From 2D maps to 3D modelling: much more than " just one more dimension "

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By analogy with geological mapping, a possible definition of 3D cartography is the ability to provide a continuous description of geology at depth from scattered and heterogeneous data. Whatever the dimension is, both activities involve building a geological model which, as in any discipline calls for the use of general concepts and knowledge to produce a synthetic and abstract representation of the subsurface. This representation is inherently 3D. While in traditional mapping an important part of the geologist’s cognitive effort is devoted to mentally project into 2D space the geometries of geological structures as imagined in 3D, the advent of computers and numerical geology considerably eased and automated this task. Consequently, 3D modellers (who should also be geologists) can focus much more on the description of geological bodies, their mutual relations and modelling choices (data selection and interpretation) and rely on algorithms to produce maps and random cross-sections or 3D volume explorations which all represent a consistent set of views of the subsurface. As enjoyable as this may seem, things didn’t get easier in adding one more dimension.

The price to pay for consistency is a substantial work to integrate all available data and specify exhaustive constraints on geometries and relations without “dashed lines”. Then, the final product, the 3D geological model, realizes a coherent synthesis and structure of knowledge available on a specific site and at a specific modelling scale. In itself, it is already a valuable tool for knowledge dissemination. Moreover, its digital nature makes it a natural candidate for quantitative analysis, and as it is often poorly constrained at depth, it immediately calls for uncertainty quantification which is far from a trivial task. Thanks to the spatial discretization of geological models (meshing) it is also possible to perform various dynamic simulations of physical phenomena: seismic wave propagation, mass and energy transfer, resource assessment, water quality… This wide range of applications combined with the increasing computing capabilities already boost the demand for ever more accurate geological models and it is likely that this trend will continue with geological modelling being at the core of both scientific understanding of the subsurface and engineering needs.

Consequently, most of current National Cartographic Programs have set 3D data management and 3D geological modelling as strategic objectives. This implies continuous methodological research both with regard to the complexity of geological objects being modelled and the efficiency of the tools used which should be as geologist friendly as possible. Based on our experience in different application fields such as 3D mapping programs, tunnelling, seismic risk appraisal, geothermal resource assessment… we point out several issues in going from the routine production of 2D maps to the routine production of 3D geological models. We will illustrate the great benefits from 3D modelling with examples from case studies and will focus on the current bottlenecks and development needs.