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British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Specification of in- and output data formats and deliverables for commissioned 3D geological models

Geology and Regional Geophysics Programme

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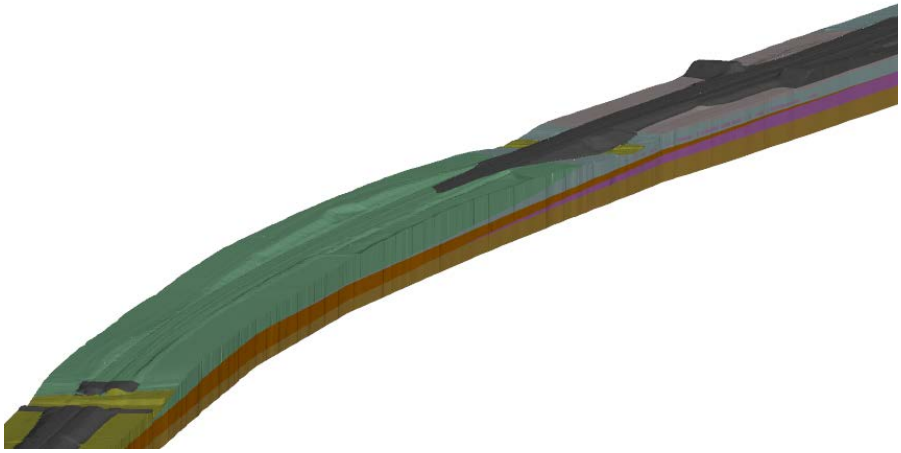

BRITISH GEOLOGICAL SURVEY

GEOLOGY AND REGIONAL GEOPHYSICS PROGRAMME

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Specification of in- and output data formats and deliverables for commissioned 3D geological models

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Parts of the Leeds-York geological model built for TSP.

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Keyworth, Nottingham British Geological Survey 2016

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Foreword

This document is intended to inform users and clients of the types of inputs and outputs required and available for 3D geological modelling. In addition, BGS always endeavour to accommodate requests outside of standard formats.

It was compiled by a selection of lead modellers and project leaders and constitutes best practice at the time of writing (January 2017), as methodologies and technology as well as client's demands advances this document needs to be reviewed and revised.

Contents

1 Introduction

The exact details are likely to be different with each modelling project especially dependant on the methodological approach taken (Groundhog/GSI3D/Gocad/SKUA) it is therefore essential to consult with the authors of this document for us to provide a relevant methodology to meet your needs.

The following sections include statements *(in Italics)* that may be appropriate for inclusion in modelling-related bids.

2 Specification of client supplied spatial data

Spatial referencing of data: *"All spatial data supplied by the client to BGS should be spatially referenced in British National Grid and Ordnance Datum (6 figure grid references for point data). Spatial data using alternative reference systems may be acceptable subject to agreement by BGS and provision of all necessary transformation parameters by the client."*

Project extent(s): *"A definite project outline must be supplied either as a polygon (ESRI shape file or Google .kml format) or if rectangular as x,y min max in British National Grid."*

Depth of investigation: The project might focus on a particular stratigraphic unit, or require a full model to a certain depth in which case is vital that the depth of the project is agreed with the client.

Digital Terrain model: *"The default Digital Terrain Model (DTM) (land surface) to be used is the OS Open Data Landform Profile DTM (50 m cell-size). Any client-supplied elevation models should be provided as ASCII grids, meshed TINs or XYZs."* Where appropriate, consider the availability/suitability of higher-resolution data, e.g.: *"EA open data LIDAR DTM (2 m cell-size) should be offered as an option for more detailed (site-scale) models where appropriate."*

Borehole data: *"Client-supplied borehole data is preferred in AGS V4 format, minimum requirement is digital data in spreadsheet or text format. If only in PDF or image format, additional time needs to be charged for manual input including interpretation and databasing."*

Image format spatial data: *"Client-supplied images should be supplied as png, jpeg or TIF with world geo-registration file (referenced to British National Grid). If images are not geo-registered then sufficient information must be provided to allow their registration; additional time needs to be charged for manual registration."*

3 QA of 3D geological models and cross-sections

In order for a geological model to be approved for publication or delivery to a client a series of QA checks is carried out. This includes visual examination of the modelled cross-sections to ensure that they match each other at cross-section intersections and fit the borehole and geological map data used. The model calculation is checked to ensure that all units calculate to their full extent within the area of interest and the modelled geological surfaces are checked for artefacts such as spikes and thickness anomalies. The naming convention of the modelled geological units is checked to ensure that recognised entries in the BGS Lexicon of Named Rock Units (http://www.bgs.ac.uk/lexicon/home.html) and the BGS Rock Classification Scheme (http://www.bgs.ac.uk/bgsrcs/) are used as far as possible. Any issues found in the QA checking process are recorded and addressed before delivery/publication of the model.

Geological models are accompanied by a standard metadata report which describes the datasets used in the model and records any geological decisions made during the model construction process. An example model metadata report describing the London Basin superficial and bedrock Lithoframe 50 model can be found on the NERC Open Research Archive at http://nora.nerc.ac.uk/507607/

4 Specification of standard outputs

Where appropriate, the *"attribution of geological units will be based on the BGS Lexicon and Rock Classification Scheme code (http://www.bgs.ac.uk/lexicon/home.html; http://www.bgs.ac.uk/bgsrcs/)"*

Any additional attribution needs to be separately agreed and costed.

A standard 3D geological model consists of (or can be exported) as one or more of the following components:

DTM, downhole data (boreholes), geological coverages (geological map lines), geological cross-sections, fault outlines, fault planes, geological surfaces, geological volume shells, geological thickness maps (isopachyte maps)

These objects can be delivered in the following standard formats (depending Terms & Conditions):

Files

- Cross-sections (including simple legend and location map)
- Boreholes (depending on confidentiality clauses) as tab separated ASCII files, Excel or AGS format
- Geological unit extents or coverages as 2D ESRI shape files
- Geological sections and boreholes as 3D ESRI shape files
- Geological sections as maps/plans (jpeg, png, 2D PDF)
- Surfaces and thickness grids as ASCII or ESRI grids
- Surfaces and fault planes as triangulated meshes (GOCAD t-surf, or ASCII Indexed Triangle Mesh)
- Coverages, sections and surfaces as Bentley CAD output (dgn)
- Coverages, sections and surfaces in Autodesk CAD format (dxf, dwg)
- Sections and boreholes as Google .kml files

Viewers/Editors

- All objects in 3D PDF format (**note limitation to Windows**)
- DTM, boreholes, coverages, sections, surfaces and shells (for structurally non-complex models) in *LithoFrame Viewer*
- Faulted model surfaces in *GeoCando* or *Geoscience Analyst* model viewer (not yet deployed in serious projects)
- Boreholes, sections and coverages in *Groundhog Desktop* compatible .xml (view and edit)

Bespoke outputs (thematic maps, bespoke software formats) can be generated at an additional cost, **if** tested beforehand. The client will be responsible for providing full specifications of any specialised/bespoke formats, or bearing the cost of BGS investigation into the format. Any edits to the specification supplied during the course of the project will incur an additional cost.

Schematic outputs, cartographically enhanced sections and 3D cartoons that require specialist cartographic/design staff need to be agreed with the client and costed appropriately.

5 Uncertainty Assessment and reporting

"The standard uncertainty layer is the display of location of all input data and section location."

"Each model is accompanied by a BGS standard Model Metadata report (example here http://nora.nerc.ac.uk/512705/1/OR15035.pdf)" containing the following categories:

- Modelled volume, purpose and scale
- Modelled surfaces/volumes
- Modelled faults
- Model datasets
- Model development log
- Model workflow
- Model assumptions, geological rules and concepts
- Model limitations
- Model images

Any additional reporting must be costed separately.

6 Model and data ownership and management

Usually BGS (NERC) retains all IPR on any background and foreground data, which means we reserve the right to incorporate the data and model into the National Geoscience Data Centre and the National Geological Model.

Any **client derived** data and models (in particular boreholes and DTMs) should by default be deposited in the NGDC and should therefore be cleared from any IPR issues. Clarification on this must be sought from the client and a period of confidentiality might be negotiated.

7 Appendix 1

The use of borehole data in 3D geological modelling or in geological assessments that involve the interpretation of borehole record information.

Key message: Project leaders should review the information below to ensure they are using the correct borehole data (open access/confidential) before commencing any 3D geological modelling projects.

1. There is an increasing emphasis and need for the data underpinning 3D geological models to be openly available. Such openness is required for model users to appreciate the data density used to build the model, to evaluate the uncertainty of geological interpretations and ultimately have confidence in our scientific output. For these reasons, careful consideration of the confidentiality of the borehole data is essential, which is the topic of this notice.
2. The confidentiality status or rating of a borehole record is indicated by the confidentiality codes 1 to 6. These are defined in table below and the usage restrictions are clearly stated. Please note that breaches could open BGS to legal proceedings.

Table 1 Confidentiality codes for borehole data

Code	Description	Example reasons for confidentiality restriction	Use restrictions	Database objects
1	No conditions apply (non-confidential)	Open data	No restrictions	QL_BOREHOLE_OPEN_ACCESS
2	Protect – management (conditions apply)	Applies where data can be non-confidential but there are restrictions or conditions on its release. These restrictions include not being permitted to supply the data	Use if other data is unavailable	QL_BOREHOLE_SEMICLOSED_ACCESS
3	Position of bore and name of owner may be given	Contractors wish to retain control of information/do not want the public to use their data without permission.	Use if other data is unavailable	QL_BOREHOLE_OPEN_ACCESS
4	Existence of bore within an area and owners name may be given **Not shown on the GeoIndex	Sensitive locations, e.g. power stations or mineral exploration sites	Do not use	QL_BOREHOLE_CLOSED_ACCESS
5	BGS will consult owners before any information is given **Not shown on the GeoIndex	Information is not allowed into the public domain e.g. Provision of information may facilitate a breach of security	Do not use	QL_BOREHOLE_CLOSED_ACCESS
6	Records contain flag to highlight that confidentiality is unknown, not entered or not applicable	In this case we are unsure about the rights of these records	Do not use	QL_BOREHOLE_UNKNOWN_ACCESS

3. Opportunities **may** exist for some of the confidential borehole data to be revisited and made openly available after discussions with the original data donator/owner. If during the course of your modelling work you feel there are significant numbers of confidential boreholes that would critically aid your modelling please highlight these to Records Management (Rod Bowie) who will establish if these records can be re-graded and therefore appear in the code 1 objects for open use.
4. A statistical analysis of borehole data and model surfaces (Dearden et al. 2013) demonstrates that it is not possible to reverse-engineer data contained in a confidential borehole records by interrogating a 3D geological model (e.g. by creating a 'virtual' borehole log output on the same site as a confidential borehole shown in the online GeoIndex).
5. To convey to the user or customer that borehole record data does not contribute to the geological model surfaces directly, text should accompany all models stating that **borehole records have been**

'considered' in the production of the model, rather than 'used'. The term 'considered' implies that the model user cannot reproduce the borehole record.

6. Currently confidentiality is defined at the borehole level so a confidential borehole may have one or more borehole logs (within Borehole Geology) associated with that borehole, these will also be considered confidential. No confidential borehole geology logs should be released externally.

Recommendations

Recommendations for system developers:

Use database objects as identified in Table 1 (which will be automatically kept up to date) when building queries to access borehole logs for modelling. Using these objects will ensure that results carry a definitive corporate confidentiality status. Recommendations for geologists:

- Use non-confidential boreholes (code 1) in preference to partially confidential boreholes (code 3) if possible.
- For boreholes coded 2, 4, 5 and 6, if confidentiality restrictions cannot be lowered (or established), do not use them.
- If you use bespoke access systems to obtain borehole data, please be aware of the confidentiality codes you should use in your queries to extract data for your modelling work.

Recommendations for data / model delivery:

- When delivering 3D geological models state that borehole records have been **considered** in the production of the model, rather than **used**.
- Delivering data from Borehole Geology database

Records in Borehole Geology linked to a Borehole with a confidentiality code of 1 can be released. All others (codes 2-6) must not be released.

- Delivering geological models via the web (Groundhog)

When preparing 3D models for release via the web (Groundhog), the geographic locations of boreholes with confidentiality codes 1 and 3 can be released. The locations, or details of boreholes with confidentiality codes 2, 4, 5 and 6, should not be released.

- Delivering geological models as surfaces

A geological model surface can be delivered with the geographic locations of code 1, 2 and 3 boreholes that were considered in the construction of that surface. It is likely that not all boreholes considered in the modelling will penetrate the surface in question; only those boreholes that penetrate the surface should be shown. The locations, or details of boreholes with confidentiality codes 4 and 5, should not be released.

- Delivering geological models in 3D viewers

When preparing 3D geological models in a viewer, non-confidential records (code 1) can be incorporated as geology-attributed borehole sticks. Confidential borehole (code 3) records must be 'empty' and not show the geological interface depths. They must penetrate the entire model so that the basal depth is not released. Accompanying text should explain this situation. The locations, or details of boreholes with confidentiality codes 2, 4, 5 and 6, should not be released.

DEARDEN R, BOWIE R, KESSLER H, Terrington R, Shelley C, Thorpe S. 2013. 3D data products: delivery of information relating to confidential borehole records. British Geological Survey, Internal Report, CR/13/127. 41pp