Digital twins for the next generation of geoscience prediction and understanding: OneGeology 4.0

In the next 10 years, OneGeology will migrate its focus to the application, technology and opportunities arising from developing a multiscale suite of digital twin earth system models. These will enable the better prediction and understanding of subsurface processes and their properties, and how these influence the world around us.

Digital twins have typically been applied to human-made infrastructure and some of the clearest examples are from the aircraft turbine engineering sector, where real-time sensor data are relayed to central control facilities running models with design constraints to update operating efficiency parameters and maintenance interventions in advance of malfunction. The existence and use of an earth system digital twin could, for example, allow users to sample a volume of rock and run numerical simulations to understand the impacts of various inputs and changes to that system, such as alternative energy storage technologies or real-time model updates in directional drilling.

These digital twin models will be an ensemble of 4D geospatial data (including sensor networks, parameters and properties), models and visualisations. One of the key elements will be the cyber–physical interaction, whereby sensor perturbation monitored in the real world will ultimately be reflected within the virtual twin model in near-real time.

We believe that a realistic model of the natural environment will provide new virtual opportunities to test and improve our understanding of these systems and to model and predict their behaviours into the future.

OneGeology digital twin pilots

OneGeology is a consortium of member organisations with similar goals. Members are currently at different levels of expertise and engagement in digital twin technologies. Globally, members are also responding to different political and economic drivers in their home jurisdictions and so are interested in developing digital twin projects aligned with their own strategic objectives. At the same time, there is ample commonality and, as has been shown in the first 10 years of OneGeology, there are opportunities to share resources and learning in building platforms of excellence to deliver the next generation opportunities highlighted above.

As a first step, the OneGeology Strategic Steering Committee (OSSC) has identified a small number of platforms to be worked on jointly between interested members.
It was agreed that these pilot implementations would be presented in a session at the International Geological Congress in Delhi in March 2020, to inform the next stage of building a global geoscience digital twin platform.

The initial digital twin pilots agreed on at the OSSC in Uppsala were:

1. Crustal-scale minerals systems — jointly led by the Geological Survey of Canada and Geoscience Australia
2. Urban subsurface interactions — led by TNO-Geological Survey of the Netherlands
3. Catchment scale e.g. Amazon basin, Rhine–Meuse — jointly led by Geological Survey of Brazil (CRPM) and TNO-Geological Survey of the Netherlands
4. High-resolution energy corridors — led by the British Geological Survey (BGS)
5. Coastal hazard — led by the Geological Survey of Japan (GSJ)
6. Active volcano: Paektu Mountain, Korea — led by the Geological Survey of South Korea (KIGAM)
7. Permafrost was discussed but is not likely to be ready for this year; the Geological Survey of Canada will lead this pilot

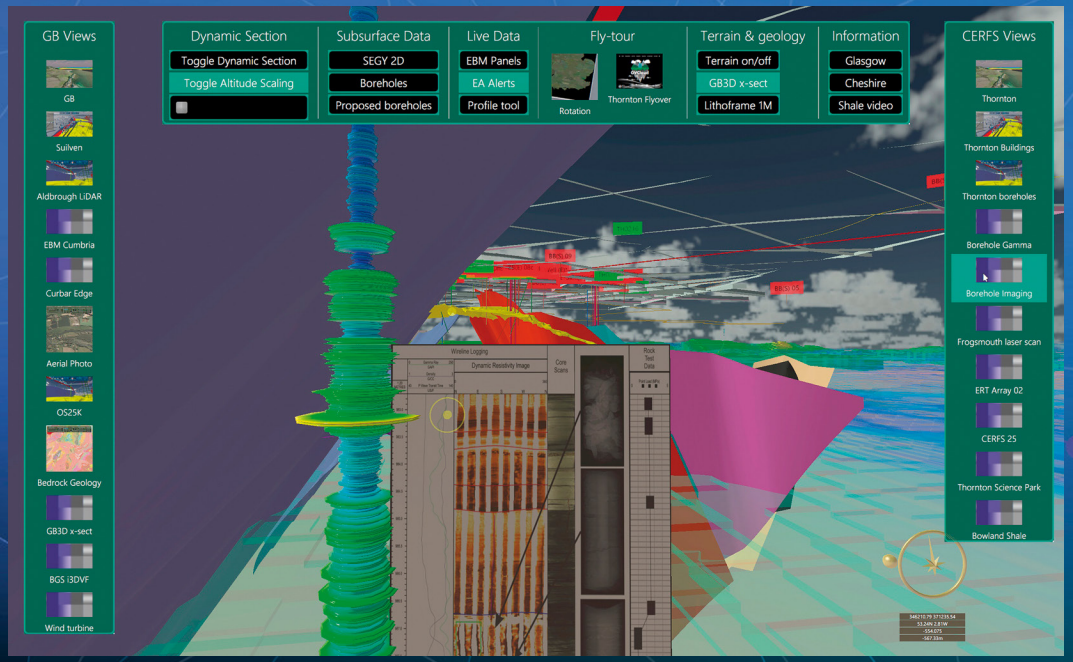
Energy corridor pilot: an illustrative example from the BGS

In 2015, the BGS developed plans for a world-first observatory that would provide unprecedented data, information and knowledge on the rocks beneath our feet. The UK Geoenergy Observatories will serve up one of the world's most comprehensive datasets on the underground environment in Cheshire in north-west England and Glasgow in Scotland. These data are being made openly available to industry, business, government, regulators and campaign groups, following FAIR ('findable, accessible, interoperable and reusable') principles and in real time wherever possible. The observatories have the scientific equipment capable of monitoring underground conditions and collecting the data needed to address the objectives set out in the geoenergy observatories' science plan.

The UK Geoenergy Observatories' digital twin ambitions

The UK Geoenergy Observatory sites include an array of boreholes of varying depth plus geophysical observatories, which will characterise a rock volume at multiple scales from 3D seismic (100–1000 m scale) down to 3D microtomographical (CT) images of core materials (micro-to nanometre scale). A network of real-time sensors measuring dynamic processes, such as rock mass properties, fluid flow and seismicity, will be installed in each borehole to carry out environmental data-monitoring tasks in real time across the rock volume.

The intention is that more than 2700 state-of-the-art sensors will be collecting a constant stream of data from the 125 boreholes. The data will be streamed back to the central data hub in Nottinghamshire and made available at www.ukgeos.ac.uk.



The team behind the creation of the UK Geoenergy Observatories digital platform are actively trying to understand the potential challenges and opportunities involved in developing underground digital twins. We want to answer questions such as:

- Who are the potential users of these services?
- What are the most important user requirements?
- How do we quality check live-streamed data that could power live updates to a digital twin service?

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