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Interactive comment on "Structural Disorder of Graphite and Implications for Graphite Thermometry" *by* Martina Kirilova et al.

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This manuscript describes the effect of shearing on crystallinity of graphite by conducting biaxial friction experiments for powder of highly-crystalized graphite and micro-Raman analysis of the recovered sample. The manuscript documents systematic increase of crystallinity index, R2 value, which is widely used to determine paleo-maximum temperature of metamorphic rocks, with increasing applied shear strain. Recently, much attention has been given to carbonaceous materials (including graphite) in and around a fault zone because of its utilities as a heat anomaly detector, displacement indicator, and lubricating agent of fault. However, crystallographic changes of graphite, especially in relation to the fault activities, are not well understood except for the effect of temperature alone. The objective of the manuscript is straightforward and their results seem sound. However, I found that some additional information and data are required and also there is room for further discussion and improvement. Hence I recommend accepting it with minor revisions.

General comments (1) The discussion about R2 and “shear strain” The main conclusion of this manuscript is R2 value of graphite increases (which implies decrease of crystallinity) with increasing applied “shear strain”. However, “shear strain” you calculated corresponds to “bulk shear strain”, and the bulk shear strain and microscopic shear strain which exactly concentrated into the narrow slip zone is quite different. Degree of compaction may differ depends on normal stress applied, hence the “bulk shear strain” reflects not only shearing but also compaction. Also I would suspect thinning due to leakage of the gouge took place under 25 MPa experiments, especially for slip rate of 100 μm/s (Exp.10). All these issues make it difficult to extract an effect of shearing on the increments of R2 value. To solve this problem, I would suggest using total frictional work (shear stress*displacement) in addition to shear strain, and to discuss its relationship to R2 value.

(2) The relationship between R2 value and graphite “crystallnity” As another referee also mentioned, D bands (and R2 value) reflect amount of grain boundary (edge of grapheme sheet) in addition to intracrystalline defects, so determining which process is dominant in your setting becomes another problem to be addressed. I could faintly see very small platelets of graphite (< 1μm) in your photograph (Figure 4e), but damages during shin-section making also make this kind of roughness. I think it is better to provide high-resolution SEM images of the slip surface if you could not make good thin section. On the other hand, I think you should mention that the friction still remains low and stable if you applied shear strain >40. This feature may suggest the graphite on the slip surface still maintain its crystal perfection. In that sense, increments of R2 value of sheared graphite attributable mainly to grain size reduction but not amorphization.

Specific comments

Line 46; I would happy if you add Oohashi et al. (2013, JGR) in the reference.

Line 60; I think initial thickness of gouge layer varies depends on applied normal stress if you put same weight of graphite powder for each experiments (becomes thinner under high normal stress). Did you change amount of graphite for normal stress of 5 MPa and 25 MPa to ensure to form exactly the same 3-mm thickness? This question is arises from why large shear strain is calculated from the experiments under 25 MPa normal stress (off course, I understand your explanation about compaction). Additionally, I would suspect thinning due to leakage of the gouge took place under 25 MPa experiments, especially for slip rate of 100 μm/s (Exp.10) because the gouge thickness seems to became less than half of the initial thickness.

Line 109-110; The authors documented μss does not depend on slip rates, and it remains constant for all experiments. However, I see clear relationship between μ at d=14-20 mm and slip rates; μ decreases with decreasing slip rates for σn=5 MPa, and μ decreases with increasing slip rates for σn=25 MPa.

Line 141-143; The authors explain graphite crystalinity decreases with increasing slip rates for samples sheared under σn=25 MPa, and no slip rates dependence is found for samples sheared under σn=5 MPa. However, as you concluded, increase of R2 value can be attributed to applied shear strain but not to slip rates. I think you can not discuss direct relationship between R2 value and slip rates unless you conduct various slip-rates experiments at exactly the same shear strain.

Line 181; I would suggest referring Di Toro et al. (2011, Nature) instead of Nakatani (2001).

Table 2 and Figure 3 Please add errors and error bars for R2 value.

Hope this helps,

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Discussion paper