MARS ATMOSPHERE ARGON DENSITY MEASUREMENTS ON MER MISSIONS.

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Introduction: Although there is no meteorology instrument on either of the MER rovers, using the on board Alpha Particle X-ray Spectrometer (APXS) on both rovers, we were able to measure the argon density variation in the martian atmosphere as a function of seasons. The freezing and sublimation of the CO_2 in the martian atmosphere at the poles creates local atmospheric lows/highs that result in an significant air mass movement from equatorial regions towards poles and vice versa.. The argon, however, never freezes and stays in the air. An enhancement of Ar/CO_2 mixing ratio by a factor of six at the martian South pole during the winter has been observed by the GRS onboard the Odyssey orbiter[1,2]. For the meridional regions, however, the signal from GRS for detecting the Ar from the orbit is very low, while the APXS can detect the Ar on the ground very accurately.

Experimental Procedure: In order to study this effect from the ground at the Opportunity and Spirit sites on MER mission, we have started later in the extended-extended phase of the mission to make dedicated APXS measurements of the Ar in the atmosphere. In this case, because of the absence of any peaks in the spectrum from a ground sample, the only significant peak in the X-ray spectrum is from the Ar (Fig.1).

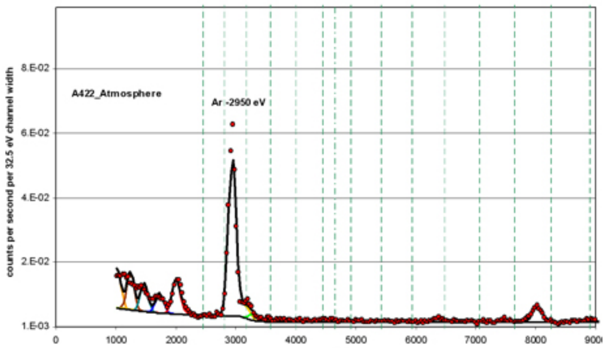

Figure1: The Ar peak in the APXS x-ray spectra from the Martian atmosphere

There is also a significant reduction in the background from the scattered x-rays emitted from the Cm radioactive sources. To a good approximation, the APXS count rate is proportional to the number of argon atoms in the constant sensing volume of the instrument, and hence the APXS measures the atmospheric density of argon, ρ_{Ar}[3]. If the atmosphere were perfectly mixed, the argon partial pressure would be constant. If we define the Local Mixing Ratio (MRlocal) as equal to the ratio of the local Ar partial pressure to the global average, then the measurement ρ_{Ar} T is proportional to the local mixing ratio. The APXS Ar experiment thus gives a direct measurement of the local mixing ratio at the MER landing sites and it is a direct probe of the global circulation between the polar CO_2 source/sink and the equatorial regions.

Results: In Figure 2 we present the results of Ar density over a period of almost 3 Martian years as afunction of martian **Ls.** We have found that the Ar amount in the martian atmosphere at the Opportunity landing site is not constant and it is changing with the changing seasons. The change of the Ar in the atmosphere follows the overall change in the atmospheric pressure but it is not in phase with it. There is a delay of many months between the maximum in Ar/CO_2 mixing ratio and the pressure maximum (Fig.3). In addition, we have even seen the asymmetry between the south and north martian poles due to a different degree of CO_2 contribution from both poles during the martian year. The actual Ar abundance that is realized at the near equatorial location of the rovers is controlled principally by the efficiency with which the atmosphere can mix away the Ar mixing ratio gradients that occur from the localized condensation of CO_2 at the poles.

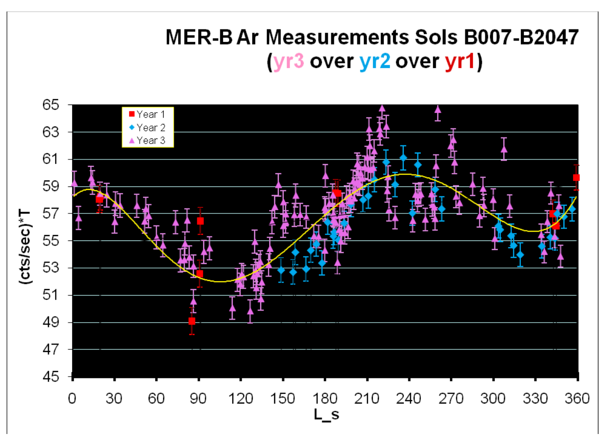

Figure 2: Ar density measurements of the Martian atmosphere over a period 3 martian years.

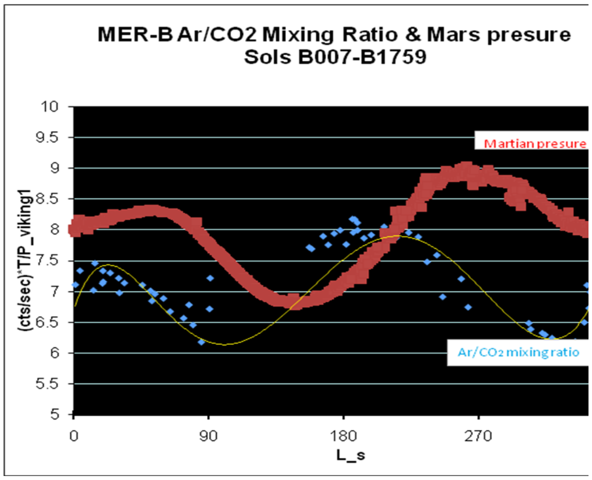

Figure 3: Ar/CO_2 mixing ratio and the martian presure as measred by Viking [4].

Discusion: While we understand the overall condensation/sublimation cycles of CO_2 in Mars atmosphere, we do not have a good understanding of the meridional mixing that controls the equatorial abundance of Ar that we are measuring on the rovers with their APXS instruments. We expect that (at least) two factors are important in controlling this mixing that smooth the Ar gradients. The first is the Hadley-cell type circulation of the Martian atmosphere that moves the bulk of the atmosphere between the regions it is heated (near the equator) and more poleward latitudes where it is cooled. However, the Hadley cell meridional circulation only extends up to ~60 degrees latitude near the winter pole. At this point, a polar vortex of fast zonal winds exists, and the Hadley cell circulation is closed off from the winter pole. Transport across Mars' polar vortex is not well understood, and indeed not only important for Ar abundance on Mars, but also the transport of H_2O and dust to the polar regions. In the Winter transport can be mediated by transient synoptic eddies, but the main mixing mechanisms during the equinox and Summer are more obscure. Further, since the rovers are measuring ground-level Ar rather than column-integrated values, the vertical mixing plays a key role in the interpretation of the results. Thus, by studying the Ar abundance at the equator on Mars, we will have some insight into the meridional circulation and mixing present on Mars, not only in the organized Hadley cell, but also across the polar vortex and in the vertical.

Conclusions: From the data obtained so far there is clear indication that even at the equator region there is a variation in the argon density that corresponds roughly with yearly seasonal variations and which is inversely correlated to the atmospheric pressure. We intend to obtain additional data as long as the MER mission will last from which we can determine the Ar/CO_2 mixing ratio that could provide a ground truth to the Mars Global Circulation Model. The scientific implications of the measurement are quite profound, considering that it directly impacts the scale of the polar caps, and their ability to sequester water, and mix in dust, all critical unknowns now.

References:

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