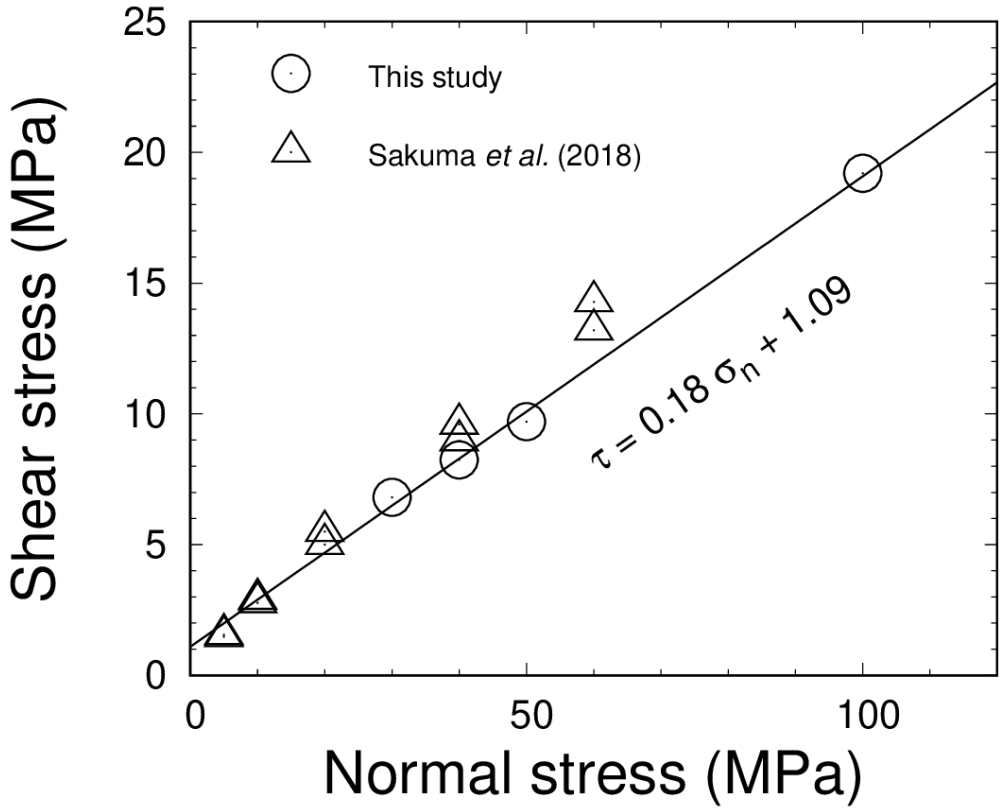

Fig. S2 Relationship between shear stress and normal stress of single-crystal mica measured using a triaxial shear apparatus in this study and a double-direct shear apparatus in a previous study [21] under room-temperature and dry conditions. The equation shown in the figure represents a linear fit to the data obtained in this study.

TABLE S1. Conditions of triaxial shear experiments and obtained "*a*" parameter.

Sample no.	Temperature (ºC)	Normal stress (MPa)	Experimental type	*a*
HS11	22	100	Velocity-stepping	0.0058 (0.0011)
HS14	65	100	Velocity-stepping	0.0028 (0.0005)
HS13	100	100	Velocity-stepping	0.0005 (0.0002)
HS12	200	100	Velocity-stepping	<0.0001 (0.0002)
HS15	22	100	Slide-hold-slide	-
HS16	200	100	Slide-hold-slide	-

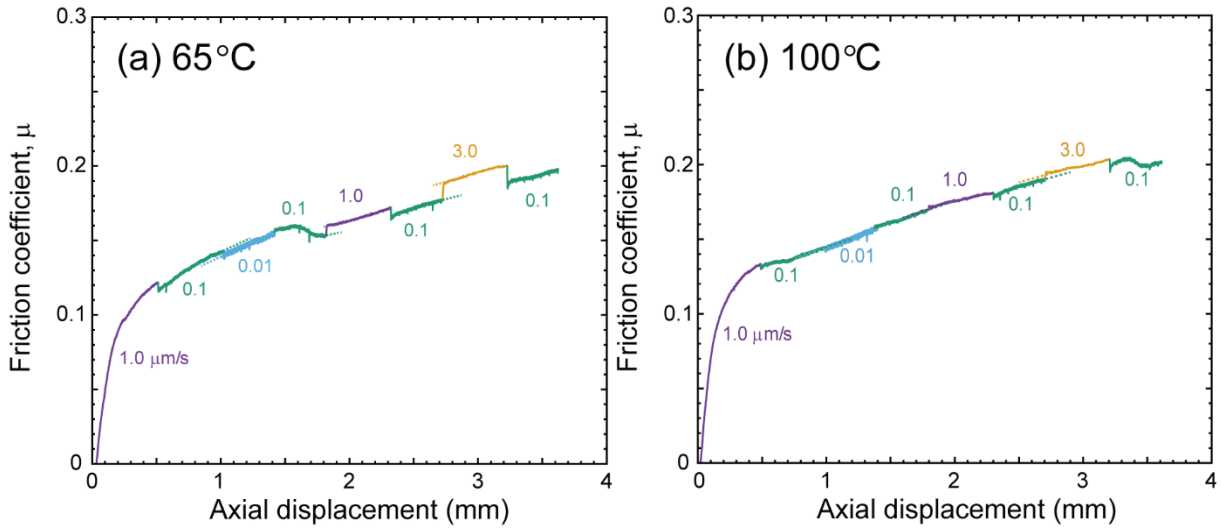

FIG S3. Friction coefficients of mica obtained from velocity-step tests at 65ºC (a) and 100ºC (b). The numbers near the lines indicate the sliding velocity parallel to the shear planes (μm/s). Dotted lines indicate the baseline of the steady-state friction used to calculate the difference in the friction coefficients before and after the velocity change.

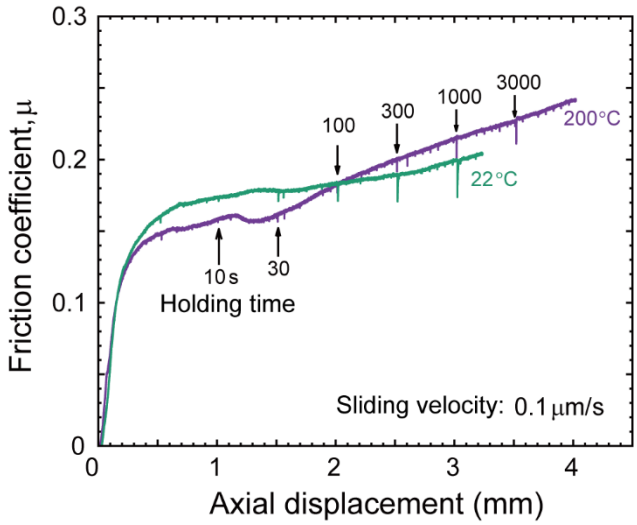

FIG S4. Friction coefficients of mica obtained from slide-hold-slide tests at 22ºC and 200ºC.

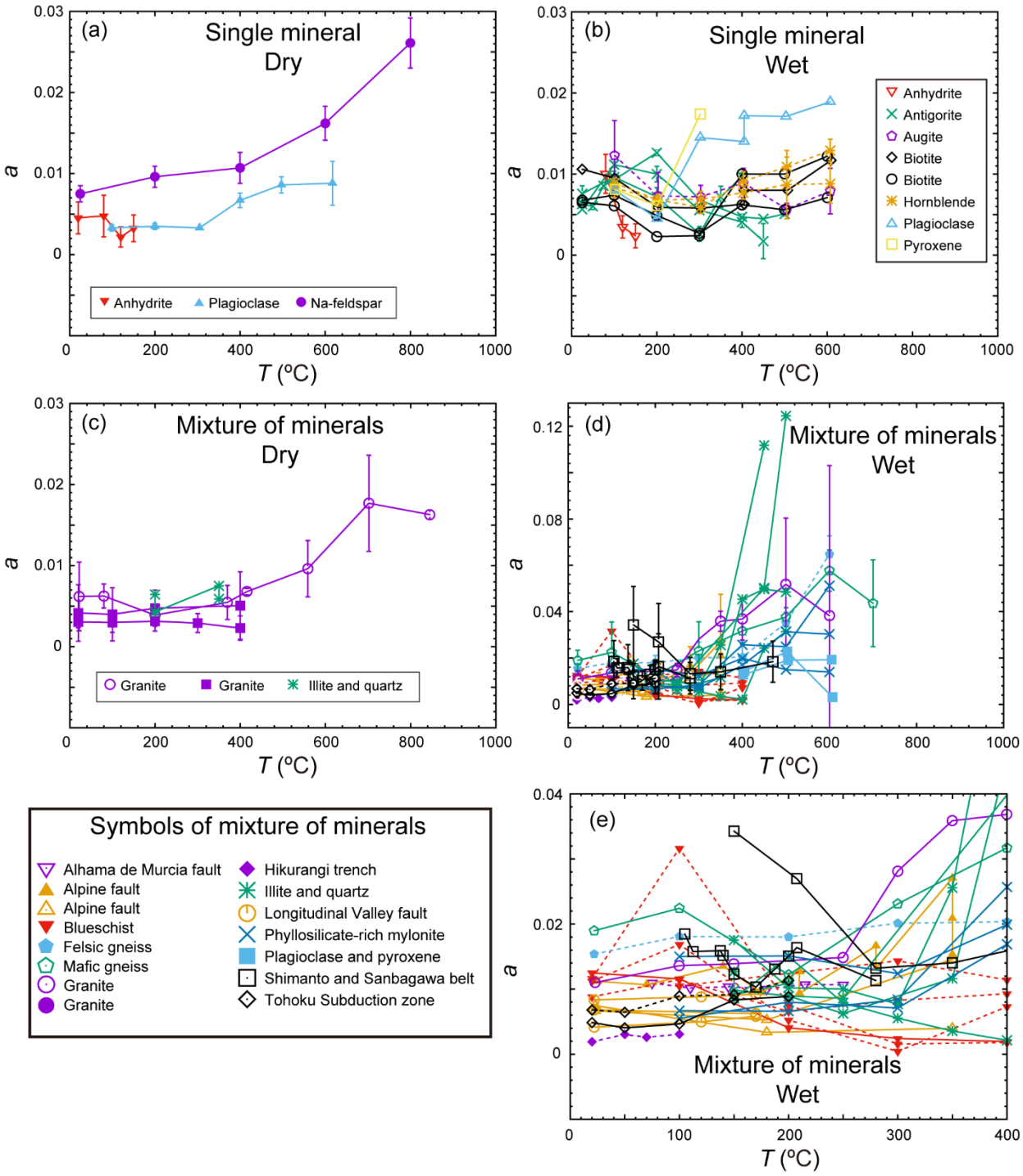

FIG S5. Available temperature dependence of the "*a*" parameter for simulated gouges composed of a single mineral under dry (a) and wet (b) conditions, and a mixture of minerals under dry (c) and wet (d and e) conditions. The data was cited from the literature (anhydrite [35], plagioclase [36,37], Na-feldspar [31], antigorite [38], augite [39], biotite [40,41], hornblende [42], granite [16,43], illite and quartz [44], Alhama de Murcia fault [45], Alpine fault [46,47], blueschist [48], felsic gneiss [49], mafic gneiss [49], Hikurangi trench [50], Longitudinal Valley fault [51], phyllosilicate-rich mylonite [52], Shimanto and Sanbagawa belt [53], Tohoku subduction zone [54]).

Non equilibrium molecular dynamics (NEMD) simulations—Classical molecular dynamics simulations were conducted by using in-house program, MXDTRICL. Muscovite is a 2:1 type sheet-silicate mineral, consisting of an [AlO_6] dioctahedral sheet sandwiched between two [$(Si,Al)O_4$] tetrahedral sheets. One-fourth of the Si^{4+} ions are replaced by Al^{3+} ions in the tetrahedral sheets and the negative charge of the sheets is compensated by the interlayer K^+ ions. Force field of muscovite used in this study is an interatomic potential model, and it has been developed to reproduce the muscovite structure and physical properties [32-34]. The calculated lattice parameters of $2M_1$ muscovite by this model are a = 5.159 Å, b = 8.966 Å, c = 20.065 Å, and b = 95.3º at 27ºC and 0.1 MPa. The electrostatic Coulomb interaction was calculated by using the Ewald method [55]. The differential equation of motion was solved by the velocity-Verlet algorithm with a time increment of 0.4 femtosecond (fs). Equilibrium lattice constants were obtained by *NPT* ensemble simulations at pressures of 6 GPa and temperatures of 27, 100, and 200ºC. The equilibrium lattice constants were used for initial structures for subsequent shear simulations. Dislocation-free and ripplocation-bearing supercells at 27ºC before the shear were a = 25.48 Å, b = 26.48 Å, c = 19.19 Å, b = 95.1º, and a = 167.1 Å, b = 26.35 Å, c = 39.58 Å, b = 94.9º, respectively. Two ripplocations were included in the ripplocation-bearing supercell; they were built with the length of 34 units of a in the primitive cell on two straight layers with the length of 165 Å in a direction (32 units of a in the primitive cell). By applying hydrostatic pressure, the initial structure for shear simulations was obtained. Shear direction and plane were fixed to <100> and (001), respectively. Shear strain was applied by tilting the c-axis of the supercell with the shear rates of 10^9, 10^{10}, and 10^{11} s^{-1}. Friction coefficients as a function of strain were calculated by simply dividing the shear stress by normal stress.