

ON THE AGE OF CUMULATE NORITE 78236: AN ^{39}Ar - ^{40}Ar STUDY.

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Lunar cumulate norite 78235-8 received much attention as a possible parent for KREEP and as a member of the Mg-rich plutonic suite in the lunar crust (1, 2,3). Much information regarding the time of formation of this norite is already available based on studies of the system Sm-Nd on splits of our sample (1) and of the systems Rb-Sr, Sm-Nd and Ar-Ar on sample 78236,4 (2). Each system was found to be disturbed presumably because of severe shock metamorphism (3). Since the Ar-age record is generally best preserved in lunar plagioclases and in view of the severe shock metamorphism, we have sampled three major macroscopically distinct plagioclases.

Plag. A (>1mm): Seven aggregates of milky-white and of minor amounts of colorless to gray plagioclases, with estimated <0.5% other phases.

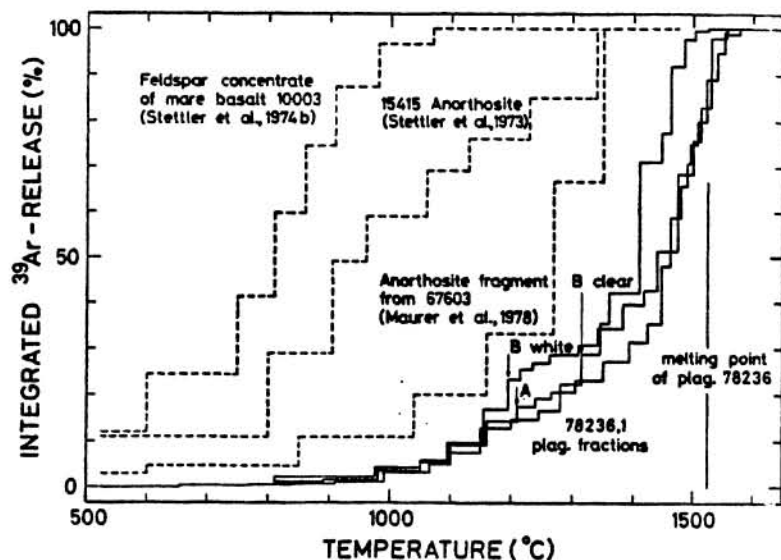
Plag. B-1 (<1mm): Grains of 0.5 to 1mm size of glassy colorless plagioclase (maskelynite) with estimated <1% adhering opx and opaque phases.

Plag. B-2 (<1mm): Grains of 0.5 to 1mm size of milky-white plagioclase (relict) with estimated <1% of adhering opx and opaque phases. The results for the Plag. samples are shown in figures 1, 2 and in (4). In all samples, Ar is only released at very high temperatures (Fig. 1). In fact, it is more retentively

sited than Ar in any other lunar material (5,6,7). All three samples show essentially ideal examples of ^{39}Ar - ^{40}Ar age plateaus with a plateau range of from ~ 0.1 to 1.0 of the fractional ^{39}Ar release. Also, the three plateau ages are identical within the narrow error limits. Furthermore, the K/Ca ratio remains constant over the plateau range as expected for high purity mineral separates. Since the total ^{40}Ar loss is less than 2%, in spite of the clear imprints of strong shock metamorphism, we conclude that the plagioclase system remained closed for the last 4.11 ± 0.02 Gy. However, our results are at variance with Ar data reported by (2) in which a 78236,4 plag. sample shows a distinct release curve and age as well as much lower K and Ca contents than our plagioclase (4). Furthermore, if plagioclase equilibrated 4.11 Gy ago, then the Sm-Nd data (1) require that ^{143}Nd in orthopyroxene (opx) was considerably evolved at this time and, therefore, older. We were aware of the inherent difficulties of Ar-Ar dating of opx of low K content, but we thought this, nevertheless, to be an important datum towards establishing the age of this norite. Sample Opx-E1 is a single aggregate of opx, and sample Opx-E2 is a collection of opx crystals and aggregates of 0.4 to 1mm size. Only grains with glass-free surfaces were hand-picked under a binocular microscope on an x-y stage. Intercumulus mesostasis was not observed on surfaces but can occur interstitially (2). The Ar release patterns in opx (Fig. 3) appear complex and do not define a plateau age. A second minor (contaminant) phase characterized by very high K and low Ca contents is present in addition to opx. Since the K concentration in Opx-E2 is only 31ppm, the K-rich phase, which fits the characteristics of intercumulus mesostasis (2), severely affects the opx age data. Fig. 3 allows a measured lower limit of 3.6 Gy to be set for the Ar-age of opx (average 1300-1400° steps), but the correct age may be compatible with the 4.11 Gy value. The K-rich phase itself reveals a very low ^{40}Ar retention age which appears to be compatible with the cosmic-ray exposure age of 300 My, as inferred from Ar and Kr spallation data. The possibility of its outgassing or formation at this time cannot be excluded. We consider two models for the early history of the norite: (i) Slow cooling in the lunar crust (2) and excavation at 4.11 Gy; (ii) Formation close to 4.4 Gy and a near-complete resetting of the ^{40}Ar -clock in plagioclase 4.11 Gy ago.

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◀ Fig. 1

^{40}K decay constants from Steiger and Jäger (1977).

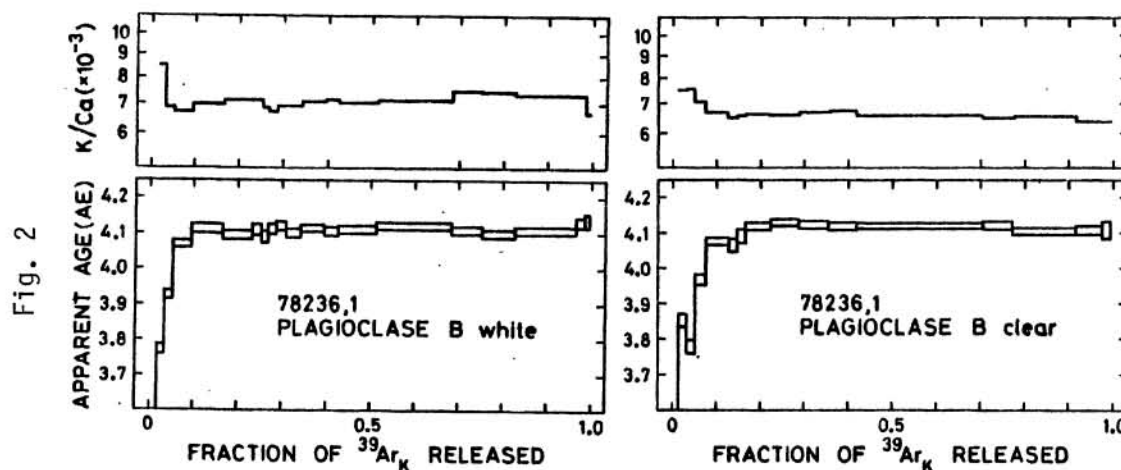


Fig. 2

Fig. 3 ▶

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