ARGON AGES: FROM PRIMITIVE PLANETESIMALS TO DIFFERENTIATED MOON.

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The use of the $^{40}$Ar - $^{39}$Ar method has lead to an order of magnitude improvement in precision over previously determined K - Ar ages of meteorites. Despite this improvement the accuracies obtainable ($\sim 30$ Ma) are barely sufficient to resolve the early metamorphic history of chondrites, which appears on several grounds to be restricted to a time integral of less than 100 Ma. The major difficulties are not instrumental but result from uncertainties in the interpretation of argon release patterns. Variations in the ($^{40}$Ar/$^{39}$Ar) ratio occur during step heating due to a variety of causes which are only partially understood. Nevertheless it is possible to treat argon data from chondrites in an objective way and obtain what we believe to be reliable cooling ages and, equally important, an estimate in some cases of the error resulting from the incompletely understood fluctuations in ($^{40}$Ar/$^{39}$Ar).

The procedure we adopt is as follows: Low ages at low temperatures are regarded as evidence of recent argon loss and this part of the release pattern ignored. Where a 'plateau' exists following the low temperature release an age, $T_p$, is calculated from all points within 20% of the plateau. When at high temperatures the ($^{40}$Ar/$^{39}$Ar) ratio drops below the plateau (thought to be the result of $^{39}$Ar recoil) we calculate a reduced plateau age, $T_A$, which would be the same as a total argon' age if the plateau had extended down to low temperatures. The difference in the ages is taken as a measure of the uncertainty in the plateau age.

A number of chondrites, usually unequilibrated ones, show monotonically decreasing ($^{40}$Ar/$^{39}$Ar) ratios as a result, we believe, of $^{39}$Ar recoil in fine grained K bearing phases (2,3). In these cases the presence of high ages at low temperatures is taken to infer negligible Ar loss and an age, $T_t$, calculated based on the total argon release. The error estimate is calculated solely on the basis of the statistical errors of the measurements and strictly speaking the age is a lower limit since it is possible for a small amount of $^{40}$Ar loss to be masked at low temperatures.

Most recently we have carried out age determinations on Tieschitz (H3), Menow (H4), Kernouve(H6), Butsura (H6) and Richardton (H5). The ages of these chondrites, together with those previously determined for Ochansk (H4), Saratov (L4), Olivenza(LL5), Queen's Mercy (H6), Mount Brown (H6), Guarana (H6), Barwell (L6), St. Severin (LL6) and Shaw (L7), all lie in the restricted interval from 4.50 to 4.58 Ga, (mean value 4.54 ± 0.03 Ga).

Kernouve, Butsura and Richardton give quite well defined plateaux with negligible Ar loss. Menow shows evidence of having lost 10% of its Ar within the last 2.5 Ga but has a well developed plateau over 60% of the release pattern. Tieschitz the least equilibrated of the chondrites shows the most extreme variation in ($^{40}$Ar/$^{39}$Ar) we have observed. The apparent

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Age decreases from a value of 5.41 Ga in the low temperature release to 2.3 Ga at high temperatures. Nevertheless the total argon age, 4.52 ± 0.05 Ga, is indistinguishable from the plateau ages of the equilibrated chondrites. The behaviour of Tieschitz is reminiscent that observed in fine grained lunar rocks such as 14321 (4).

The resolution of chondrite cooling times to better than ±30 Ma by the Ar-39 Ar method is proving difficult for reasons outlined above. However as we have previously argued the tight clustering of ages of chondrites with a range of petrologic types is difficult to reconcile with cooling rates less than 10°C/Myr and seems to imply that the parent planetesimals were small objects with radii less than 100 km.

In addition to the chondrite measurements we are currently analysing a number of small fragments from Luna 24. 24170, 1-3,2 is a 9 mg sample of crushed coarse grained basalt. Hand picking has yielded three mineral separates which will be dated separately. The separates consist of feldspar, pyroxene and a minor group of 'remainder' minerals including ilmenite and (foreign?) glasses and agglutinates. 24196, 1,9011 is a 17 mg metabasalt which has been split to yield 3 chips, two for independent dating and one for probe analysis. The polished surface of the probe fragment reveals a well recrystallised granulitic texture with roughly equal feldspar and pyroxene contents. The grain size (~20 μm) suggests that the sample should yield good Ar-39 Ar systematics.

References