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

A. Lin (Referee)

slin@ipc.shizuoka.ac.jp

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Aiming Lin

Institute of Geosciences, Faculty of Science, Shizuoka University, Japan

slin@ipc.shizuoka.ac.jp

This is an interesting paper that described a pseudotachylyte vein and its related fault breccia zone in the Shimanto accetionary complex, Japan and documented their implications to the seismic faulting mechanism in subduction zone.

Although there are large numbers of studies on pseudotachylytes in the past century, many aspects of the fault-related pseudotachylytes are comparatively rare in exhumed

fault zones reported in the world. It is still unclear whether the scarcity is apparent or whether seismic friction melting in fault zones is a genuinely phenomenon inhibited by other mechanisms. The effect of the frictional melt may play an important role in co-seismic slip as a lubricant on the fault plane. There is no doubt that more researches on pseudotachylytes are now underway, which would provide insight into earthquake generation and the seismic rupture process within whole fault zone from brittle to ductile regimes of the crust. This paper presents a good example of "Earthquake fossil" for the seismogenic fault zone in subduction zone.

Following the main topics of Okamoto et al. (2006), I would like to document two points below.

1) Okamoto et al. (2006) showed that there is some glassy material preserved in the pseudotchylyte vein by the analyses of powder X-ray diffraction and TEM. Although there are many studies describing the presence of glass or glassy materials in pseudotachylytes in recent two decades, no TEM and X-ray diffraction data show the presence of some amount of glass or glassy materials as argued by Wenk (1978). It is Lin (1994a) first reported that a large amount glassy materials upto 90wt.% is preserved in the Fuyun pseudotachylyte vein that shows little doubt of the melting origin of fault-related pseudotachylyte vein. Okamoto et al. (2006) also showed a powder X-ray diffraction pattern of the pseudotachylyte (figure 2b shown in Okamoto et al., 2006) similar to those of glassy pseuutachylytes as shown in Lin (1994a). It is well known that small amount of glass or amorphous material can be formed not only by rapid cooling of melt but also by alteration (e.g. Henley and Ellis, 1983) and comminution (Yund et al., 1990) and has also been found in the crushing-originated pseudotachylyte veins that are composed of more than 95 wt.% fine-grained clasts originated from the host granitic rock (Lin, 1996, 1997; Ozawa and Takizawa, 2006). Therefore, 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

eED

1, S70–S75, 2006

zone and could give an strong impact on the readers.

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. Such crack-filling veins including ”crushing-originated pseudotachylyte” have also been found in some active faults in central Japan (Lin et al., 1994; Lin, 1996, 1997; Shigetomi and Lin, 1998; Kano et al., 2005). These veins occurred as simple veins (fault veins) along some main fault planes and as a complex network of veins (injection veins) developed within the fault zones a few centimeters to 1m far from their source fault planes as those of melting-originated pseudotachylytes (Lin et al., 1994; Lin, 1996, 1997). The injection features of these veins show they formed by intrusion of fine-grained clasts originated from the host rocks from the source generation fault plane.

A mechanism of fluidization has also been suggested to explain the formation mechanism of injection veins developed in fault zone (Lin, 1996, 1997). Although the term fluidization was applied specifically to a gas-solid system (Reynolds, 1954), it is striking applicable to a suspension of solid particles in an upward flowing stream of liquid which has a lower density than that of the particles. The geological examples of intrusive fluidized systems are characterized by net veins of dyke, by breccias in which many of the fragments derived from the adjacent wallrocks are rounded as if by sandblast, and by mechanical hybrids (Reynolds, 1954). The other geological examples of intrusive veins are associated with seismic faulting, such as melting-originated pseudotacylyte veins (Lin, 1994a,b; Lin et al., 2005) and liquefaction veins formed during large earthquake, which also show characteristics of simple and network veins injected into the wallrocks. It has also been observed that there are a lot of clasts over 60-70vol.% contained in the typical melting-originated pseudotachylyte veins such as the Outer Hebridge pseudotachylte and Fuyun pseuotachylyte (Lin, 1994a, 1996). This hints that the clasts mixed with the melt were injected into the cavity space generated during seismic slipping by rapid intruding-like spraying in a gas-solid-liquid system, like a py-

eED
1, S70–S75, 2006

EGU

roclstic flow rather than slow flowing of liquid. The substantial cavity may accompany seismic slipping in strong rocks at depths of several kilometers (Sibson, 1986). These cavities forming transitory low-pressure channels are particular sites for the rapid passage of fluidized particles. The rapid injection of the fluidized particles may be formed by the sudden fluid-pressure differentials generated in dilational jogs during rupture arrest as suggested by Sibson (1986). It is important to realize that the bubble phase of gas-solid systems has no counterpart in liquid-solid systems, and that the turbulent expanded bed is, in consequence, specific to gas-solid systems. That is of importance to the geologist because-from recognition of turbulent expended and rock fragments which have not been appreciably transported away from their source rock, together with a lack of sorting of the fragments concerned and possible presence of druses-it can be inferred that the field agent was gas and not liquid. Closely allied in mechanism to the process of fluidization of solid particles by gas is the method of painting by spraying (Reynolds, 1954). 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.

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