Argon diffusion in chondritic minerals

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^{40}Ar-^{39}Ar dating is an important tool to decipher the thermal history of chondrites and other meteorites. Due to the fine-grained nature of primitive extraterrestrial matter, most Ar-Ar studies use rather whole rocks instead of mineral separates. Exceptions are a few studies investigating feldspar and pyroxene separates by high resolution stepwise degassing, e.g. of eucrites [1,2] or chondrites [3]. While the diffusion characteristics of extraterrestrial pyroxene [3] is similar to terrestrial pyroxene with only limited dependence on structure and chemistry [4], feldspars display more variability. E.g., Ca-rich plagioclase from unshocked eucrites [1] has an argon release pattern distinct from maskelynite in martian shergottites [5,6], and distinct from the predominantly sodic plagioclase (oligoclase) found in unshocked equilibrated ordinary chondrites or A-L chondrites [3,7]. In the two latter cases, oligoclase feldspar turns out to be the major carrier phase and, hence, whole rock ages can be considered as feldspar ages with the closure temperature of oligoclase of 550+-20 K [3,7]. Proper evaluation of closure temperature requires determination of diffusion parameters (frequency factor D_0, activation energy Q) via Arrhenius diagrams. Here, several artifacts falsifying diffusion parameters have to be excluded, e.g. effects of i) grain size distributions (in some cases caused by grain fracturing due to weak shock), ii) disturbance by minor K-bearing phases, iii) possible heterogeneity of the distribution of potassium. If closure temperatures are properly evaluated [7], and high precision Ar-Ar ages are calibrated accurately against other chronometers like U-Pb-Pb [8], cooling histories can be modeled by thermal evolution models of meteoritic parent body histories [9,10]. These allow reconstruction of parent body properties like size, initial porosity, and formation time.

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