FLUID ORIGIN AND DYNAMIC AT THE NEWLY DEVELOPED THEISTAREYKIR GEOTHERMAL FIELD, ICELAND

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Abstract

This study aim at deciphering the origin of the fluids and the hydrodynamic of the Theistareykir geothermal system using water isotopes and noble gases as a tracer of these respective contributions. Results first confirm that the magma beneath Theistareykir is a mix between a mantle plume (OIB) and an ocean ridge basalt (MORB). They also show that both magmatic fluids and surface water are present in the system in proportions that are being quantifyed. Water isotopes show that sources of surface water range from modern to Pre-Holocene. A crustal input is also present in the system with an enrichment in $\delta^{18}O$ highlighting water-rock interaction.

1. Introduction

Here we discuss results from Theistareykir, a high-enthalpy geothermal field developed in the Northern Volcanic Zone (NVZ) of Iceland, set on the mid-Atlantic oceanic ridge (Óskarsson et al 2015). Noble gases and water isotopes have been chosen as a privileged geochemical and isotopic tool to determine the sources of fluids in the system and monitor the system dynamic (Pinti et al., 2017). They can help the contributions of purely magmatic fluids versus fluids impacted by leaching of host rocks (crustal fluids) using the helium isotopic ratio $^{3}He/^{4}He$ or the argon isotopic ratio $^{40}Ar/^{36}Ar$. Noble gases elemental ratios are also very helpful to constrain solubility-driven processes such as boiling, steam condensation which are crucial processes in understanding magmatic and hydrothermal systems' dynamic (Burnard 2001, Fisher 1997, Hedenquist and Lowenstern,1994).

2. Methods and techniques

Water isotopes were analyzed at GEOTOP by Isotope Ratio Infrared Spectrometer with two lasers for the simultaneous measurements of δ18O and δ2H by Off-Axis Integrated Cavity Output Spectroscopy. Helium isotopes were analyzed at GEOTOP at the University of Québec in Montréal (UQAM) by a Pfeiffer® PRISMA-200 quadrupole mass spectrometer and Thermo® HELIX MC Plus multi-collection mass spectrometer, and at the Noble Gas Laboratory at the University of Michigan (Ma et al 2005, Castro et al 2009).

3. Results

Water isotopes show a wide range of values, especially with $\delta^{2}H$ with values ranging from -100.08 ‰ to -119.29 ‰ and $\delta^{18}O$ ranging from -19.61 ‰ to -8.50 ‰ mud pots, fumaroles and wells together. Rc/Ra ratio range from 3.00 to 11.45 showing both atmospheric, MORB and hot spot influences on the system. The crustal component seems to have less influence. Noble gas elemental ratios $^{132}Xe/^{36}Ar$ and $^{84}Kr/^{36}Ar$ show values ranging from 0.977 to 4.612 and from 0.976 to 1.878 respectively.

4. Discussion

The first results from noble gases (**Fig. 1**) confirms that the magma beneath Theistareykir is a mix between approximately 87,5 % of the mantle beneath the oceanic ridge and 12.5 % of the Icelandic hotspot. The mean $^{3}He/^{4}He$ ratio is 11Ra, when a typical MORB is 8±1Ra.

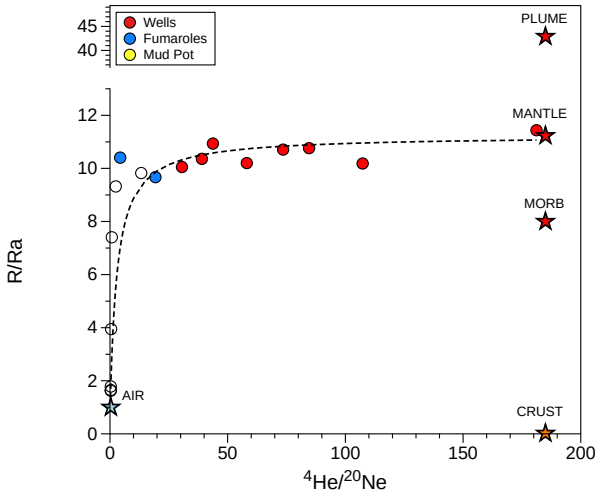

Fig. 1 Isotopic values of helium (Rc/Ra ratio) against the 4He/20Ne isotopic ratio showing the dominant mantle source of helium.

Fig. 2 shows that the field is recharged by Pre-Holocene meteoric water (Sveinbjornsdottir et al., 2013) as suggested by very depleted δ^2H values and the presence of radiogenic $^{40}Ar^*$.

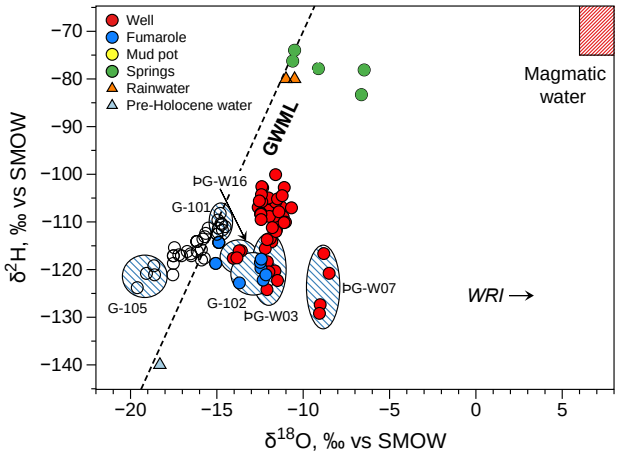

Fig. 2 Water isotopic composition of $\delta^{18}O$ and δ^2H from the water discharge of the wells and from the surface mud pots and fumaroles compare to surface springs and the hypothetical Pre-Holocene water component.

Relation between the heat flow and the ^3He excesses ($Q/^3he$) indicate that the northeastern zone of the field is directly influenced by magma degassing. The elemental ratios $^{132}Xe/^{36}Ar$ and $^{84}Kr/^{36}Ar$ indicate that the reservoir is not yet affected by boiling or re-injection effects. Hot fluids have deeply altered the reservoir, as indicated by the $\delta^{18}O$ shift and a slight increase in radiogenic ^4He and $^{40}Ar^*$ derived from local reservoir rocks.

5. Conclusions

The two main sources of magma have been confirmed in Theistareykir using helium and neon isotopes. Water isotopes showed the presence of multiple fluids in the geothermal system and both noble gases and water isotopes helped understand the dynamic of the system by highlighting processes such as water-rock interaction and magma degassing.

Acknowledgments

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