

COST Short Term Scientific Mission (STSM) TU1206-17436

GOCAD® WORKSHOP

STSM Report to COST MC Chair

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1. Rationale

Urban geology is becoming increasingly important and it is vital that the subsurface is well known to provide sufficient information to help in any issues that could arise in urban areas.

Geological Survey of Slovenia (GeoZS) has a long history of collecting geological data. But the potential of gathered data is far from being used. One of the important reasons for that is a low capability in upgrading data into information customised to the user (stakeholder) needs. There is a strong need for tools creating, exporting and visualizing the 3D geological models which could be further used as a geometric base for numerical 4D (e.g. groundwater flow) simulations. The area of our interest in this COST action - the city of Ljubljana is characterised as tectonic depression, formed by tectonic subsidence and gradual filling by alluvial and lacustrine sediments. It is a complex geological situation and to maximise the use of geological information for city needs advanced procedures and tools are required.

GOCAD® software enables subsurface modelling for geological, geophysical and reservoir management purposes. It has been used by British Geological Survey (BGS) for the past decade for the construction of 3D geological models and as a data integration and visualisation platform. Exchange of knowledge and experiences on using the software would contribute to better use of geological data in urban planning procedures.

2. Objectives

The main objectives of the STSM were to:

- Gain expertise in GOCAD®
- Identify and develop best practice guidance to construct 3D models of the subsurface in urban areas, depending on the data available
- Explore the different options of exporting models in a way that the end user can interrogate them

3. Work carried out within the STSM

The STSM involved a five day visit of the STSM applicants Beatriz Mozo (Geological Survey of Ireland), and Mitja Janža (GeoZS) to the British Geological Survey in Edinburgh. The workshop was led by Mike McCormack (BGS).

Timescale:

- Monday 31st of March and Tuesday 1st of April
 - The basic setup and operational overview of the GOCAD[®] modelling application.
 - GOCAD[®] data/object types, input/output file formats and geological feature ‘housekeeping’
 - Structure, properties and applicability of different types of 3D models
 - Gathering and preparation of typical data sets for input to the 3D modelling process.
 - Best practice methodologies for 3D model creation, using both manual (menu driven) and semi-automated GOCAD[®] ‘Structural Workflow’ utilities
 - Editing tools, model refinement, model merging and quality control protocols

- Wednesday 2nd of April and Thursday 3rd of April
 - Creation of the different types of geo-cellular 3D grids and population with petrophysical properties
 - Property manipulation with the GOCAD[®] calculator and region editor utilities
 - Geometric and stochastic property modelling; Volumetric
 - Integration of wells and well logs
 - Modelling complex folded/thrust terrains and intrusive bodies
 - Presenting 3D models to the outside world; the big problem!

- Thursday 3rd of April and Friday 4th of April
 - Working through recently created models relevant to the attendees’ current or intended project work; especially the Glasgow (Clyde Catchment) Quaternary and faulted bedrock models and offshore reservoir models.

3. 1. Overview of the GOCAD[®] modelling application

The GOCAD[®] software was developed by the Gocad Research Group during the 90's, as an integration of all research led since the inception of the project.¹ The Gocad Research Group is a team of researchers at the frontier of geology, geostatistics, computer science, reservoir engineering and geophysics, hosted by Georessources and the School of Geology at Nancy Université.¹

3. 2. Data model

To store spatial data and geobjects in a computer, a discrete data model is required. A discrete model stores the topological information and the geometry, constraints and properties. In Gocad, following models are used²:

PointsSet is the basic model object, which is composed of a set of points possessing properties such as geometry (XYZ coordinates) and arbitrary vectorial properties.

Curves are nodes which are connected by linear segments. Each node has two or one (in the case of an extremity) neighbour nodes. Curve objects can be composed of a set of isolated curve parts.

Triangulated surfaces are most important for modelling geological boundary surfaces. Planar triangles are interpolated between a set of connected nodes. A surface object is composed of a set of isolated parts. Parts possess topological features like border (boundary) and borderstones.

A sealed Model3d (BRep model) or a SGrid that is composed of voxels can be built from a set of intersecting surface parts. The geometrical and property information of surfaces is stored at the points.

Solids are composed of connected tetrahedra. A volume region which represents a geobject can be discretized using solids, which allows to model properties in 3d volumes.

3. 3. General features

The work in GOCAD[®] is stored in projects. Each project consists of a project file and a project folder. When starting work all units of measure and orientation in the project have to be defined. GOCAD[®] works with a cartesian and metric coordinate system.

The GOCAD[®] interface is divided into following areas²:

1. Main Menu Bar - data load and save, general settings, general data management, data analysis applications, help access.
 - 1a. Commands - used for object creation; topology, geometry and property editing, interpolation and computations. Upon start-up, the bar appears in General Mode, which can be changed to particular object modes (Surface Mode etc.) with respective functionality.
2. Tabs - Predefined tabs like object browsers, data tables, view windows. Arrange your data in the manner that best suits your needs.
3. Camera settings toolbar- Here you can setup the camera position, AutoSetup will direct the camera towards all selected objects (fig. b). The dialog at the very right (default value: "1") allows to scale the Z axis for vertical exaggeration.
 - 3a. Digitization Selection Bar

4. Object panel - contains the objects and data browsers from which you can access all your modelling objects, many commands for visualisation, organizing your objects and property analysis.
5. Viewer workspace/ 3D camera - shows the objects selected in the object panel in a cartesian coordinate system; left mouse button for spin, right mouse button for zoom. If the Camera Control Panel is activated using the Panel Selection Panel (5), camera settings can be changed like the increment of spin/pan/zoom actions carried out using the arrow keys (pan), numerical keys 2,4,6,8 (orbit) or numerical keys 2,4,6,8 and „+“ (zoom) of your keyboard. Selected objects can also be filtered according to many criteria.
6. Coordinates and information - Tracks the pointer in the view and displays the tracked coordinates and properties.
7. Quick attribute toolbar - depending on the currently highlighted objects in the Object Panel (6), the bar dynamically changes (fig. c) and allows to set the graphical object attributes. General hint: Many command actions correspond to standards: drag & drop, multiple selection of objects in the camera or dialogs: control or shift key, undo: control-z, save: control-s, repeat a command: space key.
8. Status toolbar - contains information about carrying out commands.
9. Terminal (not shown)

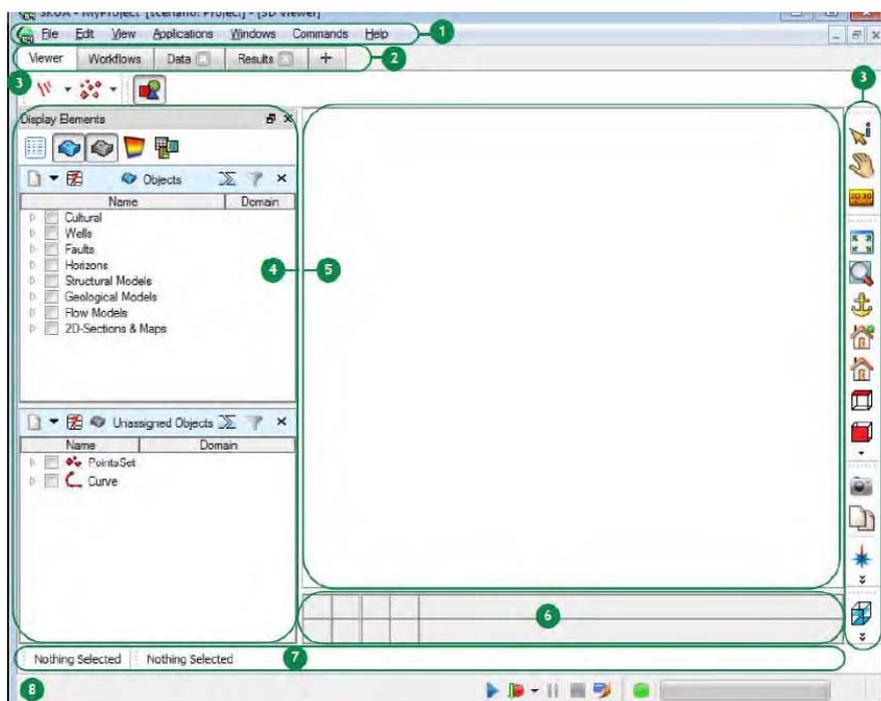


Figure 1: GOCAD® User Interface, find the names of the toolbars in the text below².

3. 4. Input/output file formats

GOCAD® enables import of different data types (txt, shp). Shape files are one of the most commonly used. The procedure for import shape files²:

Main menu – file - import objects - cultural data - ArcView shape

Example of importing georeferenced pixel images²:

File - Import Objects - Images - Georeferenced images - GeoTIFF Image

Procedure to import to import a cross sections in TIF format and locate it along the profile line profil.pl.²:

File - Import Objects - Images - As 2d Voxet "profil.tif"

File - Load object - profil.pl

3. 5. Workflows

Workflows are semi-automatic routines allowing to build consistent models with pre-defined steps. It assures that data is consistent with the demands of the workflow, this way of model building is comfortable and time-saving. The workflows are administrated in the task panel workflow menus.²

3. 6. Integration of wells and well logs

Wells are often stored in relational data bases. Some generic ASCII formats for well import including well path, markers and logs can be imported to GOCAD®, and also standard formats like WITSML and OpenSpirit. In the Gocad Suite, the depth information of a well is stored in the properties: Z and Zm: Z is the True Vertical Depth Sub Sea (TVDSS). TVDSS is defined as the vertical distance from a point in the well to normal height null. Z can be positive or negative depending on the orientation of the project (upward: negative, or downward: positive). Zm is the Measured Depth (MD). The Measured depth is the length measured along the wellbore. Whatever the orientation of the project, Zm is always positive.²

Data files can be imported with the menu file import data. Pop-up menus offer many options for the import of various data types in various file formats. After import, the data set is transformed to a GOCAD® object and can be saved.²

3. 7. SGrids

SGrids are regular 3D grids which can be deformed and cut to fit a structural surface model. This sort of discretized volume is necessary, if we want to model the distribution of a property in a geological body². The usual way to define properties of SGrids is through PointSets which contains the properties in column.

3. 8. Stochastic modelling

The surface geology and borehole data only provide limited information about subsurface structures, therefore interpretation of geological features is related with uncertainty. GOCAD® enables use of advanced mathematical techniques for interpolation of discrete data. A case study of using stochastic modelling to incorporate heterogeneity of the subsurface below city Glasgow was presented.

3. 9. Ljubljana case study

After gaining basic skills in using Gocad software exercises with data from Ljubljana city area were made. DTM, well data and bedrock information were used for creation of 3D geological model.

4. Summary

The STSM provided opportunity to get an insight into potentials 3D geological modelling. BGS presented a good practice of the use (interpretation and presentation) of geological data. Using GOCAD® software for developing 3D geological models has numerous advantages. It is modelling framework that enables integration of borehole data, geophysical methods and site observations which maximise benefit of past investment. Transfer of data (stored in different formats) into modelling system is easily achievable. 3D visualisation of the subsurface can improve understanding of geology also in the broader public which can reduce risk and uncertainty in urban planning.

Understanding of geology is in Ljubljana of vital importance, since the main groundwater resource for drinking water supply is placed below the city. Development of groundwater models, used for water resource management, must go through a geological model. Both models are complex and require experts in each domain with very specific knowledge. Advanced 3D geological modelling can bridge the gap between the disciplines and facilitate the development of the conceptual model and assist in demonstrating the hydraulics of the aquifer system.

The STSM also facilitated knowledge exchange between BGS and GeoZS and is a solid basis for further cooperation of institutions.

5. References

- 1 <http://www.gocad.org>
- 2 TU Bergakademie Freiberg: Introduction to 3D Geomodelling with gOcad lecture materials (http://tu-freiberg.de/fakult3/gy/mageo/lehre_3d/vorlesung/script_uebung.pdf)

Ljubljana, 16th April 2014

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6. STSM Host institution approval/sign-off

Report noted with approval,



Diarmad S. Campbell

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