TESTING GEOSCIENCE DATA VISUALIZATION SYSTEMS FOR GEOLOGICAL MAPPING AND TRAINING. J. N. Huffman[1], A. S. Forsberg[2], J. W. Head[3], J. L. Dickson[3], and C. I. Fassett[3], [1]Center for Computation and Visualization, Brown University, Providence, RI 02912, [2]Dept. of Computer Science, Brown University, Providence, RI 02912, [3]Dept. of Geological Sciences, Brown University, Providence, RI 02912. (John_Huffman@brown.edu).

Introduction: Traditional methods of planetary geological mapping have relied on photographic hard copy and light-tables for tracing, mapping, and analysis. In the last several decades these tools have become inadequate to deal with the large and diverse datasets that have been acquired in recent missions, necessitating the use of digital platforms. Mapping is particularly suited to Geographic Information System software (such as the ESRI ArcGIS package) that permit co-registration, rapid viewing, and analysis of multiple data sets on desktop displays.

We are investigating new developments in computer visualization in order to assess their importance and utility in planetary geological analysis and mapping [1,2]. Last year we reported on the range of technologies available and on our application of these to problems in planetary mapping [3]. We are specifically assessing how visualization display qualities (e.g., level of immersion, stereoscopic vs. monoscopic viewing, field of view, large vs. small display size, etc.) and user interaction influence scientific analysis and geological mapping.

We have been exploring four different environments: 1) conventional desktops, 2) tiled wall displays, 3) a "Practical Powerwall" (~61" HDTV), and 4) fully immersive virtual reality (IVR) (e.g., "Cave Automatic Virtual Environment", or Cave system). Formal studies demonstrate that fully immersive Cave environments are superior to desktop systems for many tasks [e.g., 4]. There is still much to learn and understand, however, about how the varying degrees of immersive displays affect task performance. For example, in using a 1280x1024 desktop monitor to explore an image, the user wastes a lot of time in zooming/panning to balance the simultaneous need for both detail and context. We have found that higher-resolution media and modern visualization techniques can improve efficiency in analysis and mapping.

1. Immersive Virtual Reality (Cave): ADVISER System Description: Our Cave system is an 8'x8'x8' cube with four projection surfaces (three walls and the floor). Four linux machines (identical in performance to the desktop machine) provide data for the Cave. Users utilize a handheld 3D tracked input device which has a joystick and is simple to use and navigate. To navigate a 3D terrain, the user simply points in the direction he/she wants to fly and pushes the joystick on the wand forward or backward to move relative to that direction. The user can push the joystick to the left and right to rotate his/her position in the virtual world. A collision detection algorithm is used to prevent the user from going underneath the surface. In the past three years dozens of graduate level researchers as well as hundreds of undergraduate students have found this technique effective and easy-to-use in the Cave.

We have developed software named ADVISER (ADvanced VIsualization for Solar system Exploration) [1,2] as a tool for taking planetary geologists virtually "into the field" in the IVR Cave environment in support of several scientific (Fig. 1). ADVISER aims to create a field experience by integrating multiple data sources and presenting them as a unified environment to the scientist. Additionally, we have developed a virtual field kit, tailored to supporting research tasks dictated by scientific and mapping themes. Technically, ADVISER renders high-resolution topographic and image datasets (as large as the full MOLA dataset, 46k x 22k px) in stereo at interactive frame-rates (25+ frames-per-second). The system is based on a modified version of the state-of-the-art terrain rendering system [5] and is highly interactive; for example, vertical exaggeration, lighting geometry, image contrast, and contour lines can be modified by the user in real time. High-resolution image data can be overlaid on the terrain and other data can be rendered in this context. Detailed descriptions and case studies of ADVISER are available [1,2].

2. High-Resolution Tiled Wall Display: As a compliment to the ADVISER Cave application, we have created a set of similar tools to explore 2D image data sets on our high resolution tiled-wall. This employs a 9-projector, active stereo, tiled-wall display with an effective resolution of 2400x1800 and a physical size of 6'x6' (Fig. 2).

The tiled-wall allows a researcher to explore and manipulate large resolution images (up to 40k x 20k) on a high resolution, high brightness display system. High resolution images can be manipulated (navigated and image processed) using similar techniques employed in the Cave ADVISER application. A user simply points to the area of the image that is of interest, pushes forward on a thumb-joystick, and the application will zoom to that location. The application also takes advantage of modern graphics card capabilities to always render at 20+ fps and to allow the user to stretch, brighten, darken, and mix various image layers together in real time, regardless of image size. These real-time capabilities compare favorably with available desktop analytical tools.

While this display does not allow the full immersive properties of the Cave system (i.e., large field of view), its large physical size and high resolution offer a compelling compliment to the existing Cave system as well as desktop systems, filling the middle ground between these two disparate visualization methodologies. Due to the size of the display, this system offers excellent possibilities for group collaboration and discussion of data sets. Weekly group discussions incorporating this system have become part of the standard routine within student research groups.

3. Practical Powerwall: The Cave and Tiled Wall are University resources housed and maintained in a separate building. As an "in lab" compliment to both the Cave system and the tiled display wall, we have created a system that uses a commercially-available 61" rear-projection TV that is stereo capable at HD resolution (1920x1080) (Fig. 3). This system is paired with a high-end graphics workstation, similar to the configuration used for the desktop visualization system in section 2.

We have adapted the software originally designed for the tiled display wall for use on the HDTV. We are able to display stereo image pairs in active-stereo at ultra-high resolution

(30k x 120k) in real time. This system also allows the user to layer multiple images sets at varying resolution, and still allow for real-time stretch, blend, and manipulation. With the prevalence of new and existing high resolution stereo pairs of the Martian and Lunar surface, this has become an invaluable tool to compliment the desktop and Cave tools already in use.

4. Adaptation of ADVISER Functions to the Desktop Environment: The desktop system utilizes common workstation components, including an nVidia graphics card, 4 GB of memory, and a current multi-core CPU. The ADVISER terrain visualization software has been adapted with a complimentary user interface to allow the geologist a more natural way to interact with the data on the desktop.

ADVISER was originally designed for a Cave [1] because we believed the Cave's large-scale stereo display was most appropriate for doing "virtual fieldwork", but we are adapting its functionality to run on conventional desktop systems to make it more generally accessible and to help us learn about the relative value of the information that can be gathered from both systems. Use of the ADVISER software on the desktop will allow the geologist to choose either the high level of immersion the Cave or display wall may provide, or the convenience of the desktop or Practical Powerwall, depending on the requirements of the task at hand.

We are also developing new workflow methodologies that allow easy transition from the desktop to the CAVE or Powerwall. Integrating the ADVISER terrain and image viewing software into the desktop environment has given the geologists the ability to integrate the software into their exiting workflow. Datasets can be directly opened up and visualized in full stereo in the ADVISER application from within ArcGIS environment. This allows for a more seamless workflow, and has increased the usability of the software.

Summary: Desktop platforms and the Cave environment address different needs when analyzing and mapping planetary surfaces. The tiled wall and Practical Powerwall provide a middle ground that is especially useful for group analysis of geological questions. The use of the display capabilities of these platforms has led to fundamental observations and discoveries which are more challenging to achieve on standard platforms. The ADVISER system was developed primarily to assist geoscience research, but its basic functions of interactively navigating 3D terrains also are well served to the educational purpose of training students in the basic principles of geological mapping at all educational levels [e.g., 7]. We have tested these systems in Geological Sciences 5 (Mars, Moon and the Earth), an introductory geosciences course at Brown University. After the experience, one student said, "[The Cave] is like going to a foreign country rather than reading about it in a book". Students learn about scientific study and analysis, and how geologists make a multitude of observations in order to document the nature of geological processes and to unravel the history of the Earth and planets. These platforms are an engaging mechanism to illustrate how geologists use geological mapping in order to organize and document the host of scattered observations that are the clues to planetary history. Furthermore, the total immersive experience of IVR brings home immediately both the wealth of observations that can be made, as well as the need to organize these observations into important generalization that are the core of geological mapping. Clearly, these capabilities need to be incorporated into classes in geological analysis and mapping at all levels in the future.

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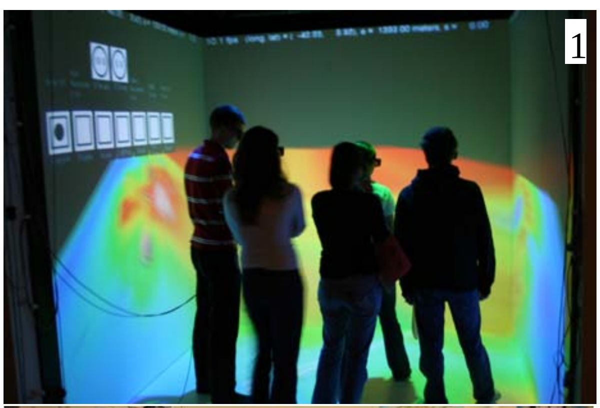

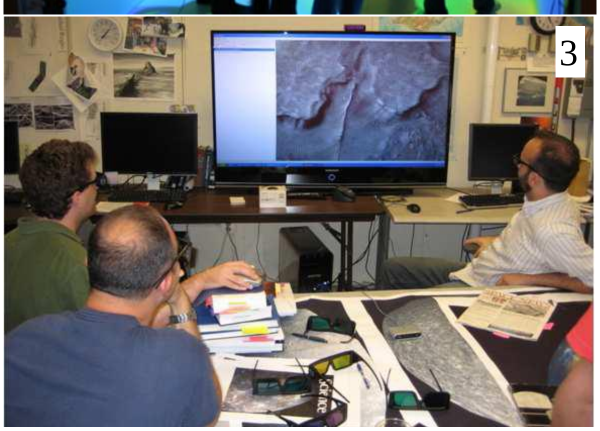

Fig. 1. Undergraduate students exploring Mars in the Cave. Notice the suite of tools on the left-hand wall.

Fig. 2. A group of ~10 scientists analyzing a full-resolution HiRISE image on a tiled-wall display.

Fig. 3. Several scientists analyzing a HiRISE stereo pair of Mars using active stereo on a 61" HDTV ("Practical Powerwall").