**MEASUREMENTS BY THE GRS ON MARS ODYSSEY OF ARGON IN MARS' ATMOSPHERE: TWO FULL MARS YEARS AND MORE.**

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**Introduction:** In this paper we present measured Ar abundance around Mars for slightly more than two full martian years. This greatly extends the previous atmospheric Ar measurements [1] over the south polar region for three seasons, and data for all latitudes for one and one half Mars years, from 8 June 2002 to 2 April 2005 [2]. Measurements of Ar in Mars' atmosphere are made by the Gamma Subsystem (GS) of the suite of three instruments comprising the Gamma Ray Spectrometer (GRS) on the 2001 Mars Odyssey spacecraft [3, 4]. The mapping orbit began 19 Feb. 2002 and continues to this day. Time periods are given in terms of areocentric longitude of Mars ($L_s$), where $L_s = 0^{\circ}$ is defined as the vernal equinox for the northern hemisphere. In this reference frame, the GRS began mapping at $L_s = 24.2^{\circ}$. Because data are binned in time to build meaningful statistics (a high signal-to-noise ratio), the first Ar measured data point is at $L_s = 27.2^{\circ}$ (MY 1, Figs. 1, 2 and 3). The last data shown are those shown in blue, $L_s$ = 0° to 30° (MY 3, Figs. 1, 2 and 3).

The GS integrates γ-ray line emission at 1294 keV generated by the decay of $^{41}$Ar created when a thermal neutron is captured by $^{40}$Ar in Mars' atmosphere. As with all the useful γ-ray lines in the energy range of the GS, they are summed over time and binned in latitude and longitude sectors after the signal is transmitted from the spacecraft to the laboratory. Details of the γ-ray peaks, energies, and continuum are given in *Evans et al.* [5]. Details of the computation of the footprint, data collection, binning, and processing, for Ar and the suite of other elemental emissions, can be found in *Boynton et al.* [4].

**Argon Seasonal Variations:** The GRS data are absolutely calibrated using the Viking Lander 2 (VL2) value for the Ar mixing ratio of 0.0145 mass mixing ratio [6]. All enhancement factors are computed taking into account the seasonal variation in column abundance and topography.

The Ar abundance enhancement over what would be expected from a homogeneously mixed atmosphere reaches a factor of 6 in the high latitude bin (75° to 90° S) in southern summer as shown in Fig. 1. The magnitude of this increase has not been reproduced in general circulation models used for predicting the seasonal transport of Mars atmosphere [7], however the general seasonal character has been reproduced.

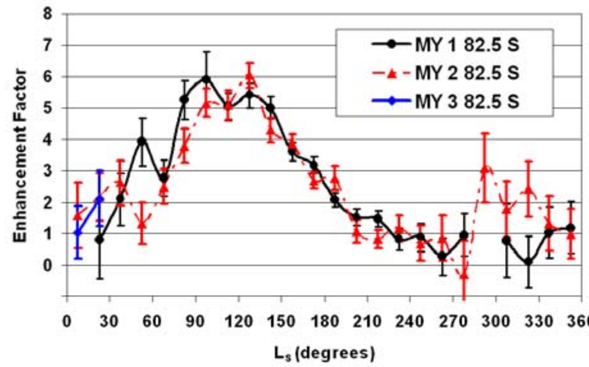


**Fig. 1.** Measured Ar abundance shown as an enhancement factor over what is expected from a homogeneously mixed atmosphere of constant mass mixing ration = 0.0145 as measured by the VL2, for the high southern polar latitude bin (75° to 90° S). The factor of 6 increase in Ar occurs for two consecutive Mars years but shows some significant variations from year

At high northern latitudes, the seasonal enhancement factor undergoes noted fluctuations reaching the expected value of three at the onset of winter [2]. Some of the fluctuations appear to be statistically significant and are probably associated with traveling waves at and around the north polar region. Especially interesting is the large difference seen in the two consecutive summers between $L_s$ = 90° and 120°. Because the GS is still measuring Ar at Mars, another year of data may help us to use these data. We hope to use the data to more finely tune circulation models of the atmosphere and help to understand the nature of the north polar vortex. The peak near the onset of winter ($L_s$ = 270°) is out of phase by 15° in $L_s$.

To better understand the high latitude north polar seasonal change in Ar abundance, the data (Fig. 3, grey points and line) have been smoothed with a simple 3 point box car algorithm (Fig. 3, black points and line), and both are compared to the absolutely calibrated homogenously mixed atmospheric model with Ar mixing ratio = 0.0145. This comparison helps to discern distinct seasonal variations and fluctuation in the Ar abundance as a function of season.

At mid-latitudes the Ar abundance varies but the signal to noise ratio is limited and no definitive seasonal or latitude differences can be discerned. By binning data in increments of 15° of $L_s$ and from 52° S to 52° N latitude we can compare the character and abundance of Ar from year to year as shown in Fig. 4.

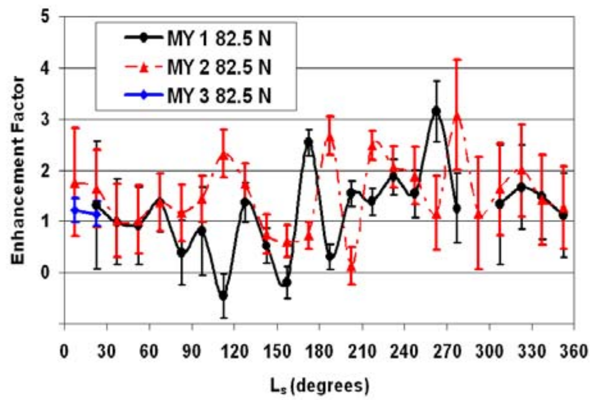


**Fig. 2.** Measured Ar abundance shown as an enhancement factor over what is expected from a homogeneously mixed atmosphere of constant mass mixing ratio = 0.0145 as measured by the VL2, for the high southern polar latitude bin (75° to 90° S). The factor of 3 increase in Ar occurs for two consecutive Mars years but shows fluctuations and significant variations from year to year.

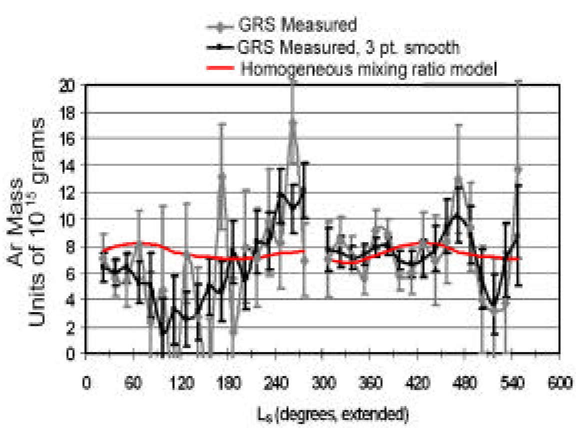


**Fig. 3.** High latitude (75° to 90°N) Ar data are plotted as a function of $L_s$ (extended through the second Mars summer) to illustrate the increase in abundance over the north pole during northern autumn and winter ($L_s$= 180° to 270°). Minima repeat approximately one year apart in late spring/early summer.

**Homogeneously mixed model using GRS $CO_2$ measurements:** The $CO_2$ frost on the ground was also measured by the GS (dotted line, data points and error bars) [8]. These measurements were used to model the atmosphere and expected Ar mass in the southern polar region. Argon measurements (solid black and dotted black lines and data points with error bars) and the GCM model (solid grey line) are also shown.

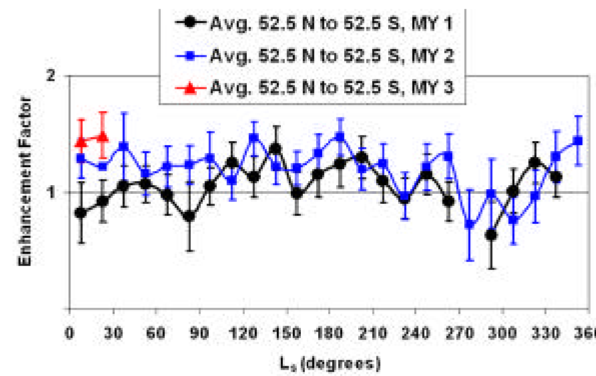


**Fig. 4.** Mid-latitude Ar measurements are binned to display seasonal enhancement factors for slightly more than two Mars' years. The low values in northern spring may be significant.

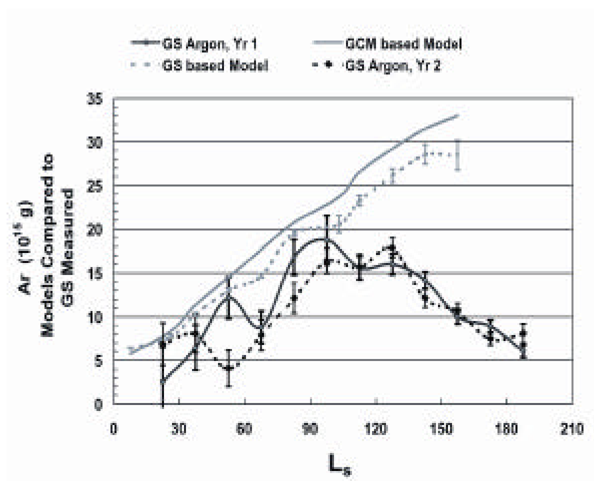


**Fig. 5.** Comparison of Ar mass at high southern latitudes: GCM based, GS based, and measured (2 years). For explanation, see text.

**References:** [1] Sprague et al. (2004) *Science, 306,* 1364 - 1367. [2] Sprague et al. (2007) *JGR, 112,* EOS02. [3] Boynton et al. (2004) *Sp. Sci. Revs.* [4] Boynton et al. (2007) *In Press,* [5] Evans et al. (2007) *JGR*, *In Press*, [6] Owen et al. (1977) *JGR, 82,4635-4639,* [7] Nelli et al. (2007) *JGR, In Press*, [8] Kelly et al. (2006*) JGR*, 111, E03S07.

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