Re-Mapping the Geology of Afghanistan

Afghanistan presents a unique set of problems for the geologic mapper. Security risks, the danger of land-mines, and the high, remote, and inaccessible landscape can severely handicap even the most intrepid field geologist. The last published geologic maps are of mid-1970's vintage and they mostly pre-date plate-tectonic concepts. Copies of the maps are also hard to locate and obtain. Nonetheless, near-complete exposures and a structurally controlled geomorphology make Afghanistan an ideal natural laboratory in which to develop modern geologic maps using remote-sensing techniques. Remote-sensing analysis is relatively new with respect to Afghan geologic maps, having evolved almost entirely, since the last of the maps were made.

The United States Geological Survey (USGS) has initiated a program designed to produce country-wide geologic maps of Afghanistan at scales of 1:250,000 and 1:100,000 under the auspices of the the United States Agency for International Development (USAID). The purpose of the mapping is to support natural resource assessment programs and to aid in the restoration of Afghan geoscience ministries to operational status. The maps are being produced in a phased effort in cooperation with the Afghanistan Geological Survey (AGS), the Afghanistan Ministry of Mines and Industries (AMMI), and the Afghanistan Geology and Cartography Head Office (AGCHO). A this point, two phases of mapping are planned.

Phase I Maps

Phase I of the USGS mapping program involves the production of geologic, cartographic, and image map sets of the entire country using only published or easily accessible data and interpretations. The Phase I map sets are intended to:

1. Render older maps, that are otherwise hard to obtain, readily available in a short time-frame.
2. Provide the Government of Afghanistan with a complete map set that can be distributed to prospective industries interested in developing resources in the country.
3. Furnish geologic input to USGS resource assessments of minerals, coal, water, and petroleum.
4. Supply a data-set to guide the next phases of geologic mapping.

The maps are being prepared at 1:250,000- scale in tiles organized around a 1° X 2° quadrangle format. Quadrangles are identified primarily by a four digit number that corresponds to the southwest geographic corner of the map in latitude and longitude format (Fig. 1). In addition, the title of each quadrangle includes the names and numbers of existing AGCHO 1:250,000 topographic quadrangles that are included within the map

PHASE I MAP-TILE SCHEME

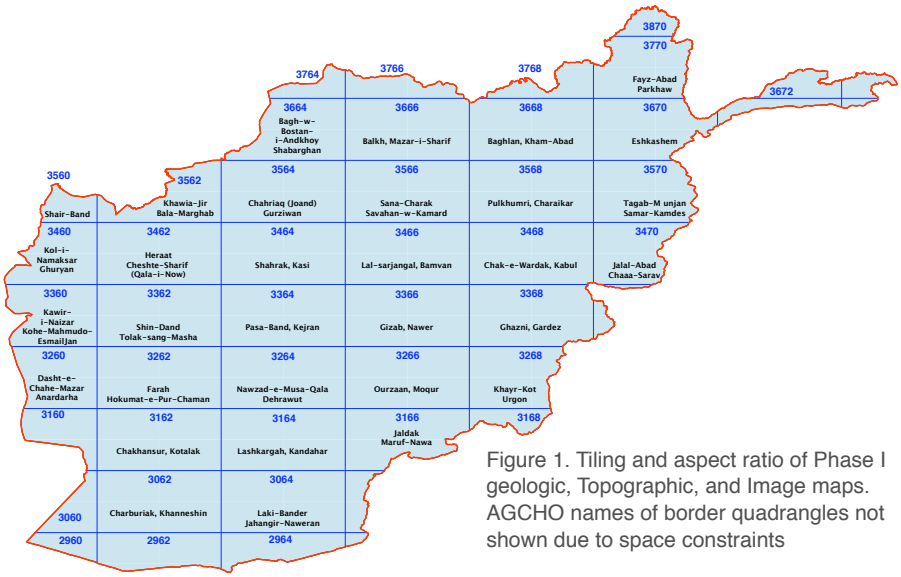

Figure 1. Tiling and aspect ratio of Phase I geologic, Topographic, and Image maps. AGCHO names of border quadrangles not shown due to space constraints

boundaries. All Phase I maps are produced in UTM zones 41-43 with a WGS 84 datum.

Phase I geologic maps are compiled from the geologic data and interpretations on the 1:500,000-scale geologic map of Afghanistan (Abdullah, S.H., Chmyriov, V.M., and many others, 1977, Map of mineral resources of Afghanistan: Ministry of Mines and Industries of the Democratic Republic of Afghanistan, scale 1:500,000). This map has been digitized and attributed to yield a countrywide geologic database that is the source of the unit polygons, fault, and contact layers that form the basis for each quadrangle map. A basic correlation chart and rock descriptions are provided. There has been no attempt to modify the geologic information from the original maps in the Phase I series. Additional data layers include: 1) a shaded-relief base 2) a 250-m-contour base, 3) primary roads, and 4) cities and towns. Topographic data were derived from the Shuttle Radar Topographic Mission (SRTM) 85-m database and cultural features are from the Afghan Information Management Service (AIMS) digital data (request@aims.org.af). The basic format of a Phase I geologic map is depicted on figure 2.

Phase I topographic maps include 1) a shaded relief base, 2) color-coded elevations, and 3) contours generated from SRTM 85 m data at an interval of 100 m. A detailed road layer is included as are cities and provincial boundaries, all from the AIMS database. A UTM grid at 10,000 m is provided as well as standardized map-collar information. The basic margin format is similar to that portrayed in figure 2, minus the geologic information on the right side.

Good topographic maps of Afghanistan have been produced at various scales in the past, and at least one copy of each of those maps is still on file at AGCHO in Kabul. The country has been well mapped over the years, but most of those maps exist only in hardcopy form and are difficult to obtain. Therefore, topographic maps are included in this Phase I map set, not due to improved accuracy (although SRTM data have a proven high degree of positional accuracy), but to make the topographic data more readily available.

Phase I image maps include only an image and standardized map-collar information. The image is a false-color composite using LANDSAT 7 bands 7,4, and 1 (RGB) that were pan sharpened to 14.28 m resolution and corrected for atmospheric affects. Individual scenes have been color corrected and mosaicked prior to extraction of quadrangle tiles. All other information layers are left off the image map so fine detail in the image is not obscured. The basic margin format and size of the image map are similar to that of the topographic map. Most features that appear on the geologic and topographic maps can be easily identified on the images, but the Landsat imagery provides much more geologic information than is shown on the published geologic maps.

Phase II Maps

Phase II maps are planned primarily to provide an improvement over the mid-70's vintage geologic maps and interpretations. Definitive plans for Phase II topographic and image maps have not yet been made. The Phase II geologic maps are intended to:

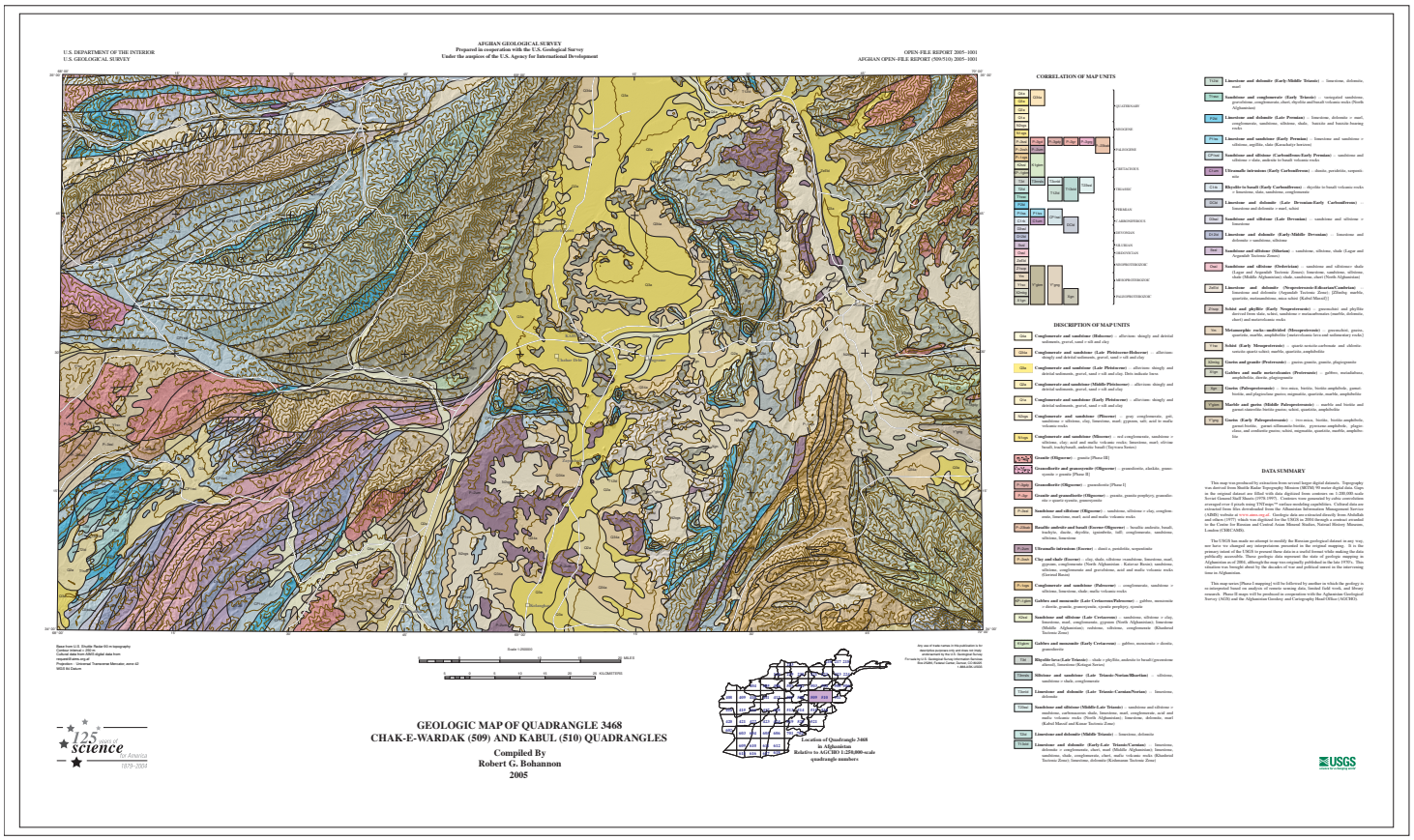

Figure 2. Basic format of a Phase I geologic quadrangle map. Example shown is Quadrangle 3460 and includes Kabul. Phase I topographic and image maps have a similar format, but lack the Correlation Chart and Rock Descriptions on the right side of this example.

1. Produce a countrywide set of geologic maps that include modern interpretations based on LANDSAT and ASTER image data.
2. Provide the Government of Afghanistan with a modern and improved map set that can be distributed to prospective industries interested in developing resources in the country.
3. Furnish high-quality and modern geologic input to USGS resource assessments of minerals, coal, water, and petroleum.
4. Provide the basis for teaching young AGS geologists the field and computer skills necessary to interpret and construct modern digital geologic maps.

Phase II geologic maps will be produced at a scale of 1:250,000 or 1:100,000 in tiles organized around 1° X 2° and 1/2° X 1° quadrangle formats. Quadrangles will be identified by the southwest-corner coordinate as are the Phase I maps. The scale of mapping will be determined at the onset of work by the primary investigator. Factors such as geologic complexity, data quality, and available time will factor into the decision whether a quadrangle warrants more or less detailed mapping. All Phase II maps will be constructed in UTM zones 41-43 with a WGS 84 datum.

The primary source of geologic map data necessary to construct the Phase II geologic maps will be provided by the LANDSAT 7, 3-band (7,4,1) images produced for the Phase I image maps. These data provide significant improvements in geologic detail and positional accuracy over the best-available geologic maps, which were mostly intended for 1:500,000-scale publication (Fig. 3). The Landsat images offer sufficient quality and detail for 1:100,000-scale mapping.

Topographic and image maps might also be included in Phase II. As higher quality topographic datasets and new, improved cultural information become available, topographic maps at scales larger than the 1:250,000 Phase I maps might be made. Phase II geologic work will require advanced image processing techniques and will make use of many other data types besides LANDSAT 7 data (such as ASTER or AVIRIS). Specific instances may warrant the production of image maps that display such data and the results of the advanced techniques.

Technical Training

One of the primary goals of the USGS geospatial activities in Afghanistan is the development of in-country expertise in mapping of all types. Phase II geologic maps will require field work, sampling, and on-site data collection, all best done by Afghan geologists. Improved facilities, new equipment, USGS advice, and training will be critical to the success of the geologic mapping program.

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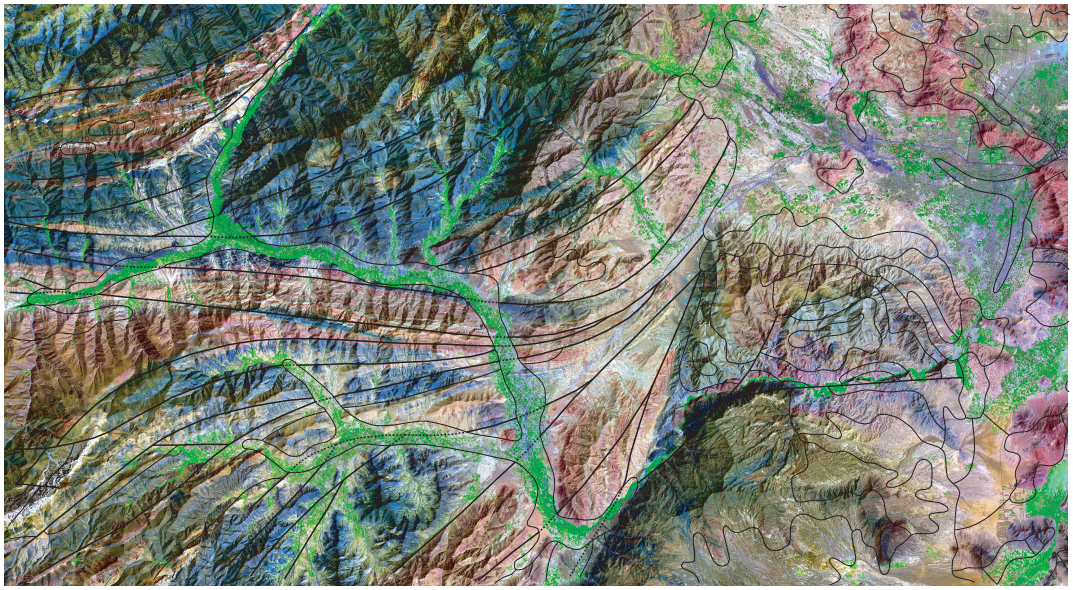

Figure 3. Portion of a LANDSAT 7 image with panchromatic sharpening in bands 1,4,7. Image is extracted from Quadrangle 3468 image and shows Kabul in the upper right. Contacts and faults extracted directly from the Russian 1:500,000-scale, countrywide geologic map are overprinted to illustrate the superior detail and positional quality of the image data.