

## Dead Sea Scrolls

Environment and Resources Management

**B**elow, Dr. Gregory Bearman, a physicist and remote sensing specialist at Jet Propulsion Laboratory (JPL), is viewing a fragment of the Dead Sea Scrolls that had mysteriously deteriorated to the point where the text was undecipherable. The previously invisible lettering on the screen was made distinguishable by use of advanced multispectral imaging techniques originally developed at JPL for Earth remote sensing and planetary probes. The work, which produced a technique with potentially important implications for archeology, was conducted by a consortium of researchers from four organizations.

Provided by the Getty Conservation Institute, Marina del Rey, California, the scroll fragments appear to the naked eye to be totally ruined and the black ink typically cannot be distinguished from the scroll's age blackened parchment.

Bearman and his colleagues then subjected the fragment to examination by highly sensitive electronic cameras and digital image processing techniques. One scanning camera uses a sensor known as a CCD (charged coupled device) that acquires images in digital form and serves as the camera's electronic film. Use of the CCD enabled a look at the fragment in longer wavelengths

beyond the sensitivity of infrared film.

Imaging in these wavelengths increased the contrast between ink and parchment and, with computer image enhancement techniques, made legible a string of Hebrew letters that translate into "He wrote the words of Noah."

The project drew on technology earlier developed by JPL and a contractor in a mid-1980s project for the National Archives. They used CCDs originally developed for the Hubble Space Telescope and the Galileo planetary probe as the basis of a system, now in use at the Archives, that regularly scans historical documents to see if there have been any deteriorating changes. The computerized system provides better and earlier detection of change than previous methods of monitoring documents.

The team of researchers in the scroll enhancement project included, in addition to Bearman, Dr. Bruce Zuckerman, a Semitic languages scholar at the University of Southern California's School of Religion; Ken Zuckerman, a photography specialist at West Semitic Research; and Joseph Chiu, a student at California Institute of Technology, JPL's parent organization.

