Identification of reactive aggregates

Alkali-Aggregate Reaction

- Problematic siliceous aggregate are easy to identify but it is very challenging to characterize reactive silicate aggregates.

- The use of extinction angle is not reliable test

Scientific question:

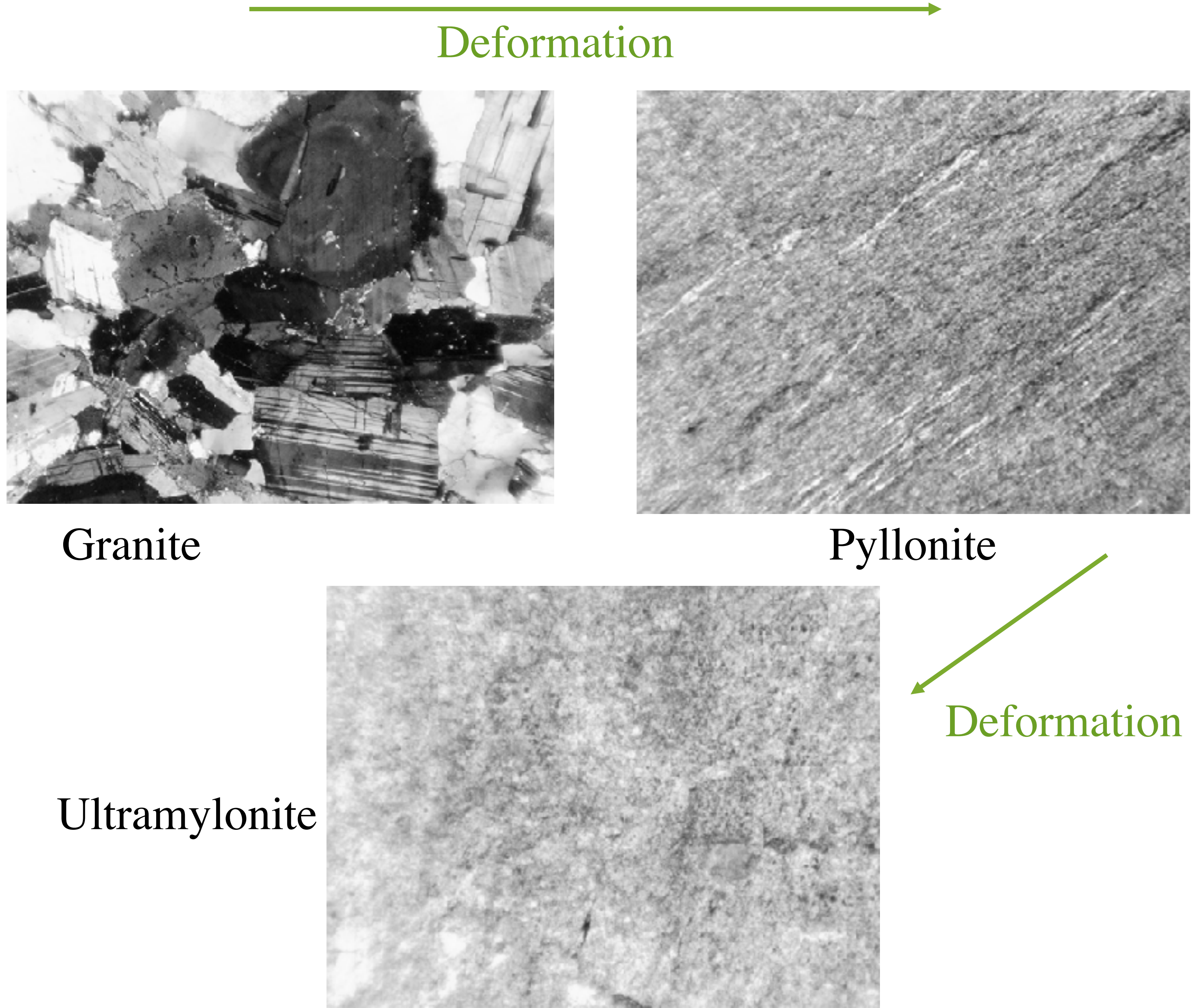
How does amount of deformation in the aggregate affect its reactivity?

Our approach:

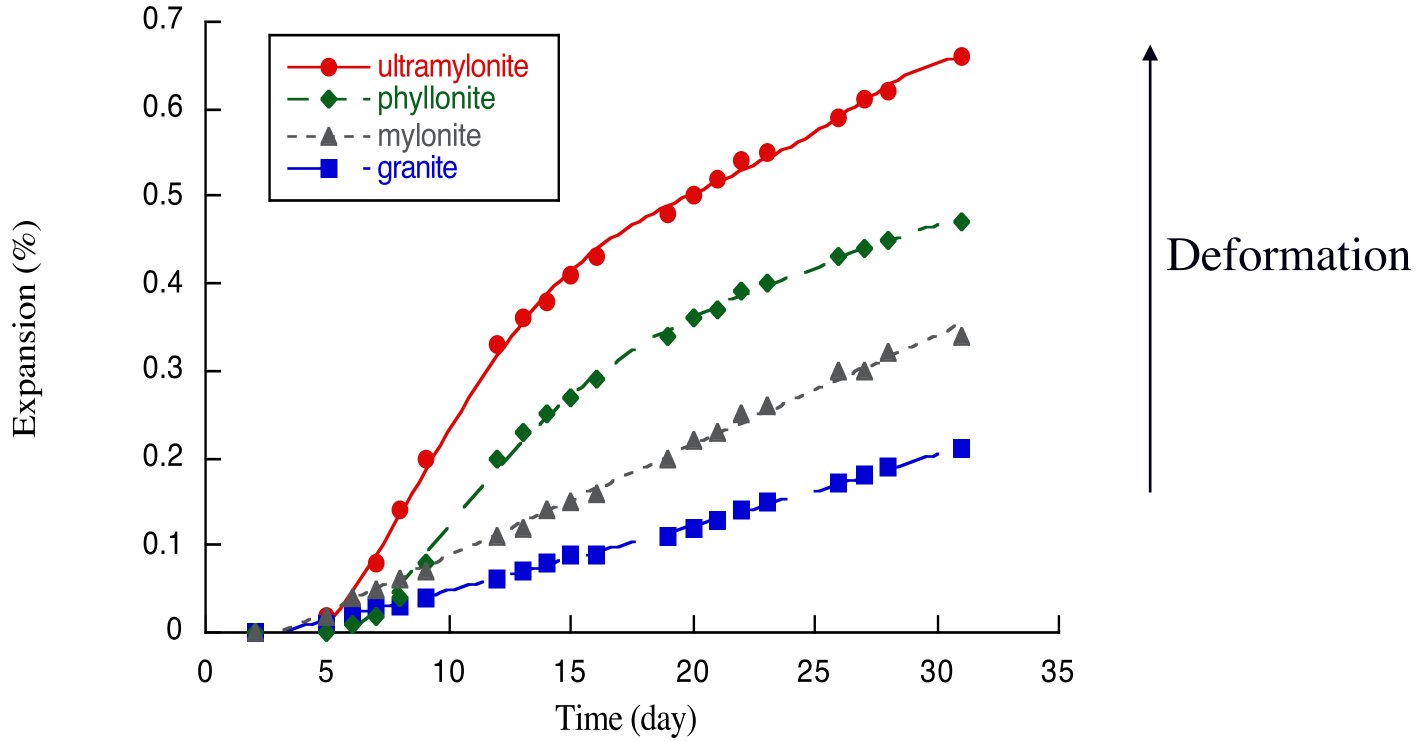
Use neutron diffraction experiments

Materials

In an interesting location in the earthquake zone of Santa Rosa near Los Angeles, we collected granodiorite, mylonite, phylonite, and ultramylonite with the same chemistry but different amount of deformation.

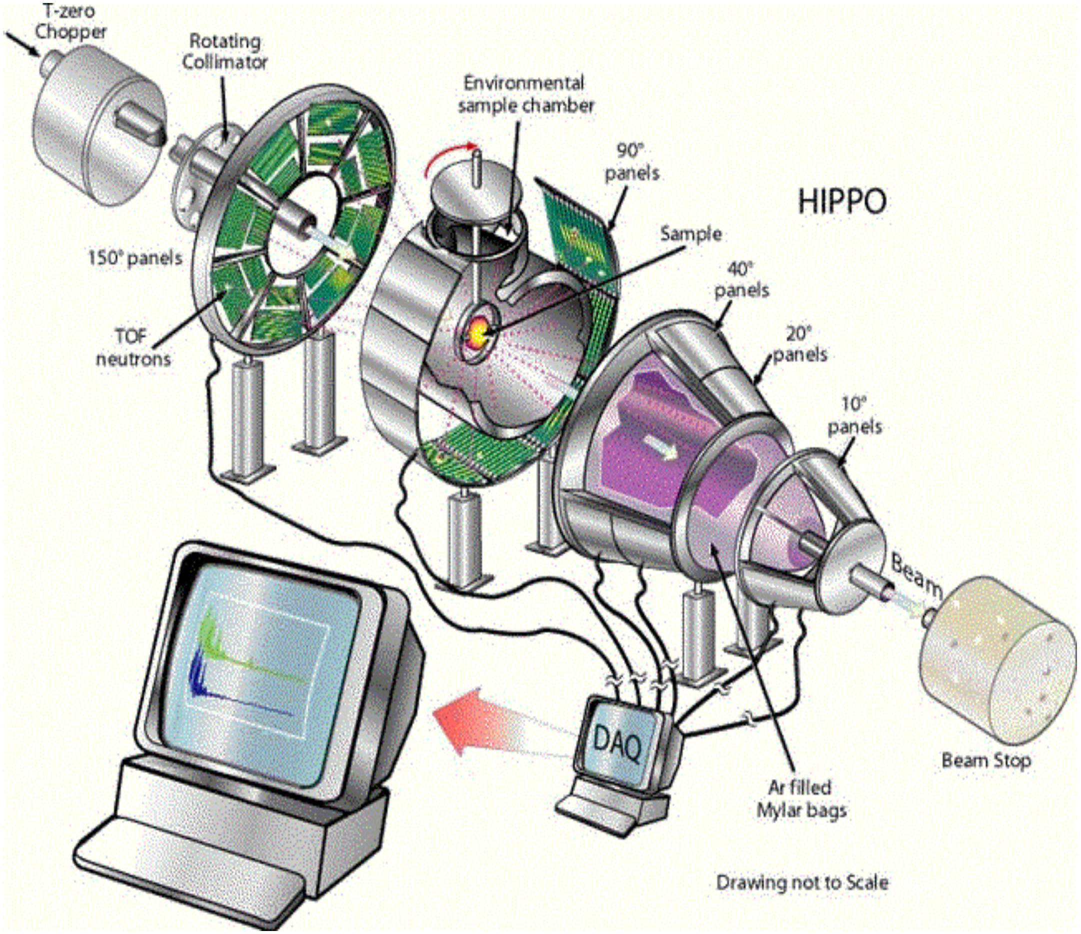

Deformation
Granite
Pyllonite
Deformation
Ultramylonite

Expansion

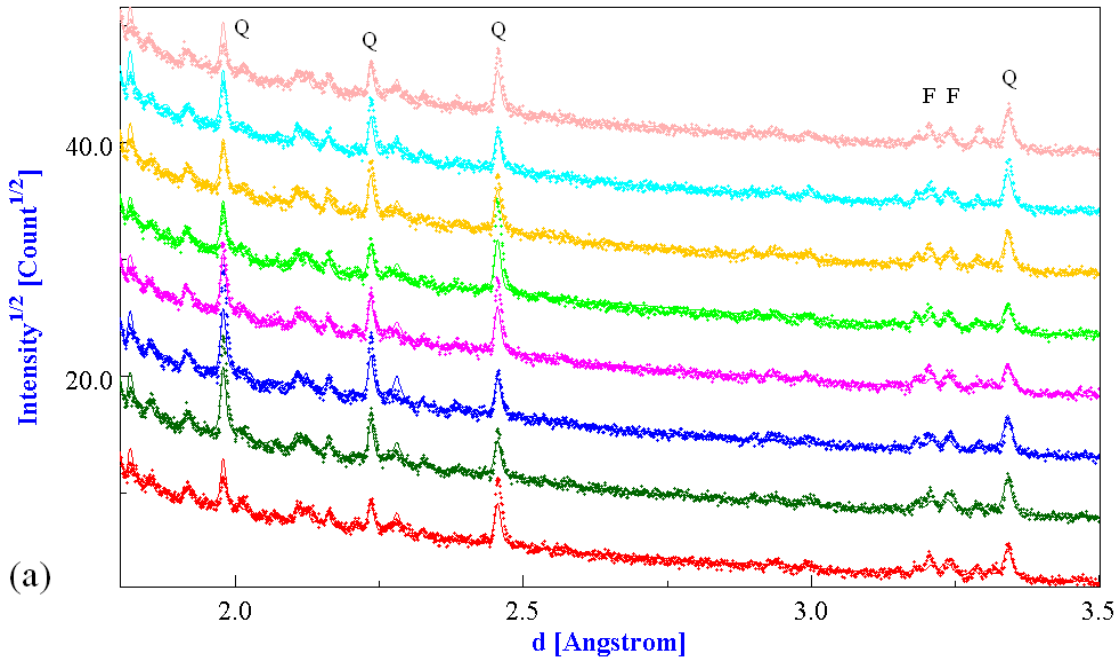


Note: all rocks had the same chemical composition

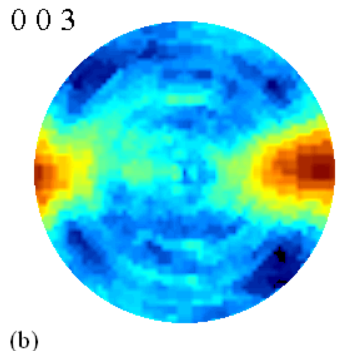
Determination of deformation in reactive aggregate



Neutron diffraction study of preferred orientation in mylonite

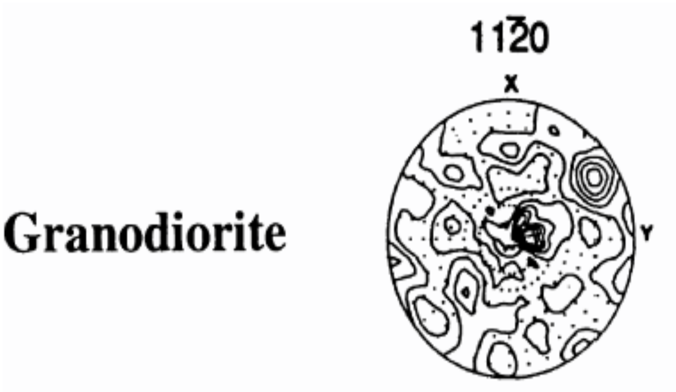


(a) Diffraction spectra illustrating intensity variations due to texture (Q quartz, F feldspar).



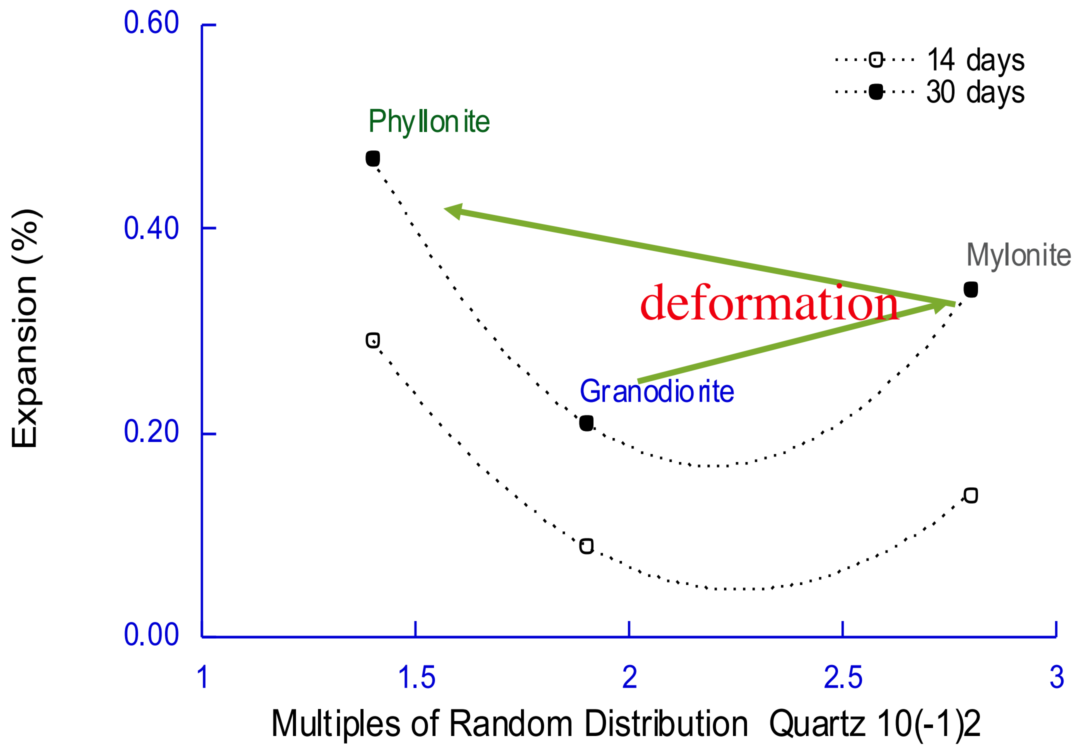
(b) Quartz (001) pole figure.

Texture Analysis – Quartz

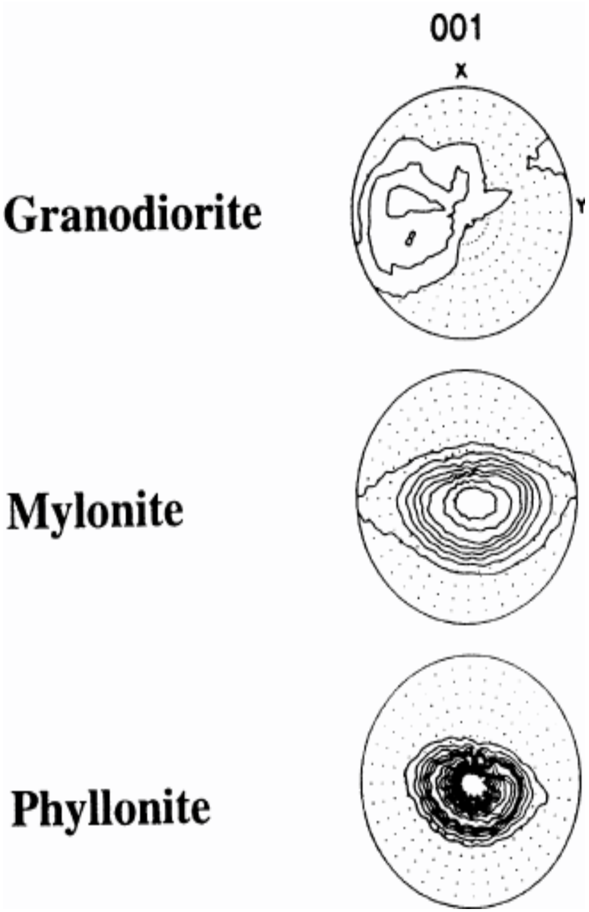


Monteiro, P.J.M., K. Shomglin, H.R. Wenk and Nicole P. Hasparyk, “Effect of Aggregate Deformation on the Alkali-Silica Reaction,” *ACI Materials Journal*, **V98** (N2): 179-183, Mar-Apr 2001.

Mortar Bar Expansion



Texture Analysis – Biotite



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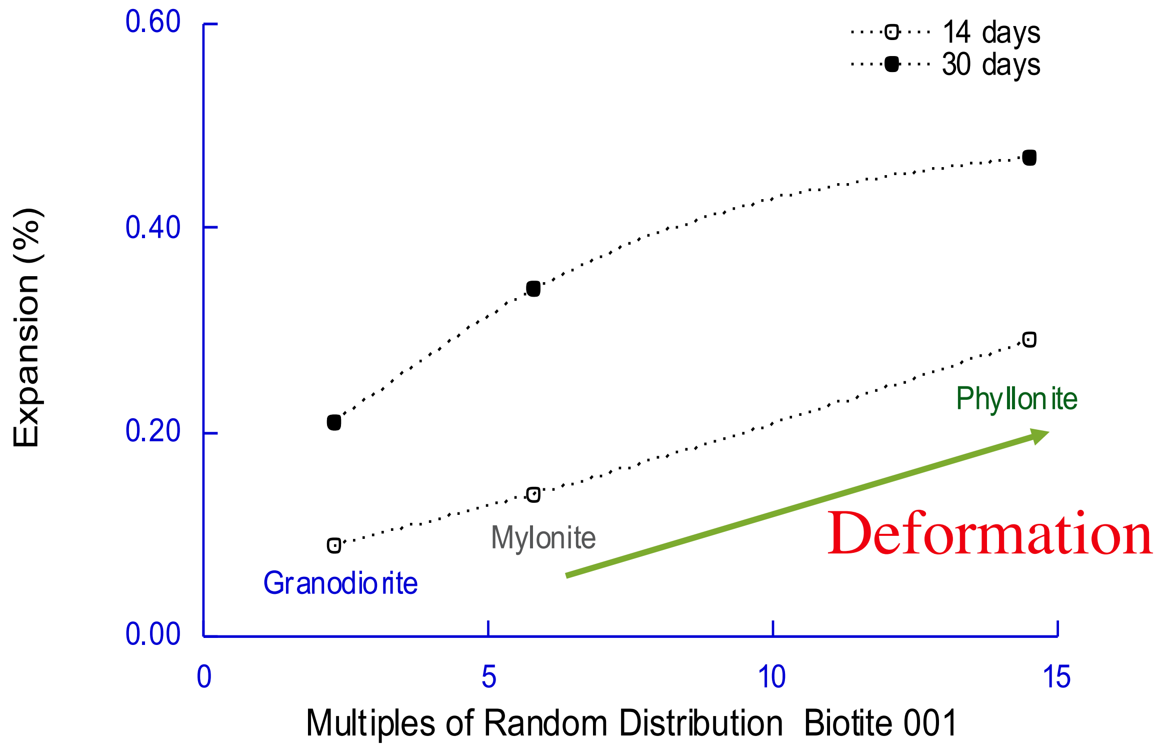

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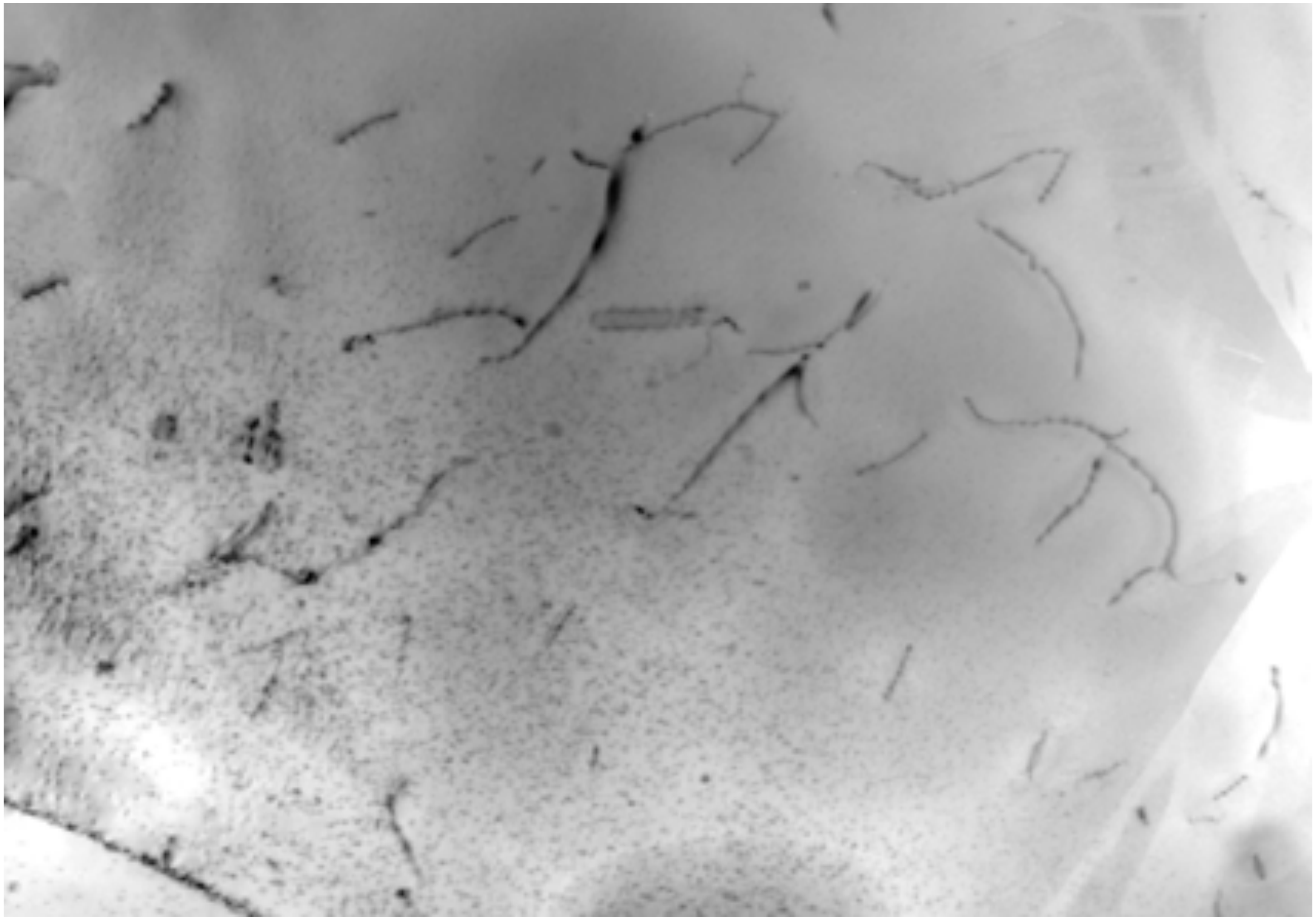
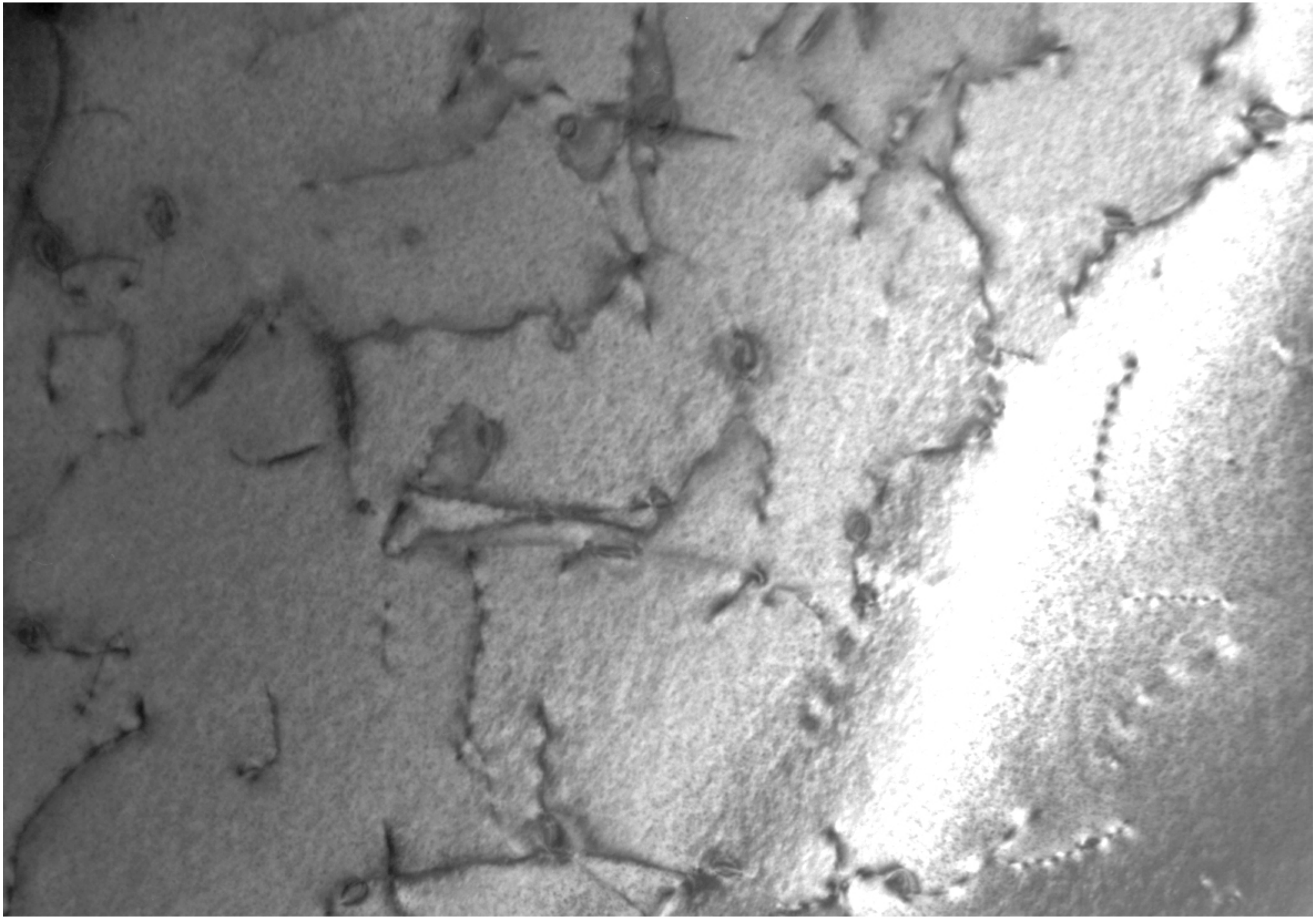
- TEM: Granite

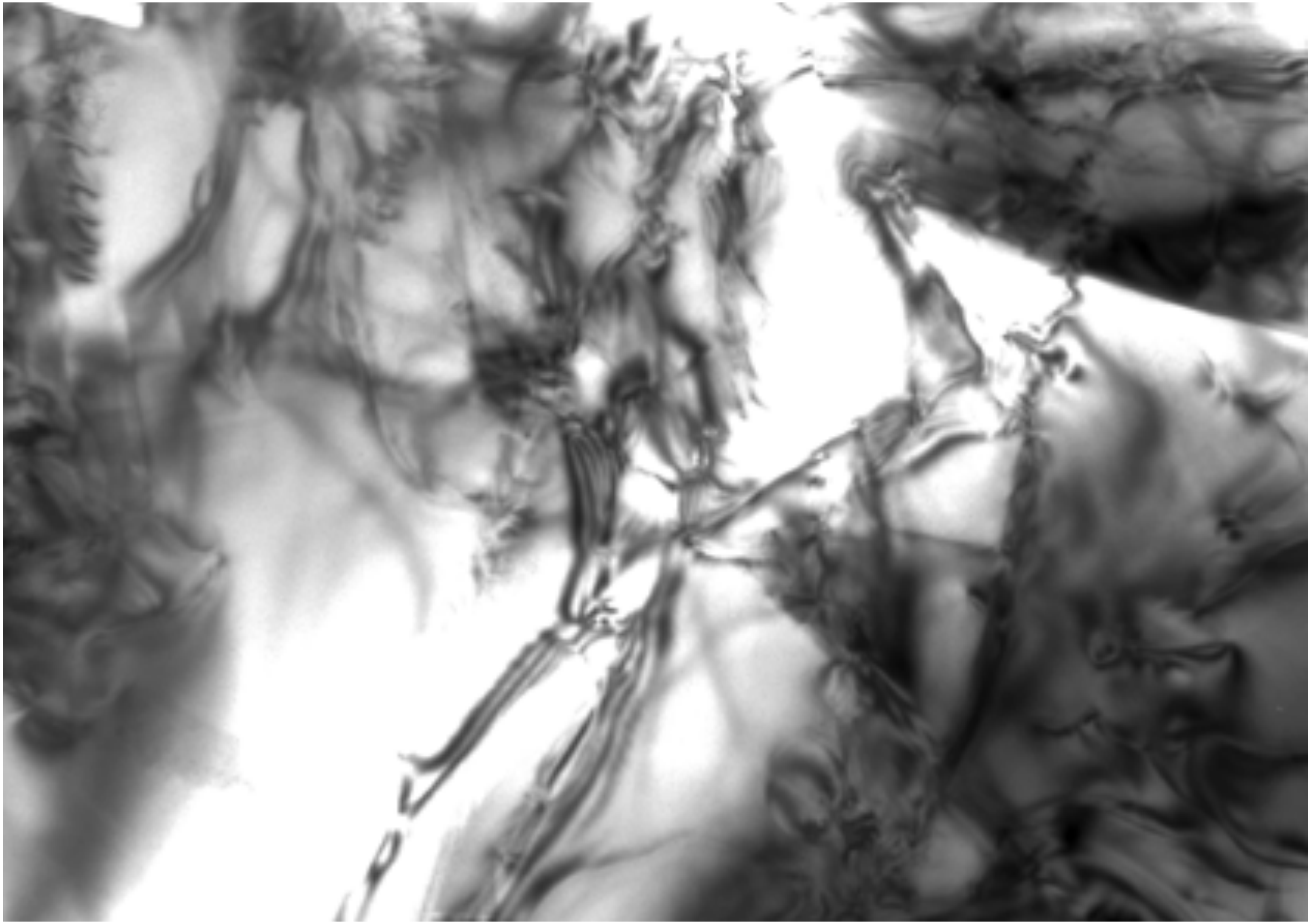


H.-R. Wenk, P.J.M. Monteiro and K. Shomglin, Relationship between aggregate microstructure and concrete expansion. A case study of deformed granitic rocks from the Santa Rosa Mylonite Zone, JOURNAL OF MATERIALS SCIENCE, Volume: 43, 1278-1285, 2008.

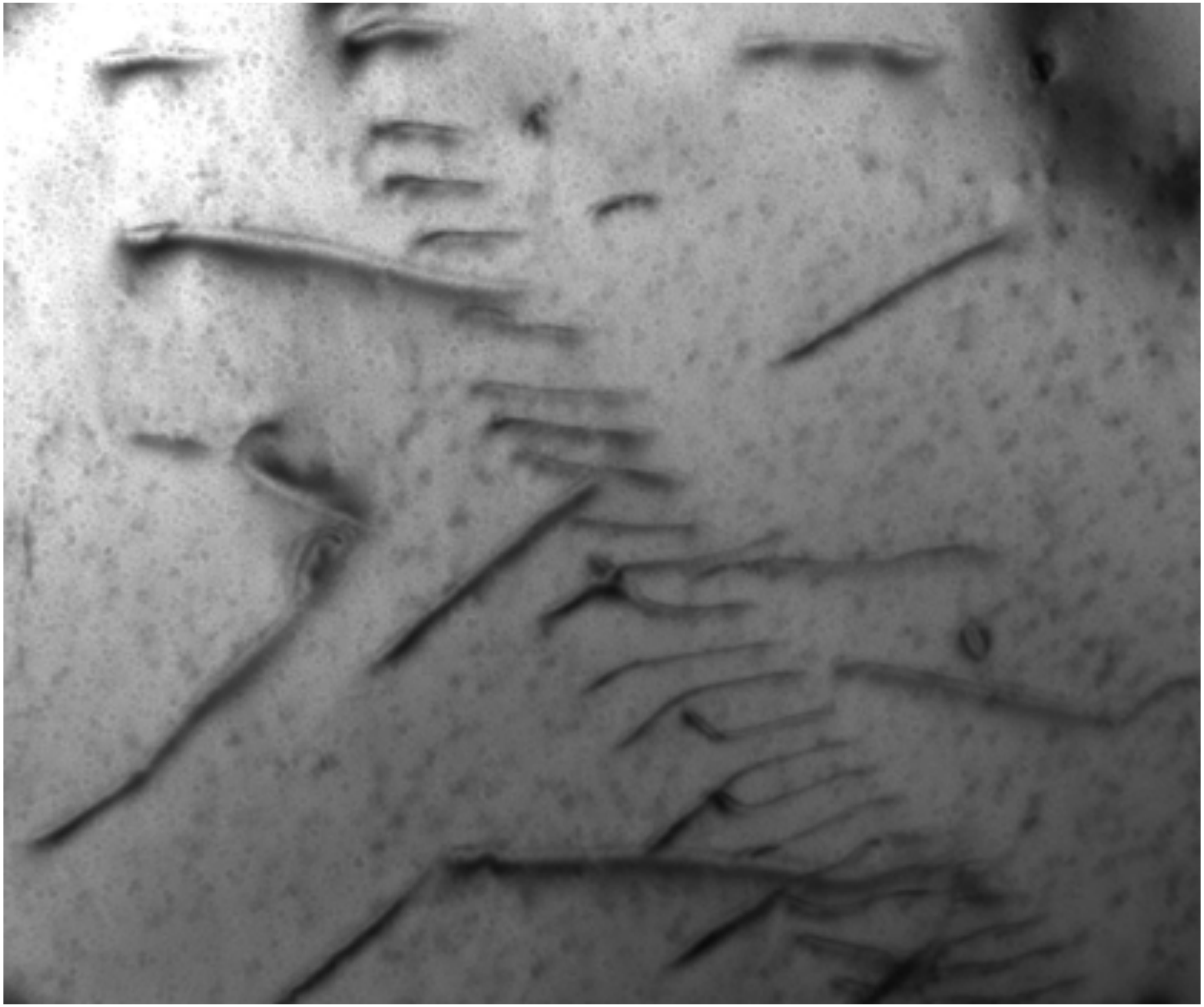
- TEM: Mylonite



- TEM: Phyllonite



- TEM: Formation of sub-grains



- Calculated changes in the internal energy (DE) of quartz at varying dislocation densities assuming screw dislocations on the <a ± c> slip system

Dislocation Density (cm^{-2})	1×10^{8}	1×10^{9}	1×10^{10}	1×10^{11}
ΔE ($J\ mol^{-1}$)	0.15	2.50	20.08	151.60
%Dissolution energy	6.5×10^{-3}%	0.11%	0.87%	6.51%

Observations

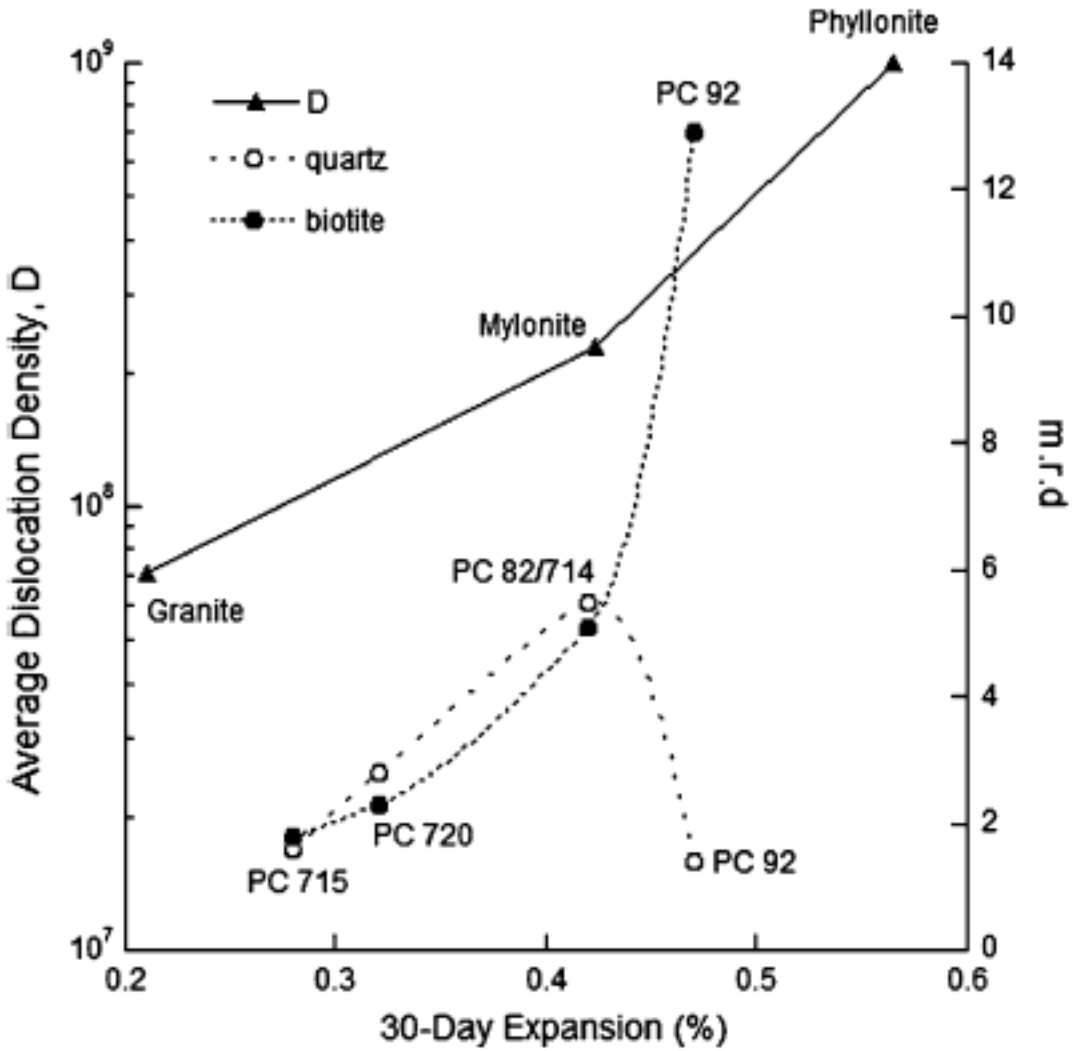
- Dislocations may not contribute much to the bulk energy increase of quartz, but they may nevertheless affect the reactivity of quartz by providing favorable areas for chemical processes such as precipitation and dissolution to occur.

Observations

- The addition or removal of the first few atoms on an atomistically flat surface results in a large change in the surface area, and thus a large change in the surface free energy.

- Once the addition or removal area exceeds a critical radius, the change in surface energy decreases, allowing for a more thermodynamically favorable reaction. Dislocations, specifically screw dislocations, provide an unending source of steps for precipitation and dissolution reactions to occur

An important correlation



Influence of mesostasis in volcanic rocks on the alkali-aggregate reaction

Mesostasis material present in the interstices of volcanic rocks is the main cause of the alkali-aggregatereaction (AAR) in concretes

Mesotasis

- Mesostasis often is referred to as volcanic glass, because it has amorphous features when analyzed by optical microscopy.
- However, our study demonstrates that mesostasis in the interstitials of volcanic rocks most often consists of micro to cryptocrystalline mineral phases of quartz, feldspars, and clays.

Francieli Tiecher; Denise C. C. Dal Molin, Márcia E. B. Gomes, Nicole Pagan Hasparyk, Paulo J.M. Monteiro, INFLUENCE OF MESOSTASIS IN VOLCANIC ROCKS ON THE ALKALI-AGGREGATE REACTION, Cement & Concrete Composites, 1130–1140, 2012.

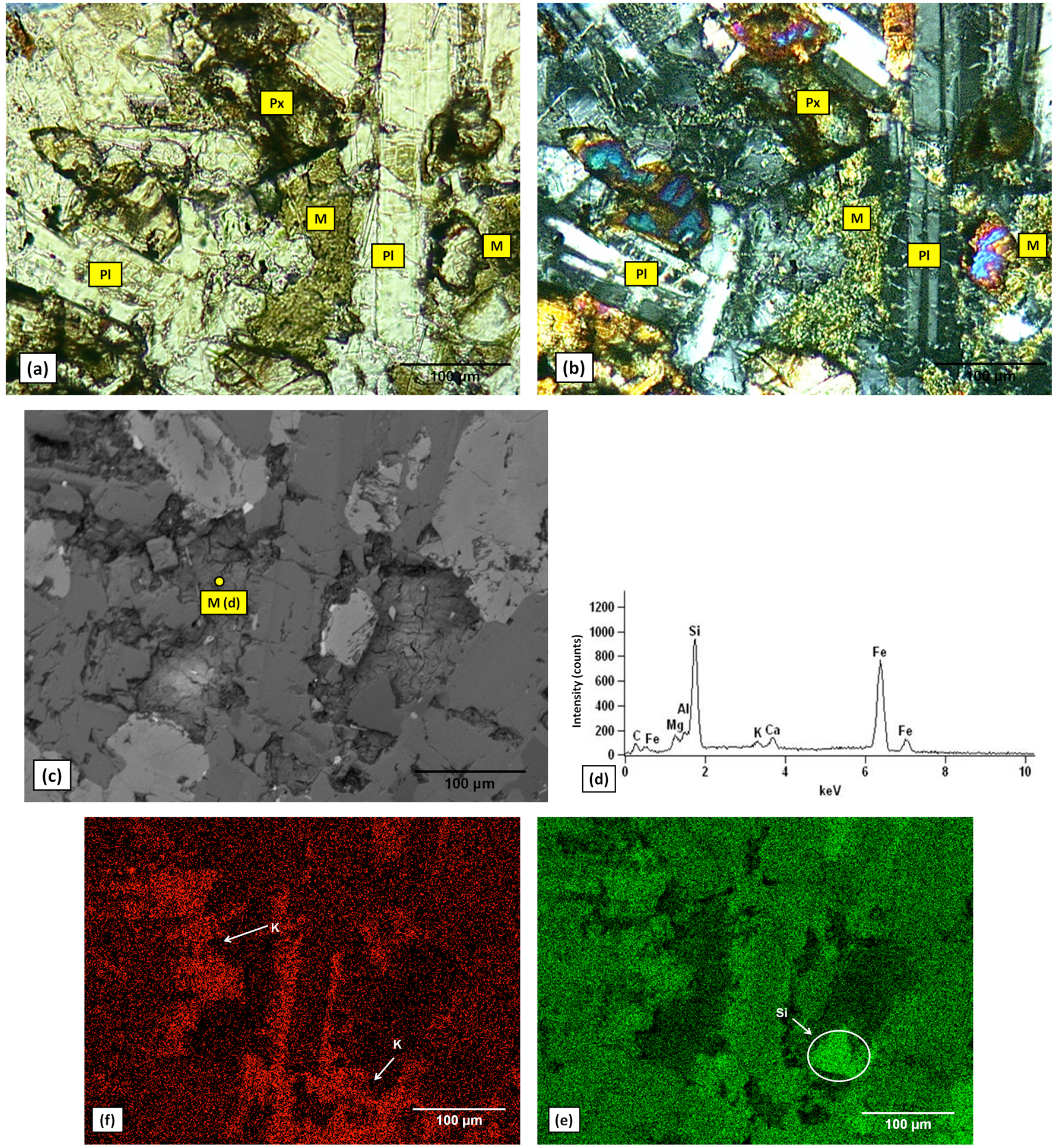


Fig. 7. Micrographs of Ma mesostasis, obtained by optical microscopy under natural light (a), cross polarization (b) (magnification = 200×) and SEM through backscatter electron beam (c) (magnification = 300×); EDS spectrum of the quartz (d) and K-feldspar of Mq mesostasis (e); map of Si (f), K (g), Ca (h); Fe (i), in which Ma = mesostasis with clay minerals, Px = pyroxene, Si = region where silica (quartz) is found, Fe = region where Fe (pyroxene) is found, Ca = region where calcium (pyroxene and plagioclase) is found, K = region where potassium (K-feldspar) is found.