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Supporting Information for

Pressure-Stimulated Rock Current as Loading Diorite to Failure: Particular Variation and Holistic Mechanisms

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Contents of this file

Text S1.

Simulation of stress distribution and microcracks growth. The Grain-Based Discrete Element Modelling (GB-DEM) method [1] was used to simulate the initiation and growth of microcracks in the process of loading the diorite specimen to failure by using the programs PFC2D. First, as shown in Fig. S5a, the initial two-dimensional grain structure model was created according to the contents and sizes of four main minerals embedded in diorite specimen (Fig. S1, Table S2), and the generated disks has been divided into four groups accordingly. By connecting the centers of the disks that share the same contact points, multiple convex polygons are formed correspondingly (black solid lines). Second, the centroids of convex polygons were calculated and illustrated by the red dots in Fig. S5b. Third, by connecting the red dots of polygons that share the same edge (blue solid lines in Fig. S5c), a new polygonal mesh was formed (yellow solid lines). Then, all of the original disks in the initial model were deleted and the remaining convex polygons corresponds to the mineral grains (Fig. S5d). Lastly, each newly formed convex polygon was filled with new disks, of which the scale is much smaller than that of polygon; thereby, the geometric model with polygon grain structure reflects the distributions of different mineral crystals (Fig. S5e and 5f). There are no gaps between polygons - each polygon edge is either internal (adjacent to two polygons) or external (adjacent to one polygon) such that each polygon and internal edge correspond with a grain and a grain-grain interface, respectively.

Based on the modulus and Poisson’s ratio of minerals given in Table S1, “trial and error” method was used for calibrating the mechanical parameters of the filled small disks in Fig. S5e, such that the established numerical model matches the macroscopic response and most of the mechanisms that occur during compression test on diorite specimen. Besides, material properties are associated with the grains and the interfaces such that both entities are deformable and capable of fracturing. The calibrated results are listed in Table S3. The overall macro-properties of simulations and experiments are well agreed.

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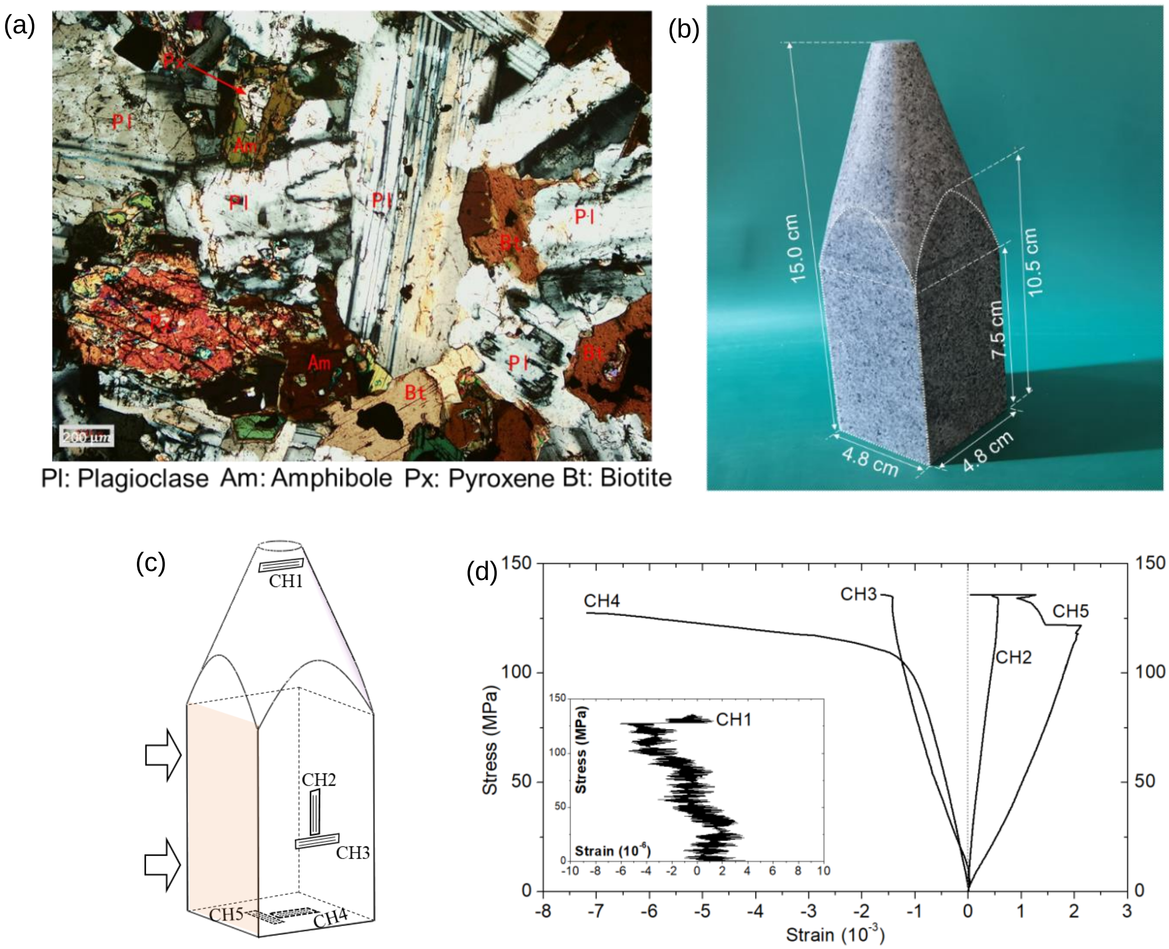

Figure S1. Preparation of rock specimen. **(a)** thin section of diorite with cross light **(b)** bar-shaped diorite specimen with a conical head **(c)** the strain gauges pasted on the specimen surface, CH2 and CH3 are pasted on side surface, CH4 and CH5 are pasted on underside surface. **(d)** the stress-strain curves of specimen in process of axially loading to failure.

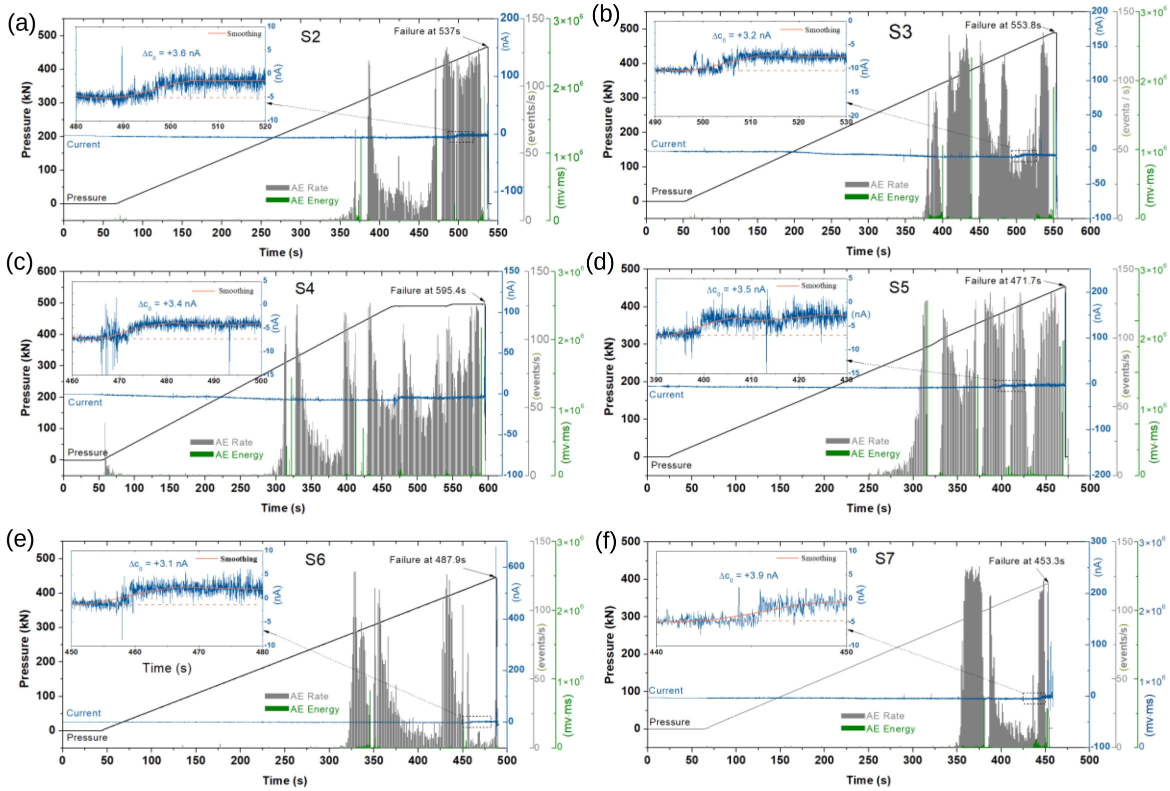

Figure S2. Detected PSRC and AE signals of diorite specimens S2 - S7, corresponding **(a) - (f)** respectively.

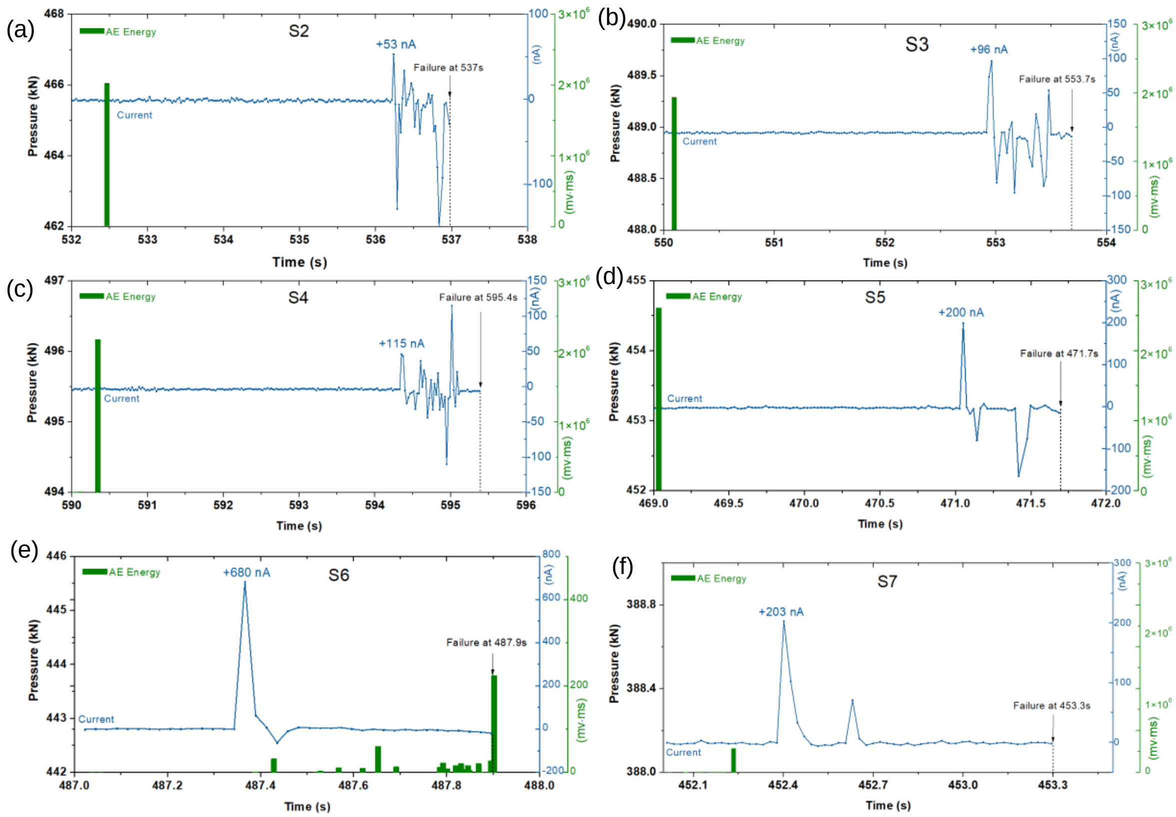

Figure S3. PSRC variations during several seconds prior to the rock failure for specimens S2-S7, corresponding **(a) - (e)** respectively.

(a)

(b)

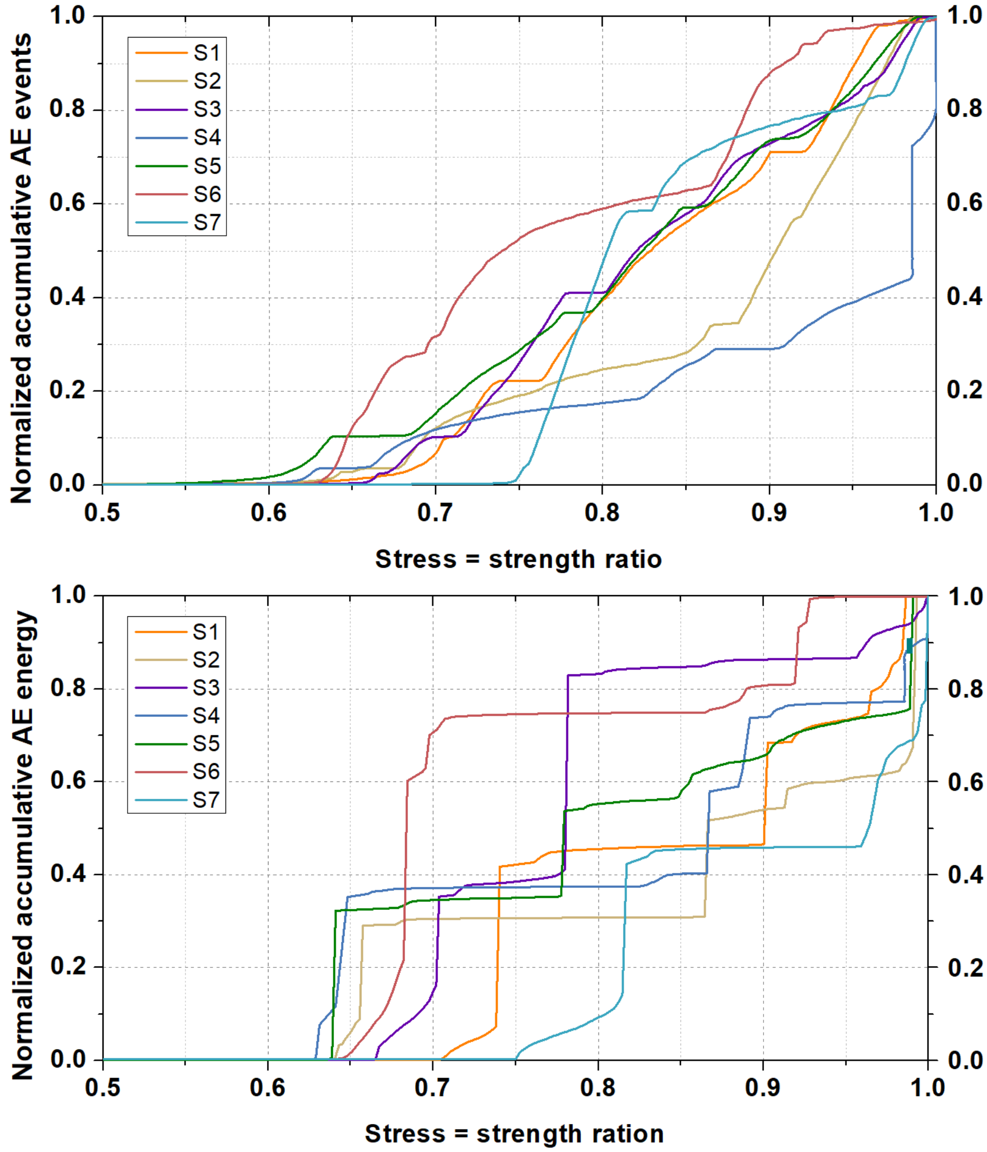

Figure S4. Relationships between the applied stress and **(a)** the accumulative AE events and **(b)** the accumulative AE energy

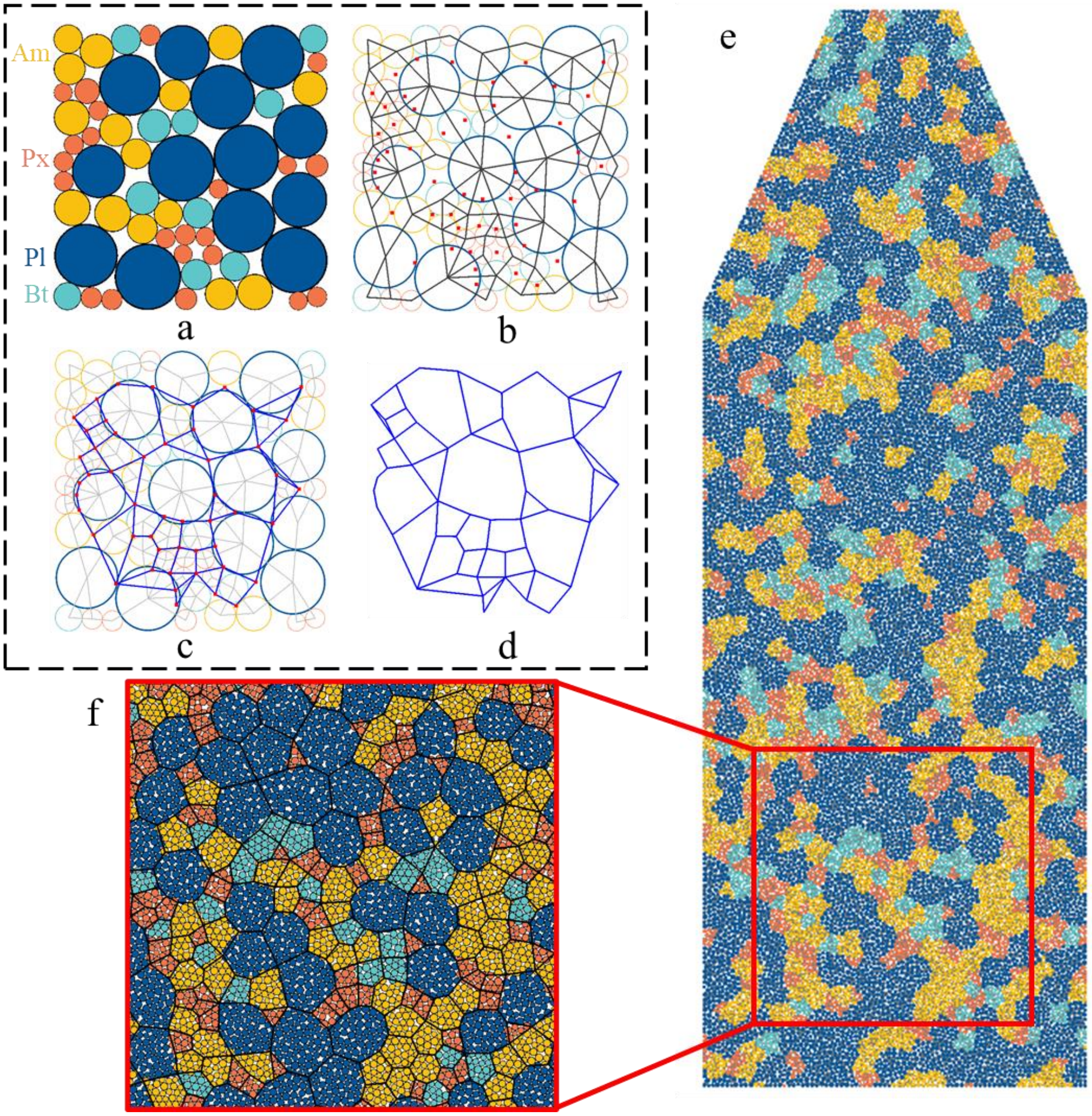

Figure S5. Construction process of grain-based discrete element method (GB-DEM). **a**. initial disk packing showing disks and contacts, where Am, Px, Pl and Bt represent four main minerals in diorite specimen that illustrated in Fig. S1. **b**. filled dots (red) at internal-void centroids. **c**. grain structure consisting of polygons, one for each internal disk, with nodes at internal-void centroids. **d**. generated polygon mesh. **e**. two-dimensional numerical model of diorite specimen in our experiment. f, enlarged polygon mesh with filled particles.

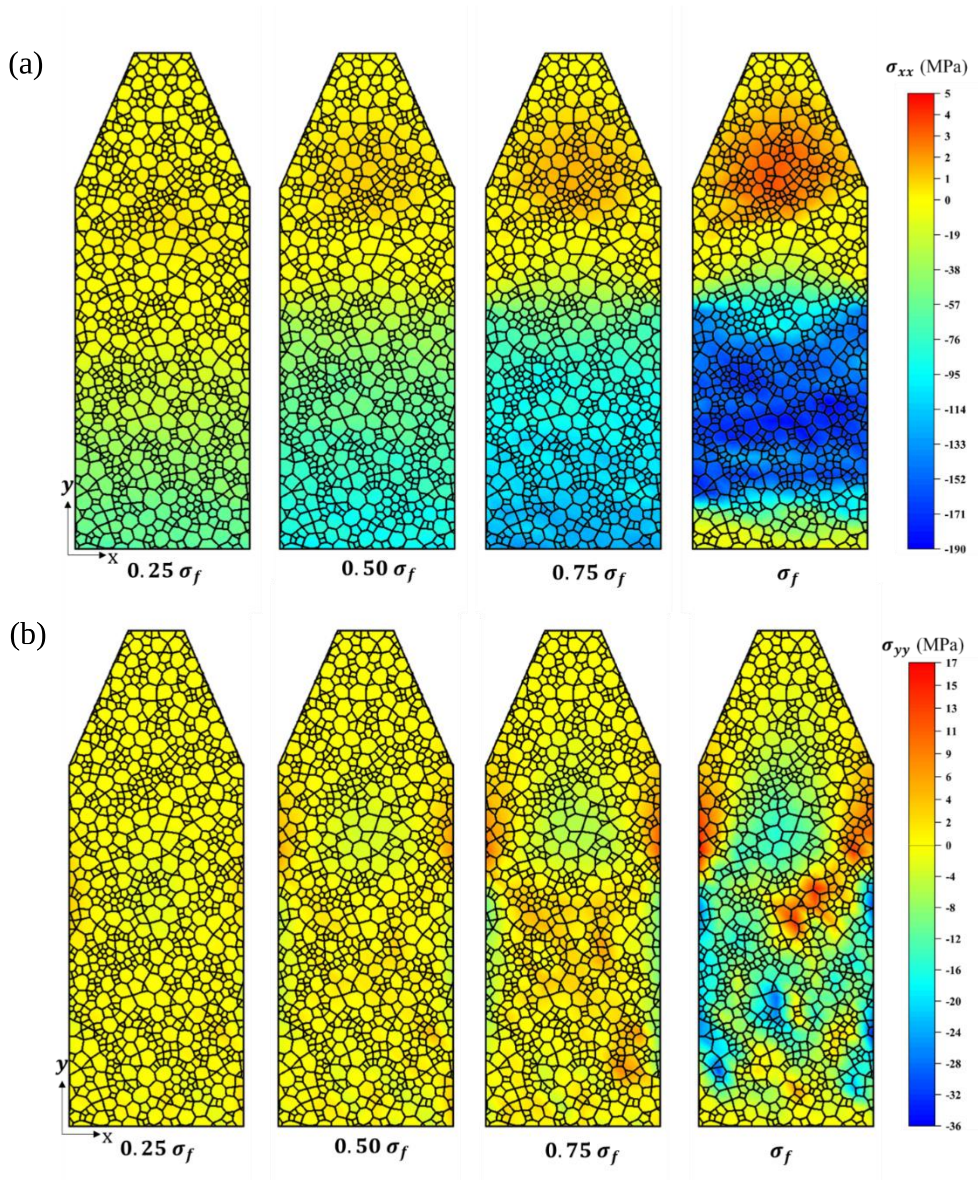

Figure S6. Results of numerical simulation (with particle flow model) for the distribution of stresses in the loaded diorite specimen. **(a)** the stress distribution at x direction; **(b)** the stress distribution at y direction.

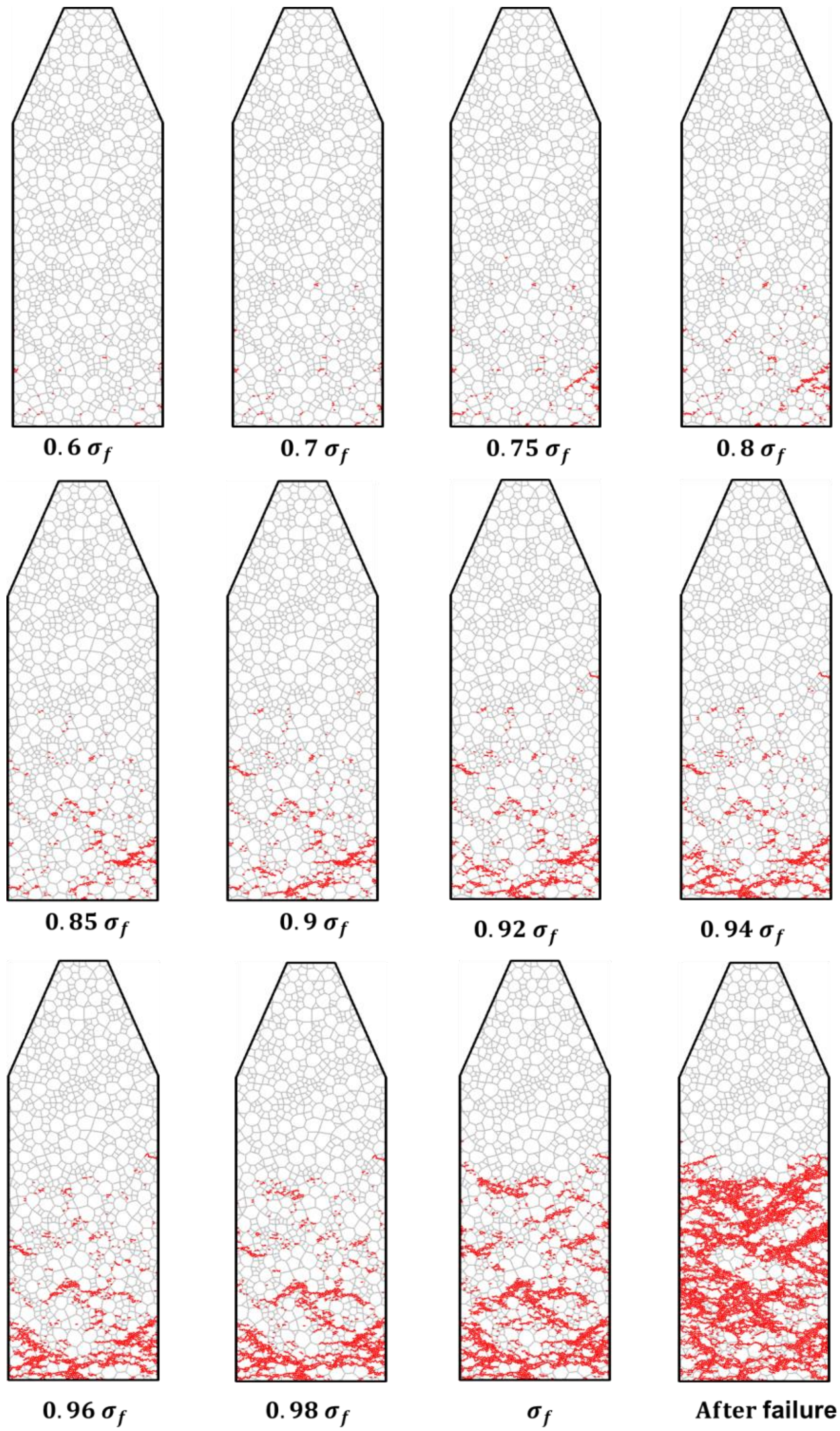

Figure S7. Results of numerical simulation (with particle flow model) for growth and propagation of microcracks in process of loading specimen to failure. $\boldsymbol{\sigma_f}$ represents the failure strength

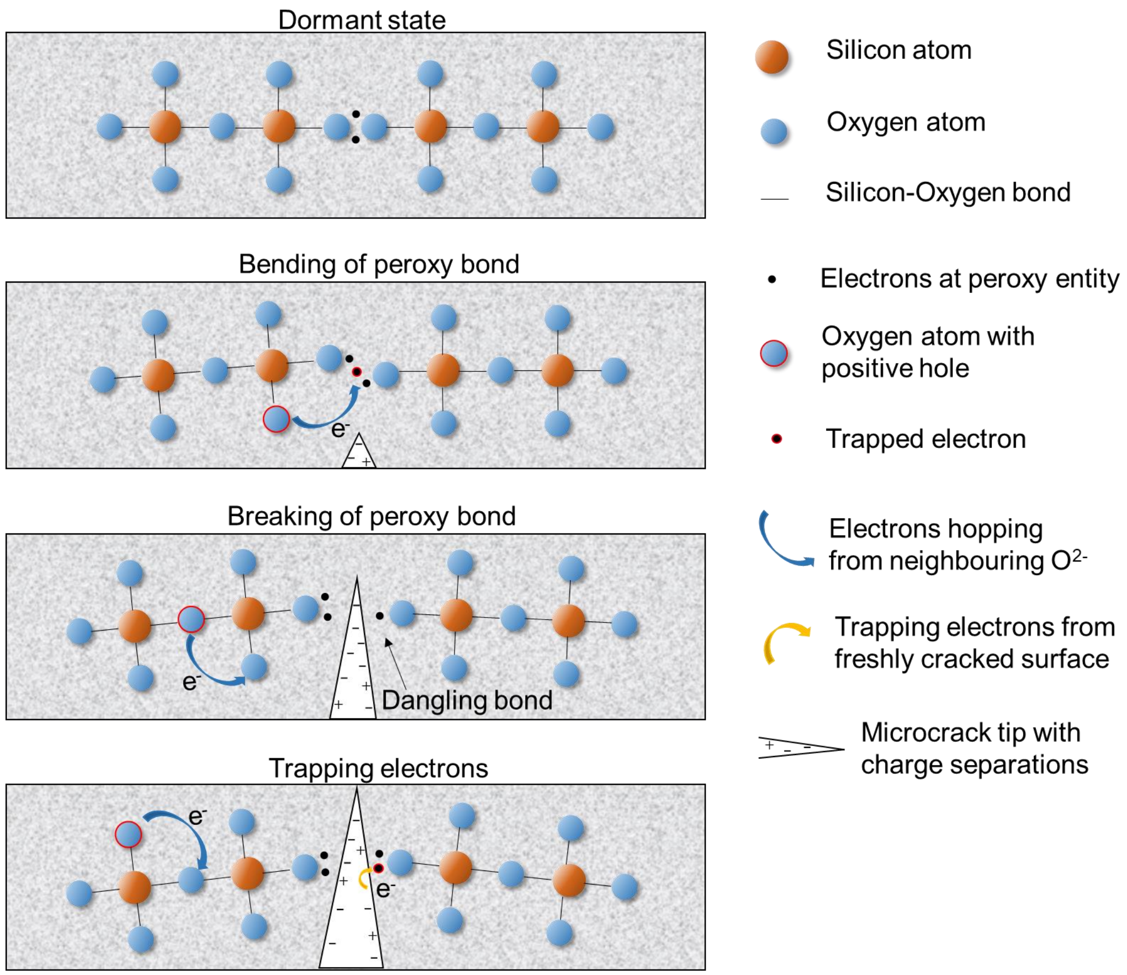

Figure S8. The schematic for illustrating the influences of growth of microcracks on the bending and breaking of proxy bond.

Specimen	σ_f (MPa)	*R*	ΔC_0 (nA)	ΔC_{1+}(nA)	$T_F - T_1$ (s)
S1	128.27	91.6%	+4.1	+114	0.48
S2	138.99	90.3%	+3	+53	0.78
S3	145.54	89.1%	+3	+96	0.89
S4	147.32	98.7%	+3.4	+115	1.11
S5	135.12	83.7%	+3.5	+199	0.64
S6	132.14	91.9%	+3.1	+682	0.61
S7	115.48	96.9%	+3.5	+203	0.95

R represents the strength ratio at which the PSRC of each specimen began to rise in a step-like way, ΔC_0 represents the increment amplitude of step-like rise in PSRC, ΔC_{1+} represents the increment amplitude of first positive fluctuations in PSRC prior to specimen failure, T_F represents the time of the specimen failure, T_1 represents the time of the first positive fluctuation in PSRC prior to specimen failure.

Table S1. The detected PSRC variations in experiments.

		Plagioclase	Hornblende	Pyroxene	Biotite
Physical properties					
Volume composite	V_{ratio}	60%	20%	10%	10%
Density	ρ (kg/m^3)	2620	3124	3260	3050
Modulus	E (GPa)	37.5	87	94.1	51
Poisson's ratio	μ	0.32	0.29	0.25	0.27
Sizes					
Minimum grain size	d_{min} (mm)	4.0	2.2	2.0	1.4
Maximum/Minimum	d_{max}/d_{min}	1.4	1.27	1.2	1.14

Table S2. Physical properties and size of particles for different mineral materials.

		Plagioclase	Hornblende	Pyroxene	Biotite
Balls					
Minimum radius	R_{min} (mm)	0.25			
Radius ratio	R_{max}/R_{min}	1.66			
Density	ρ (kg/m^3)	2620	3124	3260	3050
Young Modulus	E_{ball} (GPa)	33.5	68.0	78.0	56.0
Stiffness ratio	k_n/k_s	2.3	1.9	1.4	1.8
Friction coefficient	μ	0.5	0.5	0.5	0.5
Transgranular contacts					
Young Modulus	$E^c_{tra.}$ (GPa)	33.5	68.0	78.0	56.0
Stiffness ratio	$\bar{k}^{tra.}_n/\bar{k}^{tra.}_s$	2.3	1.9	1.4	1.8
Friction angle	$\varphi_{tra.}$ (degree)	10.0	15.0	15.0	10.0
Cohesion strength	$c_{tra.}$ (MPa)	100.0	80.0	110.0	50.0
Tension strength	$\sigma^t_{tra.}$ (MPa)	70.0	60.0	80.0	40.0
Intergranular contacts					
Linear Young Modulus	$E^c_{int.}$ (GPa)	20.0			
Linear stiffness ratio	$k^{int.}_n/k^{int.}_s$	2.9			
Parallel Young Modulus	$E^{pb}_{int.}$ (GPa)	20.0			
Parallel stiffness ratio	$\bar{k}^{int.}_n/\bar{k}^{int.}_s$	2.9			
Friction angle	$\varphi_{int.}$ (degree)	40.0			
Cohesion strength	$c_{tra.}$ (MPa)	35.0			
Tension strength	$\sigma^{int.}_t$ (MPa)	30.0			

Table S3. Calibrated parameters for different mineral materials in GB-DEM.

SI References

D. O. Potyondy. A grain-based model for rock: approaching the true microstructure. Proceedings of rock mechanics in the Nordic Countries, 9-12.