POSSIBLE EFFECTS OF THERMAL STRESS ON THE LITHIFICATION OF CHONDRITE PARENT BODIES

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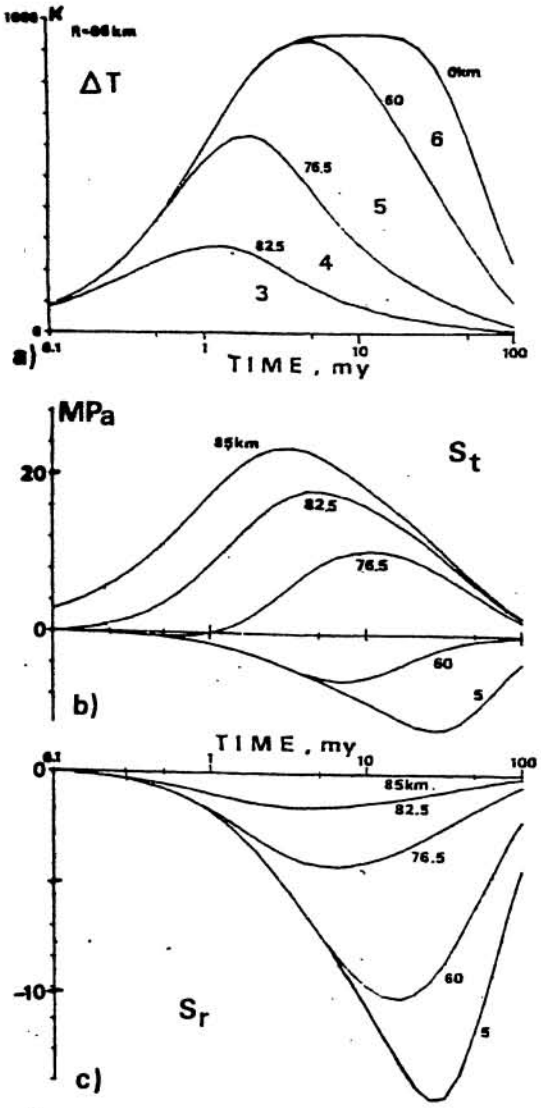
The lithification of chondrite would take place at some stage during the evolutional history of chondrite parent bodies. Thermal stress within the chondrite parent bodies is considered to be one of the causes to explain differences of strength among chondrites (1). From a view that thermal metamorphism produced the entire range of petrologic types from 3 to 6 in a chondrite parent body, the problem whether heat sources are internal (decay energy of extinct radioactive elements such as Al-26) or external (radiation energy from ambient primodial solar nebula) remains unsolved (2). Although both models expect radii of parent bodies from a few tens to several tens of kilometers, this difference of the heat sources results different thermal history and so does the thermal stress within the parent body.

By assuming a homogeneous and isotropic elastic parent body (3), thermal stress distribution can be calculated using the thermal histories for models with internal (4) and external (5) heat sources. The distribution of temperature changes $\Delta T(r)$ at any time is assumed to be differences from the initial temperature distribution, where r is the radial distance from the center of the parent body. Values of thermal expansion coefficient, Poisson's ratio and Young's modulus are taken to be 0.03/1000 K, 0.25 and 300 MPa, respectively.

In the internal heating model, the tangential stress (St) is tentional (up to about 20 MPa) and is larger than the (compressional) radial stress (Sr) in magnitude near the surface of the parent body where chondrites with types 3 and 4 are expected (Fig. 1). Inside the radius of about 60 km where chondrites with type 6 are expected, both St and Sr are compressional. If chondrites become strong under the compressional stress field, type 6 chondrites would be stronger than type 3, which seems to be inconsistent with the observations that L3 and L4 are far stronger than L6 and LL6 (1). Volatile elements could escape from depth through the cracks and faults that were expected near the surface in relating tensile stress region. The release of volatiles could loose the grain-to-grain adhesion in L6 (6).

On the other hand, both Sr and St are everywhere tensional during the heating time interval, and become compressional afterwords in the shallower region, in the external heating model (Fig. 2). Magnitude of stresses in the external heating model are larger than that in the internal heating model, where the surface temperature rise of about 1000 K during the heating interval (Δt) is considered. In the external heating model, thermal stress will act only to loose and make cracks in the chondritic parent body.

As the petrologic types are not simply relate with the variety of strength and porosity and the large anisotropy in chondrites, these variation in mechanical properties would not solely be due to the effects of thermal stress. For example, thermal stress would not attribute to the magnetic susceplibity anisotropies of chondrites (7), because of no relation with their petrologic types, even though these anisotropies indicate the uniaxial compression type stress field. It needs further investigations for the effects of thermal stress on the deformation and recrystallization of grains in chondrites during the thermal metamorphism.



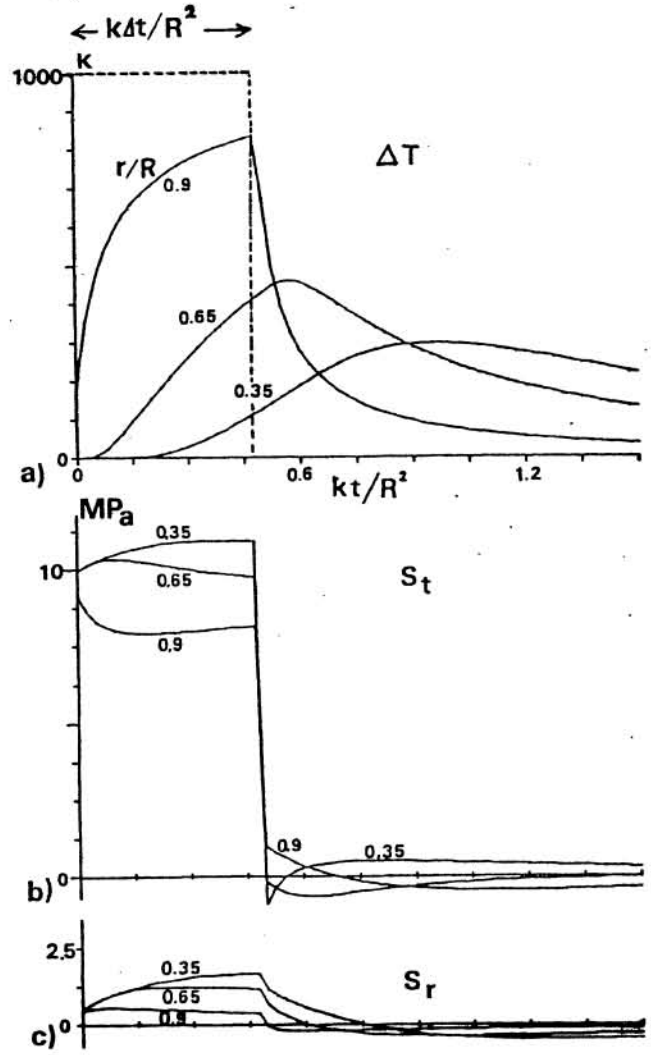


Fig. 1. Internal heat source model (4): Fig. 2. External heat source model(5): Variations of a) temperature, b)tangential, and c) radial stresses with time. Numbers from 3 to 6 correspond to petrologic types. (r; radius, k: thermal diffusivity, t: heating interval).

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