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Digital parametrised ground model in tunnelling: concept and sample application

How geology and geotechnics in tunnelling can be done with BIM

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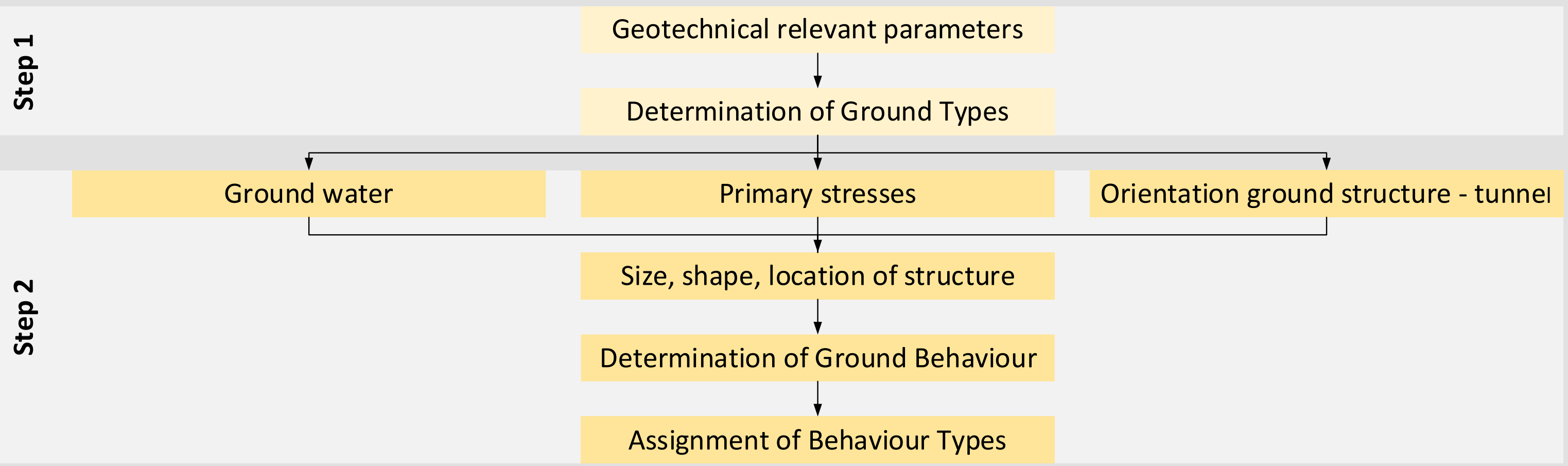
SAMPLE APPLICATION

INTRODUCTION

The renewal of the rail corridor **Köstendorf – Salzburg** is a **BIM pilot project** of the Austrian Federal Railways. From 2016 to 2021 the project was in the **environmental impact declaration** phase and developed basic methods an processes for a BIM integration. The presented **use case** is the determination and evaluation of the **to be excavated tunnel cavity** in the correct position. Geological and geotechnical design is thereby integrated in a **BIM for Tunnelling** approach based on the *Guidelines for the Geotechnical Design for Underground Structures* by the Austrian Society for Geomechanics (**Figure 1**).



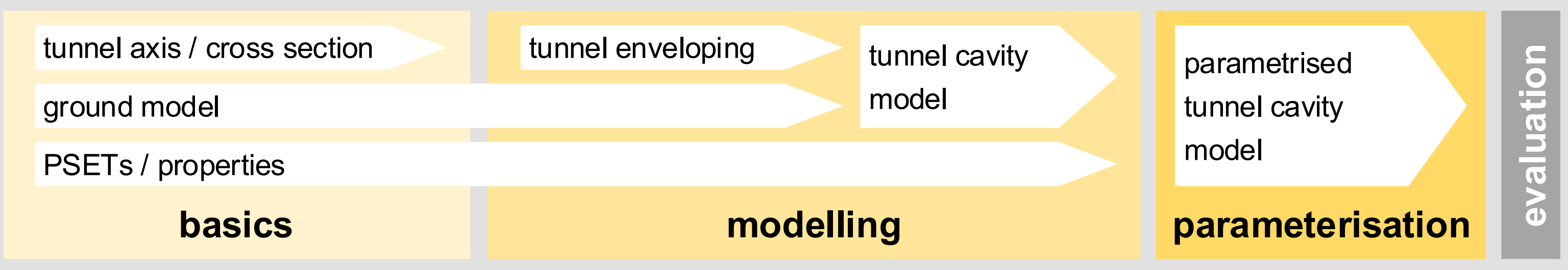
Step 1
Geotechnical relevant parameters
Determination of Ground Types

Step 2
Ground water
Primary stresses
Orientation ground structure - tunnel
Size, shape, location of structure
Determination of Ground Behaviour
Assignment of Behaviour Types

Figure 1: Considered steps from the schematic process for geotechnical design which need to be incorporated in a digital ground model in tunnelling

METHODOLOGY

Limitations of current software resulted in work-around processes (**Figure 2**). To correctly **assign the necessary property-sets** (PSETs), the tunnel cavity model was **split into sections**. The PSETs were then enriched with attributes to evaluate the to be excavated tunnel cavity.



tunnel axis / cross section
ground model
PSETs / properties
basics

tunnel enveloping
tunnel cavity model
modelling

parametrised tunnel cavity model
parameterisation

evaluation

Figure 2: Chosen approach to integrate geological and geotechnical parameters into a digital ground model for tunnelling.

PROJECT RESULTS

The pilot project showed that **current software** applications already allow for a rudimental **implementation** of the **BIM method in geotechnical design** for tunnelling. Possible workflows still involve work-arounds and result in **fragmented and incomplete BIM integration**. Missing **standardised data structures** for geology and geotechnics make this even more difficult.

DEVELOPED CONCEPT

BASIS

A to be developed ground model for tunnelling has to be able to include all relevant properties for the geotechnical design process (**Figure 1**), starting with **geotechnical properties**, over mapping of **Ground Types**, various further parameters dependant on the precise tunnel structure and finally the determination and assignment of **Behaviour Types** (BT). A new concept also has to be as adaptable as possible, to apply for different workflows and stakeholders.

TUNNELPIXEL

The resulting concept was named **Tunnelpixel**, as the innovation **rasterises the tunnel cavity model** into singular objects (**Figure 3**). If the raster interval is small enough it allows for the accommodation of all necessary geological and geotechnical properties in the model on the individual Tunnelpixel.

The **need for model changes** during the design-process is thereby strongly **reduced**, which reduces the risk of errors. A **cross-pixel property assignment** is made possible and does not lead to clashes when the model is checked, as the properties are assigned to individual objects. Finally, an extension beyond the information shown so far is simple to implement.

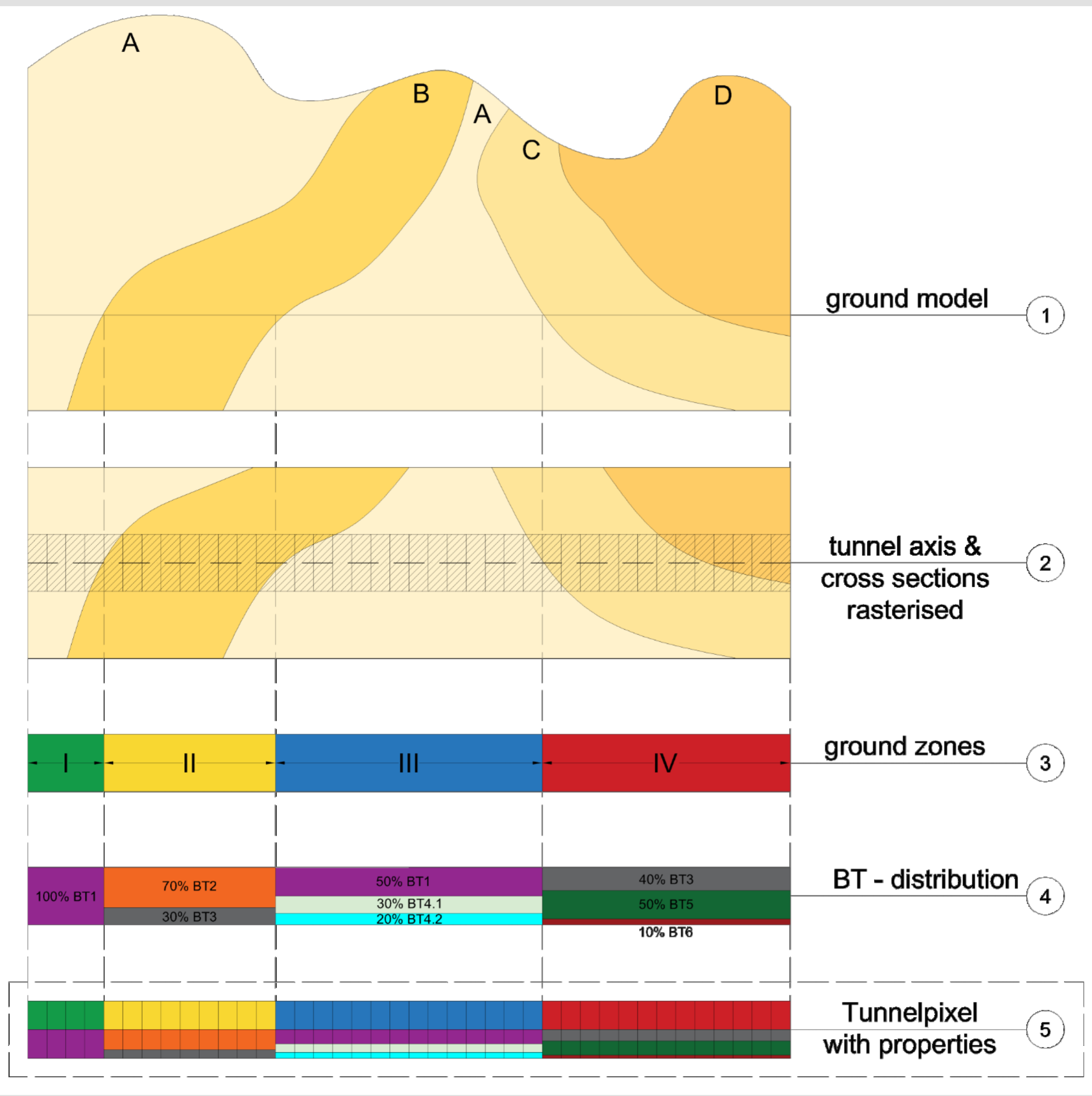


Figure 3: Concept depiction of the rasterised Tunnelpixel and its development process

USE CASES

Within the **design phase**, evenly distributed Tunnelpixel are automatically created alongside the correct position of the tunnel structure. Different stakeholders then add their relevant information to the single Tunnelpixel or a group of Tunnelpixel.

During the **construction phase,** Tunnelpixel with customized widths are necessary. These are either defined by the advance per round, when the tunnel is excavated conventionally or the stroke length when continuous tunnelling methods are used.

CONCLUSION

The **model on the right** hand side is the result and conclusion from this work. It is the combined work from the BIM pilot project and the Tunnelpixel concept. The brown and blue tubular elements, cutting through the red fault zones, can be interpreted as Tunnelpixel, as they each contain a specific PSET to accommodate for all necessary geological and geotechnical information.

It demonstrates that BIM is **already compatible** with geology and geotechnics, allows for **simple evaluations** and **semi-automated** methods today. The Tunnelpixel are seen as the **groundwork** for further research and can be the basis for extensive implementation of digital workflows within geology and geotechnics in tunnelling. They are a step towards comprehensive alignment comparison, better risk calculation to more precise cost calculation based on transparent data.

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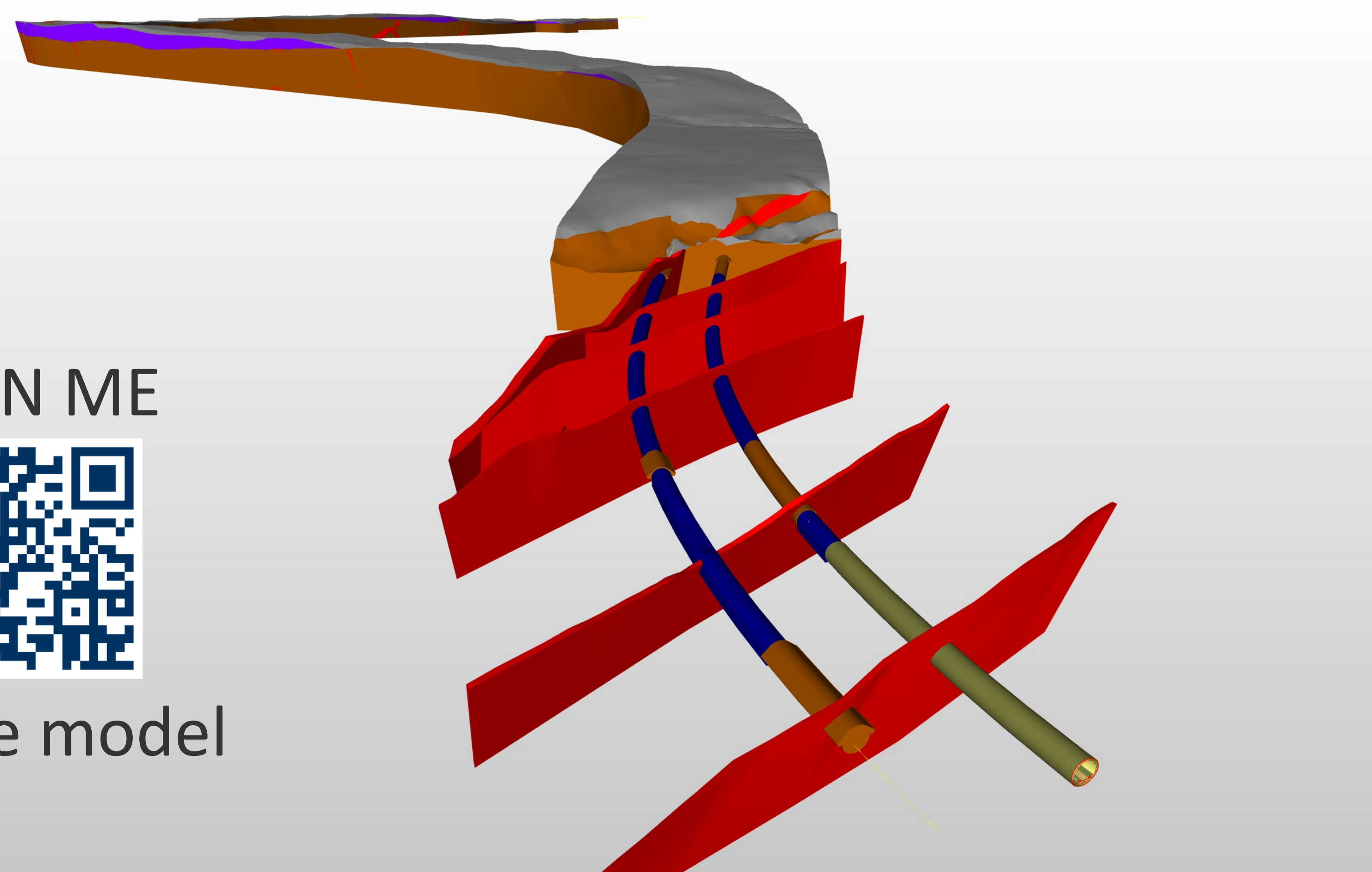
SCAN ME
for live model



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