SPECIFICATIONS FOR 3D MODELS SUBMITTED TO GSWA

by
RE Murdie and MD Lindsay

Government of **Western Australia**
Department of **Mines and Petroleum**

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Perth 2017

Geological Survey of
Western Australia

Grid references in this publication refer to the Geocentric Datum of Australia 1994 (GDA94). Locations mentioned in the text are referenced using Map Grid Australia (MGA) coordinates, Zone 50. All locations are quoted to at least the nearest 100 m.

Cover image: Elongate salt lake on the Yilgarn Craton — part of the Moore–Monger paleovalley — here viewed from the top of Wownaminya Hill, 20 km southeast of Yalgoo, Murchison Goldfields. Photograph taken by I Zibra for the Geological Survey of Western Australia

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Abstract

This document presents the minimum standards of 3D models that are accepted by GSWA as part of obligatory reporting arising under the *Mining Act 1978*, as part of research project deliverables and to provide instructions for archiving. The models will subsequently either be published on the GSWA website or be hosted in GSWA archives. The acceptable range of file formats and platforms are provided, and standards for metadata and explanatory text are detailed. Conventions are presented for handling geophysical data and imagery. Submission forms and example documents are included as appendices. As digital technology is rapidly evolving, this is a living document and is correct at the time of publication. It will be updated as changes occur.

KEYWORDS: archives, geological models, specifications, standards

Introduction

The Geological Survey of Western Australia (GSWA) is the archive custodian of various types of geoscientific data. These data are collected during exploration for, and production of, mineral and energy resources, and are submitted as part of the *Mining Act 1978* and *Petroleum and Geothermal Energy Resources Act 1967*. GSWA also conducts mapping, geochronology and geophysical surveys as part of its remit to provide pre-competitive data in order to encourage continued exploration and development of resources within the State. As part of the provision of pre-competitive data, GSWA has started receiving and producing 3D models or visualizations of geological regions, and has made them available to the public through the Department of Mines and Petroleum's (DMP) website and other digital media.

Due to reporting obligations on mining tenements, 3D models of geology and resources are already being submitted to GSWA and incorporated into the WAMEX database. The intention of GSWA is to establish an archive of 3D models of Western Australia generated either through research or industry. Where applicable, it will also be a portal by which the public can access these models.

This document sets out the basic requirements for submission of such models for archiving to GSWA. It should be noted that aspects such as software programs and platforms will be updated on a regular basis. Persons wishing to submit a model should check via email the current requirements for geology and resource models for submission to WAMEX (wamex.enquiries@dmp.wa.gov.au), for petroleum-related models to WAPIMS (petdata@dmp.wa.gov.au) and for regional structural models with the 3D geoscientist (3D.geoscience@dmp.wa.gov.au). These information lines will provide details about the current platform or version of software and file types.

Types of 3D models and background

Mineral exploration models

Models submitted to WAMEX by mining and exploration companies as part of their reporting obligations should follow the minimum guidelines as set out in the Guidelines for Mineral Exploration Reports on Mining Tenements. The guidelines can be downloaded from the DMP website at <www.dmp.wa.gov.au/WAMEX>. These guidelines are briefly outlined in the next section. The models, which are originally confidential, may be made open file after five years as per Regulation 96 of the Mining Regulations 1981, commonly referred to as the sunset clause. Models submitted as part of a surrender will be made available three months after submission.

Petroleum exploration models

At the time of writing, there is no requirement for companies to submit 3D models under petroleum reporting obligations. However, if companies wish to do so, they should follow the instructions for regional-scale models below.

Regional-scale models

Geological models generated as part of a collaborative project with GSWA or any other non-confidential project may be submitted to GSWA for archiving. This refers mainly to regional 3D geological models consisting of geological surfaces or volumes and with additional supporting data such as sections of various types, drillholes, geophysical or remotely sensed data, or inverted physical property voxels. It does not include results of forward modelling of individual geophysical anomalies.

Non-confidential models may be published through the GSWA 3D Geomodel digital package series and made available online through the Data and Software Centre at <www.dmp.wa.gov.au/datacentre>. The specific choice of product would be decided on a case-by-case basis by agreement between the author of the model and a GSWA 3D geoscientist. Authors wishing to submit models for archiving should follow the same criteria listed below.

Confidential models are also welcome. However, these would only be made available to the public under Regulation 96 of the Mining Regulations 1981. It follows the same principles as geological or geophysical data submitted under the reporting policy of the *Mining Act 1978*.

Public access

For models available to the public, the area covered by the model will be indicated on an index of surveys on the interactive GSWA Geospatial Information System GeoVIEW.WA at <www.dmp.wa.gov.au/geoview>.

Open-file models submitted as part of obligatory mineral exploration reporting can be searched for and downloaded at <www.dmp.wa.gov.au/WAMEX>. These models will only be available in the format in which they were submitted. GSWA does not verify the content of these models.

Regional-scale models will be accessible for download through the Data and Software Centre at <www.dmp. wa.gov.au/datacentre>. The models will be available in these formats: 3D PDF, SKUA-GOCAD project, Petrel project or a Geoscience ANALYST file. They are also available on a USB available from the DMP eBookshop (www.dmp.wa.gov.au/ebookshop). A short description and name of the author of the model will be provided.

Confidential models will not be visible or searchable within GeoVIEW.WA.

Software platforms

All models that are submitted to GSWA should be contained within one of the software packages currently in use at GSWA. These will be common platforms which can read many data formats. Acceptable platforms for the submission of models that are available for public download are given in Appendix A. These platforms may change as software develops, but every attempt will be made to ensure that the files are readable by most users.

Instructions for model submission

Mineral exploration models

All modelling files must be provided for all 3D modelling carried out and submitted as part of reporting obligations. These files may include, but are not limited to, geological, geophysical and resource/reserve models. Mine planning and financial modelling (including financial assumptions) are not required. 3D PDF models alone are not acceptable.

The following information is required:

1. A completed metadata submission form

2. Sufficient files required to redraw the models (i.e. having the ability to redraw the final resultant model, rather than manually regenerating the model)

3. Observations and images (georeferenced to the GDA94 datum with MGA coordinates or latitude/longitude)

4. A description of the fields in the model file and any coding used

5. Associated documentation (e.g. consultants' reports)

6. For estimates of mineral resources and reserves, all mineralization and/or geological surfaces that were used to control or constrain the 3D model (topographic surfaces, geological surfaces and/or solids in 3D DXF format).

Regional-scale models

All models should be complete and explained. Models submitted for publication should be presented as close to publication standard as possible. The instructions below should enable the author of the model to achieve this. Authors of models that are not to be published should use these guidelines as an indication of the quality expected of a submitted model.

Models must be located and built within a single UTM zone. However, it is anticipated that larger models requiring the use of spherical coordinates can be accommodated in the near future.

All models should be submitted with the following components:

1. Submission form

Each model needs to be accompanied by a submission form that contains all the basic details of the model, the authors and the construction methods and platform (Appendix B). The submission form should be emailed to <3D.geoscience@dmp.wa.gov.au>. The actual delivery of the model can then be discussed with the authors.

2. Model file in its original format

Models generated in a platform other than the platforms listed in Appendix A should be submitted in their original format. If there are problems encountered in file conversion, the original model can be referenced. Such reference models will not be made available on the DMP website, but it may be possible for the public to request them in their native format.

3. Original and derived objects

Raw, unprocessed data is not required; however, the original input data that went into building the model (e.g. seismic, geophysical, geological, remote sensing, drillhole) is required (Appendix D). The original input data should either be in a format which can be imported into one of the packages listed in Appendix A or as text (preferably ASCII) files. In the case of very large datasets or data that has already been submitted to WAPIMS or WAMEX (e.g. seismic data), it may be more practical to provide a reference number to the surveys and processing version used.

Objects that have been derived during the course of model building, such as surfaces/horizons and voxels, should be supplied as individual files in ASCII or DXF format.

All objects within the model file and their attributes (e.g. geological surfaces, inversion results, uncertainty analysis) should follow the naming conventions specified below. If there are many objects of a similar type, they should be named so that they organize into a logical order.

If the origin of the objects is complicated, a separate explanatory document should be written.

All objects should be included and deposited using the directory structure in Appendix D.

All data, including images, should be georeferenced to the Map Grid of Australia (MGA) GDA94 datum.

Drillholes

Drillholes should be supplied with a collar file, survey file and depth information such as geological logs, assays, hyperspectral logs, and other downhole measurements. All files should be supplied as .las or text files.

Geophysical data

Geophysical data grids should be supplied either as an .ers (ER mapper file) or .grd (Geosoft file) with accompanying header and projection files. The original data point or flight line data is not required although basic gridded data is required such as Bouguer/Free Air Anomaly, total magnetic intensity (TMI) plus any additional filtered or further processed grids. Details of the processing completed on the grids should be supplied in the metadata table. If new data has been collected specifically for the generation of the model, data should be submitted to GSWA or the Geophysical Archive Data Delivery System GADDS hosted by Geoscience Australia if not already submitted under obligatory reporting commitments. Forward models can be supplied as 2D section images or 3D objects.

Seismic data

Seismic data are acceptable in one of the following formats:

1. Processed, stacked or migrated SEG-Y data; navigation should be either embedded within the SEG-Y file or provided as a separate ASCII file (UKOOA format). Interpretation such as horizons and faults should be included along with the original seismic data

2. Imagery files (e.g. TIFF, BMP, PNG, JPEG formats); images should be georeferenced and supplied as both uninterpreted and, if relevant, interpreted sections.

Other geophysical data

Other geophysical data such as (aerial) electromagnetic (A)EM, or magnetotelluric (MT) should be supplied as processed data, ASCII, or in a format which can be imported into the platforms described in Appendix A.

Geological data

Geological field measurements should be supplied as an ASCII file including location, feature, lithology, strike and dip/plunge measurements.

Inversions

If inversion products are displayed in the model, a grid of observed, calculated and residual data should be included. If possible, the results on the inversion in the form of a voxet, s-grid or ASCII should be included. Details of parameters used and methodology should be included in the metadata table.

Images

Where possible, images (e.g. TIFF/GEOTIFF, BMP, PNG, JPEG formats) should be supplied at high resolution (minimum 300 dpi) and should be georeferenced to their true location within the model. All header and projection files (depending on the format) should be supplied and the coordinates of the image should be documented in the metadata.

Block models

Models can be presented as surfaces, enclosed surfaces (surrounding a volume), voxets or ASCII. Voxets should have an accompanying classification scheme which identifies the pixels. Classification of objects such as lithologies should be listed in chronological order using the number scheme '01_name' (see naming conventions below).

Digital terrain models

Digital terrain models (DTM) should be supplied in grid format or as a surface. A TIN file is also acceptable.

Geospatial vector files

Geospatial vector files such as geological boundaries or areas, fault traces, tenement boundaries, point data, and road networks can be supplied as:

• ESRI shape files and related files or geodatabase

• MapInfo TAB files.

Naming of files and objects

Original data files should be named in a manner which is understandable to a person with no background in the area. Names should contain minimal abbreviations and need not be constrained to any particular length although shorter names are easier to understand.

Each object within the project needs to be assigned a name. Object names should be given a geologically or project relevant label. For objects originating from outside the model, the object name should be relatable to the original data file. Or, if it is an object generated within the project, it should be named in an easily understood manner. If there are many items of a similar type, they should be named in a logical order, e.g. in the case of geological surfaces, in chronological order. This can be done by prefixing an identifier and number, e.g. Fault01_Ida_fault, Fault02_Subsidiary_Fault. If the object is a surface, the label should reflect what part of the geological unit it represents, e.g. 'Surface02_Gooragoora_Formation_base' for a surface representing the base of the Gooragoora Formation. Similarly 'Surface02_Gooragoora_Formation_top' should be used for a surface representing the top. Lithological descriptors are acceptable when stratigraphic descriptors are not available, e.g. a surface for the base of a gabbroic unit 'gabbro_base'. Note that many platforms do not allow characters such as a space in the name.

Different items pertaining to the same feature should carry the same identifying name, e.g. well markers, seismic picks, surfaces, and volumes of the same geological feature.

Where GSWA regularly uses a certain type of object such as geological units or structures, GSWA naming schemes should be followed where appropriate. For geological units, names should be the same as found in the Explanatory Notes System (www.dmp.gov.wa.au/ens). When a number of smaller items have had to be combined into a combined item, the name of the largest item should be used. The details of what items have been combined to make this object should be noted in the metadata. Where this is inappropriate, a suitable, easily understood name should be used. Geological codes, as per ENS, are useful but not obligatory.

Where appropriate, colour schemes similar to those used by GSWA should be used.

4. Table of metadata

The data supplied in the submission form will be the basis of the metadata and be used in the database that stores the model.

In Geographic Information Systems (GIS), data dictionaries are used to record the names of all items in the project, together with a description of their attribute values. Also within the supplied viewer each object is attributed with a short written explanation. The information for these fields is extracted from the submitted metadata. The metadata table should be set out as per Appendix B. It may be produced as a text or a spreadsheet.

Metadata should be concise. If it appears the table would not be sufficient to explain the model, the author should consider including a full explanatory document.

A full reference list should be included within the metadata table for published reference material.

5. A model within a specified platform

The whole model should be contained within one of the platforms as specified in Appendix A. These platforms are capable of importing a wide range of formats and it should be straightforward to reproduce a model built on most common platforms in these environments. Where possible, models for publication will be uploaded by GSWA into a free 3D viewer. However, users will also be able to download the project files for the specified platforms and constituent objects.

All objects within their projects and properties should be named in a manner which is understandable without the need to reference metadata. Examples of naming conventions are given below, but this is not prescriptive.

If the specified platforms are not available to the author of the model, please contact the GSWA 3D geoscientist in order to discuss the submission of the model in other formats.

6. Supporting documentation

Supporting documentation should be included, if necessary. GSWA publications written in conjunction with the model will automatically be included for distribution within the digital package. Non-GSWA non-confidential open-source material can also be added for distribution; however, this does not cover publications that are already in the public domain. These can be referred to within the digital package via a hyperlink.

Submission procedure

Models submitted as part of mineral exploration reporting on mining tenements should be submitted with the rest of the annual report as per the usual submission procedure.

Other models submitted either for publication to the public or confidential archiving should be preceded by a model submission form sent to <3D.geoscience@dmp.wa.gov.au>. Instructions for uploading the model to the GSWA server will then be sent to the submitter of the model.

Examples

Examples of models already published can be found on the Data and Software Centre at <www.dmp.wa.gov.au/Datacentre> under 'Statewide spatial datasets ► 3D geology'.

Appendix A

Current software packages

GSWA currently uses the following formats for viewing and distributing 3D models. This list will be updated as technology progresses.

SKUA-GOCAD by Paradigm is a modelling platform used by mining and petroleum companies to model subsurface regions and predict outcomes based on physical properties. GSWA has licences for the Mining Suite plug-in by Mira Geoscience which allows the import of many additional data formats commonly used within the geological and mining community. More information can be found at the Paradigm website at <www.pdgm.com> or at the Mira Geoscience website at <www.mirageoscience.com>.

Petrel E&P Software Platform by Schlumberger is commonly used in the petroleum industry from initial exploration to full production of oilfields. It includes seismic interpretation through various workflows including fracture, facies and geocellular property modelling to production simulation. More information can be found on the Petrel website at <www.software.slb.com/products/petrel>.

Geoscience ANAYLST is a free viewer available from the Mira Geoscience website at <www.mirageoscience.com>. Where possible, models will be available for viewing via an .iws file. This will enable those users without SKUA-GOCAD or Petrel to view the models.

3D PDF files will also be made available for basic viewing of the models. However, there are many limitations with what can be displayed in these files. Display parameters are limited so that models displayed here may not accurately represent the model as the author intended.

Text files of as many of the objects as possible will also be made available as ASCII files.

Appendix B

Metadata required for submission of models

AUTHOR INFORMATION

Author/s_____

_____

_____

Affiliations_____

_____

_____

Contact details (lead

author)_____

_____

GSWA documentation (if

relevant)_____

_____

Name of metadata file_____

Date model completed_____

Print name of lead author/submitter_____ _____

Signature of lead author/submitter_____

Date of submission_____

PLATFORM INFORMATION

Platform the model was built in including version number_____

Name of folder_____

Platform the model is submitted in including version number_____

Name of folder_____

PROJECT DETAILS

Name of project area or model	
Is it for publication on GSWA website ☐	Or for archive only ☐
Location GDA94 datum with MGA coordinates ☐ UTM zone_____ or latitude/longitude ☐ Height datum used_____ Coordinates of origin of model X_____ Y_____ Z_____	Local grid transformation used Y ☐ N ☐ Details of transformation _____ _____ _____ _____ _____ _____ _____ _____ _____
Spatial units Units of X and Y: m ☐ km ☐ degrees ☐ Units of Z: m ☐ (m)sec ☐ Direction of Z: positive up ☐ down ☐	
Cell size (if applicable) Parent cell size X, Y_____ Z_____	Minimum cell size X, Y_____ Z _____
Model extents Number of cells X _____ Y _____ Z _____	Or Extent of model X _____ Y _____ Z_____

Appendix C

Table of metadata to accompany a model

Abstract

Group name		
Object name	Description	Reference/Origin

Reference list

Appendix D

Directory structure for original and derived objects

This list is not exhaustive and may be added to as appropriate.

3D_DATA	Directory containing subdirectories ASCII, PETREL or GOCAD
3D_DATA*PLATFORM*\\	Subdirectory containing files in a certain format such as: ASCII GOCAD PETREL
3D_DATA*PLATFORM*\\OBJECT TYPE	Subdirectory within a particular platform containing subsubdirectories of data stored in a certain format such as: POINTSSET CURVES SURFACE VOXET
3D_DATA*PLATFORM*\\POINTSSET	Subdirectory containing subsubdirectories containing data stored as points. May contain subdirectories such as: INVERSION RESULTS SEISMIC_REFLECTION_CDP GEOLOGICAL OBSERVATIONS
3D_DATA*PLATFORM*\\CURVES	Subdirectory containing subsubdirectories for data stored as linear features. May contain subdirectories such as: GEOLOGICAL BOUNDARIES STRUCTURES ROADS
3D_DATA*PLATFORM*\\SURFACE	Subdirectory containing subsubdirectories for data stored as surface features. May contain subdirectories such as: LOWER_BOUNDING_SURFACES RELIEF STRUCTURE_SURFACES VOLUME_SURFACES SURFACE GEOLOGY FAULTS
3D_DATA*PLATFORM*\\VOXET	Subdirectory containing subsubdirectories for data stored as voxet features. May contain subdirectories such as: GRAVITY/MAGNETIC GRID INVERSION RESULTS BLOCK MODEL
3D_DATA*PLATFORM*\\DRILLHOLES	Subdirectory containing subsubdirectories for data stored as drillhole or well features. May contain subdirectories such as: SURVEY COLLAR LOCATION ASSAY GEOLOGY
3D_DATA*PLATFORM*\\IMAGES	Subdirectory containing subsubdirectories for data stored as images. These must be georectified within the project

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