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Interactive Comment

Interactive comment on "Characteristics of chlorites in seismogenic fault zones: the Taiwan Chelungpu Fault Drilling Project (TCDP) core sample" *by* Y. Hashimoto et al.

Anonymous Referee #1

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General comments:

This paper adress the following question: what the composition of chlorites in the TCDP fault rocks can tell us about the temperature rise in the fault during seismic events? The authors assume that iron content in chlorite is temperature dependant and, therefore, may reflect any temperature rise in the fault zone if frictional heating occurs. In order to anwer the question, they conducted a complete XRD study of chlorites in three fault zones drilled during the TCD Project (borehole B). Frictional heating during seismic slip is an important question for the international comunity working on energy released by earthquakes and this paper is a contribution to that point. However, the results

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obtained by the authors indicate that the low iron content of chlorite is not consistent with a temperature rise and is contradictory with other results (magnetic susceptibility) indicating a minimum 400°C temperature. Why such a contradiction? The authors attempt to explain it by radical reactions related to fracturation of minerals and inducing surface reactions and change in pH of the fluid. But they do not provide evidences for such reactions in the fault-rocks nor discuss that possibility on the light of grain-size distributions measured in the fault zones by Ma et al. (2006). A comparison of the XRD methods for iron determination in chlorite with other chlorite thermometers and a comparison of the results with those obtained on borehole A, could increase the interest of the reader for that paper.

The paper is well written and organized. The title clearly reflects the content of the paper and the abstract provide a concise and complete summary. There is an inversion in the formulae for iron symetry and content in chlorite which should be corrected. Here below are some suggestions aiming to improve the overall quality of the paper.

Specific scientific comments:

The methods used to determine the total iron content and its repartition in different sites in chlorite are complex and based on the intensity of diffraction peaks and on the assumption that Fe and Mg are the only significative heavy and light metals, respectively, which control the peak intensities. As grain size is larger in the host rocks than in the fault rocks, it would be interesting, if possible, to check or calibrate the method by some EPMA analyses of individual chlorites in those host rocks.

Iron in chlorite as a thermometer is not well known from the readers. The authors refer to Ohta Yajima (1988) but this reference is not easy to find . Recently a Fe-thermometer has been proposed by Munoz et al. (2006) and Vidal et al. (2006). Al in tetrahedral sites is also a chlorite thermometer (Cathelineau and Nieva 1985, CMP 91, 235-244) although controversed. How do the authors results compare with the different methods? Could the authors results be translated quantitatively or do they

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remain qualitative?

Munoz, M., DeAndrade, J., Vidal, O. Lewin, E., Pascarelli, S. and Susini, J. (2006): Redox and speciation micro-mapping using dispersive X-ray absorption spectroscopy: Application to iron in chlorite mineral of a metamorphic rock thin section. G-cube, vol /11

Vidal, O., DeAndrade, V., Lewin, E., Munoz, M., Parra, T. and Pascarelli, S. (2006) P-T-deformation-Fe3+/Fe2+ mapping at the thin section scale and comparison with XANES mapping. Application to a garnet-bearing metapelite from the Sambagawa metamorphic belt (Japan). J. Metam. Geol, 24, 669-683

The authors have worked on samples from borehole B which is only 45m to the SE from borehole A. However, some previous papers (Ma et al. 2006, Nature; Hirono et al. 2007, JGR, 2006a and 2006b GRL amongst others) have been published on both borehole A and B. In some of these papers (Ma et al. 2006 for example), the fault zone FZB 1111 and FZB 1136 (which are on the same fault) are interpreted as the slip zone of the Chi-Chi earthquake on the basis of several evidences. In some other papers, the authors did not conclude on the position of the slip zone (Hirono et al. 2006a, 2007).

Kuo et al. (2005, Eos Trans. AGU, 86(52), abstract T43D-05) describe a drastic change in different clay (smectite, illite, kaolinite and chlorite) proportions across the FZA 1111. Do smectite, illite and kaolinite vary in proportion across the three faults? Only the iron content of chlorite is considered in this paper and nothing is said on the relative quantity of chlorite in the fault zones. Comparing XRD charts from host-rocks and black material, there is a clear difference in chlorite contents.

These two last points are not discussed in the light of previous papers. The authors should compare their results with those already published.

Technical corrections:

- page 87 line 3: precise (TCDP, borehole B)

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- page 87 line 10: The hydroxide and silicate layers of chlorite

page 87 line 15-18: "Therefore, on the basis of chlorite characteristics, the reactions at the seismogenic fault are due not only to the thermal decomposition resulting from the temperature rise but also to rock-fluid interactions". - Page 87 line 24: "mechanical processes and reactions" (because there is probably several mechanical processes and reactions resulting in the presence of clays within fault rocks and because both are strongly linked, Vrolijk and van der Pluijm, 1999) - page 88 line 9: thrust instead of thurst

- page 88 line 21: seismicity instead of seismisity

- page 88 line 24-25: "We use chlorite to examine the mechanisms of clay mineral formation along seismogenic fault." Chlorite will help to precise the thermal and chemical conditions within the fault zones related to earthquakes rather than to decipher the formation (neocrystallization?) of clays during seismic events.

- page 89 line 6: shales instead of shale, "composed of black shales"

- Page 89 line 2: "we identified three fault zones". The passive form would be more appropriate: "three fault zones have been identified" because there is several already published papers dealing with core samples from TCDP holes A and B (Ma et al. 2006, Nature; Hirono et al. 2007, JGR, 2006a and 2006b GRL amongst others).

- Page 89 line 20-21, 25 and 26-27: "The fractured-damaged zone (up to 1.2 m) is located outside the breccia zone (Fig. 2)." Not clear. Replace by something like: "Two fracture-damaged zones are located above and below each breccia zone" or "on both sides of the fault zone" or "constitute the outer parts of the fault zone".

- Page 90 line 5: "using 1.4 mm grains". Do you mean "using $<$1.4 mm grain-sized fraction after crushing and sieving"?

- Page 90 lines 8-9: show also the peaks for smectite, illite and kaolinite on figure 3.

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- Page 90 line 16: how can you tell the polytype (clinochlore-1MIIb) from XRD on oriented samples?

- Page 90 line 18: "Although the oriented samples" replace by "Although oriented samples".

- Page 90 lines 31-33: there is an inversion for calculation of parameters. I(003)/I(005) gives the symetry of Fe distribution (D value in Moore and Reynolds, p. 213) and (I(002) + I(004)/I(003)') gives the number of Fe atoms in six octahedral sites (Y value in Moore and Reynolds, p. 214).

- Page 90 lines 48-21: the sentence is too long and the syntax is incorrect (number of verbs). Replace by something like: " We have estimated the iron and magnesium contents in chlorite from XRD charts following the method proposed by Moore and Reynolds (1989)". These authors use also oriented samples for clay mineral determination but procedure proposed by Brown and Brindley (1980, in Moore and Reynolds, 1989) has been calculated for random orientation of crystallites.

- Page 91 line 1: the equation (1) is from Brown and Brindley (1980, cited in Moore and Reynolds, 1989).

- Page 92 line 2: as the reference Ohta and Yajima (1988) is not easily available, the authors should say explicitly if iron content increases or decreases with increasing temperature.

- Page 92 line 4: "can control" instead of "can be control".

- Page 92 lines 5-8: "In this study, however, the source materials of Chinsui shale is enough homogeneous and could not control the low value of iron content. This might be supported by that the iron and magnesium contents in host rocks are enough constant as represented in Fig. 4." This is in apparent contradiction with what is written in the previous page on line 17-18. I suggest to replace this sentence by: "However, the Chinsui shale is very homogeneous as shown by the constant iron and magnesium

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contents in host rocks (Fig. 4). Therefore, the source material also was probably homogeneous and is not the cause of the low value of iron content in the gouge."

- Page 92 line 9-11: Be concise: A thermal anomaly has been reported on the basis of borehole logging in TCDP borehole A at the FZA 1111 fault which corresponds to FZB 1136 in borehole B.

- Page 92 line 16-18: Mishima et al. (2006) have worked on FZB 1194 and FZB 1243 fault rocks and not on FZB 1136.

- Page 93 line 1: give again the reference for pH of fluid controlling the iron content in chlorite (Ross, 1969; Malmstrom et al. 1996).

- Page 93 line 8: "where magnetite or maghemite is supposed to have formed (Mishima et al. 2006)"

- page 94 line 28: Sibson instead of Shibson

- Page 95 figure 1: Shuagtung fault: the name is not visible on the pattern for Miocene rocks. This pattern appears different on the figure and in the legend.

- Page 96 caption: precise "distributions of I(003)/I(005) (indicative of the symetry of Fe distribution, gray circles) and (I(002) + I(004)/I(003)' (indicative of the total number of Fe atoms, black triangles)"

- Page 97 figure 3: show also the peaks for smectite, illite and kaolinite

- Page 98 figure 4: put a vertical light line for I(003)/I(005) = 3.83 which corresponds to the symetry zero (Fe = Mg in the two sites). This is more explicite for reader who are not familiar with the XRD Moore and Reynolds method.

Interactive comment on eEarth Discuss., 2, 85, 2007.