
Jilin is one of the largest stone meteorites and especially the intact main mass (1770 kg) allowed investigations on locally documented samples which are not possible for smaller meteorites. Jilin is intensively studied by a consortium led by F. Begemann, Mainz. In its context we performed a high resolution 40Ar-39Ar analysis of two samples from the main mass which were 15 cm (sample identification: 1-2) and 45 cm (sample identification: 1-4) below the preatmospheric surface as determined by the 60Co activity [1]. They had the largest (1-4) and lowest (1-2) K-Ar age of the main mass samples measured by Begemann et al. [2]. The age spectra are shown in Fig. 1. Previous 40Ar-39Ar studies of undocumented Jilin samples resulted in similar spectra [3,4]. In the present study, however, the low temperature extractions vary over a much wider age range (0.4 AE to 3.5 AE). The high temperature ages obtained in both studies agree and date the last total outgassing of Jilin 4.0 AE ago.

The results clearly indicate 40Ar losses of greatly varying degrees from samples which in the meteorite were only 60 cm apart, and that the surface sample suffered the highest loss. Thermoluminescence data from Wagner [5] set a limit for the near-surface temperature during the last 33000 y, 300 K. This low temperature certainly is insufficient to produce the measured 40Ar loss. From the age of Jilin, 4.0 AE, and the K-Ar ages determined by Begemann et al. [2] we calculate 40Ar losses also for samples from other depths. These are plotted versus the depths determined from the 60Co-activities (T1/2 = 5.27 y) [1] in Fig. 2a. Similarly, from 4He-2 [2] and U-Th-6 [1] contents we calculate losses of 4He (Fig. 2b). Clearly, both losses are correlated to the shape of the meteorite during the last couple of years. Jilin has assumed its shape 400 000 y ago when it was separated from its parent body (beginning of the 4m-geometry irradiation [1]). Before that event Jilin was > 0.4 m below the surface of its parent body for 8 my (2m-irradiation [1]). The 4He and 40Ar losses are not correlated to 21Ne [2], the measure of the 2m-irradiation depth. The losses and hence the heating of Jilin from its surface then happened between 33 000 y [5] and 400 000 y [1] ago.

To gain more information on the temperature and duration of the heating event, we performed stepwise gas extraction of an unirradiated aliquot of sample 1-4 and measured the release of radiogenic 4He and 40Ar. From Arrhenius plots we infer activation energies for 4He and 40Ar of 33.9 kcal/mol and 45.6 kcal/mol, respectively, and diffusion parameters αD/a2 of 1.3x105 sec-1 and 6.8x107 sec-1. As a first step to estimate the temperature history we calculate using these parameters that for sample 1-2 475°C for 24 h and for sample 1-4 225°C for 160 y produces just the measured losses of 4He and 40Ar. We then performed a more refined estimate employing an initially hot surface layer around Jilin and heat transport into the meteorite. The initial surface temperature (1050 K) and the surface cooling rate (6.4 K/h) were fixed to the measured 40Ar losses of samples 1-2 and 1-4. For 40Ar we then derive losses for various depths which are comparable to the measured ones (solid line in Fig. 2a). The calculated 4He losses at the surface are also similar to the measured ones. Inner portions of Jilin had lost more 4He than our model yields. This may indicate an additional low temperature heating period which only affected 4He and not 40Ar.

Most probably the heating happened when Jilin was separated from its parent body. If this is correct, the same process would have affected also other meteorites and could be the process responsible for "late" disturbances observed in some isotope systems [8,9]. It could also be the driving force.
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for late hydrothermal alterations seen, e.g. in Qinzheng [11,12].

References


Figure 1: Age and K/Ca spectra of a near surface (1-2) and an inner (1-4) sample of the Jilin meteorite.

Figure 2: Measured losses (bars) of 40Ar and 4He versus distance of the respective samples from the preatmospheric center of the meteorite (data from [1,2] and this work). Calculated loss profiles (see text) are shown by solid lines.

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