^{39}Ar-^{40}Ar Studies of Lherzolitic Shergottites Yamato 000097 and 984028. J. Park[1,2,3], L. E. Nyquist[2], D. D. Bogard[2], D. H. Garrison[4], C.-Y. Shih[5], T. Mikouchi[6] and K. Misawa[7], [1]Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX 77058, USA, [2]ARES, Mail Code KR, NASA Johnson Space Center, Houston, TX 77058, USA, [3]Current address: Space Science Office, NASA Marshall Space Flight Center, Huntsville AL 35812, and University of Alabama in Huntsville, Huntsville AL 35805, USA, [4]ESCG/Barrios Technology, Houston, TX 77058, USA, [5]ESCG/Jacobs Engineering, Houston, TX 77058, USA, [6]Department of Earth and Planetary Science, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan, [7]Meteorite Research Center, National Institute of Polar Research, 10-3 Midoricho, Tachikawa, Tokyo 190-8518, Japan.

Introduction:
Yamato 984028 (Y984028) was discovered by the Japanese Antarctic Research Expedition (JARE) in 1998 and recently classified as a lherzolitic shergottite with large pyroxene oikocrysts enclosing rounded olivine and chromites. It also contains shock veining and maskelynite [1]. Y984028 is paired with the more recent lherzolitic shergottite finds Y000027/47/97 based on similarities in mineralogy and chemistry (e.g., [2]), as well as isotopic composition (e.g., [3, 4]). We present here the studied ^{39}Ar-^{40}Ar of Y-984028 whole rock (WR) and pyroxene (Px), in order to gain better understanding of trapped Ar components with a comparison of the possibly-paired Y000097 Ar release.

Ar-Ar results:
^{39}Ar-^{40}Ar age spectra and K/Ca ratios for whole rock (WR) and pyroxene mineral separates of Y984028 and plagioclase mineral separates of Y000097 [5, 6] are shown in Figs. 1, 2 and 3. Age spectra for Y984028 WR and Px are roughly ~2 Ga, indicating several Ar components, such as radiogenic 40Ar*, cosmogenic Ar and trapped Ar from multiple minerals, as well as multiple source origins. The ^{39}Ar-^{40}Ar age for Y000097 gives ~260 Ma [5, 6]. The reported Sm-Nd and Rb-Sr ages for Y984028 are 170±10 Ma and 170±9 Ma, respectively [4]. Y000097 yields a Rb-Sr age of 147±28 Ma and a Sm-Nd age of 152±13 Ma [5]. Apparently, Ar-Ar ages of Y984028 and Y000097 show trapped Ar components. Fig. 4 shows K/Ca of mineral phases in Y984028 determined by electron microprobe. This gives mineral modes and we can compare the K/Ca ratios from the different techniques and discuss the relative importance of each mineral in the K budget of Y984028 WR and Px. Open boxes in Fig. 4 can be interpreted as the multiple mineral phases in the Ar-Ar whole rock data (Fig. 1), which are complicated to be distinguished. The mineral pyroxene spectra (Fig. 2), although nominally that of a single phases, show an order of magnitude more variation in K/Ca than does the Ar spectra in WR. As shown in Fig. 4, pyroxene shows a large range in K/Ca, but because opx has low modal abundance compared to pigeonite and augite, the K/Ca ratio pyroxene is effectively restricted to the range 0.0001 to 0.01, i.e., to the last ~20% of the ^{39}Ar release.

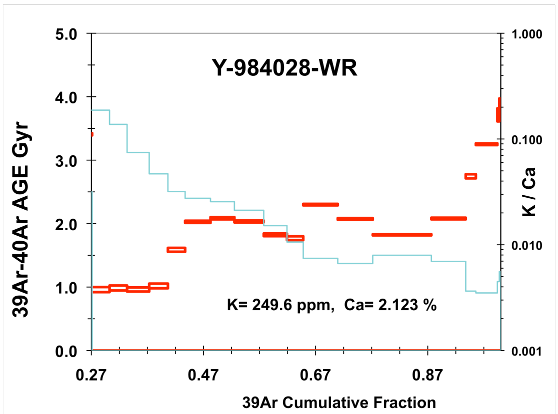

Fig. 1. ^{39}Ar-^{40}Ar ages and K/Ca ratio as a function of ^{39}Ar release for Y-984028 whole rock.

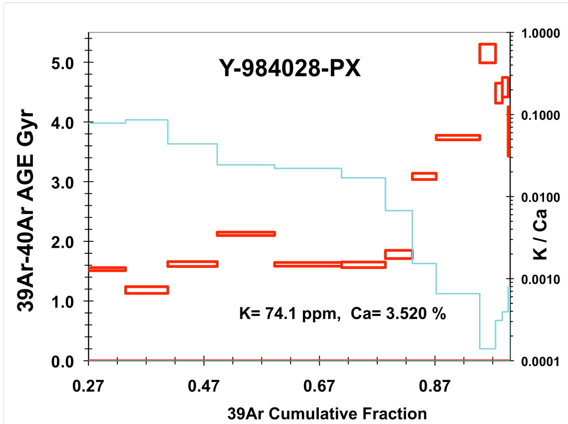

Fig. 2. ^{39}Ar-^{40}Ar ages and K/Ca ratio as a function of ^{39}Ar release for Y984028 pyroxene separate.

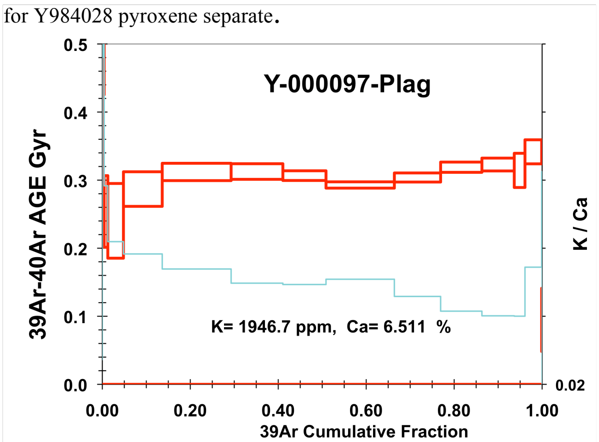

Fig. 3. ^{39}Ar-^{40}Ar ages and K/Ca ratio as a function of ^{39}Ar release for Y000097 plagioclase separate.

Besides, K/Ca ratio in Fig. 2 shows that the gas released during the first ~80% of the ^{39}Ar release must be from plagioclase (maskelynite) or olivine.

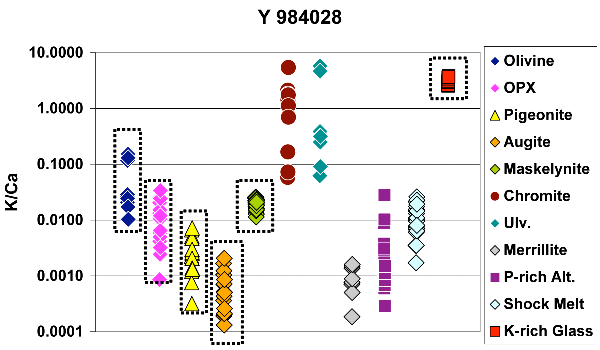

Fig. 4. K/Ca ratios for each minerals in Y984028.

Isochron plot for Y984028-Px:

Fig. 5 is the cosmogenic corrected $^{40}Ar/^{36}Ar_{(trapped)}$ versus $^{39}Ar/^{36}Ar_{(trapped)}$ of Y984028 pyroxene separate. Because we do not have an accurate way to determine the cosmogenic ^{36}Ar concentrations of the pyroxene, we used the minimum measured $^{36}Ar/^{37}Ar$ and an estimated value of cosmogenic ^{36}Ar of 1.9×10^{-9} cm^3STP/g, which is similar as 1.3×10^{-9} cm^3STP/g of Y984028 noble gas whole rock data [3]. The isochron slope of lower temperature extractions at 300-650 °C is consistent with an apparent age of ~170 Ma [4], with the similar initial $^{40}Ar/^{36}Ar$ of terrestrial atmosphere (~296). Intermediate temperature data (from 800-1100 °C), nominally consistent with a similar slope of the radiometric age of ~170 Ma [4] with an approximately Martian atmosphere trapped Ar composition with a ratio of $^{40}Ar/^{36}Ar$ as ~1800 [7]. Based on the K/Ca ratio, we know that ^{39}Ar released at both lower and intermediate temperatures is primarily from plagioclase and olivine. ^{39}Ar released at higher temperatures (1200-1500 °C) shows a higher slope, distinct from lower temperatures.

Isochron plot for Y000097-Plag:

Fig. 6 is the Y000097-Plag isochron plot of $^{40}Ar/^{36}Ar_{(trapped)}$ versus $^{39}Ar/^{36}Ar_{(trapped)}$ with multiple Ar-components; radiogenic, trapped Martian atmosphere, terrestrial atmosphere, inherited Ar. some of these components are more dominant in some gas fractions than others, making interpretation more complicated. Interestingly, we can find three isochron slopes with different ages. The slope at the lower temperature release (500-700 °C) gives an age of ~182 Ma, while most of the Ar released at intermediate temperatures (800-1200 °C), except the 1060 °C and 1110 °C fractions, gives a slope age of ~269 Ma, which is similar to the Ar age spectrum of Y000097. It is unclear why the 1060 °C and 1110 °C data differ, but it is plausible that these Ar releases have the presence of inherited, mantle ^{40}Ar, with a little higher initial $^{40}Ar/^{36}Ar$ ratio of ~627.

Discussions:

Ar isotopic components of Martian meteorites are complicated because they represent the sum of several Ar origins, such as Martian atmosphere, Martian mantle, inherited Ar, terrestrial atmosphere, and cosmogenic Ar. Obviously, Ar released at higher temperatures from pyroxene separates should not have any detectable signature of the terrestrial atmosphere. Reported analyses of $^{129}Xe/^{132}Xe$ from higher temperature extractions (1200-1800 °C) [3] give a value higher than the terrestrial Xe ratio of 0.98. We suggest the presence of Martian mantle ^{40}Ar, as well as excess ^{40}Ar assimilated from inherited magma [6, 8].

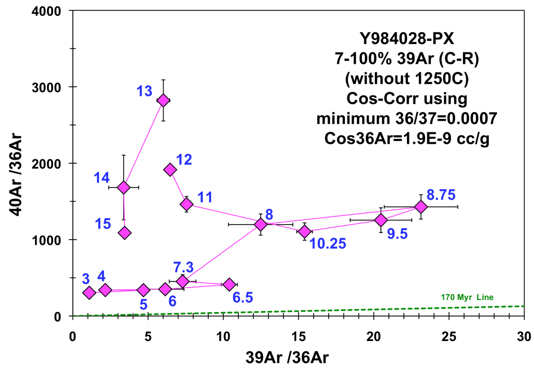

Fig. 5. $^{40}Ar/^{36}Ar$ *vs.* $^{39}Ar/^{36}Ar$ in Y984028 pyroxene separate.

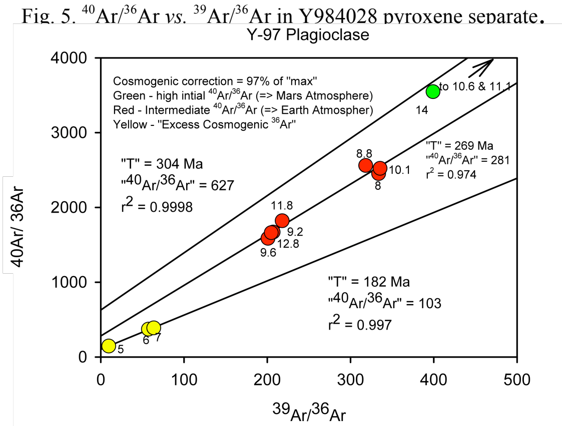

Fig. 6. $^{40}Ar/^{36}Ar$ *vs.* $^{39}Ar/^{36}Ar$ in Y000097 plagioclase separate.

References:

[1] Kojima H. and Kaiden H. (2008) *Meteorite Newsletter 17,* 1-5 (ed.). [2] Mikouchi T. et al., (2009) *Antarct. Meteorites*, XXXII, 35-36. [3] Nagao K. (2009) *Antarct. Meteorites*, XXXII, 43-44. [4] Shih C.-Y. et al., (2010) *Polar Science,* in press.[5] Misawa K. et al. (2008) *Polar Science, 2,* 163-174.[6] Bogard D. D. et al. (2009) *Meteorit. Planet. Sci., 44,* 905-923. [7] Bogard D. D. and Garrison D. H. (1998) *GCA, 61,* 1829-1835. [8] Bogard D. D. and Park J. (2008) *Meteorit. Planet. Sci. 43*, 1113-1126.