How to use AI-based algorithms for identification and evaluation of nuclear waste disposal sites

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1 Introduction

The German nuclear waste disposal site identification process is marked by a step-by-step approach: First generally suitable areas, marked by the presence of certain geological formations in the underground, and areas blocked by certain disqualifiers, are identified. At the same time the remaining potentially positive territories are ranked according to their suitability considering further weighting criteria. While in most cases there is sufficient knowledge for the identification of positive areas, and areas blocked by several disqualifiers (e.g. seismic and volcanic regions), other criteria, like active fault systems, are sometimes very hard to identify. In many cases the level of knowledge is simply not sufficient for their correct identification and evaluation.

The further evaluation of potentially positive areas and their narrowing down to single sites and recommendation for further processing require a very careful and as far as possible non-destructive investigation. Especially the so-called hybrid approaches (Figure 1) combining both data-driven predictions and knowledge-based analysis provide best possible results [1]. This approach is able to transfer existing knowledge and empiric models into areas / 3D spaces with less knowledge and data coverage.

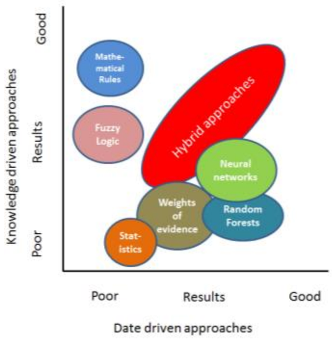


Figure 1: Data driven, knowledge-based and hybrid approaches

2 Status of AI applications in geo-sciences

In the last years, the applicability of AI methods for solving geoscientific tasks developed strongly [0]. Methods were implemented for the creation of geological and soil maps, the interpretation of remote sensing data, the identification of exploration targets (Figure 2), the estimation of mineral resources [2][4], the identification of geo-hazard prone areas (landslides, mudflows, soil creeping), and the identification of lineaments and ring structures.

As an example, the favourability of large rock volumes for the formation of skarn deposits was estimated by transferring the existing knowledge from one 3D space with well-known spatial relationships, faults systems and lithological properties to a large unknown space (Figure 4). Depending on the existing data, ANN cover the prediction of qualitative parameters (how similar is an unknown site to the training area/space) and qualitative parameters (e.g. prediction of grades of metals in ores) in unknown areas/spaces.

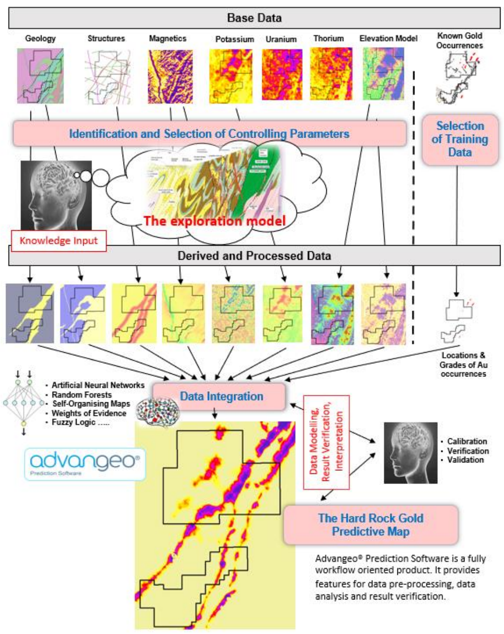
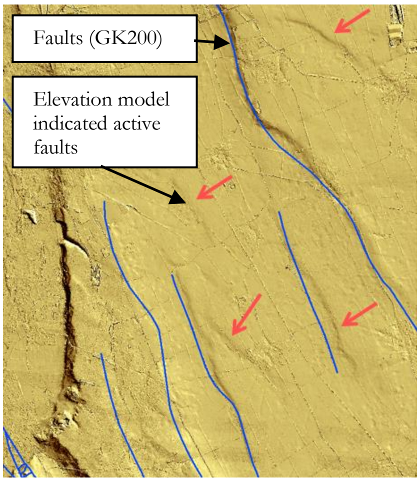


Figure 2: Work flow of AI based mineral occurrence potential mapping, implemented in advangeo® Prediction Software

3 Identification and evaluation of disqualifying and weighting criterions



As the spatial knowledge regarding several disqualifying and weighting criterions is very different from place to place, known empiric dependencies and existing controlling data can be used to fill data gaps in unknown areas/ spaces. A good example is the identification of recently active faults and potentially active faults by using geomorphological criteria [5] and other relevant data (Figure 3). The semi-automatic identification of even very subtle geomorphological scarps and their classification into man-made and natural structures will support the classification of the entire German territory into suitable and unsuitable areas regarding the criteria “active faults” and “fault systems”.

Figure 3: Identification of neotectonics using high resolution elevation models

4 Modelling of physical and chemical rock properties in 3D spaces

After the identification of potentially suitable areas in the 2D space, a 3D site evaluation is required. Here, key rock parameters (like permeability and heat conductivity) have to be extrapolated / interpolated using few existing data points (bore holes, shafts, etc.). As the space of the future storage site must be kept as untouched as possible, the use of AI based technologies is simply without alternative. Here, geophysical 3D data will obviously be used as controlling parameters, together with 3D rock models, and 2D surfaces (e.g. fault systems) to fill the data gaps in the 3D space (Figure 4).

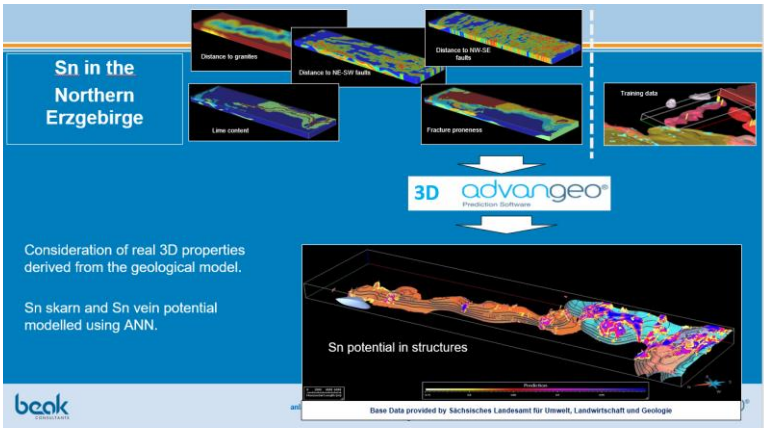


Figure 4: Identification of 3D mineral potentials using various rock properties

5 Conclusions

AI methods will find their definitive place in the entire chain of data collection, data gap filling and decision-making processes of the nuclear waste disposal site selection and evaluation process. They will support a maximally objective site selection process and preserve the spatial integrity of the potential disposal sites. The technologies are ready for their test and application.

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