Ber. Inst. Erdwissenschaften K.-F.-Univ. Graz	Bd. 8	ISSN 1608-8166	Isotope Workshop Volume	Graz 2004

3D modelling of isotope ratios in geological bodies

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Introduction

The main goal of this work was to construct a tool for three-dimensional computer modelling, and consequently visualization, of isotopic variations in rock massifs. The method applied is based on computer programming. The real time modelling enable to

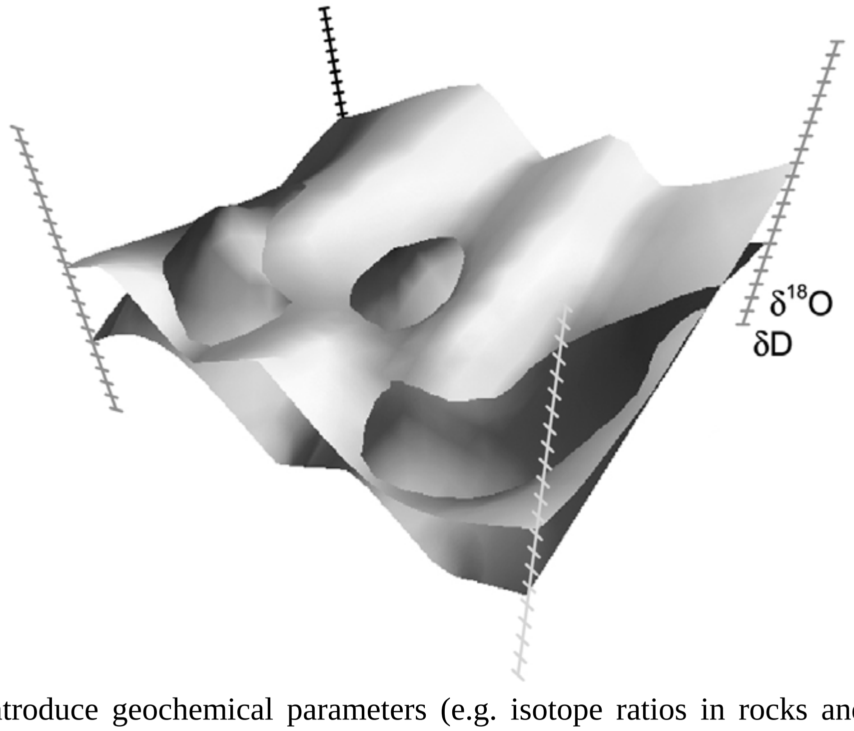


Fig. 1: Computer-generated model of spatial distribution of hydrogen and oxygen isotope ratios

introduce geochemical parameters (e.g. isotope ratios in rocks and fluids, water-to-rock ratio, temperature, α fractionation factor *etc.*) and observe results directly on the computer display. The "module building" applied (plugging) enables to use the tool in various geological units and larger areas of diverse geological structure.

Discussion: The modeling of the isotopic composition of the whole rock

The spatial distribution of isotopic composition of minerals and rocks are interpolated and written in the numeric matrix and these is be represented as a surface. Therefore, isotopic variations of different minerals in a massif can be shown as subsequent surfaces, one above another, which have the same dimensions and position with respect to X-Y-Z axis - spatial variation of isotopic composition of these minerals is observed. This method enable to carry out mathematical calculations with respect to these surfaces, manipulate with them in non-linear way and accept hypothetical values to test the model. Finally, the output is be the outcome matrix of the accepted model.

In practice, we have tested this technique to observe the final isotopic composition of water in ultramafic rocks during serpentinization and while changing, in the real time, the water-to-rock ratio when the Rayleigh distillation model is applied. Obviously, more than one parameter can be modelled or changed the free way, to describe the fluid motion through the rocks. The Fig. 1 shows two crossing surfaces. Four surfaces showing the initial and final isotopic composition of rock and fluid have to be constructed, when calculate spatial distribution of the water-to-rock ratio. When manipulate with one vertical coordinate of any of the surfaces in the selected area, variations in water-to-rock molar ratio can be observed. To discriminate between these surfaces, we have used separate colours for different surfaces and saturation of the respective colour represents the magnitude (value) of the parameter modelled.

Discussion: modeling the isotopic composition of veins

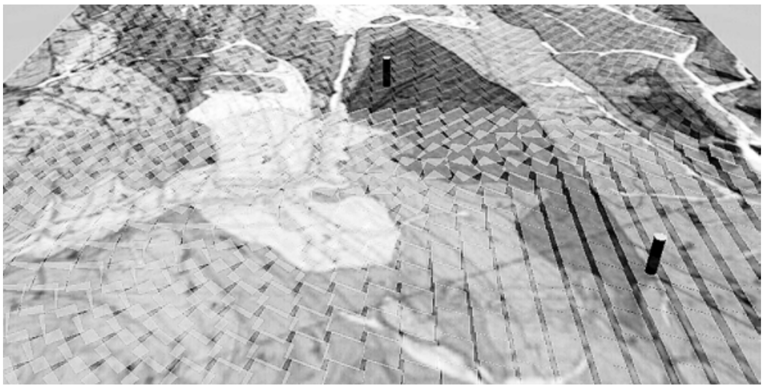
The isotopic composition of veins compared to their spatial orientation may help to find direction of fluid flow and sequence of events (Mydłowski and Jędrysek, 2003b). However, the spatial distribution of isotopic composition of vein-forming minerals requires advanced knowledge with respect to variation in the orientation of veins. Another problem

Fig. 2. Spatial distribution of fracutres in Nowa Ruda serpentinite massif (SW Poland) – view 1.

appears when compare isotope ratios of veins to isotopic composition of the host rock Namely, the thickness of veins, especially when the a vein show several meters thickness and is isotopically independent from the host-rock, become important parameter.

It is important to apply the model when large amount of veins occur, because the model become statistically reliable (Mydłowski and Jędrysek, 2003a). The same situation concern fractures. The Fig. 2 and 3 show the orientation of two perpendicular fracture systems in the Nowa Ruda serpentinite massif (SW Poland). This fractures, shown here as a

Fig. 3. Spatial distribution of fractures in Nowa Ruda serpentinite massif (SW Poland) – view 2.



set of surfaces with the same dimensions, can represent fluid flow pathways. When one know the relation between the isotope composition of mineral in the vein and in the rock, some attempts can be made to find spatial distribution of water-to-rock ratio.

Conclusions

Numeric modelling of isotopic composition in the real time three dimensional system enable a simple and reliable visualization of fluid flow and water/rock isotope exchange, observe spatial a temporal variation in water-to-rock ratio and temperature, etc. This is very important to describe geological processes especially in the open system.

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