Sharing Technical Information with Nontechnical Users— An Example from the Monterey Bay Area Quaternary Fault Atlas

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Introduction

One of the critical issues in geoscience is to effectively communicate information to a target audience. Even more difficult is to communicate the same information to more than one audience. This paper presents a case history of designing earthquake fault maps to be easily understood by geoscientists as well as by nontechnical users.

Situated approximately 150 kilometers (km) south of San Francisco, the project study area is subject to significant earthquake hazards. Several active faults cross the Monterey Bay area, including the well-known San Andreas Fault and Hayward Fault, as well as the lesser known but also hazardous Calaveras Fault and San Gregorio Fault (Figure 1). California law prohibits constructing buildings across Holocene-active (about 11,000 years or younger) faults. However, existing maps showing these faults are commonly at different scales (typically 1:24,000 to 1:100,000) and different vintages (1970s to 2000s). Hence, local governments do not always have access to accurate, recently published fault maps, even in paper format, on which to base their land-use decisions.

Engineering geologists investigate the presence of faults and their recency of movement by digging trenches across the faults using backhoes and creating a descriptive log of the subsurface conditions. The geologist's reports are submitted
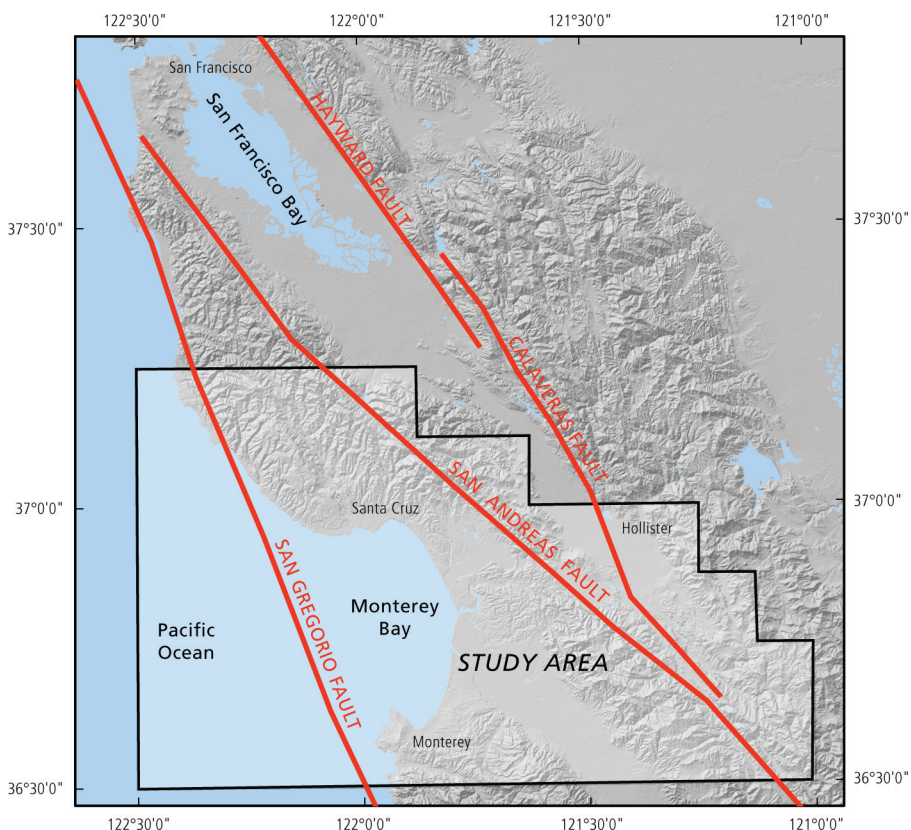

Figure 1. Map showing location of study area and active faults.

to local government as part of the land-use permit process. However, not all government agencies keep or catalog these fault studies. Having access to previous fault studies is a valuable asset in targeting areas where additional studies are needed. Digitally storing fault studies is one way to accomplish the archiving of these valuable records.

The purpose of this study was to compile fault maps and trench logs for the faults within areas that have been active during the Quaternary (from about 1.8 million years ago to the present day). Two grants from the U.S. Geological Survey's National Earthquake Hazard Reduction Program (NEHRP) funded this study. Although much of the NEHRP-funded research is extremely useful to geologists and seismologists, the findings are commonly written in language that is unfamiliar to the layperson. An important goal of NEHRP is to provide information that nontechnical users can understand, in order to help them reduce their exposure to earthquake hazards. Thus, one of the goals of this study was to provide a method of communicating complex geoscience information to laypeople as well as to scientists.

NEHRP also requires that products be in some type of digital format. Owing to the large study area (nearly 12,400 km^2), the map design presented some challenging issues. For example, even though the map was a digital product, many users absorb the information more effectively from traditional paper maps, or at least seem to prefer this medium. Ideally, the data could be designed with a micro/macro composition to help users visualize both the details and the "big picture" (Tufte, 1990). Oversize map sheets initially were considered, but the constraint of needing several sheets to cover the study area made that concept unsuitable. An atlas format using 8½ × 11 inch sheets had the advantage of presenting detailed data, but lacks the regional perspective.

On the other hand, a strictly digital map satisfies the ability to zoom in for a detailed perspective and to zoom out for a regional perspective. However, one of the barriers to acceptance of digital maps is the cost of software and learning the program needed to view and query the map. For example, it is not obvious that ESRI shapefiles are a collection of three to seven related files, not just the .shp file itself. This misunderstanding can cause difficulty in using GIS files. For these reasons, the data from this study were published as Keyhole Markup (KML) files, in addition to shapefiles. The advantage of this dual-format approach is that there are many more users familiar with Google Earth software (which uses KML files) than the more specialized ESRI software.

Nontechnical users can easily view fault locations and exploratory trench locations with Google Earth, or with Web browsers using the Google Maps or the Virtual Earth viewers. They can also combine these data with other information, such as house locations provided by their

real estate agent. Thus, presenting the information in KML format helps the non-technical user to reduce their risk from earthquake hazards by providing a familiar approach to help them recognize active faults in relation to their property.

The KML file for this study contains low-resolution thumbnail images of the fault trench logs. Hyperlinks to high-resolution scans of the trench logs are also included. The low- and high-resolution images are stored remotely on a server where they can be downloaded from anywhere. This approach has the advantage of providing users with a relatively small KML file.

Building the KML File

There are several methods that can be used to build KML files. One method involves working with software through the Internet ("cloud computing") and utilizes an online spreadsheet program, Spreadsheet Mapper, developed by Google for ease in creating KML files. The spreadsheet is preformatted, with the user filling the blank cells with latitude, longitude, and descriptions. The advantage of Spreadsheet Mapper is that it allows collaboration with other locations; so more than one geologist or cartographer can work on the same project from anywhere. The disadvantage is that only point data can be created with Spreadsheet Mapper. Lines and polygons need to be created with other software. An example of the spreadsheet is shown on Figure 2.

The trench data were exported from ArcGIS files into Microsoft Excel spreadsheet files that contained the site coordinates, the site name, the geologic consultant, and URL links for the low- and high-resolution map and trench log images. The data from the Excel files were cut and pasted into
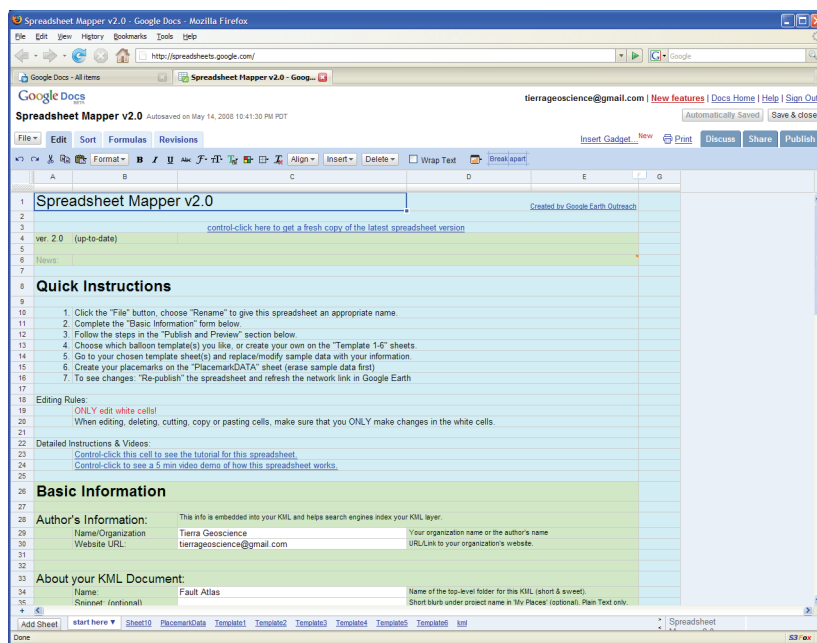

Figure 2.   Screenshot showing Google Spreadsheet Mapper.

Spreadsheet Mapper. There are also several preformatted "bubble" templates in Spreadsheet Mapper, which display descriptive information when an icon in Google Earth is selected. The format and content of the bubbles can be modified using a text editor or commercially available HTML creation software.

Another technique for building KML files is to use the "Layer To KML" toolbox in ArcGIS 9.3, which creates a KMZ file (a compressed KML file) for point, polyline, and polygon features. This method has the advantage of being simpler, but the trade-off is less flexibility in displaying the results. The default ArcGIS information display in Google Earth is a table-style balloon (Figure 3). Commercial software such as "Arc2Earth," provides additional capabilities in creating KML files, such as formatting bubbles, utilizing ArcGIS renderers (Unique Value, Class Breaks), exporting three-dimensional shapefiles, and exporting KML files directly to Web servers such as Amazon S3.
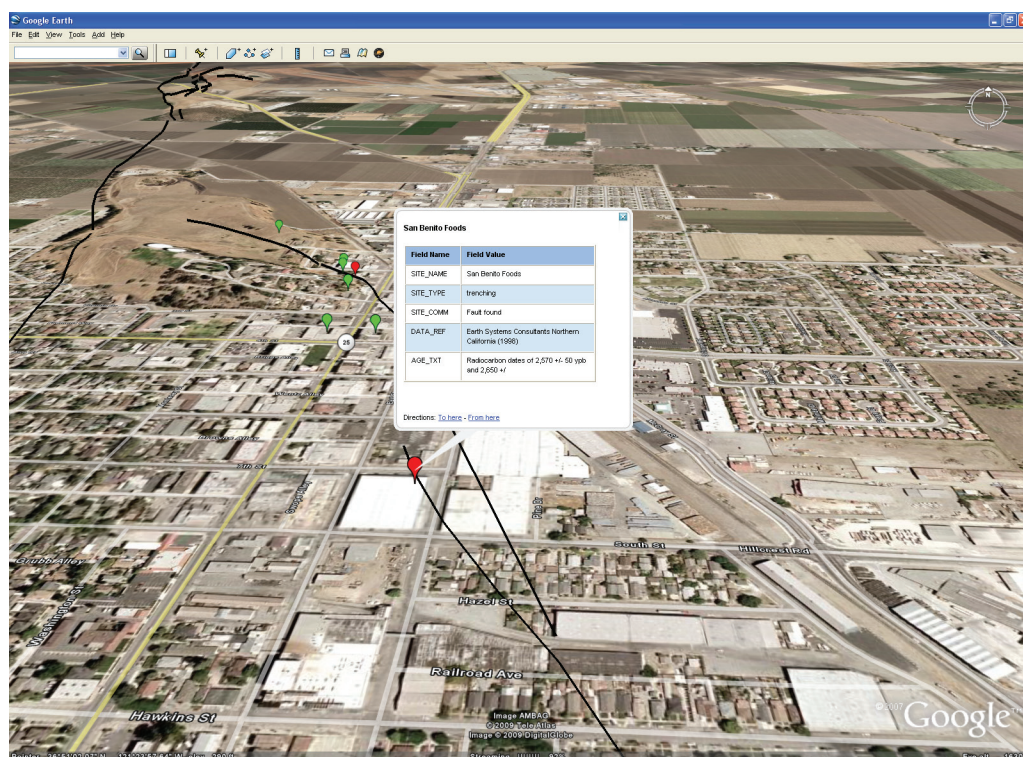

Figure 3.   Screenshot of Google Earth Web interface showing Quaternary fault traces (solid black lines), location of fault trenches where fault was found (red teardrops), location of fault trenches where fault was not found (green teardrops), and summarized information (in bubble).

Storing Data on Amazon S3

Files for this study are stored on the Amazon Simple Storage Service, commonly referred to as Amazon S3. The advantage of using Amazon S3 is that the data are stored on servers that are accessible worldwide, are scalable, and are encrypted. The current (2009) cost for storing data is relatively inexpensive with rates of $0.15 per GB per month for the first 50 TB of storage used, $0.10 per GB for all data loaded to the server, and $0.17 per GB per month for the first 10 TB of data downloaded by users.

However, Amazon does not include a front-end interface for their Amazon S3. One solution is the freeware S3Fox Organizer plug-in for Mozilla's Firefox Web browser. As shown in Figure 4, S3Fox Organizer provides a graphical interface to move files to and from Amazon S3. One nice feature of the Arc2Earth software is the ability to directly export KMZ files to Amazon S3 within the ArcGIS environment (Figure 5).
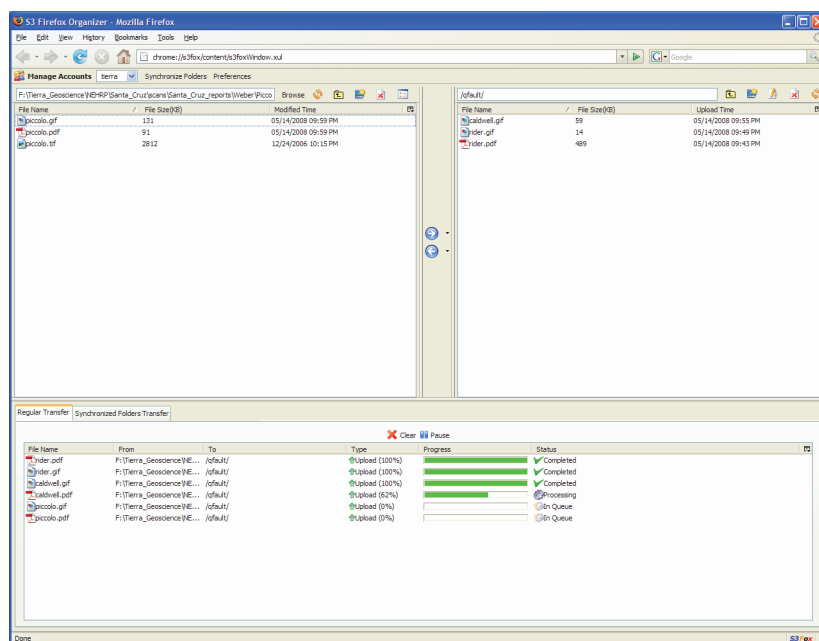

Figure 4.   Screenshot showing S3Fox Organizer file management interface to the Amazon S3 server.
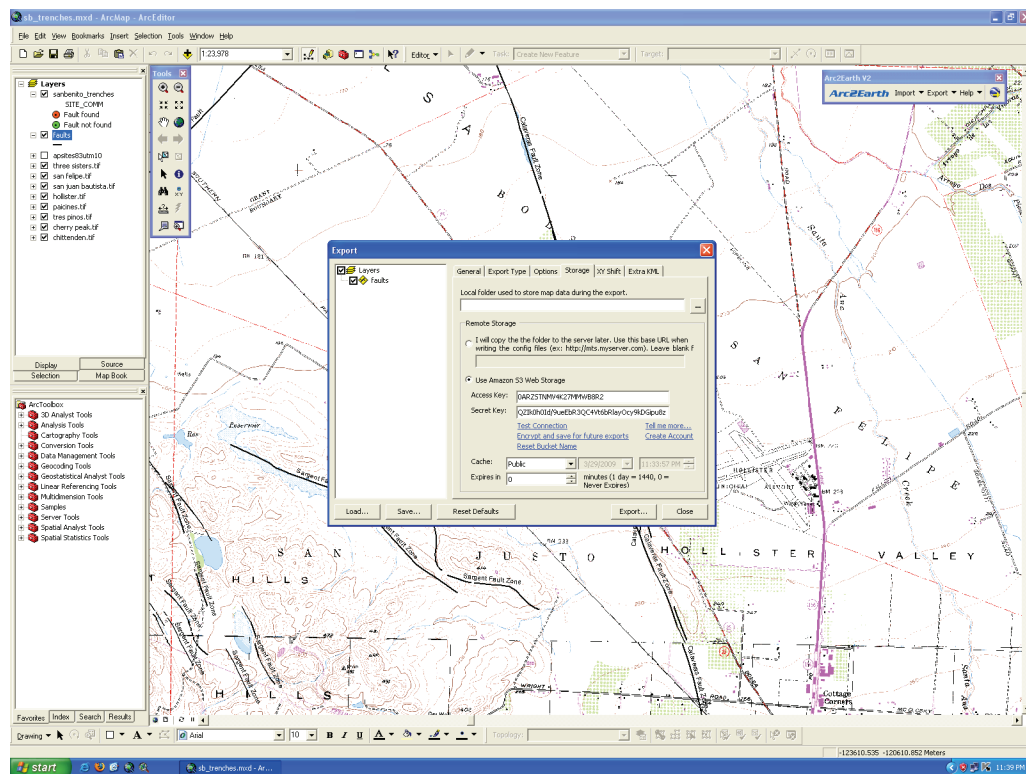
Figure 5.   Screenshot showing Arc2Earth export from ArcGIS to Amazon S3 server.

Viewing and Downloading Data

The resulting KML and KMZ files can be displayed in Google Earth, in Google Maps, and in Microsoft Virtual Earth or other software capable of reading KML and KMZ files. Other advantages of using this approach include the ability to combine the fault trenching sites and fault layers with features such as parcel boundaries and roads.

Images of fault trench logs and site maps are stored as files on Amazon S3 and accessed from URL hyperlinks shown in the Google Earth information bubble for each fault trench site. The ArcGIS files for this study are also stored on Amazon S3, with a URL providing access to the data. This method has the advantage of being easier, faster, and less expensive than supplying the files on a CD. It also facilitates having the most current version of the database available to users.

The approach of using Spreadsheet Mapper, Amazon S3, and Google Earth also has potentially useful application in many geologic mapping projects, especially for post-natural disaster mapping. The collaborative nature of Spreadsheet Mapper combined with the distributed storage of Amazon S3 could be valuable for their ease of use, rapid sharing of data, and resistance to data loss from computer servers in the affected areas. However, there is the potential issue for

Web servers to go out of business, so it is advisable to retain backups of all files. In addition, there are possible privacy issues for cloud computing, especially for sensitive or proprietary data. As this technology matures, the cloud computing applications will likely become more common and the uses for collaborative spreadsheets and distributed storage will become more widespread among geologists and cartographers.

Acknowledgments

Reference

Tufte, E.R., 1990, Envisioning information: Cheshire, CT, Graphics Press, 126 p.

Vendor Contact Information

Amazon S3—Amazon.com, 1516 2nd Ave., Seattle, WA 98101 USA, (800) 201-7575, *http://aws.amazon.com/s3*.

Arc2Earth—Arc2Earth LLC, 270 Davidson Ave., Suite 301, Somerset, NJ 08873 USA, *http://www.arc2earth.com*.

ArcGIS—Environmental Systems Research Institute (ESRI), Inc., 380 New York St., Redlands, CA 92373-8100 USA, (909) 793-2853, *http://www.esri.com*.

Firefox—Mozilla, 1981 Landings Drive, Building K, Mountain View, CA 94043 USA, *http://en-us.www.mozilla.com/en-US/firefox*.

Google Earth—Google Inc., 1600 Amphitheatre Parkway, Mountain View, CA 94043 USA, (650) 253-0000, *http://earth.google.com*.

Google Maps—Google Inc., 1600 Amphitheatre Parkway, Mountain View, CA 94043 USA, (650) 253-0000, *http://maps.google.com*.

Microsoft Excel—Microsoft Corp., One Microsoft Way, Redmond, WA, 98052 USA, (425) 882-8080, *http://office.microsoft.com/en-us/excel/default.aspx*.

S3Fox Organizer—Suchi Software, *http://www.s3fox.net*.

Spreadsheet Mapper—Google Inc., 1600 Amphitheatre Parkway, Mountain View, CA 94043 USA, (650) 253-0000, *http://spreadsheets.google.com*.