GRANT FINAL REPORT

Program Element:	Mars Global Surveyor Data Analysis Program
NASA Award:	NAG5-11187
Title:	MGS MAG/ER Data Analysis Using a Time and Magnetic Field Dependent Electron Transport Model
PI:	M. W. Liemohn
Collaborators:	D. L. Mitchell, A. F. Nagy
NASA Technical Officer:	Dr. Curt Niebur

Dear Dr. Niebur,

This letter is to inform you of our activities supported during the 3 years of this grant.

The goal of that project was to examine certain details about the dayside electron environment at Mars as seen by the Mars Global Surveyor (MGS) magnetometer/electron reflectometer (MAG/ER) instrument. Specifically, we stated that we would use the Khazanov and Liemohn (K&L) kinetic electron transport model to analyze features in the observations. This code includes a non-uniform magnetic field and time-dependence in the result (different from most other models of this type). It was originally developed for electron motion along field lines in the Earth's magnetosphere (between conjugate ionospheres), and is thus quite appropriate for application to the Mars magnetic field scenario. Numerous code developments were implemented and the Mars version of the K&L model is fully operational. Initial results from this code have focused on the examination of MGS MAG/ER observations in the crustal field region when it is on the dayside. After several presentations at scientific meetings, this study culminated in a JGR publication last year.

In that paper we explored the formation of the pitch angle anisotropy observed at low energies (below 50 eV). The data-model comparisons placed constraints on the magnetic topology and upper atmospheric conditions during this orbit pass. An interesting discrepancy between the data and model results is that the observations of E>100 eV electrons are far more isotropic than the numerically calculated pitch angle distributions for this energy range. This indicates that collisional processes are inadequate to explain the near isotropy of the high-energy electrons. Several possible scattering mechanisms that preferentially affect the higher-energy electrons are being explored (for instance, wave-particle interactions [e.g., *Kennel and Petschek*, 1966; *Liemohn et al.*, 1997b] and demagnetization [e.g., *Speiser*, 1965; *Anderson et al.*, 1997]). This analysis is expected to lead to another publication (to be published during our new MDAP grant period). At the beginning of this study, it was thought that collisions would be the dominant process acting on the superthermal electrons. The unexpected discovery of this high-energy isotropy could lead to the identification of an unappreciated process acting on the electrons at Mars.

After the 2001 and 2002 Fall AGU Meetings, both in San Francisco, CA, I remained in the bay area and visited my collaborator, Dr. David Mitchell, at the University of California in Berkeley. These meetings have been invaluable for understanding the MAG/ER data and for ideating new research projects with these observations. It is a rich data set with many unexplored signatures, and I hope to continue my studies of the Mars plasma environment in the years to come.

In the summer of 2002, I directed the research of an undergraduate student, Ms. Tamara Reimer, for the summer. She was funded by an NSF Research Experience for Undergraduates (REU) grant here at U-M. She downloaded MGS data for many orbits of interest, wrote programs to plot the data in useful formats, and helped in the analysis of this data. She made great progress for us, and for her efforts she is a coauthor on the JGR paper.

Beginning in Fall 2002, I took on a new graduate student, Ms. Jacki Frank, as a research assistant on this project. She continued the data collection and analysis of Ms. Reimer, and amassed a large database of relevant orbits through the crustal field regions. She binned the data according to numerous parameters. The two most notable parameters are solar flux (F10.7) and solar wind dynamic pressure (P_{dyn}). We have also sorted the data according to magnetic field strength and dip angle, geographic latitude, and electron spectral features (i.e., photoelectron of solar wind electron dominance).

We hope to have two papers submitted in the very near future: one discussing the features of the data according to these parameters, and another comparing the data to results from our model. These studies will elucidate critical factors that influence the photoelectrons at Mars. Unfortunately, Ms. Frank has ended her graduate career at the Master's level. The photoelectron data survey paper is very near completion and will be submitted this fall. The modeling effort is underway and submission is expected early next year.

Thank you for supporting us in this endeavor. It was our pleasure to serve NASA and the scientific community with investigations of the Martian electron environment.

Sincerely,

Michael Liemohn

Publications Fully Supported by the Grant:

Liemohn, M. W., D. L. Mitchell, A. F. Nagy, J. L. Fox, T. W. Reimer, and Y. Ma, Comparisons of electron fluxes measured in the crustal fields at Mars by the MGS MAG/ER instrument with a B-field dependent transport code, *J. Geophys. Res.*, *108*, 5134, doi: 10.1029/2003JE002158, 2003.

Liemohn, M. W., J. Frank, and D. L. Mitchell, Parametric study of dayside photoelectron flux observations in the strong crustal field region of Mars, to be submitted to *J. Geophys. Res.*, 2004.

Liemohn, M. W., D. L. Mitchell, J. Frank, and A. F. Nagy, Data-model comparisons of dayside photoelectron fluxes in the strong crustal field region of Mars, to be submitted to *J. Geophys. Res.*, 2004.

Presentations Fully Supported by this Grant:

Liemohn, M. W., A. F. Nagy, D. L. Mitchell, and J. L. Fox, Initial results of Martian electron distribution calculations including a nonuniform magnetic field, *Eos Trans. AGU, 82*(47), 2001 Fall Meet. Suppl., F720, 2001.

Liemohn, M. W., D. L. Mitchell, T. W. Reimer, A. F. Nagy, and J. L. Fox, Magnetic field variation effects on electron distributions at Mars: Comparisons of theory and data, *Eos. Trans. AGU, 83*(47), Fall Meet. Suppl., Abstract P21B-0370, 2002.

Liemohn, M. W., D. L. Mitchell, A. F. Nagy, J. L. Fox, T. W. Reimer, and Y. Ma, Examining the crustal field loop topology at Mars with the MGS MAG/ER data: Comparisons with a B-field dependent transport code, IUGG 2003 General Assembly, Sapporo, Japan, June 30 - July 11, 2003.

Liemohn, M. W., J. Frank, and D. L. Mitchell, Solar Flux and Solar Wind Dependence of Dayside Photoelectron Fluxes In Mars' Strong Crustal Field Region, *Eos Trans. AGU, 85*(17), Jt. Assem. Suppl., Abstract SA23B-03, 2004.