The following was presented at DMT'08 (May 18-21, 2008).

The contents are provisional and will be superseded by a paper in the DMT'08 Proceedings.

See also earlier Proceedings (1997-2007)
http://ngmdb.usgs.gov/info/dmt/

VIRTUAL GEOLOGIC MAP AND FIELD TRIP OF THE ST. GEORGE 30' X 60' QUADRANGLE, WASHINGTON COUNTY, UTAH – PRECURSOR TO THE REAL THING

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ABSTRACT

The Utah Geological Survey recently released a preliminary geologic map of the St. George 30' x 60' quadrangle in southwest Utah. The area is known for its extraordinary geologic diversity, rapidly expanding population in a region with significant geologic hazards, and significant tourist economy based in part on several local, state, and national parks created because of their geological significance. This new geologic map displays the regional geology in unprecedented detail. However, while useful to geologists, such standard geologic maps remain obscure to most of the general population who could benefit from their use and understanding.

To make it easier for nongeologists to visualize the relationship between the geology and modern landforms, we intend to use Google Earth™ to create a virtual geologic map and field trip, in addition to our standard map publication. Our virtual map will use a variety of overlays and placemarks to present geological highlights of the region, and will use 3-D visualization that brings maps to life, thus dramatically showing the relationship between geology and topography. Coupled with placemarks that serve to highlight selected geologic features; point, line, and polygon hotlinks that serve to identify geologic map attributes; and a variety of field trip routes that explain the local geology, we intend that the geologic map will be useful to a much wider audience than normal. The virtual map will also enable people to preview real field trip routes, stimulating interest in actually getting people outdoors to observe and begin to understand the rocks, landforms, geologic resources, and geologic hazards in the region.

METHODOLOGY

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 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, allowing geologic highlights or placemarks to be viewed in their wider geologic setting. The map overlay, coupled with the 3-D capabilities of Google Earth, can be thought of as a platform for a virtual geologic field trip in its own right, especially for those with a modest geologic background. The map can be viewed from any angle at any resolution, vividly bringing to life the relationship of geology and topography.

Our goal is to create high quality representations of our original published geologic maps for display in Google Earth. All lines are maintained as vector lines instead of lower quality raster lines. Symbolized geologic lines and geologic map symbols need to be "exploded" into line segments, representing their original characteristics, otherwise Google Earth only displays simple lines with no distinction between various geologic line types. We do this "exploding" using VrOne, a photogrammetry CAD software that we use to create many of our original geologic maps.

Other steps in this process are done using ArcMap from ESRI, and a free extension to ArcMap called Export To KML. We use ArcMap to export an 800-ppi raster and world file of the colored geologic polygons. Export To KML is used to export polygon attributes for display in Google Earth.

Another software, Global Mapper, is used to create the final line work with specified line weights and colors, and a tiled raster of the colored geologic polygons in KMZ format, compatible with Google Earth.

In summary, here are our simplified steps for creating KMZ files of geologic maps for use in Google Earth. We started with ArcGIS files of the geologic map.

1. **VrOne or AutoCAD** – Explode all CAD symbolized lines and geologic symbols and export to DXF or SHP format.
2. **ArcMap with Export To KML** – Export 800-ppi raster and world file of the colored geologic polygons. Use Export To KML to export polygon attributes as points.
3. **Global Mapper** – Import exploded CAD data and then specify desired line weights and colors; export as vector KMZ file. Import the raster file of the colored geologic polygons and then export it as a raster KMZ file; this creates a tiled raster compatible with Google Earth.

The resulting .KMZ file is about 30 MB for this complex geologic map. We broke the file into four parts to speed downloading of the file.

CREATING A VIRTUAL GEOLOGIC FIELD TRIP

We used Excel and Google Earth to create our virtual geologic field trip of the St. George 30' x 60' quadrangle. By working as much as possible in Excel, we are able to more efficiently design the trip and format the display than if we assembled the trip using Google Earth alone. Here's an outline of what we did:

- Use Google Earth to add placemarks. Latitude, longitude, and viewing properties (altitude, range, tilt, heading, etc.) are then saved as a .KML file.
- Rename the .KML file as an .XML file, which can be opened in Excel.
- In Excel, create additional columns for text, 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.
- Number each placemark and organize the trip using the sorting routine in Excel.
- Using basic html tags and the information in the Excel table, create a macro that will autoformat each placemark. This allows for standardized formatting of multiple placemarks simultaneously.
- To aid technical review of the virtual field trip, we extracted the text and pasted it into a Word document. Reviewers can then take the virtual tour, yet have a copy of the text on which to make comments.

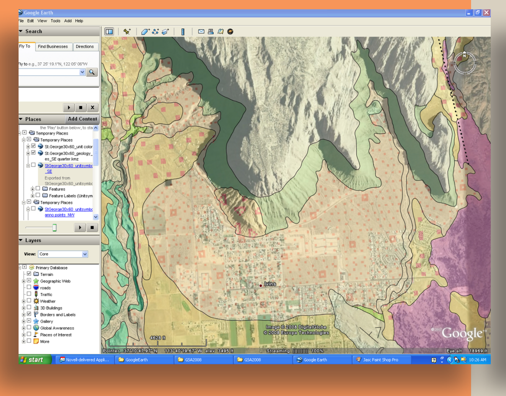
FUTURE POSSIBILITIES

Google Earth is an excellent platform for disseminating a variety of geologic information. In the future, we may:

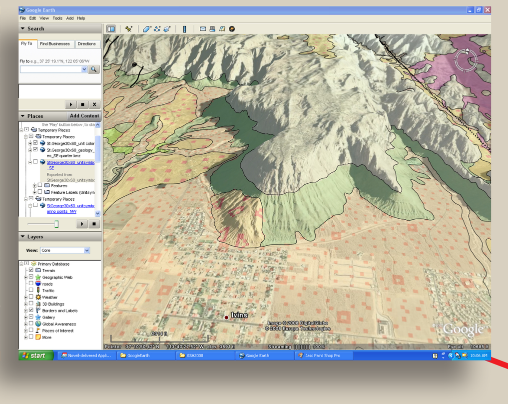
- Add additional placemarks that serve to highlight the full range of geologic units and structures in the quadrangle.
- Create placemarks to show a variety of geologic hazard and geologic resource information.
- Create several different, possibly theme-based, field trip routes.
- Add links to stratigraphic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

MELDING GEOLOGY AND TOPOGRAPHY

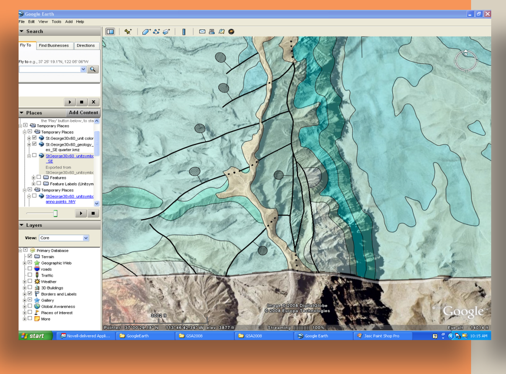
One of the most powerful applications of Google Earth or other virtual globes is the ability to overlay transparent geologic maps over a 3-D surface, and, using built-in navigational tools, view the landscape and geology at any angle and at any scale. This "bird's-eye view" readily enables users to gain a better appreciation of what geologic maps are trying to show.



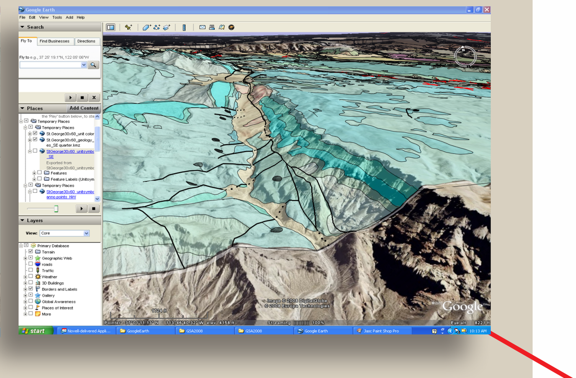
Vertical, map view of Red Mountain, partly ringed by pediment deposits on which the town of Ivins is built. Note landslide deposit at the southwest end of Red Mountain.



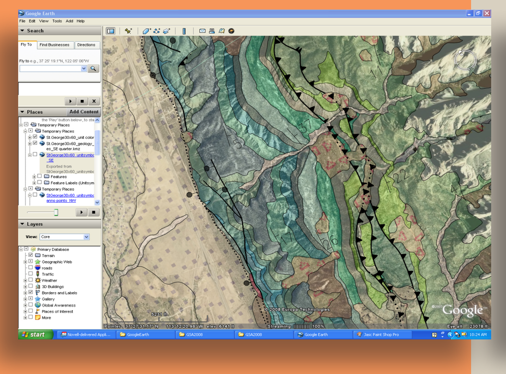
When viewed obliquely, and especially when viewed from a variety of different angles, the landslide comes clearly into view, and its relationship to the topographically higher Red Mountain and the broad pediment becomes clear.



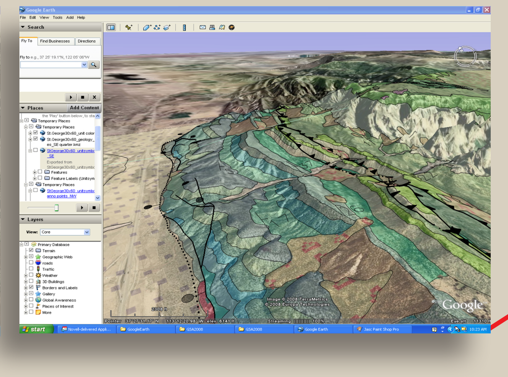
Vertical, map view of the Grand Wash fault zone and the Utah-Arizona state line.



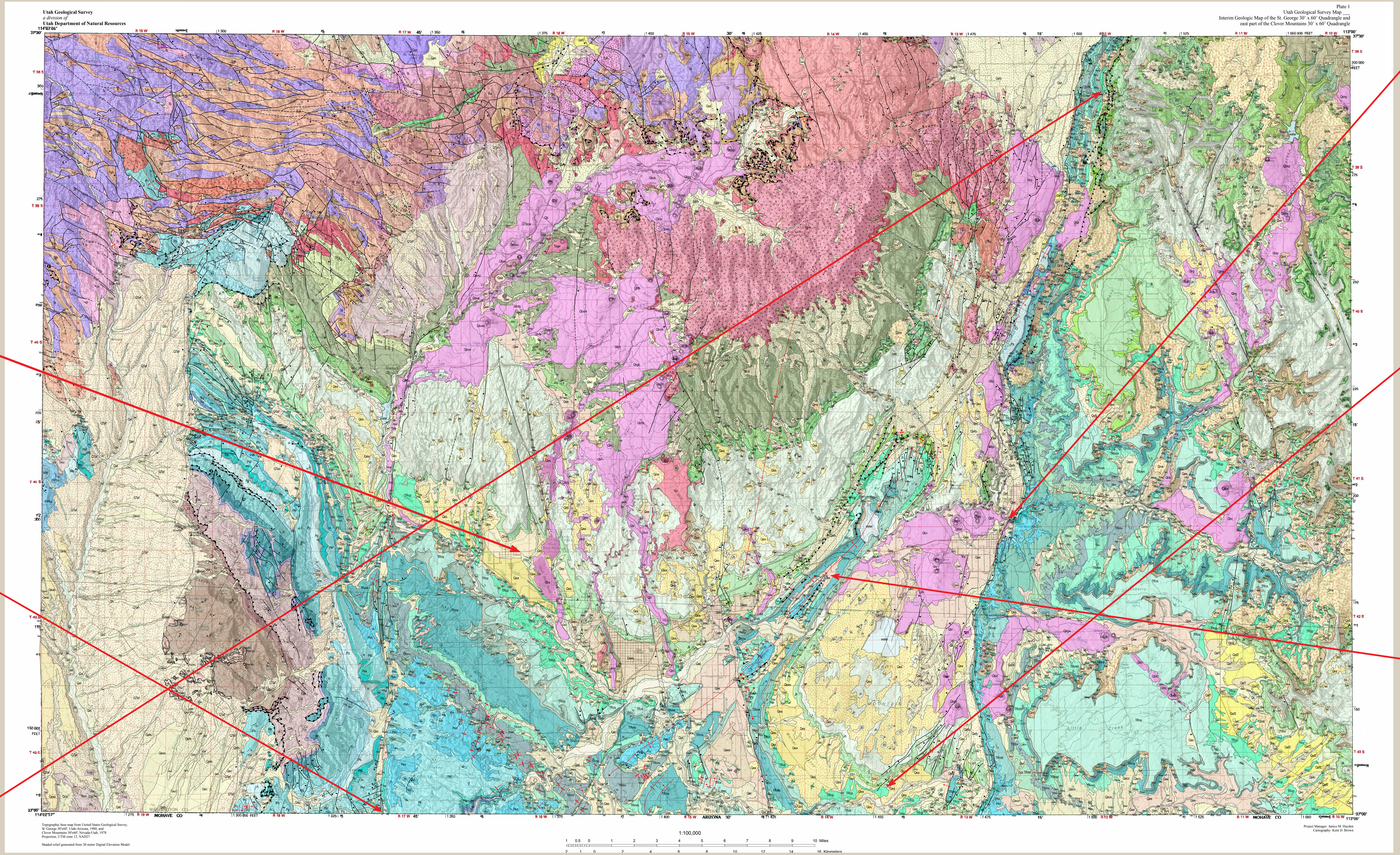
This oblique view shows how well the geology matches topography, with the members of the Kaibab and Toroweap Formations draping over cliffs and slopes in the footwall of the fault.

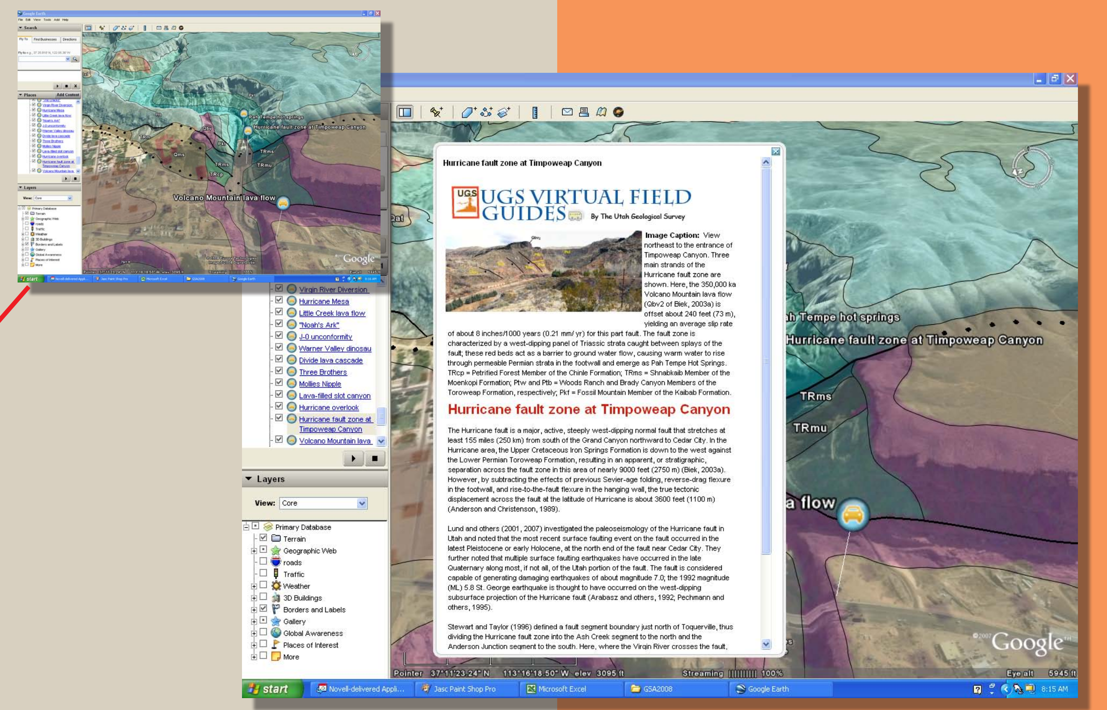


Vertical, map view of the Kolob Canyons part of Zion National Park.

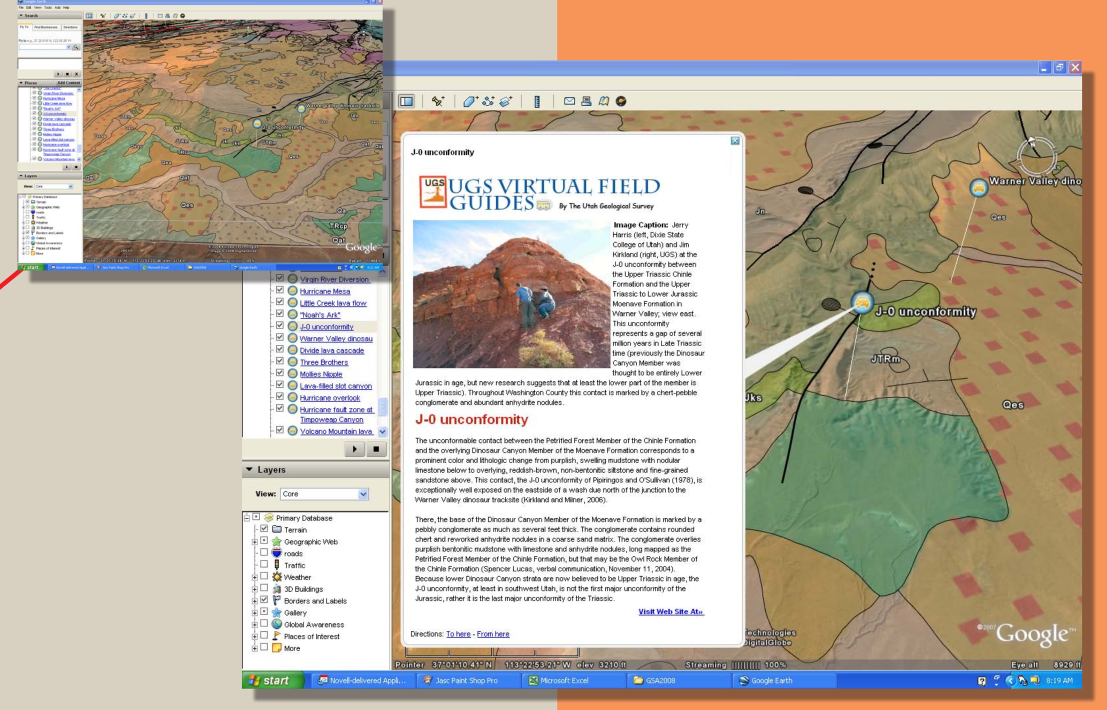


Once again, a bird's-eye view allows map users to more clearly see the relationship of geology to topography. Here, Triassic and Jurassic strata dip east on the east limb of the Kanarra anticline, a Late Cretaceous frontal fold of the Sevier orogenic belt; the west-directed Taylor Creek backthrust repeats the Springdale Sandstone, forming three hogbacks.

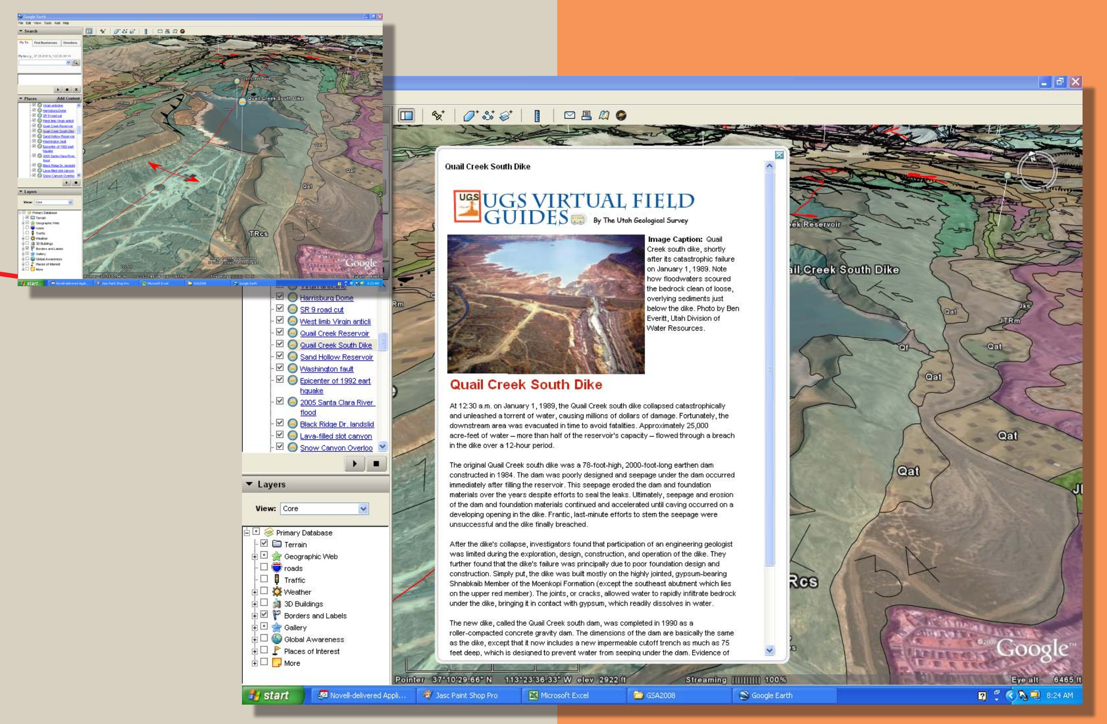




Oblique, eastward view of the Hurricane fault zone at Timpoweap Canyon; inset shows geologic map overlay and the view before user opens placemark. Text, photos, and web links describe geologic features visible at this location.



Excellent, uncommon exposure of the "J-0" unconformity near the Warner Valley Dinosaur Tracksite. Placemarks can show map users exactly where to go to visit interesting geologic features.



Oblique view of the Virgin anticline and Quail Creek Reservoir. The south dam of the reservoir failed catastrophically on January 1, 1989, which is clearly visible in the accompanying photograph.