Diffusion in a mineral and unclosure temperature: sphere

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The concept of closure temperature (Tc) was proposed by Dodson (1973) from a view of a cooling rock unit, and it has been widely applied to interpret cooling ages in many geological settings. Although the derivation of the diffusion parameters is based on rigorous physicochemical experiments, some ambiguity remained in estimation of Tc. Dodson defined Tc as the temperature in which an isotopic clock practically starts due to drastic drop of diffusion coefficient by temperature change. However, it is unclear what value corresponds to the practical end of diffusion, and uncertainty still remains in cooling rate in spite of the resulting difference in Tc is within $\pm$ 50^{o}C. Here, we consider a diffusion process due to a secondary heating as in a case of stepwise heating during ^{40}Ar/^{39}Ar exeriments.
Exact solusions of a diffusing element at temperature of some duration are given for various geometries (Crank, 1975). A unclosure temperature of diffusion in a sphere is estimated since it is the most heat resistant geometry. When 99% of the starting quantity is lost, it is regarded as total reset. This determines the maximum of unclosure temperature. When nearly 20% is lost, the calculation by Turner (1968) shows that a sphere barely retains near-primary age in the highest temperature fractions. This defines the minimum of unclosure temperature. Both of the temperature is solved in terms of t, the duration using proper approximations. It is better to provide an expression of t in terms of T. This corresponds to the relation between reheating temperature and relaxation time in paleomagnetism (Pullaiah *et al.*, 1976). The closure temperature in cooling body lie between the curves of the minimum and maximum of the unclosure temperatures. The concept of relaxation time provides a clear view of temperature-time relation in geological settings.
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