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# Evaluation of strain-induced graphitization during slaty cleavage development

**REBECCA STOKES**[1], AARON M JUBB[1], RYAN J MCALEER[1], DAVID BISH[2] AND ROBERT WINTSCH[3]

[1]U.S. Geological Survey

[2]Indiana University

[3]Wesleyan University

Presenting Author: mstokes@usgs.gov

Graphitization of sedimentary organic matter is understood to be a thermally activated process where the expulsion of heteroatoms and progressive formation of hexagonal aromatic carbon rings eventually forms three-dimensionally stacked layers of graphene sheets, i.e., graphite. The irreversibility of the graphitization process and well-documented correlations with other geothermometers make graphite geothermometry an attractive method for assessing peak temperatures in metamorphic terranes. However, several studies, both experimental and field-based, have documented variable impacts of strain on graphitization. This study presents results documenting isothermal graphitization across a greenschist facies ductile strain gradient with a two-fold perspective on graphite use as a geothermometer and for graphite commodity exploration in deformed terranes.

Ten carbonaceous material (CM)-bearing slate samples were collected along a 2 km transect across the ductile Lishan fault zone in central Taiwan. Scanning electron microscope images document muscovite and quartz recrystallization concomitant with metamorphic fabric development via a dissolution-precipitation process. X-ray diffraction results show an increase in the 2θ values of the 004 muscovite peak and a sharper composite peak shape approaching the fault, reflecting an increase in strain and the resultant proportion of cleavage-forming muscovite. This composite peak was modeled in Rietveld refinements as two distinct muscovite populations with variable microstrain values. Isothermal conditions across the Lishan fault zone are constrained by calcite-dolomite geothermometry to be ~325ºC. Raman parameters used to evaluate peak temperatures of CM [D1-peak full-width-at-half-maximum (D1-FWHM), Raman band separation] show robust east-to-west linear trends across the strain gradient consistent with increasing temperature. However, the G-peak FWHM trend was opposite of that expected from thermally driven graphitization. Together these results are interpreted to reflect a strain-driven reduction in CM crystallite size but an improvement in structural ordering in coherent graphite domains. Moreover, a multiple linear regression of the data shows a strong positive correlation of the CM D1-FWHM values with the XRD-derived ratio of muscovite populations and muscovite microstrain. These results provide a holistic demonstration of strain-induced recrystallization of CM, muscovite, and quartz during slaty cleavage development and clarify the micro-structural effects of strain on CM crystallinity, a critical variable in graphite geothermometry and use in high-technology applications.