THE SEARCH FOR VOLCANIC HEAT SOURCES IN TANZANIA:
A HELIUM ISOTOPE PERSPECTIVE

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Outline

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  - Helium isotope composition of fumaroles and springs
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  - Helium isotopes as low-budget exploration tool
- Conceptual Model

**Conclusions / Recommendations**
Sampled sites in northern Tanzania

Source: www.gmis-tanzania.com, modified
Source of salinity

Source: data (yellow squares) this study; data basement samples (brown dots, e.g. Canadian and Scandinavian Shield) and dissolved salts Bucher & Stober (2010 and references therein)
Source of salinity

Source: data (yellow symbols) this study; data Mananka spring James (1957)
Solute Geothermometers

Source: data (yellow symbols) this study; data Mananka spring James (1957)
Solute Geothermometers

Source: data (yellow symbols) this study; data Mananka spring James (1957)
Fluid evolution

Source: data (yellow symbols) this study; data Mananka spring James (1957); data L. Manyara water Talling & Talling (1965), Melack and Kilham (1974)

Source composition of foidite, sand, phonolite: May (2005)
Fluid evolution

Source: data (yellow symbols) this study; data Mananka spring James (1957)
Source of encircled water types: Vaselli et al. (2002)
Water isotopic composition

Source of map: IAEA (2007, modified)

Source of data: IAEA (2007) and this study
Gas composition

Source of diagram (a): Fischer et al. (2009)

Source of data (b): Walker (1969) and this study; diagram after Giggenbach et al. (1983)

Uv = Uvinza; Ite = Itebu; Kon = Kondoa; Mt = Mtagata

N₂ 84.3%
He 12.0%
Ar 1.9%
CH₄ 1.6%
CO₂ 0.2%

δ¹³Cₐₕ₄ₐ₉₉ -14.9‰
(C₄ plants)
Carbon and hydrogen isotope composition of methane

(a) Bernard diagram, modified after Whiticar et al. (1986)

(b) Updated Schoell diagram after Etiope & Sherwood Lollar (2013)

Source of data (a) and (b): Botz & Stoffers (1993; blue symbols) and this study (yellow symbols)

\[ M = \text{microbial}; \quad T = \text{thermogenic}; \quad A = \text{abiotic}; \]

\[ \text{MCR = microbial carbonate reduction; MAF = microbial acetate fermentation; ME = microbial in evaporitic environment; TO = thermogenic with oil; TC = thermogenic with gas-condensate; TD = dry thermogenic; TH = thermogenic with high-temperature CO2-CH4 equilibration; TLM thermogenic low maturity} \]
Lake Manyara carbon isotope composition

$\delta^{13}C$ of CO$_2$ = -11 to -12‰ (C4 plants)

Source: Casanova & Hillaire-Marcel 1992
Helium isotope composition of fumaroles and springs

Data sources: this study, Pik et al. 2006; Kraml et al. 2014a; Barry et al. 2013; Fischer et al. 2009;
Helium isotope composition of Lake Tanganyika

Source (a): Pflumio et al. (1994) and Coussement et al. (1994) modified

Source (b): Craig (1974)

\[ R/R_a = 0.28 \]
Helium isotopes as low-budget exploration tool

Conceptual model for fault controlled basement systems

Source of geological section: Macgregor (2015), modified
Conclusions / Recommendations

**Hydrochemistry:**
- Bromide analyses should be done to assess the source of salinity of basement brines.
- Most solute geothermometers of subduction zone environment cannot reliably be applied in rift environments (compare e.g. Marini & Pasqua 2014). Different reservoir rocks and fluid evolution should be considered and alternative geothermometers have to be established.

**Isotope Geochemistry:**
- The major gas and carbon isotopic composition of CO\textsubscript{2} gives a first indication on a possible magmatic origin of the gas, but due to various and abundant fractionation affects, noble gas isotope analyses should confirm those preliminary findings. He isotopes can be used as low-budget geothermal exploration tool prior to geophysics.

**Overall Conclusions:**
- Mount Meru, which might host a volcanically heated viable high-temperature geothermal system, should be explored to close the data gap.
- The same holds true for the Pemba site which might indicate a volcanically heated system hopefully continuing into Tanzanian territory (as well as Kalemie-Mahali-Ridge of Lake T.).
- Also numerous low-temperature resources can contribute to Tanzanian energy supply by delivering sustainable power with high supply security in rural and touristic areas.
Thank you for your attention!

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