

Geologic Field Mapping Using a Rugged Tablet Computer

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INTRODUCTION

The Utah Geological Survey (UGS) publishes geologic maps principally at scales of 1:24,000 and 1:100,000. Each geologic map, regardless of scale, requires a certain level of field mapping where data are recorded on aerial photographs and in field books. Traditionally, geologic line work is hand-transferred to a topographic base map on which the final map is prepared for publication using accepted cartographic techniques. Since about 1991, however, the UGS has used digital technologies to prepare the final map for publication, and for the past few years to record data in the field, making geologic fieldwork and map preparation more efficient. This is particularly true for some of our 1:100,000-scale geologic maps.

Using digital technologies for geologic field mapping has many distinct advantages: (1) improved precision in placement of geologic features and sample locations using Global Positioning System (GPS) and on-screen display of geospatially corrected imagery and topographic base maps for reference, (2) increased efficiency in drawing field-attributed geologic lines because they do not need to be hand-transferred or redrawn on another map in the office and then digitized, (3) graphical notation on digital photographs with geologic relationships, and (4) accessing key publications in a digital library.

Utah Geological Survey mapping geologist Doug Sprinkel began a field trial in 2005 using a rugged tablet computer and GIS software to create and attribute geologic map data for the Dutch John, Vernal, and Seep Ridge 30' x 60' quadrangles in northeastern Utah. This paper describes the experience of that trial.

TECHNOLOGY CHOICES

The merits of using various electronic devices and software for field collection of geologic map data has been studied and debated by numerous researchers (e.g., Struik and others, 1991; Brodaric, 1997; Walsh and others, 1999; Kramer, 2000; Edmondo, 2002; McCaffrey and others, 2005; Clegg and others, 2006). Many geoscientists have used a palm-sized Personal Digital Assistant (PDA) or similar device and customized

software applications (Brodaric, 1997; Walsh and others, 1999; Brimhall and others, 2002; Edmondo, 2002), while others have chosen systems based on a larger rugged tablet computer (De Donatis and others, 2005, Sprinkel and Brown, 2008), which is bulkier but offers distinct advantages. A detailed comparison of both types of systems (Clegg and others, 2006) along with the development of Map IT GIS software for geologic field mapping (De Donatis and others, 2005; De Donatis and Bruciatelli, 2006) convinced us to choose a rugged tablet computer and Map IT GIS software for a UGS mapping program field trial.

Several brands and models of rugged tablet computers are now available. We chose a rugged tablet model from Xplore Technologies that meets military specifications for water, dust, and shock resistance and has a relatively large 10.4" LCD screen and illumination technology that enhances the display's legibility, even in bright sunlight. The tablet has a 1.2 GHz Intel Pentium M 753 - ULV processor, 1 GB of RAM, an 80 GB hard drive, Integrated 802.11 wireless networking, and Microsoft Windows XP Tablet Edition. Although the tablet and software will work with a full range of GPS devices from the simplest inexpensive USB units, Bluetooth devices, or survey-grade equipment costing thousands of dollars, we chose the integrated GPS receiver.

OVERVIEW OF METHODS

Geologic mapping using digital field techniques is really not that much different from traditional methods. A geologist still has to go in the field with a rock hammer, hand lens, and compass, aided by stereo pairs of aerial photographs and a stereoscope (needed to see the map area in three dimensions) to determine formation contacts and faults, measure bedding attitudes (strike and dip), collect samples, and take field notes. However, instead of carrying a map board and drawing lines on paper-based aerial photographs or topographic base maps using an ink pen, the geologist uses a rugged tablet computer with a touch-screen as the map board and GIS software and a stylus to draw lines on digital base map images that are displayed on the screen for positional reference; digital images could be topographic, geospatially corrected photographic (orthophoto) images (Figure 1) or shaded relief maps, as well as images of other geologic maps.

In addition to drawing lines using the stylus, line data can be collected using an active GPS receiver while walking the contact or fault. Point data such as bedding attitudes and sample locations can also be easily and accurately collected using the GPS receiver and displayed on the digital base (Figure 2). Field notes are electronically written into word processing software using the stylus or a portable external keyboard. Finally, digital photography permits the geologist to capture an image of a scene, transfer the image to the tablet computer, and then easily make graphical notations on the photograph in the field.

Map IT, the GIS software, allows us to create custom data input forms with pull-down pick-lists to simplify and standardize the collection of geologic data. This allows the geologist to create a digital map while still in the field, with attributed and colored map unit polygons, geologic symbols, and feature labels.

Pre-Field Mapping Procedures

Any successful mapping project begins with a certain amount of office preparation before the first step is taken in the field. This is particularly true for digital field mapping. For example, in Map IT and other spatial database software, the geologic database must be configured, and tables must be created to accept the necessary feature attributes. When the tables are ready for feature attributes, then data entry forms are created, one for each data type (e.g., points, lines, and polygons). On a tablet computer using Map IT, these forms are important so the geologist can draw lines and points and easily select their attributes from choices in a list. These pick-list choices populate the data tables' attribute fields. The forms are fairly easy to create and using them keeps errors to a minimum and makes the data consistent from map to map. Forms are simple to very complex depending on our needs and they can be reused from one project to the next. We prepare and check project files in Map IT to ensure that all of the forms, scripts, and data tables are in the new project and that they function properly. There is nothing more frustrating than to be in the field attempting to enter a data point, only to discover that the data table or forms linked to lookup tables are not present. Data tables and forms can be created on the fly in the field but that takes up valuable field time.

We still use paper copies of stereo pairs of aerial photographs, and a pocket stereoscope, so the geologist can see the field area in 3-D. In addition to assembling the aerial photographs needed, we gather the best-available digital orthophoto files and DRG topographic map files. Finally, we assemble a library of digital documents on the tablet computer containing important articles and existing geologic maps that pertain to the map area. Most journal and government-agency articles and maps are available in PDF format. Accessing these digital publications on the outcrop is handy and may save you a repeat trip to the outcrop.

IN THE FIELD

We believe that digitally collecting geologic field data using the tablet PC with Map IT permits the geologist to easily and consistently attribute data, reduces potential errors in transferring line work and point locations, and saves time by not having to redraw line work from one step in the map production process to the next. Line work and data points are directly mapped in layers using the tablet's stylus, or their positions are recorded from the GPS receiver. Lines and points representing contacts, faults, fold axes, bedding attitudes, structural data, and sample locations are attributed in the field using pull-down dialog boxes linked to look-up tables (Figure 3).

Map IT has many tools very similar to those in other GIS software. For example, it is easy for the field mapper to create preliminary geologic unit polygons with attributes, and to color the polygons by their unique values. With this in mind, unit symbol annotations are placed in each unit so they can be used as ID points to automatically generate polygon attributes for use in the field, as well as in the publication process.

Another viable use for this wireless-enabled system is collecting and transferring time-sensitive data (maps, field notes, and images) from the field to the office during

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(see <http://ngmdb.usgs.gov/Info/dmt/>)

geologic hazard events or other natural disasters. Earthquake hazard is relatively high in the western US and these systems could prove to be valuable assets to government agencies involved in emergency response.

Photos and Field Sketches

Photographs of key outcrops, sample locations, or field relationships are taken using a digital camera and the images are transferred to the tablet via USB cable where the geologist can draw graphical interpretations on the photos, in the field, using a simple image viewing and editing tool included with Map IT. By these means, traditional paper field sketches can be replaced with digital drawings and photos (Figure 4).

Voice Recordings

The Xplore tablet computer has both a built-in microphone and an external microphone line-in port, which is useful because Map IT includes an easy-to-use voice-recording tool. This is a great way to audibly record thoughts and interpretations as they occur without having to grab a notebook and write everything down. It is likely that voice recognition software eventually will enable conversion of these recordings to text!

Easy-Notes

The Map IT Easy-Notes tool is arguably the most interesting and useful tool we've seen in a GIS. It allows the user to tie all sorts of information to a single clickable geographic point on a map. It works by pointing to a spot on your map and making it a point of interest, symbolized with a pushpin icon. Clicking on this icon pops-up a yellow note box similar to the familiar paper "Sticky Notes" (Figure 5) commonly used in the office. In this yellow note box, you can use the stylus to make handwritten notes, to drag-and-drop photo images, text documents of any type, or Internet URL's, and to link your personal voice recordings to that locality. As you drop documents into your Easy-Note, they are listed there with the familiar icons of their associated software. Display of Easy-Note pushpin icons can be turned on or off. Clicking on a pushpin opens the Easy-Note to reveal documents tagged to that geographic location, which you can then open with the touch of the stylus. This is very useful for indexing annotated photos, field sketches, and notations to a particular outcrop or viewpoint, for example.

Concerns

Disadvantages of this technology include a fairly steep learning curve for the software, and getting accustomed to using a tablet computer and stylus in the field. Newer models of the Xplore tablets have much improved screen brightness technology, although at times it is still difficult to see the display in the field, which can be very

frustrating. This is particularly true in bright sunlight when wearing sunglasses; polarizing sunglasses especially tend to darken the display. This can be somewhat remedied by using a case with a flap (Figure 6) to shade the screen from direct sunlight.

A more important issue is, of course, reliance on battery power and the fact that the rugged tablet craves power! These devices run on fairly powerful batteries that can operate continuously for up to 4 hours; however, battery life can be extended if the power-saving schemes are enabled such as using the hibernation mode when you are not entering data. Our newest rugged Xplore tablet uses a more energy-efficient Intel processor, which should help with this problem, but no matter what power-saving scheme is employed or the number of spare batteries, you still need daily access to a power source to charge the batteries. This means using a vehicle power adapter or returning to your motel each evening to charge the tablet's batteries for the next day of field mapping. Digital mapping in remote areas for more than a couple of days may not be an option, unless solar panels or other compatible remote power sources are used.

CONCLUSIONS

Each field-mapping technique, ranging in complexity from pen and field notebook to a rugged tablet computer and software, has advantages and disadvantages. Regarding the modern, computer-based systems, acquiring geologic data in the field using the tablet with a GPS receiver and Map IT GIS software saves time, and in our opinion, is more efficient than other tested methods. Being able to capture digital images of outcrops, sample locations, and key geologic relationships, and carefully annotating them while still at the spot where the image was captured and then tagging them to a geographic point of interest on the digital map is very useful and greatly improves our ability to interpret our field observations as we compile our geologic maps.

The disadvantages of using this system include a fairly steep learning curve (unless the field geologist is already familiar with GIS software) and the insatiable appetite that any field computer system has for power. However, we think these are manageable problems.

Digital acquisition of geologic data in the field will likely increase as organizations discover the advantages of porting data seamlessly from a geologist's tablet computer to the GIS analyst's desktop. This may be particularly true as more wireless-enabled tablets are deployed to geologists who must transfer time-sensitive data from the field to the office during times of natural disasters.

NOTE

The UGS does not endorse any computer software or hardware products or manufacturers. Reference to any specific commercial product or process by trade name, trademark, or otherwise, does not constitute endorsement or recommendation by the UGS.

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RESOURCES

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Figure 1. Rugged tablet computer showing geology mapped in the field superimposed over digital orthophoto.



Figure 2. Field-collected bedding attitudes on a geologic map. Symbol size is exaggerated for clarity.

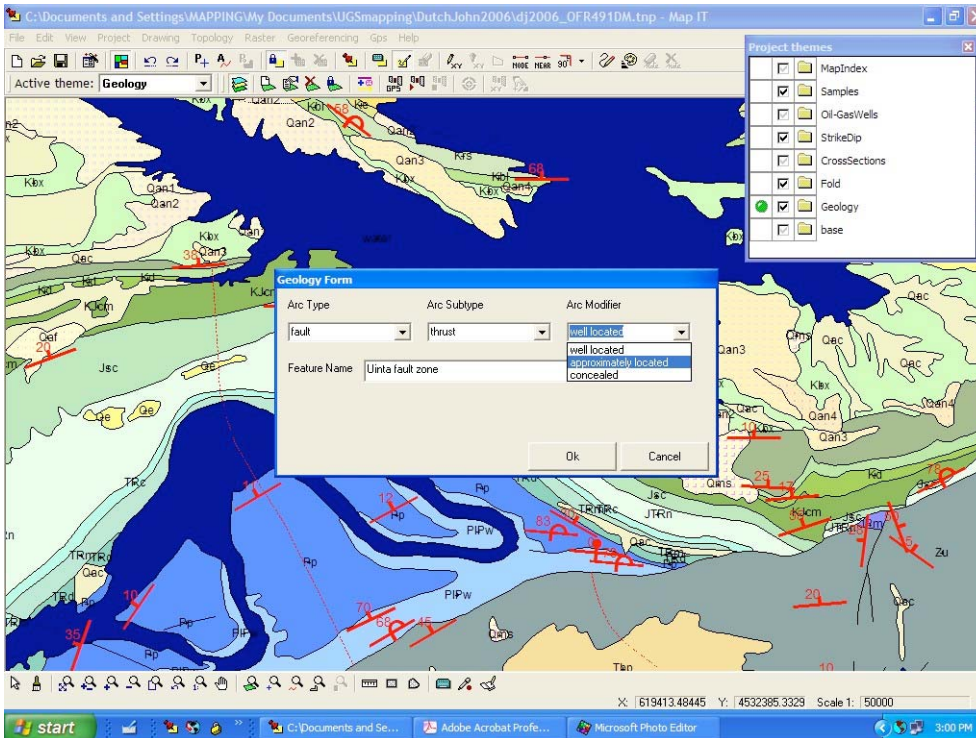


Figure 3. A simple Map IT data form with pick-lists is used for field-attributing geologic features.



Figure 4. Digital photographs can be annotated and sketched upon, in the field, with a simple image-editing tool included in Map IT.

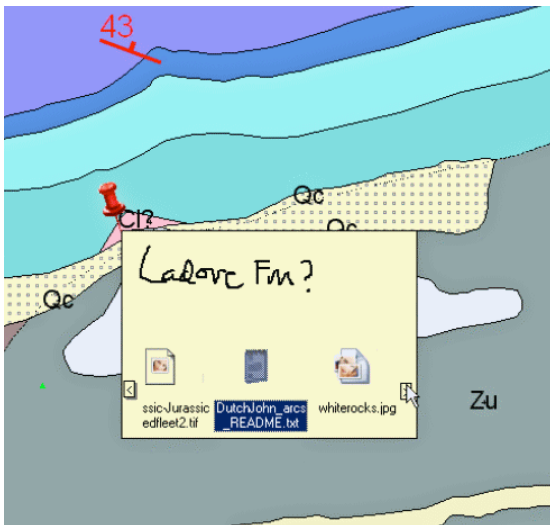


Figure 5. The Map IT Easy-Note tool is a useful way to link to or access various information files relating to a single geographic point on a map.



Figure 6. To improve readability in the bright sun, a tablet PC carrying case with sunshade can be used, as this soft case made from durable rip-stop nylon shows.