

# Creating a Virtual Geologic Map and Field Trip of the St. George 30'x60' Quadrangle, Washington County, Utah: An Adventure in Google Earth

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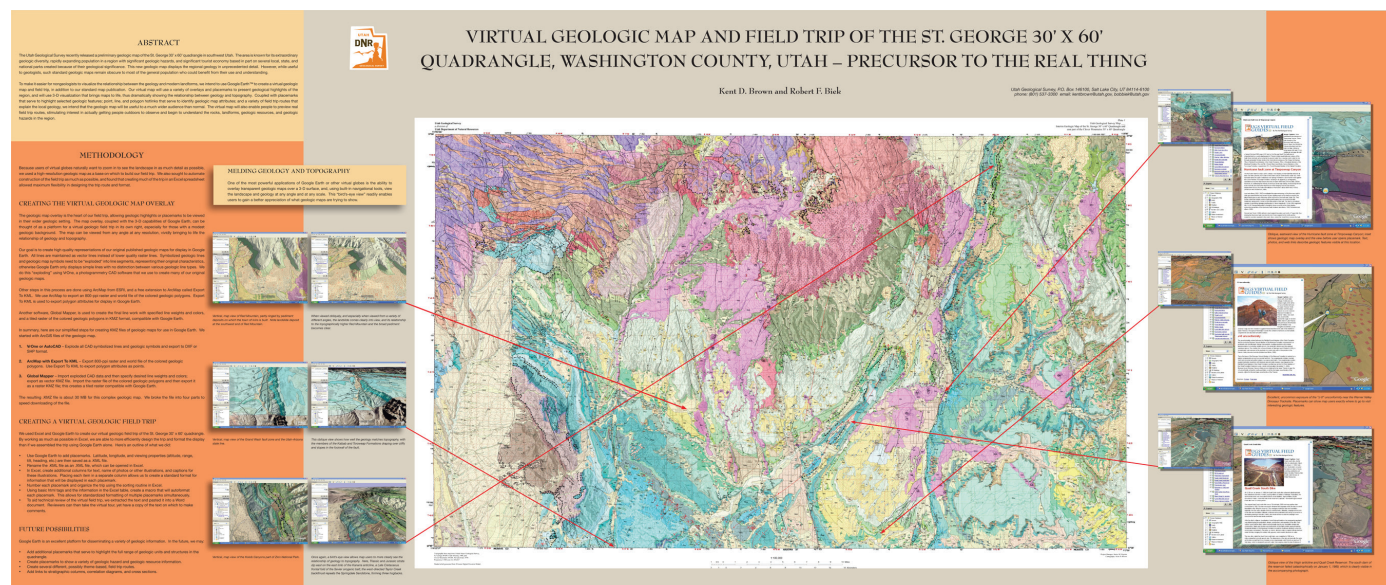
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## Introduction

The concept of a virtual geologic field trip is very attractive to a geologist who wants a more interactive and visual method of telling a geologic story to others, especially non-geologists, than is possible using a traditional paper geologic map. This virtual field trip uses the popular internet virtual globe interface, Google Earth, in combination with a transparent geologic map overlay, photographs, illustrations,

and descriptions of selected geologic features, to help users understand the geology of the greater St. George, Utah, area. An overview of the product and the method are shown in the accompanying poster (Figure 1).

Because users of virtual globes naturally want to zoom in to see the landscape in as much detail as possible, we used a high-resolution geologic map as a base on which to build our field trip. We also sought to automate construction of the field trip as much as possible, and found that creating much of the



**Figure 1.** Poster created to show concept and procedure (presented as a poster; see full-resolution image at [http://ngmdb.usgs.gov/Info/dmt/docs/DMT08\\_Brown.pdf](http://ngmdb.usgs.gov/Info/dmt/docs/DMT08_Brown.pdf).)

trip in an Excel spreadsheet allowed maximum flexibility in designing the trip route and format.

## Creating the Virtual Geologic Map Overlay

The geologic map overlay is the heart of our field trip, as it allows geologic highlights and placemarks to be viewed in their wider geologic setting. In Google Earth, the map can be viewed from any angle at any scale, vividly bringing to life the relationship of geology and topography (Figure 2). For those with even a modest geologic background, the map overlay, coupled with the 3-D capabilities of Google Earth, serves as a virtual geologic field trip in its own right, even without adding photographs and descriptions. However, we feel that the viewer's experience and geologic understanding of this virtual map are improved with these added features.

Our goal is to create high quality representations of our original published geologic maps for display in Google Earth, so that all lines are maintained as vector lines instead of lower quality raster lines. The GIS data we use to create these Google Earth maps is in ESRI geodatabase format.

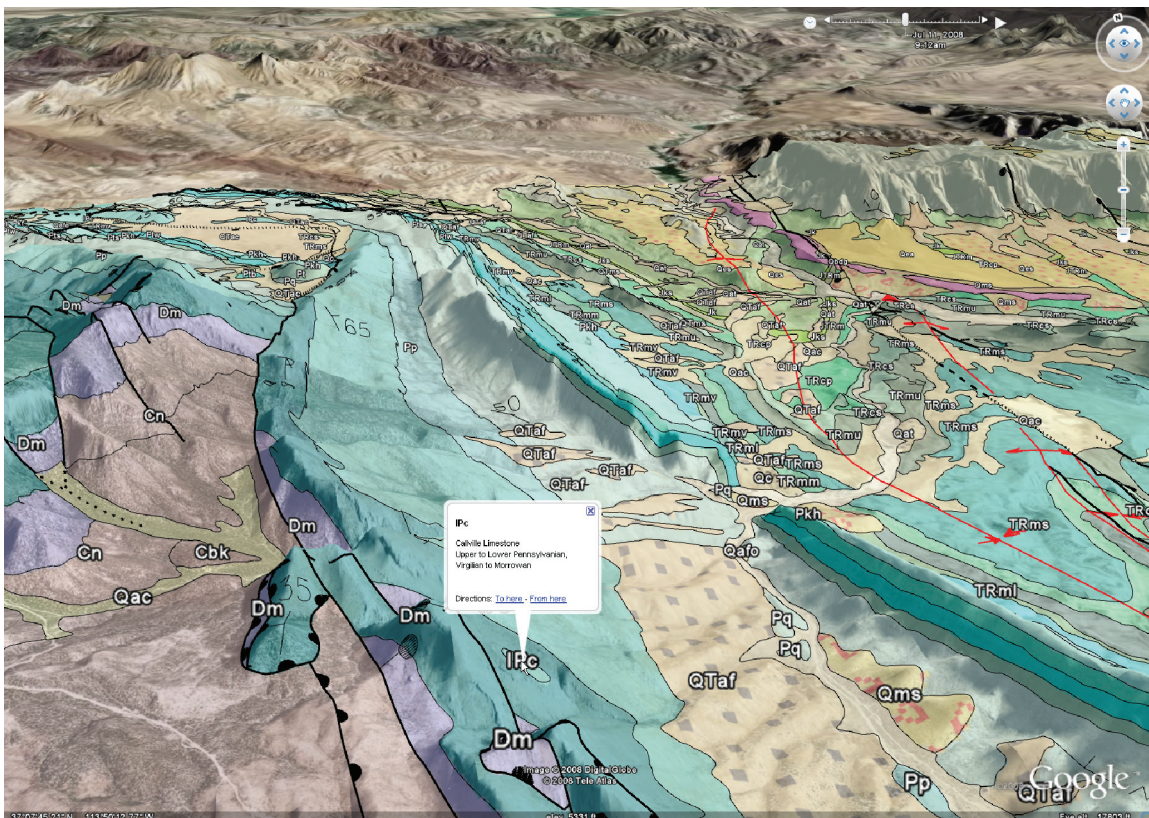
Because Google Earth does not currently support ESRI ArcMap line symbology, (dotted lines, dashes, teeth on

thrust faults, etc.) only the line colors and line widths can be exported to Google Earth KML (Keyhole Markup Language) format. Geologic map point symbols (bedding symbols, fault symbols, fold symbols, etc.) and geologic unit polygons with pattern fills are also unsupported. Therefore, to display our geologic maps correctly in Google Earth we find it necessary to "explode" symbolized geologic lines and geologic map symbols into line segments representing their original symbol characteristics. We do this "exploding" using VrOne photogrammetry CAD software from Cardinal Systems, LLC. (Our primary use of VrOne is to create the initial symbolized lines and geologic map symbols for many of our original geologic maps, before the GIS data are created.)

We further process the data using ArcMap v. 9.x from ESRI, and a free user-created extension to ArcMap called Export To KML, which we use to export geologic polygon attributes for display in Google Earth. We also use ArcMap to create a "high-resolution" geo-referenced raster image of the colorful geologic polygons.

Global Mapper, from Global Mapper Software, LLC, is used to create the final line work with specified line weights and colors, and a tiled raster image of the colored geologic polygons in KMZ (a compressed version of KML) format, that are compatible with Google Earth.

In summary, we follow four simplified steps for creating KMZ files of geologic maps for use in Google Earth:



**Figure 2.** Example of a virtual geologic map overlay in Google Earth, showing geologic unit information in a "balloon."



1. **VrOne or AutoCAD** – Initially, all geologic lines and map symbols are created in a CAD environment. We explode all CAD symbolized lines and geologic symbols and export them to DXF or SHP format.
2. **ArcMap with Export To KML** – We export an 800-ppi raster image (BMP or TIF) and world file of the colored geologic map polygons. Exporting this raster image from the ArcMap view is currently the only way we can preserve the cartographic patterns that are used in some of the geologic unit colors. Then we use the Export To KML extension to export geologic unit symbols from the polygons. This gives us a KML file of points, along with attributes for unit name and geologic age that are used in Google Earth as clickable points that display the attributes of the geologic units in a pop-up information balloon.
3. **Global Mapper** – We import the exploded CAD data, specify desired line weights and colors for the features, and then export them once again as a vector KML file. Then we import the raster image of the colored geologic polygons and then export it back out as a raster KMZ file; this creates a more efficient tiled raster image that is compatible with Google Earth.
4. **Google Earth** – We open the three files created in the above sequence; that is, the raster KMZ file of the geologic unit colors, the KML file of the vector lines, and the KML file of the geologic unit symbols. Then we export them all together as one KMZ file.

The resulting KMZ file for this complex 30'x60' geologic map is about 30 MB. Therefore, we divided the map into four parts to speed downloading of the files and to increase the display performance in Google Earth. We recommend that the geologic unit colors of these maps be made about 50% transparent in Google Earth so the terrain imagery is visible through the geology.

## Creating the Virtual Geologic Field Trip Stops

To further enhance the experience of the virtual geologic map and to partially recreate an actual geologic map field trip, we created numerous virtual field trip stops as Google Earth placemarks. The placemarks activate informational balloons that include photographs of key geologic features, illustrations, and descriptive text about each stop, in addition to links to larger versions of the photos and to the Utah Geological Survey website. The result is a sequence of placemarks that are “played” in Google Earth as if they are a video, automatically flying over the terrain and zooming in at each placemark to display the balloon information (Figure 3).

We created the Virtual Geologic Field Trip of the St. George 30' x 60' quadrangle using Microsoft Word, Microsoft Excel, and Google Earth. By working as much as possible in Excel, we were able to more efficiently design the field



**Figure 3.** A virtual geologic field trip stop in Google Earth, showing an information balloon that explains gravity-slide blocks.

trip and to format the display than if we had assembled the field trip using Google Earth alone. We also created an Excel spreadsheet with a UGS-specific macro application (**Excel-to-KML.xls**, which is available at [http://ngmdb.usgs.gov/Info/dmt/docs/DMT08\\_Brown.zip](http://ngmdb.usgs.gov/Info/dmt/docs/DMT08_Brown.zip)) that we use as a template for organizing and streamlining the creation of these virtual field trips. You can use this template to create a KML file for your field trip, by simply pasting your data on top of the examples in the “example-data” sheet and then running the macro application.

This project has three principal aspects: writing the field trip stop descriptions using Microsoft Word; creating the field trip placemarks in Google Earth, and setting the viewing angle, azimuth, distance to subject, and picture link locations; and combining the field trip placemark names and stop descriptions with the geographic coordinate information from Google Earth, in order to build the KML-based field trip.

Here’s how we do it:

1. Create the field trip stop descriptions in Microsoft Word.
2. Use Google Earth to add placemarks to appropriate geographic locations. You could use the “add placemark” feature of Google Earth to do the whole process of creating the KML, but that would require copying and pasting each field trip title, description, image, and HTML formatting into the placemark boxes individually. To save time, create only the placemark names and locations, and, optionally, altitude, range, tilt, and heading in Google Earth. After creating your virtual trip placemarks, simply save them as a KML file, not a KMZ file. KMZ files are compressed and you cannot edit them in Excel, which we do in step 4.
3. Rename your placemarks KML file extension to **.xml** (Note: viewable file extensions must be enabled in Windows Explorer to do this). This XML file can now be opened in Excel versions 2003 and later (Excel 2007 does this best) and will be automatically parsed into a tabular format. Google Earth tends to add a large amount of extraneous style information, but you only need fields such as latitude, longitude, altitude, range, tilt, heading, etc. Search through the XML file in Excel to find the data that match the pattern shown in the “example-data” sheet of the **Excel-to-KML.xls** spreadsheet. Select the ranges of cells you need and copy and paste them into the appropriate columns in the “example-data” sheet of the **Excel-to-KML.xls** file.
4. In the Excel “example-data” sheet, paste in column information for each field stop description, name of photos or other illustrations, and captions for these illustrations. Placing each item in a separate column allows us to create a standard format for information that will be displayed in each placemark. Note that getting the data properly into Excel may require some formatting or using the “paste special” command.
5. Number each placemark and organize the trip as desired using the sorting feature in Excel.
6. Lastly, export the finished data from Excel to a KML file using the embedded macro in the **Excel-to-KML.xls** spreadsheet.

The visual appearance of the placemark balloons in Google Earth is determined by HTML formatting, which can be the trickiest part of this whole process. Currently, this HTML format is hard coded into the “**export-to-KML**” macro, and must be manually changed outside of the application’s user interface. Thus, some knowledge of how to use the Visual Basic editor is required. In the Visual Basic editor, you can access the editable code by right-clicking on the “KML-Generator” form in the project explorer and selecting “view code.” The HTML is fairly easy to find at the top of the code block. The “**export-to-KML**” macro uses URLs to the UGS web server, so at the very least you will simply need to change the base URLs for the images from the UGS Web server to the Web address of your images. We created two different image directories, one for image thumbnails and one for full-sized images.

To aid technical review of the virtual field trip, we maintained the **Excel-to-KML.xls** spreadsheet as our master copy of all field trip stop description and caption text and simply exported those columns into a Word document for review (see “copy-to-word” tab in the **Excel-to-KML.xls** spreadsheet). Reviewers can then view the virtual field trip and also have a copy of the text on which to make comments.

## Tour Settings

The behavior of this virtual tour is determined by the settings in Google Earth. The fly-to speed, tour speed, and tour stop duration settings are found in the Tools-Options-Touring menu. We recommend that the user set these parameters so the virtual field trip does not travel too fast between placemarks, and so the terrain will redraw properly. Also, users need to set the tour stop duration long enough to view the photos and read the information in the balloons. The tour can be paused, but since doing so causes the balloon to disappear, the user will need to click on the placemark to renew the balloon; when the user finishes viewing the balloon information they can then resume the tour.

These tour settings are important to configure so that the virtual tour will run as intended by the author. Prominent instructions to the user, for optimal tour settings, must be simple but descriptive. Our suggested settings are included here: [http://geology.utah.gov/geo\\_guides/st\\_george/UGS\\_VirtualFieldGuides\\_settings.htm](http://geology.utah.gov/geo_guides/st_george/UGS_VirtualFieldGuides_settings.htm).

## Future Possibilities

Google Earth is an excellent platform for disseminating a variety of geologic information. Widespread interest in displaying geoscience data in this manner will undoubtedly ensure that newer and better tools will be developed for this purpose.

In the future, we may:

- Add additional placemarks that serve to highlight the full range of geologic units and structures in the quadrangle.
- Create placemarks to show a variety of geologic hazards and geologic resources information.
- Create several different, possibly theme-based, field trip routes.
- Add links to stratigraphic columns, correlation diagrams, and cross sections.
- Add information balloon links to the complete description of map units.

## Postscript

In just one year since working out the above procedure for creating this virtual map and field trip project, there have been many advances in software capabilities. ESRI and Google have both released newer software versions that allow us to streamline this process. Example: Google Earth 5 supports the ability to mouse-click anywhere on attributed polygons to initiate pop-up information balloons. Former versions required attributed point features that you click on to pop-up the balloons; this nice improvement eliminates one production step!

The exploded CAD data can now be formatted and exported directly from ArcMap 9.3 to a KMZ file, using an ArcToolbox tool, eliminating the Global Mapper step used previously for this. The free user-created extension for ArcMap “Export To KML” has been upgraded to version 2.5 and has much better support for HTML layer and feature balloon styles and descriptions. Examples of our virtual map and field trip can be found at [http://geology.utah.gov/geo\\_guides/st\\_george/index.htm](http://geology.utah.gov/geo_guides/st_george/index.htm).

## Software Resources

ArcGIS - ESRI, 380 New York St., Redlands, CA 92373-8100 USA, (909) 793-2853, <http://www.esri.com>.

“Export To KML” - City of Portland, OR, Bureau of Planning, email: [kmartin@ci.portland.or.us](mailto:kmartin@ci.portland.or.us), “Export To KML” is an ArcMap extension available as a free download from ESRI Support Center, <http://arcscripts.esri.com/>.

Global Mapper - Global Mapper Software LLC, 11835 N. Tomahawk Rd., Parker, CO 80138 USA, Email: [support@globalmapper.com](mailto:support@globalmapper.com), <http://globalmapper.com>.

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

Microsoft Office 2003 - Microsoft Corporation, One Microsoft Way, Redmond, WA 98052-6399 USA, (800) 642-7676, <http://www.microsoft.com>.

VrOne - Cardinal Systems LLC, 175 Lehigh Avenue, Flagler Beach, FL 32136 USA, (386) 439-2525, Email: [mike@cardinalsystems.net](mailto:mike@cardinalsystems.net), <http://www.cardinalsystems.net>.