Exploring for Radiogenic Heat:
A Case Study from the Saxothuringian Zone of Germany

GFZ POTSDAM | HELMHOLTZ GEMEINSCHAFT

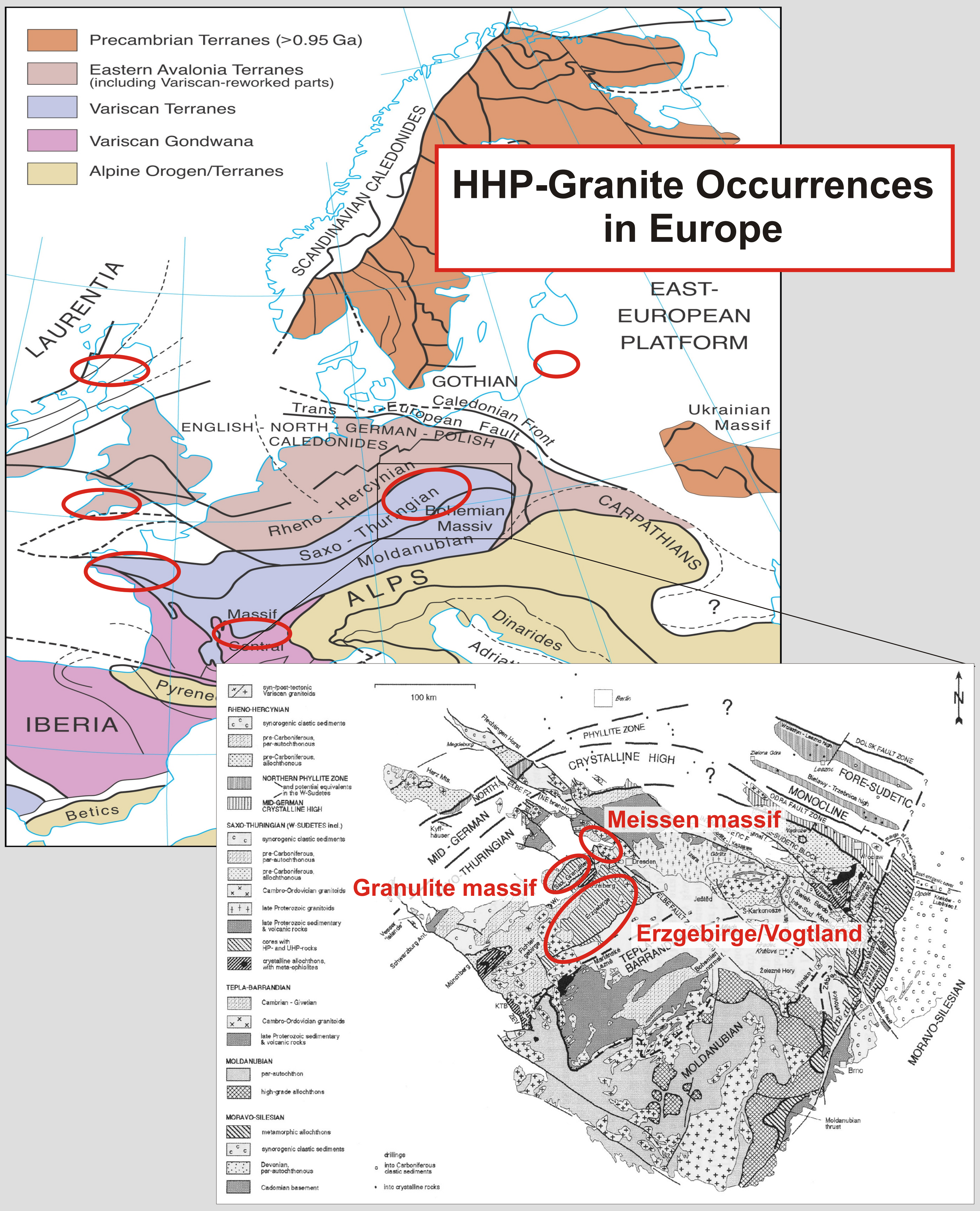
A. Förster and H.-J. Förster

Universität Potsdam

The Saxothuringian zone in eastern Germany hosts a multifaceted assemblage of high heat production (HHP) igneous rocks (from monzonite/syenite to alkali-feldspar granite) of different volume, depth range, type of country rock, geochemical affiliation, and mineralogy of heat-producing elements. From the viewpoint of radiogenic heat production, regions particularly perspective to more thoroughly explore for EGS are:

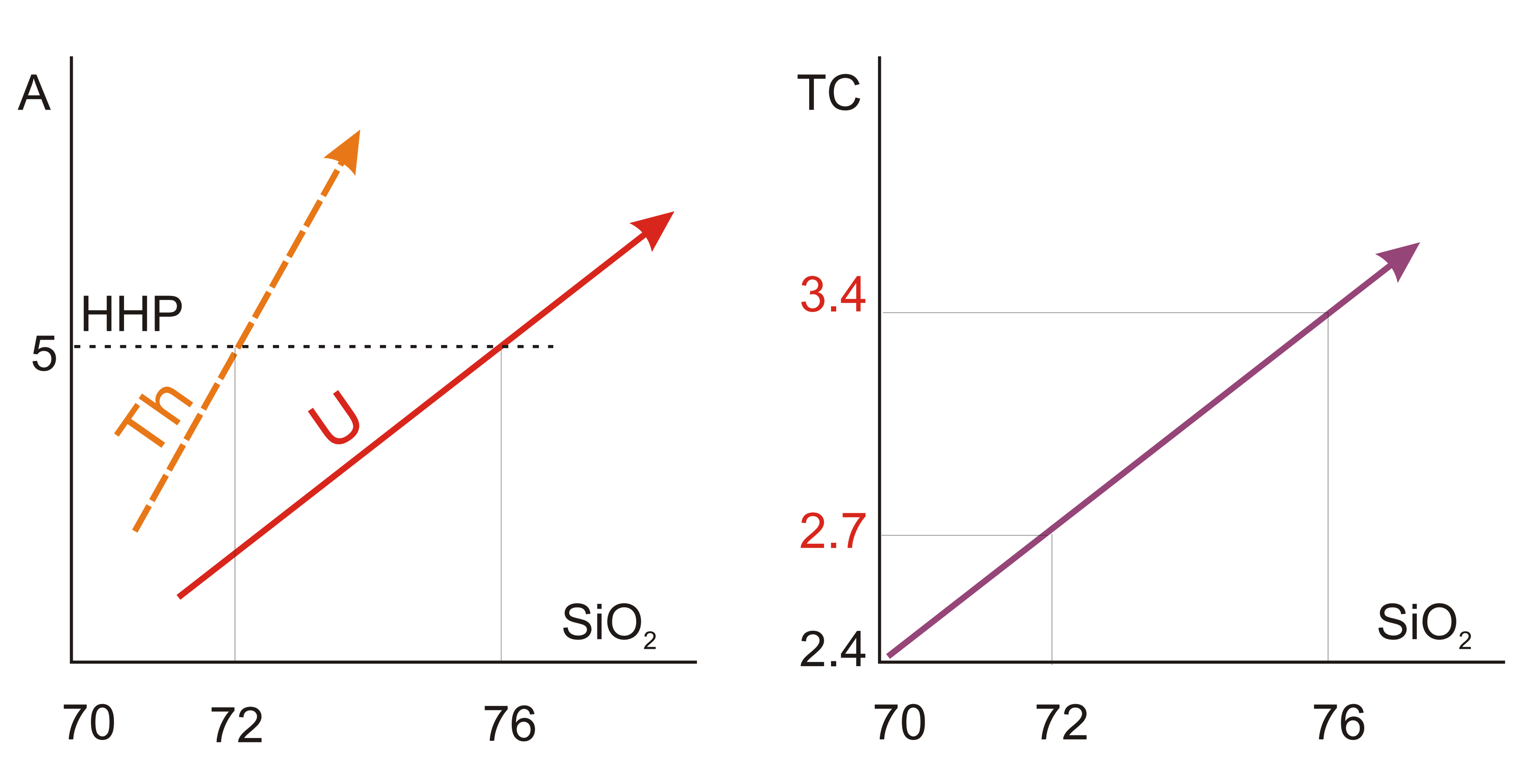
the Erzgebirge/Vogtland,
the Meissen massif and
the Granulite massif.

Although igneous rocks in these areas show roughly the same range in heat production, petrophysical and mineralogical properties differently qualify them for an EGS.



Geological map of the Bohemian massif and adjacent areas (Franke & Zelazniewicz, 2000)

Thermal Conductivity and Th/U Ratio



General trends of increase in radiogenic heat production (A) and thermal conductivity (TC) with increasing SiO_2.

Due to the inverse correlation of thermal conductivity and temperature gradient for a given heat flow, preference may be given to rock masses of low thermal conductivity. The thermal conductivity in general is positively correlated with the silica content of a rock, which roughly approximates the modal abundance of quartz. Th-rich HHP rocks (high Th/U ratio) often are lower in silica (and, thus, have a lower thermal conductivity) compared to U-rich rocks with a low Th/U ratio.

The Erzgebirge HHP granites are silica-rich (73–77 wt% SiO_2, 4–12 µW/m³) and display a relatively high thermal conductivity (2.8–3.6 W/mK). U-rich S-type granites show lower Th/U ratios (0.1–0.7) relative to their more Th-rich counterparts of I- and A-type affiliation.

The Granulite massif HHP monzogranites (69–73 wt% SiO_2; 4–14 µW/m³) are intrusive into felsic to mafic granulites and have a calculated thermal conductivity of 2.2–2.8 W/mK. They have Th/U ratios in the range 2 to 9.

The uncommonly Th-rich monzonitic to syenitic rocks of the Meissen massif (52–64 wt% SiO_2; 4–13 µW/m³) exhibit calculated thermal conductivities of < 2.2 W/mK. Their Th/U ratio varies between 2 and 8.

Fluid-Rock Interaction in EGS

The selection of an appropriate EGS in HHP rocks also requires consideration of the distinct behaviour of U and Th during fluid-rock interaction. At some conditions, up to 90% of the original U budget of a rock may be lost to fluids whereas usually less than 20% of the Th content could be mobilized even if fluid penetration is intense.

Particularly prone to leaching are U-rich HHP granites (normally S-type rocks), where the bulk of the U is fixed in easily soluble Th-poor uraninite and U-micas and, in addition, is deposited along grain boundaries. Less problematic may be Th-rich HHP rocks, which typically contain more stable radioactive accessory minerals (Th-rich uraninite, monazite, xenotime, thorite) and typically classify as I- and A-type granites.

Conclusions

For diverse HHP granites in the Erzgebirge/Vogtland it could be shown that temperatures sufficient to develop an EGS will be attained at depths < 3.5 km. This may also be a possible scenario for the Meissen massif and the Granulite massif, but a more precise knowledge in terms of heat flow, depth range, and mineralogy of their HHP rocks is required.

It is recommended that the consequences of U/Th mobilization in water need to be considered more in-depth in EGS assessment and, later on, in EGS engineering.