The Frictional Strength, Pore Pressure, and Heat in the Chelungpu Fault During the 1999 Chi-Chi Earthquake

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On September 20, 1999, the M_s7.6 Chi-Chi earthquake ruptured the Chelungpu fault in central Taiwan. During faulting of an earthquake, the strain energy, ΔE, was transferred into the seismic radiation energy (E_s), fracture energy (E_g), and frictional energy (E_f), that is $\Delta E=E_s+E_g+E_f$. Integrating observed data and inversed results of source parameters of the Chi-Chi earthquake, the values of ΔE, E_s, and E_g can be evaluated for the fault and its northern and southern segments. Thus, E_f is calculated by subtracting E_s+E_g from ΔE. The values of E_f are: (1) $E_{fS}=1.21\times10^{17}$ J; (2) $E_{fN}=1.45\times10^{17}$ J; and (3) $E_f=2.65\times10^{17}$ J for the whole fault. During faulting, on a fault plane, with an area of A, heat generation caused by the dynamic frictional stress σ_d in an average displacement of D is $E_f=\sigma_d DA$, which can be represented by an average temperature rise, ΔT. Heat is assumed to be distributed within a layer of thickness h around the ruptured plane. Hence, ΔT is given by $\Delta T=E_f/C\rho Ah$, where C and ρ are, respectively, the specific heat and density of crusal rocks. Define $Q=E_f/C\rho A=\Delta T\cdot h$ to represent the strength of a heat source. In general, the values of C and ρ are, respectively, 10^3 J/kg-^{o}C and 2.6×10^3 kg/m^3. Hence, the estimated values of Q and ΔT are: (1) $Q_S=102^o$C-m and $(\Delta T)_S=(102/h)^o$C for the southern segment; and (2) $Q_N=154^o$C-m and $(\Delta T)_N=(154/h)^o$C for the northern one. Obviously, heat generation is higher in the northern segment than in the southern one. Together with core samples, heat generated by the earthquake is elucidated based on a 1-D lithostatic model and a 1-D cooling equation. Results show that the frictional strength and pore pressure are two significant factors in controlling the generation of heat during faulting of the earthquake.