52N GEOLOGIC TOOLBOX:
Bringing Geologic Data Into the GIS World

White Paper

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Abstract:
The objective of the GEOLOGICTOOLBOX *is to provide software tools that bring geologic data into the GIS world. A first step provides a collection of functions to import geologic layer models and borehole information into ESRI's ArcGIS Pro environment or into 52°North's* TRITURUS *framework. The* GEOLOGICTOOLBOX *is available as an open source project embedded into the activities of the 52°North initiative. Prospectively, we would like to establish a community of geologic users and interested software developers that promotes the integration of the complementary worlds of geologic modeling and geo-spatial data fusion and analysis, which traditionally is available inside GIS solutions. This paper explains our project vision as well as the basic concepts underlying the software framework.*

Project Vision

As part of 52°North's 3-D community, we are in the process of establishing a new project – the GEOLOGICTOOLBOX! This open project will focus on bridging the gap between geologic modeling and the world of traditional GIS software.

Geographic information system (GIS) technology offers a promising means to support spatial decision making processes or to communicate geo-information to the public. This also applies to geologic application scenarios. Since 3-D functionality is currently available inside GIS environments, and platforms to access geospatial information on the Web are utilizable by almost everyone, the provision of geologic models inside 3-D GIS seems to be highly desirable.

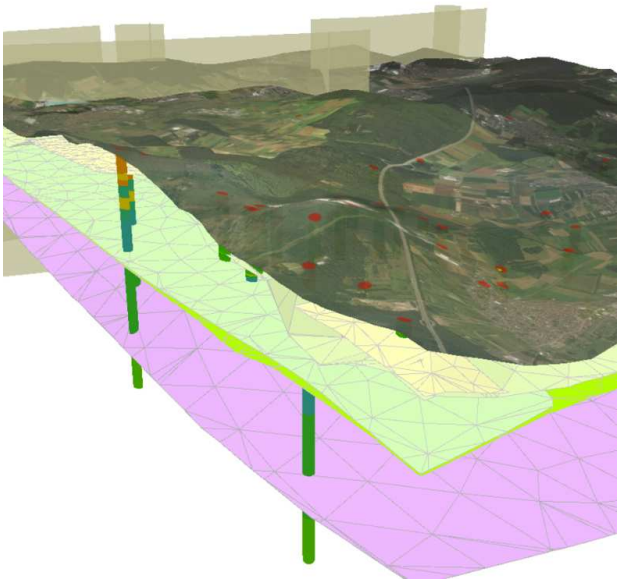
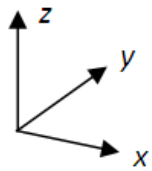


Figure:3-D subsurface model (HLNUG)

GIS environments, however, rarely support geologic modeling approaches, e.g. topologically interrelated surface layers and volumetric solids in between, or 3-D triangulations (instead of GIS-like "2.5-D" surfaces) needed to represent stratigraphic layers or discontinuities. Specific software tools, such as drillhole data import, cross-section generation, or model consistency checks (e.g. surface/surface intersection) are often missing on the GIS side.

The GEOLOGICTOOLBOX project will set up a suitable software environment to overcome the deficits mentioned above. At the same time, it opens application potentials offered by GIS technology to geologists.

The community's vision is to establish a *creative* surrounding, which allows efficient and sustainable development of innovative software solutions in the context of geologic modeling and geo-visualizations referring to spaces consisting of *three* geometrical coordinate-axes (*x, y,* and *z*). Development goals are to provide



- tools to import geologic data into GIS applications and thus to support *data-fusion* processes,
- domain-specific *analysis and exploration* tools, and
- capabilities to *publish and distribute geologic models* and resulting interactive visualizations on the Web.

We strive for compatibility with existing standards in the context of geo-object modeling and computer graphics (OGC, ISO, W3C).

Project Initialization Inside 52°North

Open source solutions available within the 52°North initiative currently focus on, among others, security issues, sensor web applications or Web Processing Services (WPS). The GEOLOGICTOOLBOX activities will be embedded in the initiative's 3-D community, which is open to anyone interested in 3-D geo-visualization applications based on open source software.

In the long run, the project's acceptance will be determined by the suitability of the concepts developed. Software contributions, as well as, test cases, user experiences etc. will be appreciated. You are very welcome to participate in the activities!

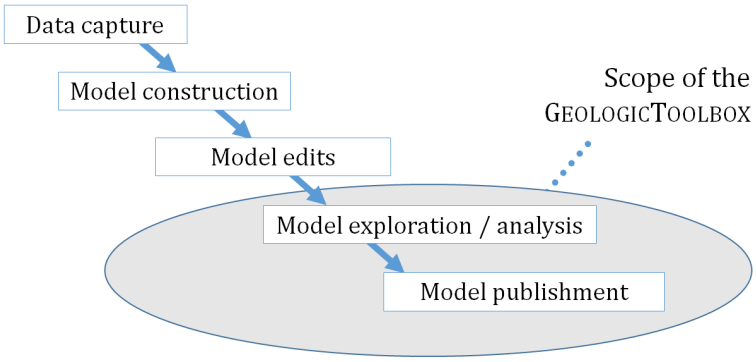
Community Organization

At present, the community is organized as follows. (Contact information is given at the end of this paper.)

- *Technical project lead:*
  Benno Schmidt, Geovisualization Lab, Bochum University of Applied Sciences
- *Project participants:*
  Holger Lipke, ESRI Germany GmbH, Münster
  Rouwen J. Lehné, Hessian Agency for Nature Conservation, Environment and Geology (HLNUG), Wiesbaden
  Johannes Ruban and Till Riemenschneider, University of Applied Sciences, Bochum

Project Objectives

The project will provide software solutions that will make geologic models available inside GIS applications [1]. The focus will be on data import into GIS applications, GIS-based model exploration and analysis, as well as model publication and distribution.



From the software engineering perspective, we envision a lightweight solution. This means that compact "stand-alone" code is preferred. Unnecessary dependencies on software artifacts which are outside the framework should be avoided.

Interoperability with other software solutions is an important issue. With regard to geo-information, the *interface specifications* of the Open Geospatial Consortium (OGC) and the International Organization for Standardization (ISO) are of high importance [3]. In the field of computer graphics (a discipline likely relevant with regard to 3-D visualization issues, e.g. image representation or real-time rendering), we should first mention the World Wide Web Consortium (W3C) and the Web3D consortium [4].

Project History and Project Roadmap

The GEOLOGICTOOLBOX project was originally initiated in 2016. Since then, ESRI Germany Münster and Bochum University of Applied Sciences carried out a number of experimental student projects dealing with this topic. The Hessian Agency for

Nature Conservation, Environment and Geology (HLNUG) has accompanied these activities right from the beginning.

At the end of 2018, we provided a first basic executable software version for ESRI's ArcGIS Pro under https://github.com/52North/GeologicToolbox. The GitHub platform serves as the technological basis to manage and distribute the underlying source code.

Innovative research in the context of GEOLOGICTOOLBOX project might include topics, such as

- the development of tools to import geologic 3-D models ("lossless") into ArcGIS Pro;
- the description of an abstract "business object model" to provide a common understanding between computer scientists, GIS practitioners, and geologists;
- volumetric solid visualizations;
- WebGL-based HTML5 renderer realization (e.g., X3DOM or others);
- integration of Web-based services (geologic data, 3-D portrayal etc.).

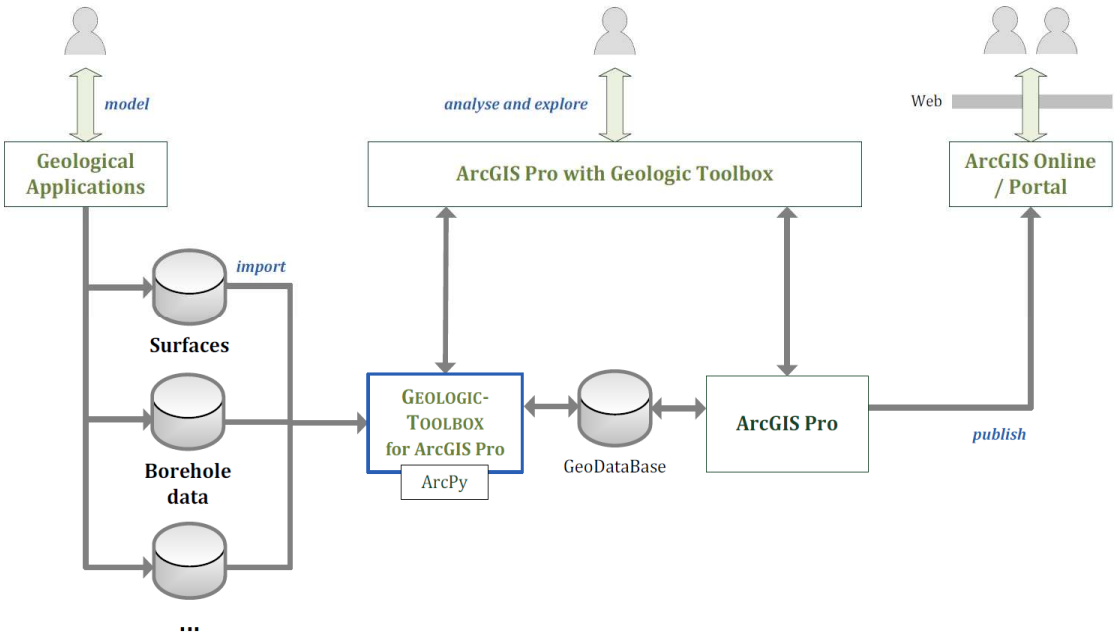
Software Components

Toolbox for ArcGIS Pro

The community has developed a first prototype implementation toolbox extension for ESRI's prominent ArcGIS Pro. We examined it with respect to its functionality for geologic purposes, as well as technical aspects, such as processing and rendering performance and software abstraction. The toolbox is available to end-users as a Python application using ESRI's ArcPy site package, which builds on the ArcGIS scripting module [5].

The prototype implementation offers promising application perspectives. Particularly promising are the option of combining geologic data with geo-information from other application areas, Web publishing options (e.g., 3-D Web scenes in ArcGIS Online/Portal), and highly-interactive data exploration facilities.

The figure below illustrates a typical GEOLOGICTOOLBOX workflow for ArcGIS Pro. Once geological data is imported from geologic modeling applications, it can be combined with geospatial data from other application domains. Optionally, the resulting workspaces can be published as interactive 3-D Web scenes for ArcGIS Online or ArcGIS portal.



The first version of the GEOLOGICTOOLBOX for ArcGIS Pro offers these tools:

- Import of GOCAD [6] TSurf data (optionally including color codes)
- Import of DUDE TIN files and borehole data in BIF2 format (specific formats of the German Ruhrkohle AG)
- Simple cross section generation
- Surface layer intersection check utility

There is, however, still a demand for specific model importers and more data exploration tools.

Toolbox for 52N TRITURUS

TRITURUS [2] is a Java-based software framework available via 52°North (http://52north.org/triturus). The software's I/O layer allows the storage of surface models as triangle meshes and the export of these meshes to various document formats such as interactive 3-D worlds (e.g., VRML/X3D scene-graphs).

Summary and Conclusion

Our vision is to establish a creative surrounding that allows the set-up of innovative 3-D GIS geologic applications.

We have explained the design philosophy and the basic concepts underlying the GEOLOGICTOOLBOX software. The application scenarios presented in this paper might be inspiring to software developers. However, there still is a lot of work to be done to complete the project's vision. You're very welcome to participate in our project activities!

References

[1] Schmidt, B., J. Ruban, H. Lipke & R. Lehné (2017): "Geologic Toolbox": Three-dimensional GIS Tools for Subsurface Model Visualization and Publishment. GeoBremen 2017, "The System Earth and its Materials - From Seafloor to Summit", Joint Meeting of DGGV and DMG, Bremen, Gemany, Sept. 24-29, 2017.
https://github.com/52North/GeologicToolbox

[2] Schmidt, B. & M. May (2011): Triturus: A Java-Based Framework for 3D Geo-Visualization Applications. White Paper, 52°North Initiative.
https://52north.org/research/rd-communities/3d/

Web Links

[3] Open Geospatial Consortium, Standards and Specifications – *http://www.opengeospatial.org/standards*

[4] Web 3D Consortium: *http://www.web3d.org/*

[5] What is ArcPy? – *http://desktop.arcgis.com/en/arcmap/latest/analyze/arcpy/what-is-arcpy-.htm*

[6] GOCAD Product Information (Paradigm): *http://www.pdgm.com/products/gocad/*

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