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A Window to the National Geologic Map Database (NGMDB) Map Catalog via ArcGIS Image Server – Wyoming Pilot Project

By Christopher P. Garrity, David R. Soller, and Mark E. Reidy

U.S. Geological Survey
12201 Sunrise Valley Dr.
Reston, VA 20192
Telephone: (703) 648-6907
Fax: (703) 648-6977
email: *cgarrity@usgs.gov*, *drsoller@usgs.gov*

Introduction

The Association of American State Geologists-U.S. Geological Survey (AASG-USGS) National Geologic Map Database (NGMDB), through its Geoscience Map Catalog, provides access to >89,000 maps and reports by >630 publishers. More than 23,000 of these publications are geologic maps. Access to these geologic maps and other types of geoscience reports is provided via the Catalog’s Product Description Pages (PDPs) and the links to sales offices, libraries, and Web servers where the products can be downloaded.

The NGMDB Web site was developed in 1996, initially as strictly a text-based system. In 2003, scanned maps began to be provided through the Catalog, viewable on-screen and downloadable (Soller and Berg, 2003). At that time, the available technology did not lend itself to efficiently and quickly displaying many maps simultaneously in the same view, and so maps were available only via a custom LizardTech ExpressServer-based image viewer linked from the PDPs. However, in 2009, we were introduced by Willy Lynch (ESRI) to their ArcGIS Server Image Extension, which enabled us to reconsider how to efficiently provide access to a set of maps within the same view, as a mosaic showing all available maps of an area. This idea was prototyped in cooperation with the Wyoming Geological Survey, and the preliminary results are presented here. The prototype will provide access to geologic maps for (1) users of ArcGIS, who can directly link to our Web Service (fig. 1) and (2) the general public, who will gain access via a map viewer in the NGMDB Map Catalog Web pages (fig. 2).

ArcGIS Server Image Extension

Image Extension is part of the ArcGIS Server family; it streamlines cataloging, processing, and disseminating large quantities of raster datasets. With Image Extension, raster processing is handled by the server, allowing client requests to be performed on the fly. This alleviates the need to create multiple preprocessed derivative datasets. Image Extension allows tiled raster datasets to be mosaicked seamlessly on the fly, thereby eliminating the need to process a single, static raster dataset. In most cases only the source imagery needs to be managed, thereby greatly simplifying data management and distribution. Image Extension allows authors to update datasets more efficiently because individual tiles in the image service can be revised without reprocessing the full mosaic. Image Extension supports multiple raster dataset formats (with varying compression types), including TIFF, JPEG, SDE Raster, and MrSID.

A noteworthy feature of Image Extension is that the client can manipulate a number of geometric (pixel location) and radiometric (pixel display) processes dynamically to the image service through what are called process chains. Process chains are essentially a list of actions, defined by the user, that are performed on the source data prior to mosaicking of the final image seen by the client. This enables the user to create multiple imagery products from a single raster dataset source. An example of a process chain might be to fuse a lower resolution Landsat ETM+ scene with a higher resolution panchromatic band (pan-sharpen process) and then reorder the bands (band-stack process) to produce a pan-sharpened true-color or near-infrared band combination.

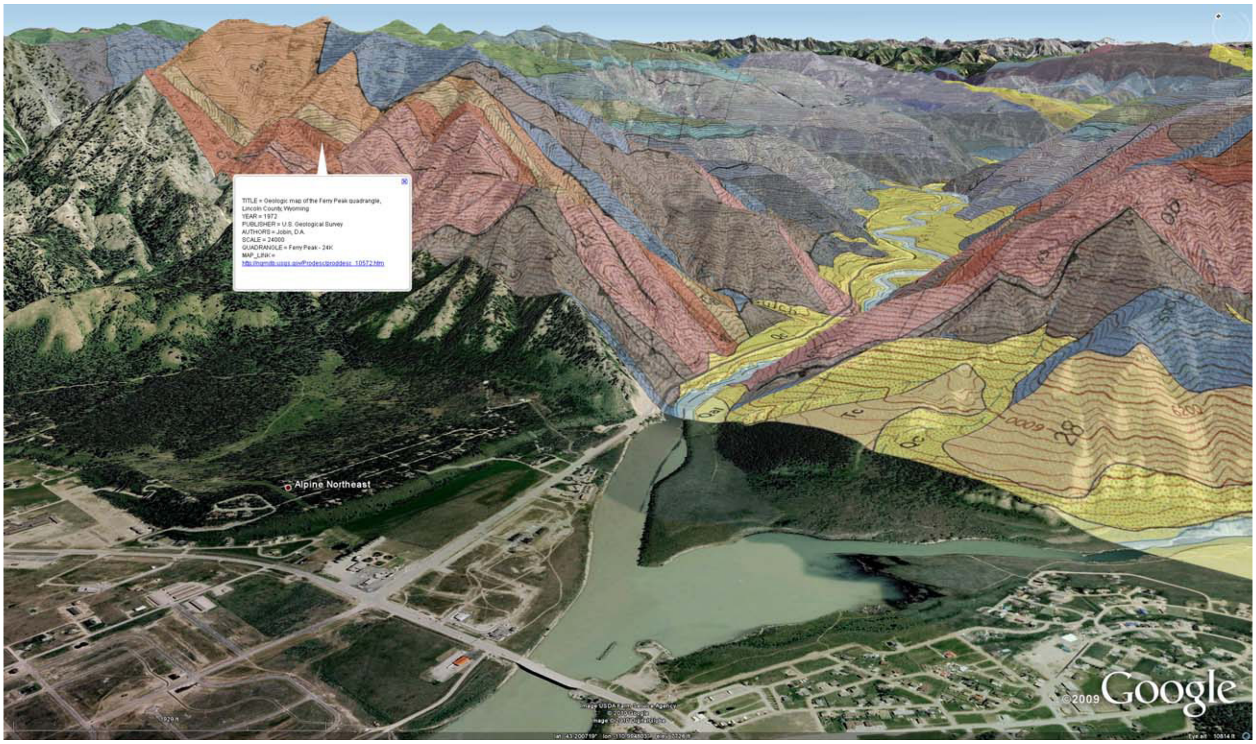

Figure 1. Geologic map Image Service, showing Geologic Map of the Ferry Peak quadrangle (USGS GQ-1027, 1:24,000 scale) draped along the Snake River near Alpine, Wyoming. Image Services published through ArcGIS Server can be consumed by Web clients that support OGC WMS/WCS or KML services, such as Google Earth. Metadata overlays link the client directly to the source data in the NGMDB Catalog (see white callout box) when the map area is clicked.

Figure 2. Image Server as a visual front-end, or "window," into the collection of geologic maps available through the NGMDB Map Catalog. In ArcGIS or in the Web client interface (left-hand image), when the user clicks on a map, a popup shows citation information and a link to the NGMDB Product Description Page (prototype page shown in center image). From that page, links are provided to the publisher, to downloadable files, and to the ImageViewer (right-hand image), where the entire map can be viewed.

In many cases, an image service will have raster tiles (for example, geologic maps) that overlap or will contain groups of tiles that are stacked. For these instances, Image Extension offers a method of controlling the stack order in which tiles are displayed through a user definable parameter called mosaic method. Mosaic method can be enabled to display imagery based on an author-defined attribute. For example, the client could sort by attribute “Time” to view the most recently acquired tile or by attribute “Map Type” to promote “bedrock” or “surficial” geologic maps.

To control unwanted pixel data (map collars, NoData values, and so on) authors can take advantage of a feature in Image Extension called the footprint layer. The footprint layer is a collection of polygons created when raster tiles are added to the image service. Each map tile has an associated polygon “footprint” to which pixels in the tile are clipped. By default, a footprint matching the spatial extent of the tile is created. Footprints can be modified by a variety of methods, including substitution with existing polygon feature class geometry. This is especially useful for removing unwanted collar information from maps when creating a seamless mosaic.

ArcGIS Image Extension distributes metadata about the image service through service-level metadata as well as individual, raster-level metadata (for example, for each geologic map in the service). When a client connects to the image service, the Image Service Properties dialog box can be opened to display an extensive list of the image service metadata that defines its source and accuracy. At any zoom level, the metadata for each input raster currently viewed on screen is transmitted to the client application and can be viewed from within the properties dialog or exported by the client to a file. Details of processes applied to the raster and the parameters for processes are also stored in the metadata. A view of the prototype is shown in figure 3.

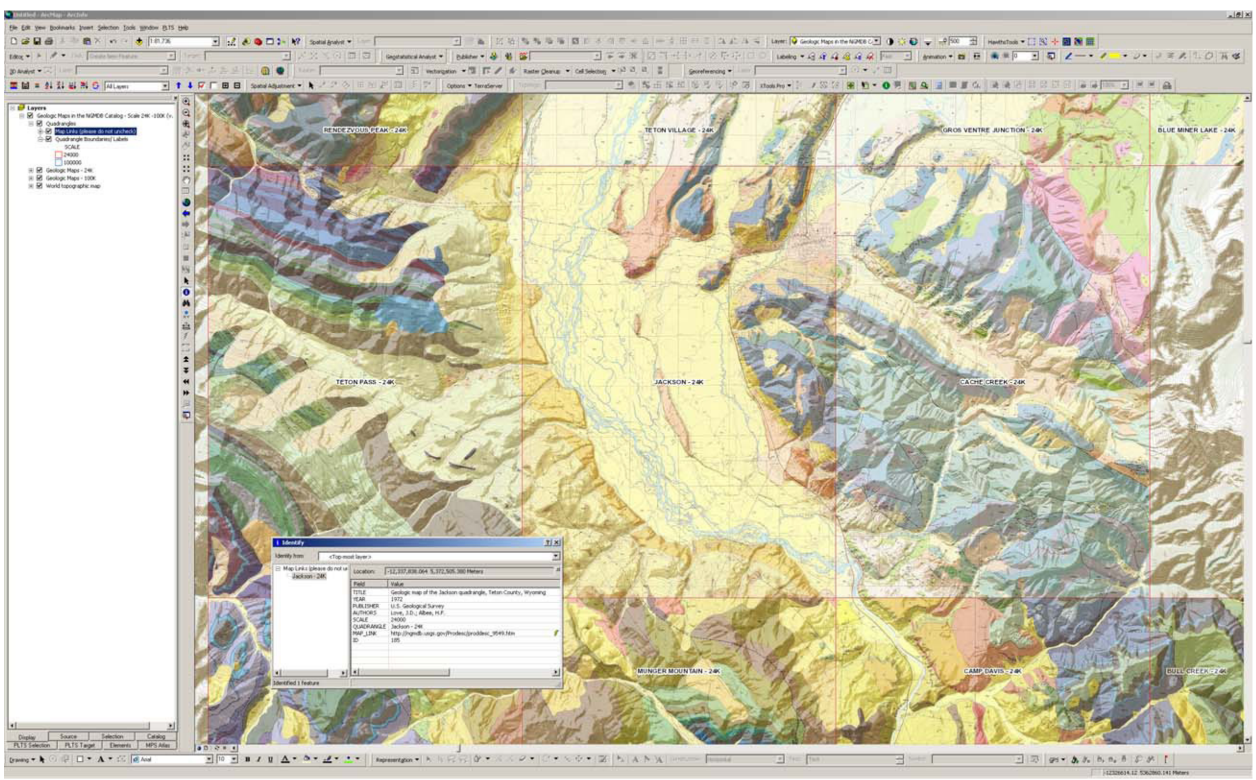

Figure 3. Screen capture of the Wyoming 1:24,000 geologic map Image Service in ArcGIS. The Image Service is bundled with a polygon footprint feature class and is served to ArcGIS clients as a layer (.LYR) file. The overlying footprint enables the user to hotlink to the source geologic map images in the NGMDB Catalog (see Identify pop-up). If desired, clients can export the Image Service raster layer directly from a data view to a local machine.

Workflow

To identify maps appropriate for this prototype, the NGMDB Catalog was queried for 24K to 250K geologic quadrangle maps that had already been scanned. From the candidate maps, each catalog record was quality-checked (for example, for image quality and correct coordinates) and prioritized for display in Image Server. Because only the topmost map in a "stack" is shown, the maps in a quadrangle were prioritized in order to list (1) the most current and comprehensive bedrock or surficial map and (2) older, and preliminary, maps of bedrock and surficial geology. The maps then were processed for Image Server application as follows:

1. Raw (uncompressed TIFF) geologic map scans were compressed using Open Source GDAL utilities and batch processed through Python scripting. The following compression and internal tiling parameters were applied, resulting in about 7X compression ratio:

   gdal_translate.exe -of Gtiff -co COMPRESS=JPEG -co JPEG_QUALITY=85 -co TILED=YES -co PHOTOMETRIC=YCBCR <in_tiff> <out_tiff>

   gdaladdo.exe -r average --config COMPRESS_OVERVIEW JPEG --config USE_RRD NO --config JPEG_QUALITY 85 --config TILED YES--config PHOTOMETRIC_OVERVIEW YCBCR <in_tiff> 2 4 8 16

2. Compressed images were georeferenced in the native UTM projection of the map using a second order polynomial transformation method. Sixteen-control point georeferencing was semi-automated using custom georeferencing software. Average time per map sheet was about 5-10 seconds.

3. An image service was created in a WGS 1984 Web Mercator (Auxiliary Sphere) projection. Geographic transformation (NAD 1927 to WGS 1984) was handled by adding an additional definition to the AISDatums.txt file. Images were added to the service in groups by UTM zone. The option to utilize internal tiling was activated upon image import.

4. Quadrangle boundary shapefiles were related to the footprint layer of the image service. A "clip by related geometry" (clipping mask) was performed to remove all map collar information, effectively creating a seamless geologic map service.

5. Service overviews (low resolution tiles, similar to a traditional map cache) were created for faster access to the image service at small scales.

6. Client-side compression was set to reduce transmission time to the client. A JPEG compression at 55 percent was set as default on the client side.

7. Raster level metadata was exposed through links to the footprint layer attribute table. Linked fields tagged as metadata in the Field Properties dialog appear in the Metadata tab.

8. Mosaic method was set to "By Attribute" to allow promotion of stacked images by map type. Attributes were linked to the footprint attribute table; map types included bedrock, surficial, and preliminary.

Web Client Interface

The ESRI ArcGIS Web application programming interface (API) uses the same ArcGIS Server services used by the ArcGIS desktop client. The API is offered in three different programming environments; we chose the ESRI ArcGIS Web API for Flex mostly for convenience. It offers rapid prototyping, cross-browser support, and a modern programming environment.

The ArcGIS Web API and the Adobe Flex framework favor an event-driven programming design in which the application's behavior is dictated by user interaction, as opposed to a series of operations performed in a predetermined order. In this case, the user interface consists of a user-selected base map, overlain with the 'footprint' and image layers mentioned above. User interactions include panning and zooming, switching of the base maps, changing layer opacity and visibility, and querying for the footprints of maps available through the NGMDB Catalog.

The ArcGIS Web API map 'object' provides the map functionality. The Adobe Flex framework provides the user interface needed to manipulate the map properties – map navigation controls offer panning and scale change, and a layer object has properties for visibility and opacity. By binding a Flex slider widget's current value to a layer's alpha property, the user can change the layer's opacity via the slider.

The query function, provided by the ESRI API, is called when the user clicks on the map. The map coordinates for the click location are sent as input, and the function returns a collection of features (maps) whose 'footprint' includes the coordinates passed. Feature attributes returned include Title, Publisher, Authors, and a URL to the feature's Product Description Page in the NGMDB Catalog.

Figures 4 and 5 show the interface at the time of presentation, and after revisions were made in late 2011, prior to publication of these Proceedings. The most significant change was in how the map files are managed – in order to improve display speed, all maps (regardless of scale) are now managed in a single image service.

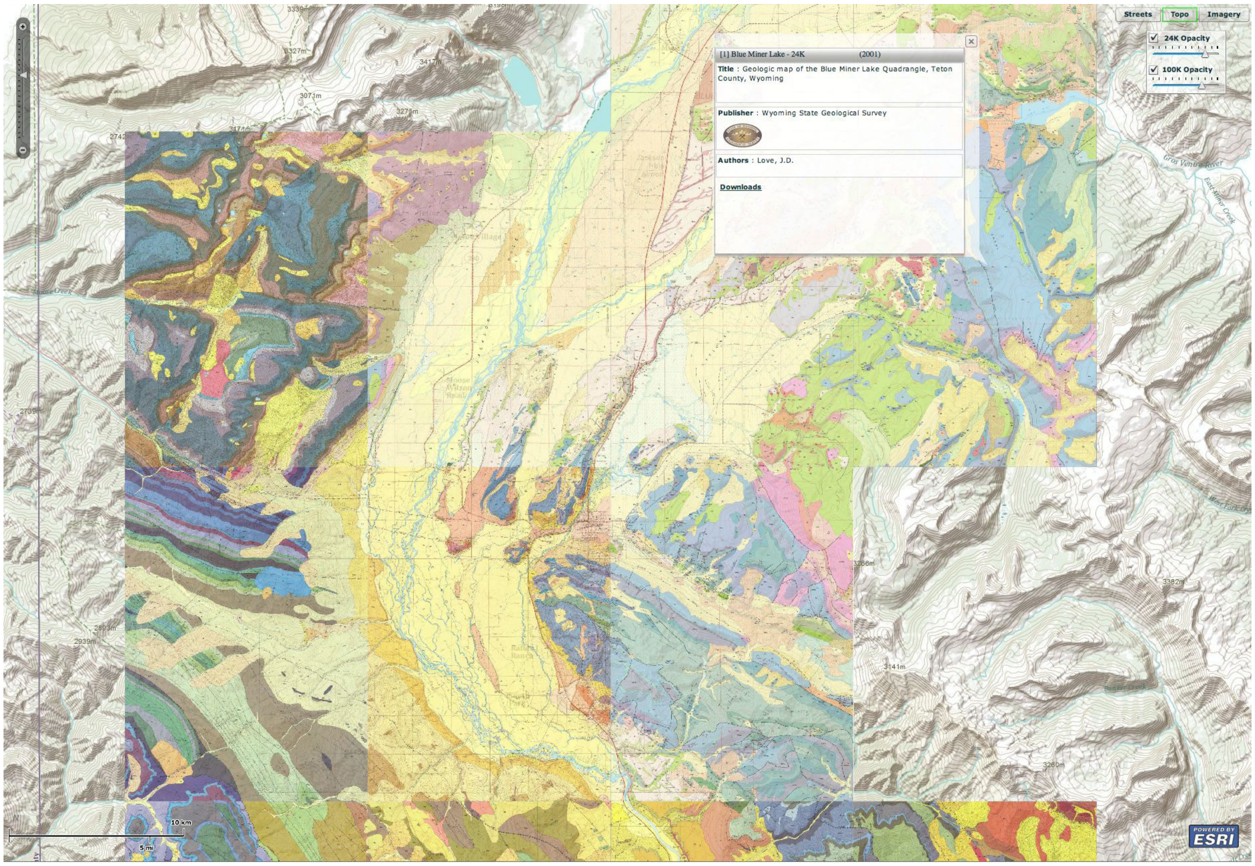

Figure 4. NGMDB map viewer prototype, circa 2010, as shown at the DMT'10 meeting. Maps of various scales (for example, 1:24,000 and 1:100,000) were managed in separate image services. Map area is northwestern Wyoming, near Jackson Hole, and display scale is roughly 1:150,000. Pop-up shows publisher information, with link to NGMDB Product Description Page.

Figure 5. The updated NGMDB map viewer, showing same area as in figure 4. All maps are managed in a single image service, with larger scale (for example, 1:24,000) maps "stacked" above smaller scale (for example, 1:250,000) maps. The default view shows the most detailed map of each area (in this view, all maps showing are 1:24,000 except in the extreme upper right, where the most detailed map is at 1:62,500 scale). In order to view maps of less detail (for example, 1:100,000), the slider (upper right) permits the user to "step" down through maps of lesser detail, eventually showing only the most regional maps such as those of 1:250,000 scale.

Acknowledgments

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Reference

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