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^{40}Ar-^{39}Ar Ages of H-Chondrites: Constraints on Parent Body Thermal Metamorphism

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If different radio-chronometers are applied to chondrites of different petrological types that are unaffected by secondary collisional shock or reheating, this can reveal insights into the early cooling history of the respective chondrite parent body. This is possible because closed system behaviour occurs at different (chronometer specific) temperatures. High precision U-Pb data (Göpel et al., 1994) and ^{244}Pu-fission track cooling rates (Pellas and Fiéni, 1988) indicate later isotopic closure and slower cooling for the equilibrated H6-chondrites Kernouve and Guarena than for the lesser equilibrated chondrites St. Marguerite, Forest Vale (both H4), Richardton, Nadiabondi and Allegan (all H5). We analysed these meteorites by the ^{40}Ar-^{39}Ar dating method, because it is well suited to provide additional information about the cooling history due to its intermediate retention temperature (Turner et al., 1978). This study provides the first ^{40}Ar-^{39}Ar-data for some of the meteorites, but also serves to check discrepancies emerging during former ^{40}Ar-^{39}Ar analyses (Turner et al., 1978; Flohs, 1979). Improvement was achieved by using step-heating with a high resolution and by an improved monitoring of the neutron flux. For the less equilibrated chondrites the main analytical problem arises from their fine grained nature leading to redistribution of ^{39}Ar by recoil (Huneke and Smith, 1976) from K-rich phases (mostly feldspar) into more retentive K-poor phases like pyroxene and olivine. Improving the resolution of the age spectra enables to detect fine scale structure due to ^{39}Ar recoil and to identify partial plateaus (Trieloff, 1998). This is also the base for quantitative modelling of such age spectra, which allows to extract proper chronological information.

All H6-chondrites yield well defined plateau ages. Guarena displays a plateau age of 4,45 ±0,02 Ga, defined by 10 extractions over 75% of the fractional ^{39}Ar release. An indistinguishable result was obtained for Estacado. The plateau age of Kernouve is 4,47 ±0.02 Ga (13 extractions over 70% of the fractional ^{39}Ar release). The plateau ages correspond well with the results of Turner et al. (1978) within the quoted uncertainties, which include the age uncertainties of the respective flux monitors (standard used in this study is NL25 hornblende). However, relative uncertainties defining the age difference due to parent body cooling are as low as 5 Ma in this study. The H5-chondrite Richardton shows a more complex age pattern with a relatively poor defined high temperature plateau age of 4,48 ±0,02 (9 extractions over 25% of the fractional ^{39}Ar release). The age spectrum of Richardton will be discussed in more detail together with the spectra of Nadiabondi and Allegan. H4-chondrite Forest Vale gives a partial plateau with an age value about 80 Ma higher than for the equilibrated chondrites. The results confirm slower cooling and later isotopic closure of more equilibrated H-chondrites, and are consistent with an internally heated parent body having an onion shell structure, i.e. with an origin of the equilibrated chondrites at the interior part of the parent body, whereas the unequilibrated chondrites were located closer to the surface. Collisional disruption of the parent body did not occur before closure of the K-Ar-system due to thermal metamorphism that lasted at least 80 Ma.

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