eEarth Discuss., 1, S136–S141, 2006
www.electronic-earth-discuss.net/1/S136/2006/
© Author(s) 2006. This work is licensed
under a Creative Commons License.

eEarth Discussions

eED

1, S136–S141, 2006

Interactive Comment

Interactive comment on "Earthquake fault rock indicating a coupled lubrication mechanism" *by* S. Okamoto et al.

S. Okamoto et al.

Received and published: 29 October 2006

With regard to suggested comments by 2 referees, we made discussions and some changes in the manuscript.

Reply to A. Lin (Referee #1)

Comment 1: 1) - - - - - if the authors can give a quantitative data to show there are how many percentages of glassy or amorphous materials presented in the pseudotachylyte vein, it would be a convincing evidence for the melting-origin of the pseudotachylyte veins found in the subduction zone and could give an strong impact on the readers.

Reply 1: We agree to that it is important to quantify glassy or amorphous materials in pseudotachylyte, however, it is difficult to give quantitative data by X-ray diffraction because a new mineral (parygorskite) has been formed in this pseudotachylyte. There-

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

EGU

fore, we focused whether frictional melting occurred or not in this fault. We suggest that this pseudotachylyte is melt-origin, because melting and quenching related textures are well observed. The quantitative analysis by X-ray diffraction is our future work.

Comment 2: 2) This paper presented a clear example of crack-filling veins and breccia zone containing carbonate material and explained it to be resulted from an abrupt drop of fluid pressure in fault zone. - - - - - It is possible that the injection veins of both the melting and crushing-originated pseudotachylyte and some crack-filling veins were formed by such fluidization of fine-grained materials in a gas-solid-liquid system during seismic faulting.

Reply 2: We almost agree to the referee's comments. As we mentioned in our manuscript, a uniqueness of this fault is that carbonate minerals precipitated from fluid fill the matrix of tension cracks and dilation jogs. Moreover, a sequence of implosion breccia and pseudotachylyte is a newly-discovered occurrence. This observation suggests the following continuous event during a fault propagation; fluid thermal pressurization, depressurization due to implosion and fluid escape into the tension cracks, and dilation jogs, then frictional melting.

Reply to Anonymous Referee #2

Comment 1: - Page 138, section 3 line 5-10: The evidences for the deformation sequence (for the two stages) are very weak. Much stronger evidences are necessary to argue the deformation order.

Reply 1: Evidence for the deformation sequence is a cross-cutting relationship. We add that in the sentence as follows; - Page 138, Line 8 The planer slip section shows two-stages of deformation, first by - - . => The planer slip section shows two-stages of deformation as documented by the cross-cutting relationship, first by - - .

Comment 2: Jogs (Sibson, 1989) are very systematically related with fault slip senses and systematically arranged along fault bends or steps. However, the gaps along the

eED

1, S136–S141, 2006

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

EGU

fault surface in Figure 2 of this paper are very irregular and do not give any strong information for the movement along the fault. It may be better to describe the patterns more clearly. Furthermore, I am not sure about the “dilational jogs” in the Figure 2. It looks like “asperity” of only a result of irregular fault surface to me.

Reply 2: We put a new data set in Figure 2 in our paper, which shows a geometrical relationship among the slip direction, fault surface and trend of dilation jog. A cartoon for the geometric relationship is herein shown in figure1 in this author comment. The orientation of the step walls of the dilation jogs is perpendicular to the slip direction as shown in additional stereogram in Figure 2G of our paper. Such geometric relationship and the occurrence filled by implosion breccia as described in the text clearly indicate the “dilation jog”.

Comments 3: Page 138 line 25: It is a very vague evidence for displacement. It may be better to replace “displacement” to “slip sense”. The lengths of the jogs are not always indicative of displacement along the faults. Some of jogs may be opened by mode I extension (or normal fault; Crider and Peacock, 2004.), by injection of the fault related materials or by fault surface asperity. Therefore, more careful observations and key marks are necessary to talk about displacement or amount of displacement.

Reply 3: We agree that length of dilation jog in parallel to slip direction is not perfectly the amount of displacement. We have to think the amounts of open of the asymmetric micro-cracks developed in footwall and the amount of normal fault slip along the dilation jog wall. Therefore we modified the text as follows; Page 138, line 25: - - which is indicative of displacement along the fault. => - - which is minimum indication of displacement along the fault.

Comment 4: - Page 140, line 13-15: Although some large pseudotachylyte systems are interpreted as a single rupture event (e.g. Allen, 2005). If the pseudotachylyte was injected from deeper parts into previous fault slip surface later, the texture may be reasonable for two separate stages. Thus, it may be better to suggest a much clearer

eED

1, S136–S141, 2006

Interactive Comment

supporting evidences for a progressive deformation.

Reply 4: It is easily understood that extremely thin (1mm) melt injection into the crack of the cold host rock (maximum320C°) from deeper parts is impossible because immediate quench prevents the injection. Therefore, the injection hypothesis suggested by the referee is unrealistic.

Comments 5:

- Page 140, line 19-20: Why do you think that the fractures are generated by fluid implosion? What is the structural difference from fluid implosion along previous fractures?

Reply 5: We speculated that stress concentration at a fault propagation tip might first open the cracks in the tensional stress filed quadrant (e.g. Scholz et al, 1993), and immediately after that interstitial fluid in the fault zone drained into the cracks due to large pressure gradient. Thus, we suggested that "the fluid implosion with fracturing might have occurred early"

Comment 6: - Page 140, line 19-20: If the fluid implosion and pseudotachylyte injection is a progressive deformation by a single event, it is necessary to explain the different mechanisms that generated different materials at the same fault surface. If your mechanism is rapid decrease of the fluid pressure and fusion melting at the slip plane, it is necessary to explain the possibility to recover the temperature and pressure in a single event period.

Reply 6: We already discuss on these points on page 142, line6 -line23.

Comment 7: - Page 140, line 21-24: The difference of the planar parts and the jogs (?) may be related with the asperity of the fault surfaces. Also it partly depends on the stress condition during seismic event, that is, the planar parts mainly experience shear and friction, but the jogs experience opening and fluid injection from the deeper parts. Therefore, it may be possible at irregular fault surfaces.

Reply 7: We agree with the initial irregularity of the fault surface that differentiates the

eED

1, S136–S141, 2006

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

EGU

part of slip and jog but whether the fluid injecting to the jog came from deeper parts or not is unclear at this moment. We keep studying the fluid source problem.

Technical comment 1: - Page 139, line 26: Fig. 4H =>may be 4F (?)

Reply 1: We correct the part; Page 139, line 26: Fig. 4H => Fig. 4F

Technical comment 2: - Page 140, line 6: Figs. 2A, D => may be 4A, D (?)

Reply 2: We observed the pseudotachylyte pinches out as approaching to the dilation jog. Fig 2D (photo and schematic illustration in its bottom) indicates its occurrence. We quit referring Fig 2A because it shows only the location of 2D. - Page 140, line 6: Figs. 2A, D => Fig. 4D

References: Scholz, C. H., Dawers, N. H., Yu, J. Z., Anders, M. H.: Fault growth and fault scaling laws - Preliminary results: Journal of Geophysical Research-Solid Earth, J. Geophys. Res., 98, 21951-21961, 1993.

Interactive comment on eEarth Discuss., 1, 135, 2006.

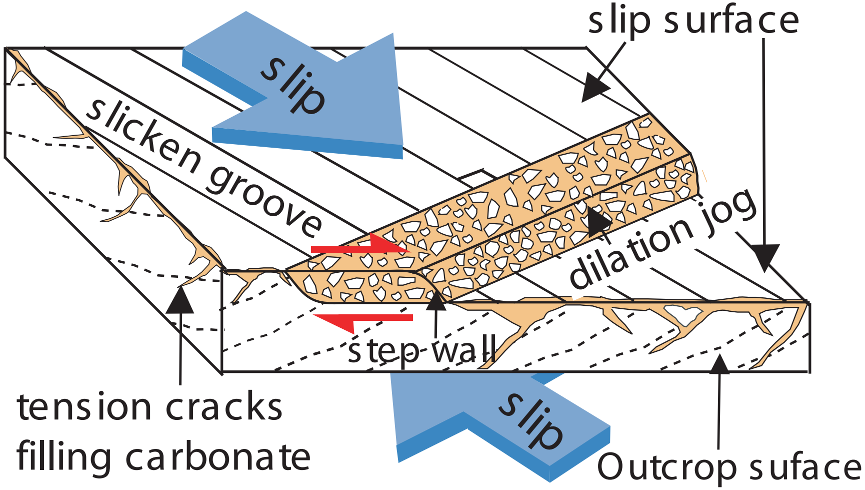

Figure 1: A cartoon for the geometric relationship among the slip direction, slip surface, and trend of dilation jog. Red arrows indicate the apparent slip direction on the outcrop surface. The dilation jog is perpendicular to the slip direction as shown in additional stereogram in Figure 2G of our paper.

eED
1, S136–S141, 2006

Interactive Comment