Correction to "Thermal decomposition of carbonates in fault zones: Slip-weakening and temperature-limiting effects"

Jean Sulem, Vincent Famin, H. Noda

HAL Id: hal-01241170

https://hal.univ-reunion.fr/hal-01241170v1

Submitted on 24 Oct 2016

Correction to "Thermal decomposition of carbonates in fault zones: Slip-weakening and temperature-limiting effects"

J. Sulem, V. Famin, and H. Noda

[1] In the paper "Thermal decomposition of carbonates in fault zones: Slip-weakening and temperature-limiting effects" by Sulem and Famin (*Journal of Geophysical Research,* 114, B03309, doi:10.1029/2008JB006004, 2009), the mass of CaO produced in the chemical reaction of calcite decomposition (decarbonation) $CaCO_3 \rightarrow CaO + CO_2$ was neglected. Following a remark of H. Noda (private communication, 2009), this term can be taken into account in the mass balance of the solid phase and equation (5) of Sulem and Famin is changed as follows:

$$\frac{\partial n_d}{\partial t} = -\frac{1}{\rho_{CaCO_3}}\frac{\partial m_{CaCO_3}}{\partial t} - \frac{1}{\rho_{CaCO}}\frac{\partial m_{CaO}}{\partial t} \qquad (1)$$

with

$$\frac{\partial m_{CaCO_3}}{\partial t} = -\frac{M_{CaCO_3}}{M_{CO_2}}\frac{\partial m_d}{\partial t}$$
$$\frac{\partial m_{CaO}}{\partial t} = \frac{M_{CaO}}{M_{CO_2}}\frac{\partial m_d}{\partial t} \qquad (2)$$

where m_d is the mass of emitted CO_2.

[2] The change of mass of the solid phase is simply equal to the mass of emitted CO_2 and equation (9) of Sulem and Famin is corrected as follows:

$$\frac{\partial m_s}{\partial t} = \frac{\partial m_{CaCO_3}}{\partial t} + \frac{\partial m_{CaO}}{\partial t} = -\frac{\partial m_d}{\partial t} \qquad (3)$$

Consequently equation (11) of Sulem and Famin becomes

$$\frac{\partial p}{\partial t} = \Lambda\frac{\partial T}{\partial t} + \frac{1}{n\rho_f(\beta_n + \beta_f)}\frac{\partial}{\partial z}\left(\rho_f\frac{k_f}{\eta_f}\frac{\partial P_p}{\partial z}\right)$$
$$+ \frac{1 - \rho_f\zeta/\rho_s}{n\rho_f(\beta_n + \beta_f)}\frac{\partial m_d}{\partial t} \qquad (4)$$

with

$$\zeta = \frac{M_{CaCO_3}}{M_{CO_2}} - \frac{\rho_{CaCO_3}}{\rho_{CaCO}}\frac{M_{CaO}}{M_{CO_2}}.$$

With $M_{CaCO3} = 100$ g/mol, $M_{CaO} = 56$ g/mol, $M_{CO2} = 44$ g/mol, $\rho_{CaCO3} = 2.71$ g/cm^3 and $\rho_{CaO} = 3.35$ g/cm^3, $\zeta = 1.24$.

[3] The governing equations (equations (19) of Sulem and Famin) are changed accordingly

$$\frac{\partial p}{\partial t} = \Lambda\frac{\partial T}{\partial t} + \frac{1}{n(\beta_n + \beta_f)}\frac{\partial}{\partial z}\left(\frac{k_f}{\eta_f}\frac{\partial P_p}{\partial z}\right) + \frac{1 - \rho_f\zeta/\rho_s}{n\rho_f(\beta_n + \beta_f)}\frac{\partial m_d}{\partial t}$$
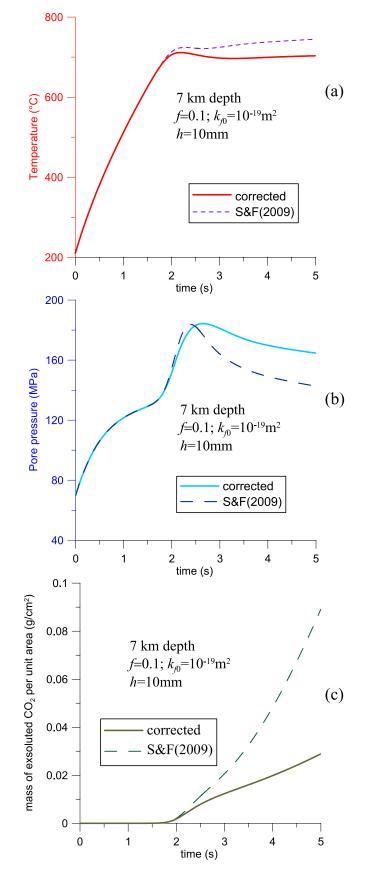
$$\frac{\partial T}{\partial t} = \frac{1}{\rho C}\frac{\partial}{\partial z}\left(k_T\frac{\partial T}{\partial z}\right) + \frac{1}{\rho C}f\left(\sigma_n - \frac{1}{h}\int_0^h P_p(\xi, t)d\xi\right)\frac{\partial v}{\partial z}$$
$$- \frac{(1-n)}{\rho C}\frac{\Delta_r H_T^0}{M_{CaO_3}}\rho_s A\exp\left(-\frac{E_a}{RT}\right) \qquad (5)$$

The numerical results are not significantly changed. Figure 1 compares the "old" computation (Figure 2 of Sulem and Famin) and the revised one.

[4] The conclusions of the paper are not changed: The endothermic character of the decarbonation reaction limits the co-seismic temperature increase; decarbonation is a source of CO_2 that significantly increases the slip-weakening effect of thermal pressurization; the pore fluid pressure exhibits an initial phase of increase due to thermal pressurization, then a sudden acceleration of generated pore pressure when the solid decomposition is activated. The increase of permeability limits the pore pressure that reaches a maximum and then decreases. The numerical results reproduce this pore pressure pulse and the initial fault weakening followed by a restrengthening of the shear stress.

Figure 1. Fault at 7-km depth. Comparison of the corrected computation with the one plotted in Figure 2 of Sulem and Famin (S&F (2009) in the legend): (a) Evolution of temperature and pore pressure in the center of the shear band, (b) evolution of the shear stress, and (c) evolution of the mass of emitted CO_2.