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Final Report of Accomplishments
NASA Planetary Geology and Geophysics Program Grant NAGW-1358
Title: Paleoclimatic and Tectonic History of the Eastern Desert, Egypt and Surroundings
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Report:
This report covers work done from Oct 1989 until June 1997 for the Planetary Geology and Geophysics Program, specifically:

a. Scientific Research
   Research accomplished under Grant NAGW-1358 has focused on three areas: analysis of the tectonics and paleoclimatic conditions in north eastern Africa, analysis of surficial geology and damage associated with the 1993 Missouri River floods and rates of lava flow degradation at Lunar Crater volcanic field in Nevada. Work has resulted in several dozen abstracts, several dissertations and a number of papers. The papers and dissertations are as follows, with available copies attached to this document:

Duncan, I.J., B. Rivard, R.E. Arvidson, and M. Sultan, 1990, Structural interpretation of and tectonic evolution of a part of the Najd Shear Zone, Saudi Arabia, using Landsat Thematic Mapper data, *Tectonophysics, 178*, 309-335.

Stern, R.J., K.C. Nielsen, E. Best, M. Sultan, R.E. Arvidson, and A. Kroner, 1990, Orientation of late Precambrian sutures in the Arabian-Nubian Shield, *Geology, 18*, 1103-1106.

Sultan, M., K.R. Chamberlain, S.A. Bowring, R.E. Arvidson, H. Abuzied, and B. El Kaliouby, 1990, Geochronologic and isotopic evidence for pre-Pan-African (550-950 Ma) crust in the Nubian Sgield Shield, Egypt, *Geology, 18*, 761-764.

Sultan, M., I.J. Duncan, R.E. Arvidson, R.J. Stern, and B. El Kaliouby, 1990, Reply—Extension of the Najd Shear System from Saudi Arabia to the central Eastern Desert of Egypt based on integrated field and Landsat observations, *Tectonics, 9*, 539-543.

Rivard, B., 1990,Lithologic Mapping in the Southwestern Greenland and Nubian Shields Using Field, Laboratory, and Landsat Thematic Mapper Data, A Ph.D. dissertation presented to the Graduate School of Arts and Sciences, Washington University in St. Louis

Sultan, M., R. Becker, R.E. Arvidson, Shore, R.J. Stern, Z. El Alfy, and E.A. Guinness, 1992, The Nature of the Red Sea Crust: A Controversy Revisited, *Geology, 20*, 593-596.

Sultan, M., M.E. Bickford, B. El Kaliouby, and R.E. Arvidson, 1992, Common Pb Systematics of Precambrian granitic rocks of the Nubian Shield (Egypt) and Tectonic Implications, *Geol. Soc. Am. Bull., 104*, 456-470.

Arvidson, R.E., I. Duncan, G. Green, B. Rivard, and M. Sultan, 1993, Geological mapping using Landsat Thematic Mapper data over oak-hickory forest, arctic and hyperarid terrains, Chapter 12 in *Remote Geochemical Analysis*, Cambridge University Press, 247-280.

Arvidson, R.E., M.K. Shepard, J. Plaut, E. Guinness, D. Evans, T. Farr, R. Greeley, N. Lancaster, and L. Gaddis, 1993, Characterization of lava flow degradation in the Pisgah and Cima volcanic fields, California, Landsat Thematic Mapper data, *Geol. Soc. Am. Bull., 105*, 175-188.

Sultan, M., R. Becker, R.E. Arvidson, Shore, R.J. Stern, Z. El Alfy, and R.I. Attia, 1993, New constraints of Red Sea rifting from correlations of Arabian and Nubian Neoproterozoic outcrops, *Tectonics, 12*, 1303-1319.

Shepard, M.R. 1994 Application of Cosmogenic Exposure Age Dating and Remote Sensing Observations to Studies of Surficial Processes, A Ph.D. dissertation presented to the Graduate School of Arts and Sciences, Washington University in St. Louis

Arvidson, R.E., R. Becker, A. Shanabrook, W. Luo, N. Sturchio, M. Sultan, Z. Lofty, and A.M. Mahmood, 1994, Climatic, eustatic and tectonic controls on Quaternary deposits and landforms, Red Sea Coast, Egypt, *J. Geophys. Res., 99*, B6, 12175-12190.

Becker, R.H., 1994, Construction of Regional Scale Digital Landsat Thematic Mapper Mosaicks, and Applications for Regional Mapping and Plate Reconstructions in the Red Sea Area, A Ph.D. dissertation presented to the Graduate School of Arts and Sciences, Washington University in St. Louis.

Shepard, M. R. Arvidson, M, Caffee, R. Finkel, L. Harris, 1995, Cosmogenic exposure ages of basalt flows: Lunar Crater Volcanic Field, Nevada, *Geology, 23*, 1, 21-24

Brackett, R.A. 1995, Microwave Remote Sensing and Fluid Transport Modeling of Surface Change: Earth and Venus, A Ph.D. dissertation presented to the Graduate School of Arts and Sciences, Washington University in St. Louis

Izenberg, N.R. 1995 Assessment of Damage from the 1993 Floods on the Missouri River Floodplain Using Landsat, SPOT, SIR-C, TOPSAR and Field Data, A Ph.D. dissertation presented to the Graduate School of Arts and Sciences, Washington University in St. Louis

Izenberg, N.R., R.E. Arvidson, R.A. Brackett, S.S. Saatchi, G.R. Osburn, and J. Dohrenwend, 1996, Erosional and depositional patterns associated with the 1993 Missouri River floods inferred from SIR-C and TOPSAR radar data, *J. Geophys. Res.*-Planets, SIR-C Special Issue, 101, 23149-23167.

Luo, W., R.E. Arvidson, M. Sultan, R. Becker, M.K. Crombia, N. Sturchio, and Z. El Alfy, 1997, Groundwater sapping processes, Western Desert, Egypt, *Geol. Soc. Am. Bull., 109*, 43-62.

Crombie, M. K., R. E. Arvidson, N. Sturchio, Z. El Alfy, K. Abu Zeid, 1997, Ages and paleoclimatic implications of travertine deposits, Kurkur Oasis, Western Desert, Egypt, *Palaeogeography, Paleoecology, Palaeoclimatology, 130*, 337-355.

Crombie, M.K., 1997, Remote Sensing and Geochemical Investigations of Selected Surface Processes in Egypt and Missouri, A Ph.D. dissertation presented to the Graduate School of Arts and Sciences, Washington University in St. Louis

b. Tectonics and Paleoclimatic conditions in the western desert, Egypt

Under this task Mohamed Sultan finished leading a number of studies of the tectonics of opening the Red Sea Rift. Additionally,Arvidson was responsible for planning and implementing a field expedition to the Kukur Oasis in the Western Desert of Egypt. Travertines were mapped and samples were collected for analytical analyses. U-Th ages and carbon and oxygen isotopes were obtained using the Argonne National Laboratory facilities. We concluded from the observations and data that wet periods over the past several hundred thousand years have been driven by Milankovitch cycles. During peak insolation periods, monsoons from the Atlantic Ocean increased moisture and reactivated springs that produced travertines. Three papers were published (see above) from this research. Later in 1996, Sultan completed studies of work in the Egyptian desert including acquisition of pristine travertine samples and fossil ground water in areas in the western desert. These samples are to be used to better define the timing of pluvial epochs and confirm our hypothesis.

c. Damage Assessment associated with the 1993 Missouri River floods

Under this task, Arvidson spearheaded the working group that acquired AIRSAR and TOPSPAR data over Jameson Island bottoms/Arrow Rock bottoms flood plains that were severely damaged during the 1993 Missouri River floods. We conducted extensive analysis of the data, completed several field trips, modeling and laboratory analyses. This work was published in a paper by Noam Izenberg and part of the Ph.D thesis work by Mary Katherine Crombie.

d. Lava Flow degradation, Lunar Crater Volcanic Field

We used remote sensing and cosmogenic exposure age dating to understand lava flow degradation processes and rates at the lunar Crater Volcanic Field in Nevada. The work included use of Al-26, Cl-36, and Be-10 to date the Black Rock Flow and to determine mechanisms of desert pavement formation on an old flow south of the Black Rock Flow. We found that desert pavement occurs by a rapid accumulation of aeolian mantle, with basalt clasts remaining on the surface and riding on the mantle as it builds. This work was published in a paper by Mike Shepard who also did his Ph.D. thesis on this topic.