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Project Title: Kentucky Geological Survey Categorizing and Documenting Geologic Map Discontinuities

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Abstract:
The Kentucky Geological Survey proposed to use our existing detailed statewide digital geologic map dataset—digitized in a 10-year period (1996-2006) from hard copy maps produced during a joint USGS-KGS effort from 1960 to 1978—to identify and categorize the conceptual origins of polygon busts, compile best-practice options for resolution of busts, and develop appropriate metadata and documentation. These discontinuities in the digital data arise from the two stages of geologic map production: the original geologic mapping project included more than 200 geologic field mappers over 18 years and resulted in multiple sources for quadrangle-boundary disagreements. The subsequent digitization process utilized multiple geologists and technicians and heads-up digitizing techniques in an attempt to produce 1:100,000-scale sheets with consistent mapping across the internal 1:24,000 quadrangle boundaries. This process resulted in some mapping inconsistency between the 1:100K sheets. During the digitization process, major discontinuities in the data were identified, but this was not consistently done across the entire dataset and feature-level metadata about these discontinuities lacked detail.

This project proposal focused on using a geologist/GIS technician to reexamine each of the discontinuities (or "busts") in the data to identify the conceptual origin of the bust and add feature-level metadata about each of these discontinuities. We also proposed to explore the best options for bust resolution including reconciliation with GeoLex and adjacent published geologic maps, and to develop a model of metadata and documentation to identify the type and origin of busts identified.

Procedures

To achieve our objective, KGS hired a Temporary Geologist GIS Technician, Nolan Whitt, to examine the contact line and geologic unit polygons from the KGS Digital Vectorized Geologic Quadrangle (DVGQ) data and develop metadata at the feature level describing the decisions made to eliminate geologic unit busts, and also create features and metadata describing justification for geologic unit busts between quadrangle boundaries. Douglas Curl, William Andrews, and KGS stratigrapher, Steve Greb, provided input and consultation about GIS techniques and software, geologic mapping questions, and stratigraphic issues.

Identifying Discontinuities

Whitt performed the bulk of the GIS work on this projectand developed the following techniques using ESRI ArcPro to parse the discontinuities in a copy of the DVGQ polyline contacts data. Her overall goal with this procedure was to copy identified discontinuity polyline features into a new feature class:

1) Whitt first identified existing features in the geologic contact polyline feature class which were attributed as a stratigraphic bust. She achieved this by searching the polyline data for features that were assigned a contact_style attribute of “STRATIGRAPHIC”. This resulted in three combinations of “contact_type” and “contact_style” attributes (the identifying attributes for the type of polyline):
    - contact_type: BOUNDARY; contact_style: STRATIGRAPHIC
    - contact_type: BORDER; contact_style: STRATIGRAPHIC
    - contact_type: CONTACT; contact_style: STRATIGRAPHIC

    The BOUNDARY and BORDER contact_type features are quadrangle boundaries, which is where most of the discontinuities occur (3790 features) in the data. The CONTACT contact_type features are intra-quadrangle discontinuities and are represented by 1108 features in the data (Fig. 1).

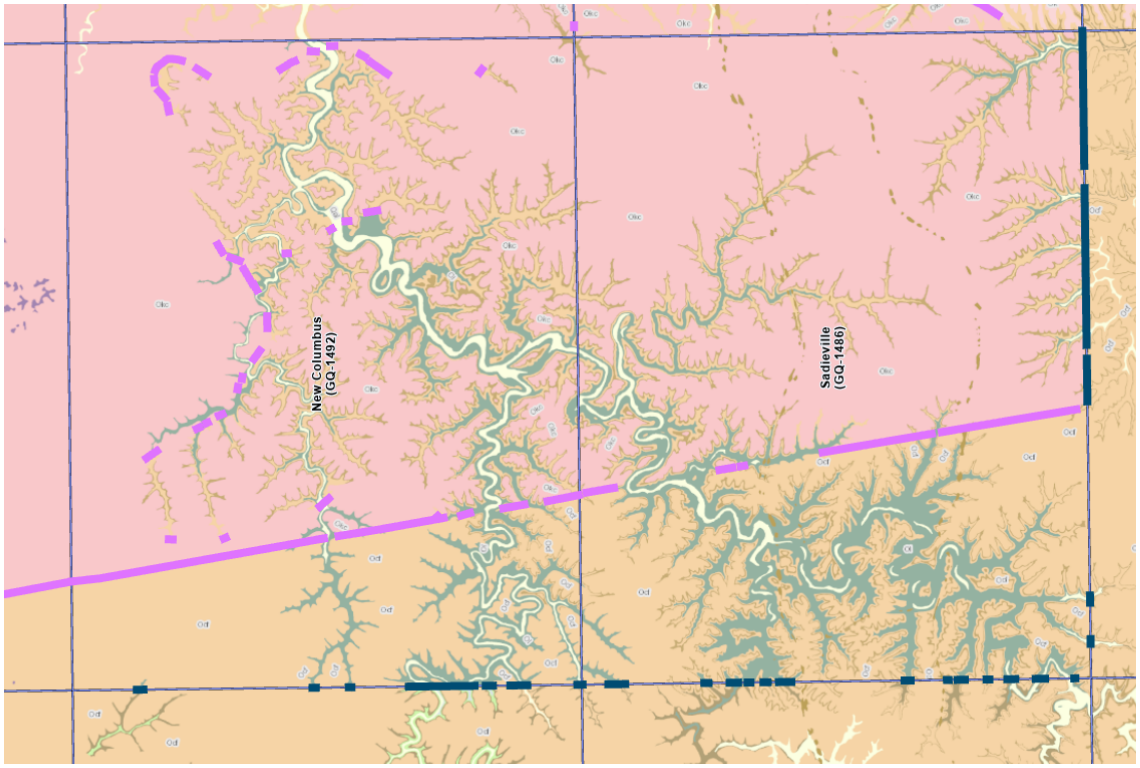

Fig 1. Portion of the Kentucky DVGQ data showing types of originally attributed discontinuities. Basemap is the DVGQ polygon data symbolized by formation. The 7.5-minute geologic quadrangles are also displayed. Thick purple lines are the CONTACT contact_type discontinuities. Thick blue lines are BOUNDARY or BORDER contact_type discontinuities.

Whitt copied these identified polylines to a new feature class that was created for isolating the DVGQ data discontinuities.

2) After identifying the busts from the method described above, it became apparent that some busts were not attributed as stratigraphic breaks in the original DVGQ contact polyline data. To locate those busts not identified in the DVGQ data (i.e. a polyline of these types did not have an discontinuity identifying attribute), Whitt systematically (by quadrangle) visually examined the digital data to locate discontinuities. These were polylines that were attributed as ordinary contacts between formations, but represented a bust in the geologic map data. In most cases these occurred at quadrangle boundaries. Whitt copied these identified polylines (184 features) to the isolated DVGQ discontinuity feature class and attributed their "contact_style" and "contact_type" to indicate the type of discontinuity (most are contact_style = BOUNDARY and contact_type = STRATIGRAPHIC).

Whitt identified a total of 5001 polyline features (Fig 2) from the DVGQ formation contact data which represented a bust between geologic units. These were all copied into a separate feature class which was then used for the next step of further refining the discontinuities into descriptive categories.

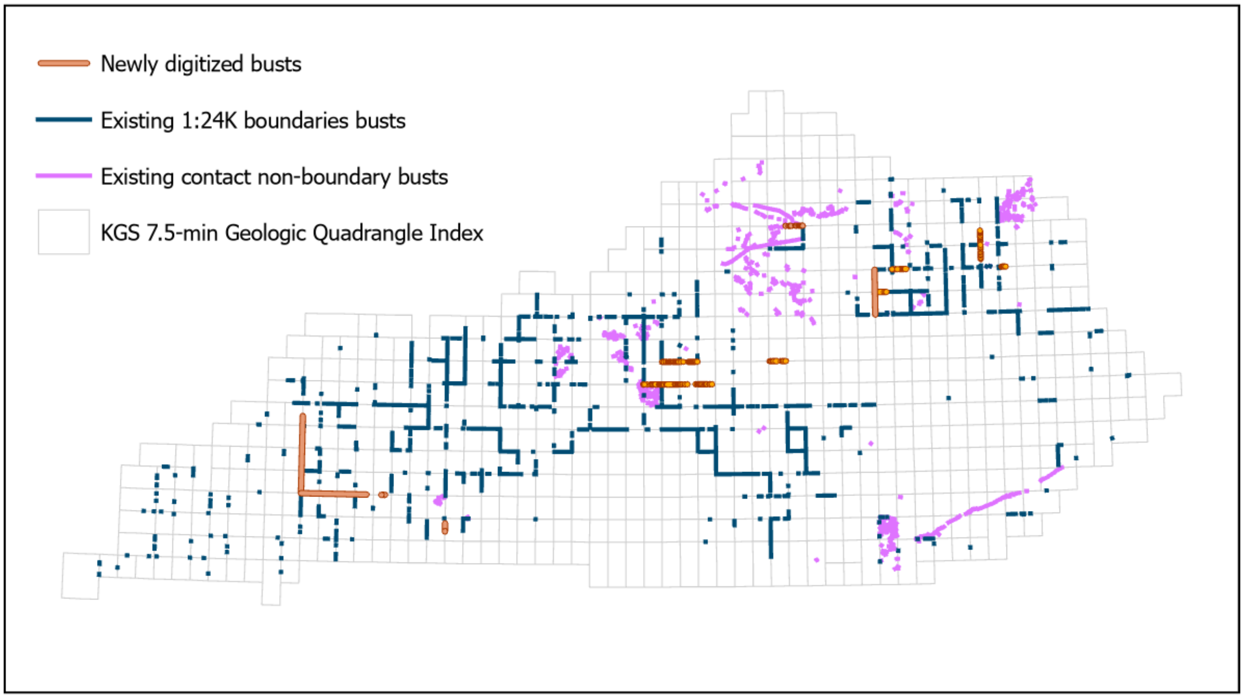

Fig 2. Statewide map showing the distribution of the 5001 polyline features which represent discontinuities isolated from the DVGQ data through the two identification techniques.

Categorizing Discontinuities

Following the identification and isolation of all the discontinuity features in the DVGQ data, Whitt categorized the types of busts into categories which describe their genesis. The purpose of this is to provide a more complete geologic context for each type of discontinuity (beyond the broad category of "stratigraphic" as indicated in the DVGQ attribute data). Whitt worked with stratigrapher Steve Greb to develop a descriptive nomenclature and a 6-part feature-level attribution scheme (Table 1). Her next step was to systematically attribute each feature with the appropriate code.

Code	Alias	Description	Examples
A	Geologic change	Mapping change due to change in geology (e.g. gradual changes in rock type)	NKY Kope/Clays Ferry
B	Thinning Whole Unit	Units become too small for 1:24,000 scale, combined with overlying units	Brassfield/ Overlying Silurian
C	Thinning Key Bed	Key small units/beds become too small/truncated, combined with larger units above/below	Thinning or loss of key coal beds
D	Combining of Beds	Units are combined due to a lack of exposure/outcrop data	Combining WKY Caseyville/Tradewater Formations
E	Time Frame/ Nomenclature	Direct result of the timeline of the mapping project. Name change, re-name etc.	Pennsylvanian Lee à Bee Rock à Grundy
F	Faults	Geologic Faults	WKY Flourspar District

Table 1. Attribution scheme developed for describing discontinuity types in the DVGQ data.

Faults (code 1) are included in this attribute scheme, but for the purpose of this project were omitted from the re-attribution workflow. Faults are a geologic feature that can cause a discontinuity between rocks units in the data, but the KGS DVGQ data has a separate fault feature class which provides detailed feature-level metadata about these features. Therefore, we decided that isolating the fault contacts for this project was not needed and to instead focus on the other types of discontinuities which were not well documented in the feature-level metadata.

Whitt also developed an attribute scheme to add supporting data about the discontinuity type such as the origin of the digitized polyline feature in the DVGQ data (e.g. an existing quadrangle boundary, a geologic contact, or newly digitized line) and the formation codes and quadrangles between which the discontinuity exists (Table 2).

Attribute	Attribute Value Format and Description	Example
contact_style	All are STRATIGRAPHIC. Preserves original DVGQ data value.	STRATIGRAPHIC
contact_type	Either Border, Boundary, or Contact. Preserves original DVGQ data value.	BOUNDARY
contact_comments	Describe boundary between affected geologic units	Boundary between New Albany Shale and Beechwood Limestone Member of Sellersburg Limestone/New Albany Shale
contact_formation_code	Format: FMCODE|FMCODE* KGS FMCodes (found via lookup table) separated by a | (pipe) which encode the two or more contact boundaries described in the contact comments: West| East and North|South – determination is a judgement based on most prominent trend of the contact polyline.	341NALB|344BCHD
DVGQ_quadrangle_boundary	Format: USGS Geologic Quadrangle Code|USGS Geologic Quadrangle Code* For Boundary contact types, DVGQ codes (found via lookup table) of the two DVGQ (1:24,000) quadrangles the boundary exists between (for contacts withing a quadrangle, provide the code for that single quadrangle).	GQ1034|GQ1048
Quadrangle_boundary_1K	Format:Quadrangle Name|Quadrangle Name* For Boundary contact types, enter the 1:100,000 map names of the two 1:100,000 quadrangles the boundary exists between (for contacts within a quadrangle, provide the code for that single quadrangle).	ELIZABETHTOWN
bust_type_code	Possible Values: ND100KB, ND24KB, ECD24KB, ECDF24KB Metadata code describing where the line which creates a stratigraphic bust is derived (boundary or contact and if a new line or existing) ND100KB: Newly Digitized 100K Boundary ND24KB: Newly Digitized 24k Boundary ECD24KB: Existing contact data 24k boundary ECDF24KB: Existing Contact data floating 24k bust	ND24KB
bust_type_detail	Possible Values: A,B,C,D,E,F Values from Table 1 above.	A

Table 2. Attribute table and guide for applying feature-level metadata to the discontinuity feature class.
* Names listed West|East and North|South – determination is a judgement based on most prominent trend of the contact polyline.

Whitt started the process of applying the metadata from Table 2 to attribute each feature in the discontinuity feature class. This process is time consuming because it requires selecting each of the 5001 discontinuity features and calculating the appropriate attribute values. Whitt used several bulk select methods for attributing "like" features (such as known 1:24,000 or 1:100,000 quadrangle boundaries), but it still requires examining each feature to add attributes such as the bust_type_detail, contact_comments, and contact_formation_code. Whitt completed approximately 25% of the attribution on the discontinuity feature class before the project ended.

Future Work

The work of attributing discontinuities to the feature class is ongoing, as this procedure requires meticulous examination and attribution of each feature, and this process is scheduled for completion during fiscal year 2024 by current KGS staff. Once this is completed, we will conduct QA/QC on the resulting feature class (reviewing all the attributes and features). The discontinuity will then be added to the suite of detailed geologic map data and will be available both for download and as a layer on the KGS Geologic Map Service.

KGS GIMS director Douglas Curl is currently working with the publications editor to draft a formal publication (either KGS or external) which will provide a history of the Kentucky detailed geologic mapping program, the subsequent development of the digital geologic mapping data, and describe the schema and rubric used for creating the discontinuity feature class and the feature level metadata describing geologic discontinuities.