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A NEW IDEA FOR 3D MODELLING OF WATER-TO-ROCK RATIO IN GEOLOGICAL BODIES BASED ON H-O STABLE ISOTOPE ANALYSIS

Abstract: The main goal of this work was to construct a tool for three-dimensional computer modelling, of water-to-rock ratio in rock massifs. The method applied is based on computer programming. Isotope variations of different minerals in a massif can be shown geometrically as subsequent surfaces. Likewise, combination of isotope composition of veins and whole rock compared to spatial orientation of veins and planar structures, respectively, may help to find direction of fluid flow and sequence of geological events. Numeric modelling of isotope composition in the real time three dimensional system enable simple and reliable spatial visualization of fluid flow and water/rock isotope exchange.

Keywords: isotope, hydrogen. oxygen, planar structures, water-to-rock ratio

INTRODUCTION

In this paper we propose new tool for three-dimensional computer modelling of fluid flow motion. The new technique applied is based on combined isotope variations and orientation of two dimensional structures (fractures, foliation) and their 3D visualization. The real time modelling enable to introduce geochemical parameters (*e.g.* isotope ratios in rocks and fluids, water-to-rock ratio, temperature, α fractionation factor – see *e.g.* Jędrysek 1990, Valley, Cole 2001) and to observe results directly on the computer display. The "module structure" applied in the computer program (plugin) enable to use the tool in various geological units of diverse geological structure.

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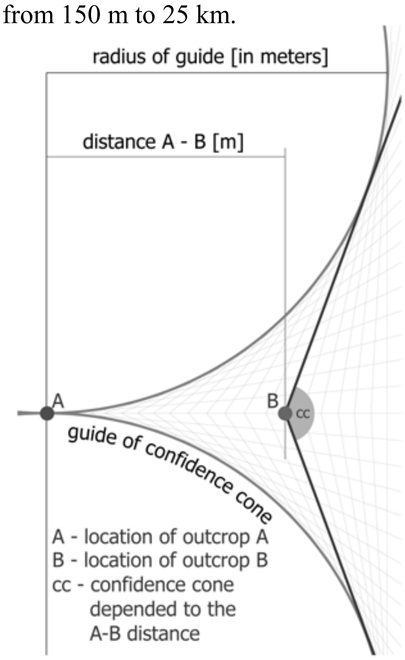
DISCUSSION: THE MODELLING OF ISOTOPE COMPOSITION OF WHOLE ROCKS

The spatial distribution of isotope composition of minerals and rocks is interpolated, written in the numeric matrix and represented as a surface. Therefore, isotope 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. Consequently, spatial variation of isotope composition of these minerals can be observed. This method enable to carry out mathematical calculations with respect to these surfaces, manipulate with them in non-linear ways and accept hypothetical values to test the model. Finally, the output is the outcome matrix of the accepted model.

Fig. 1. Relationship between the A-B distance and radius of confidence cone guide, tested for the distance from 150 m to 25 km.



In practice, we have tested this technique to reconstruct the final isotope composition of water in gabroic rocks during metamorphic processes in Nowa Ruda massif, while changing, in the real time, the water-to-rock ratio when the Rayleigh distillation model (see *e.g.* Ray and Ramesh 1999) is applied. Obviously, more than one parameter can be modelled or changed independently, to describe the fluid motion through rocks. Four surfaces, showing the initial and final isotope composition of hydrogen and oxygen in the rock and fluid, have to be constructed, when calculate spatial distribution of the water-to-rock ratio. When manipulate with vertical coordinate(s) of any of the surface(s) in the selected area, variations in the water-to-rock molar ratio can be observed in the real time on the computer display. 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: THE MODELLING OF ISOTOPIC COMPOSITION OF VEINS

The isotope composition of veins compared to their spatial orientation may help to find the direction of fluid flow and sequence of metamorphic/tectonic events (Mydłowski, Jędrysek 2003b). However, this require extensive data on the spatial distribution of isotope composition of vein-forming minerals with respect to variation in the orientation of veins, or isotope ratios in whole rocks and corresponding planar structures (foliation, fractures, *etc*.). Another problem appears

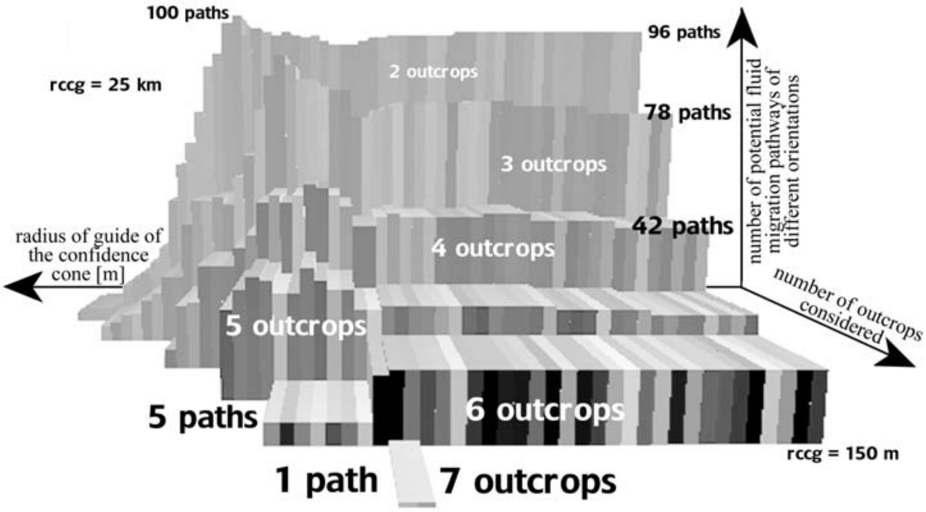


Fig. 2. Variation in the number of directions of fluid migration pathways corresponding to the confidence cone and number of outcrops in Nowa Ruda massif. Each shade represents one successful test (of the number of pathways of fluid flow) for one stable parameter, when the remaining parameters are variable. rccg – radius of confidence cone guide.

when compare isotope ratios of veins to isotope composition of the host rock. Namely, the thickness of veins, especially when a vein shows thickness of several meters and it is isotopically independent from the host-rock, become an important parameter. It is crucial to apply the model when large amount of veins occur, because the model become statistically reliable (Mydłowski, Jędrysek 2003a).

The important parameter, in the algorithm applied, is the confidence cone which represents potential margins of spatial torsion of planar structures. This parameter is crucial to trace and identify the same system of planar structures at different outcrops. At this stage of the modelling, the planar structures represents potential pathways of migration of metamorphic fluids. When the radius of confidence cone guide increases, the number of independent potential pathways of migration of metamorphic fluids decreases (Fig. 2). Obviously, the same relation concern fractures when omit isotope or other geochemical results from the database and stay with the remaining structural data only. Fig. 3 shows the orientation of one selected migration pathway based on the measured orientation of fracture systems in the Nowa Ruda massif (SW Poland). When one knows the isotope composition of minerals in the vein or/and in the whole rock, spatial distribution of water-to-rock ratio can found.

CONCLUSSIONS

1. The proposed numeric modelling of isotopic composition, in the real time three dimensional system, provide a simple and reliable visualization of fluid flow and water/rock isotope exchange, spatial and temporal variations in water-to-rock ratio and temperature, *etc*.

2. Preliminary modelling shows that H and O isotopic ratios and tectonic (orientation of planar structures) parameters from seven outcrops can define one dominant pathway of fluid migration. Lower number of outcrops define much more, but in less reliable way, pathways.

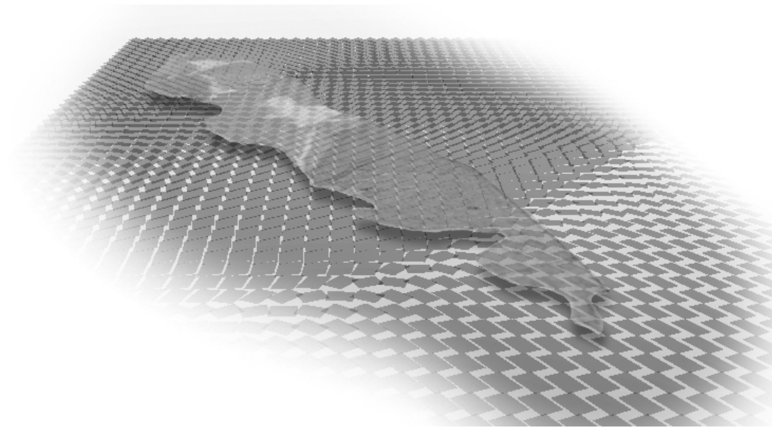


Fig. 3: Potential dominant pathway of fluid migration in the Nowa Ruda massif (simulated view 1400 m a.s.l.).

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