

Thermophysical Properties of Potential Geothermal Reservoir Rocks: An Outcrop Analogue Study of the Sedimentary Series of the Buda Mts., Hungary

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Introduction

The use of deep geothermal systems is based on a detailed knowledge of their distinct reservoir characteristics. In the early stages of hydrothermal reservoir exploration, characterization of the reservoir is mainly accomplished by evaluation of drilling data and in some cases seismic surveys. However, for reservoir prognosis, the main geothermal parameters such as (1) permeability, (2) thermal conductivity, and (3) reservoir heat flow have to be quantified with respect to a 3D structural model of the subsurface. Outcrop analogue studies serve to predict such subsurface thermophysical properties, and based on detailed facies analysis, the geothermal exploration concept becomes more precise and descriptive. Furthermore, the detection of distinct sedimentological features and their stratal and lateral architecture will lead to a better understanding and interpretation of the spatio-temporal development of sedimentary facies within a specific exploration area, and thus may contribute to establish integrated structural 3D reservoir models.

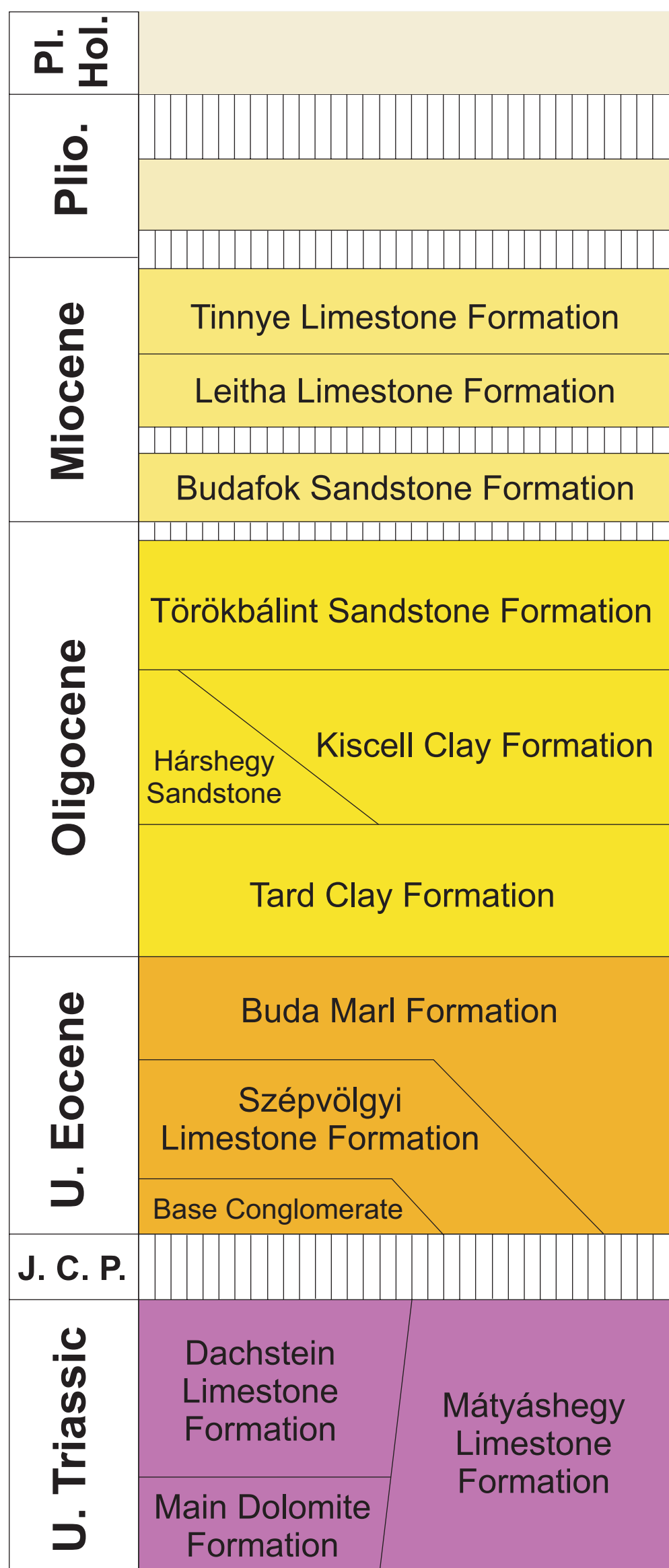
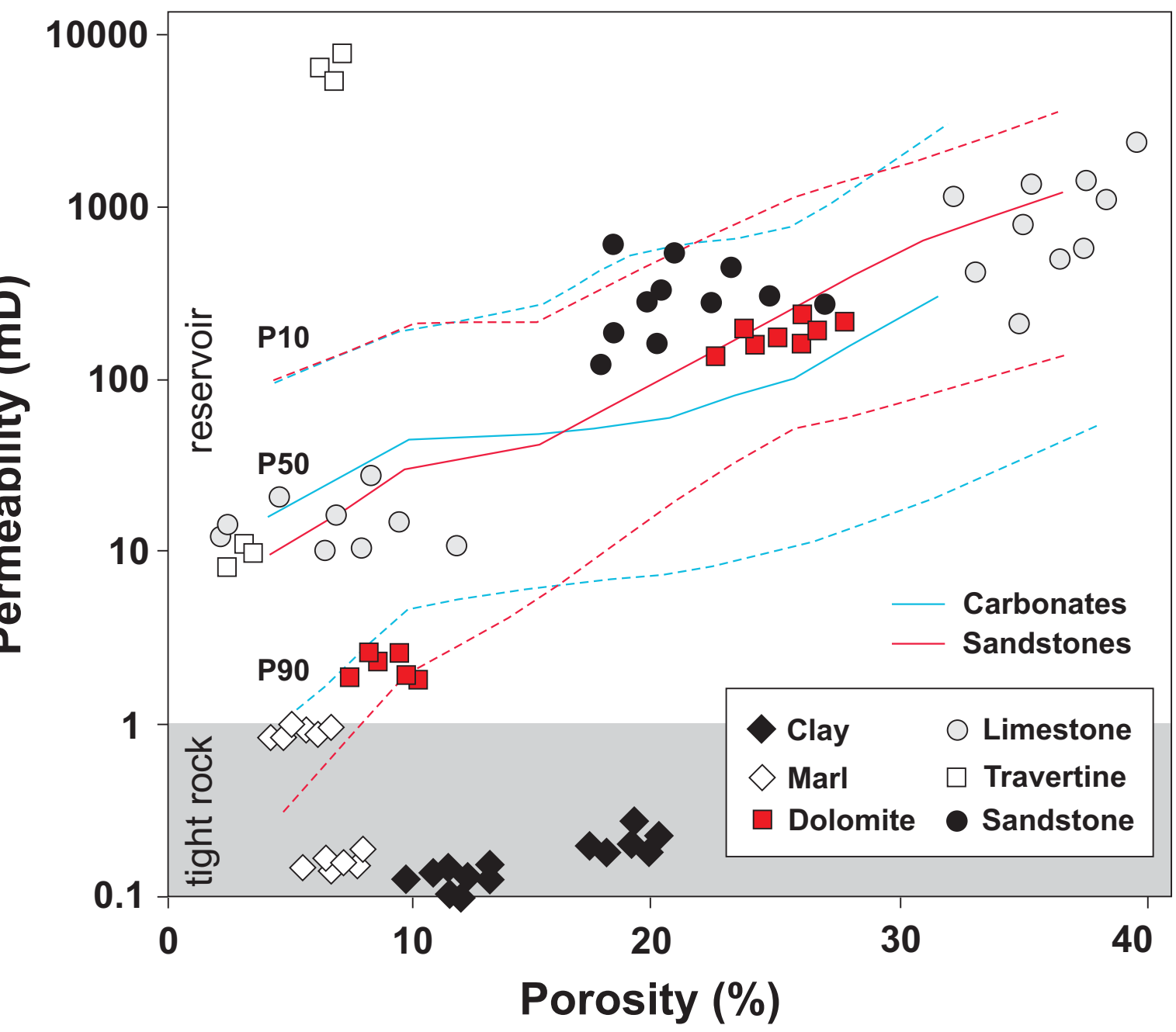


Fig. 1. Lithostratigraphic units of the Buda Mts., Hungary (above) comprising Triassic and Cenozoic deposits and porosity-permeability plot of the different lithofacies types (left) in comparison to international carbonate and sandstone hydrocarbon reservoirs.

Materials and Methods

Our samples from the Meso- and Cenozoic sedimentary series of the Buda Mts. include carbonates and clastic sediments of Triassic, Eocene, and Oligo-Miocene age as well as Pleistocene travertine, exposed on the western side of the river Danube. Separate measurements of skeletal density (Helium Pycnometer AccuPyc 1330) and envelope density (DryFlo Pycnometer GeoPyc 1360) enabled the calculation of porosity. Permeability measurements were carried out using a gas permeameter constructed by the TU Darmstadt. Thermal conductivities of the different rock types were measured by an optical scanning device applying the method after Popov et al. (1999). Reservoir rock classification follows the thermofacies concept of Sass & Götz (2012).

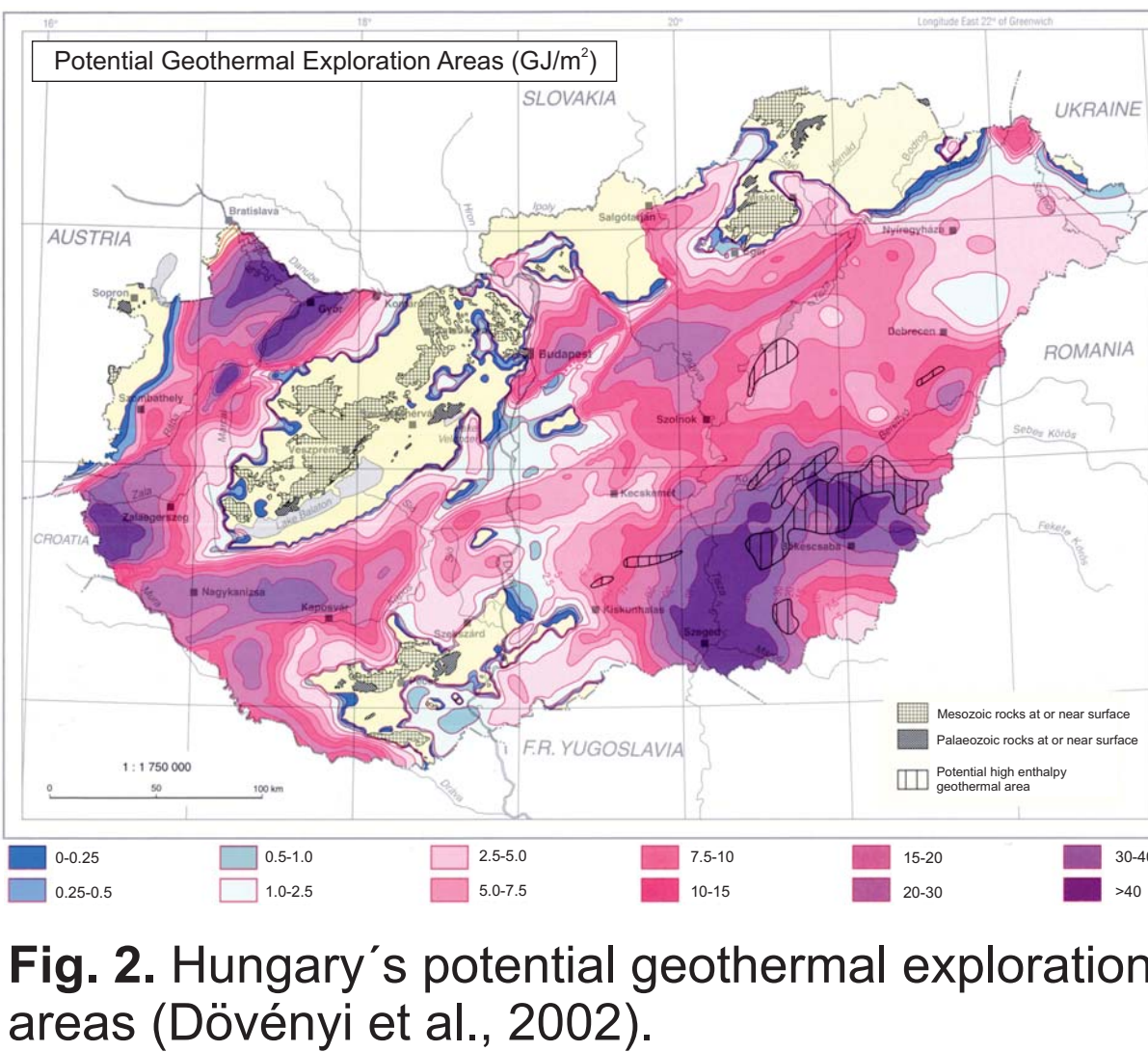
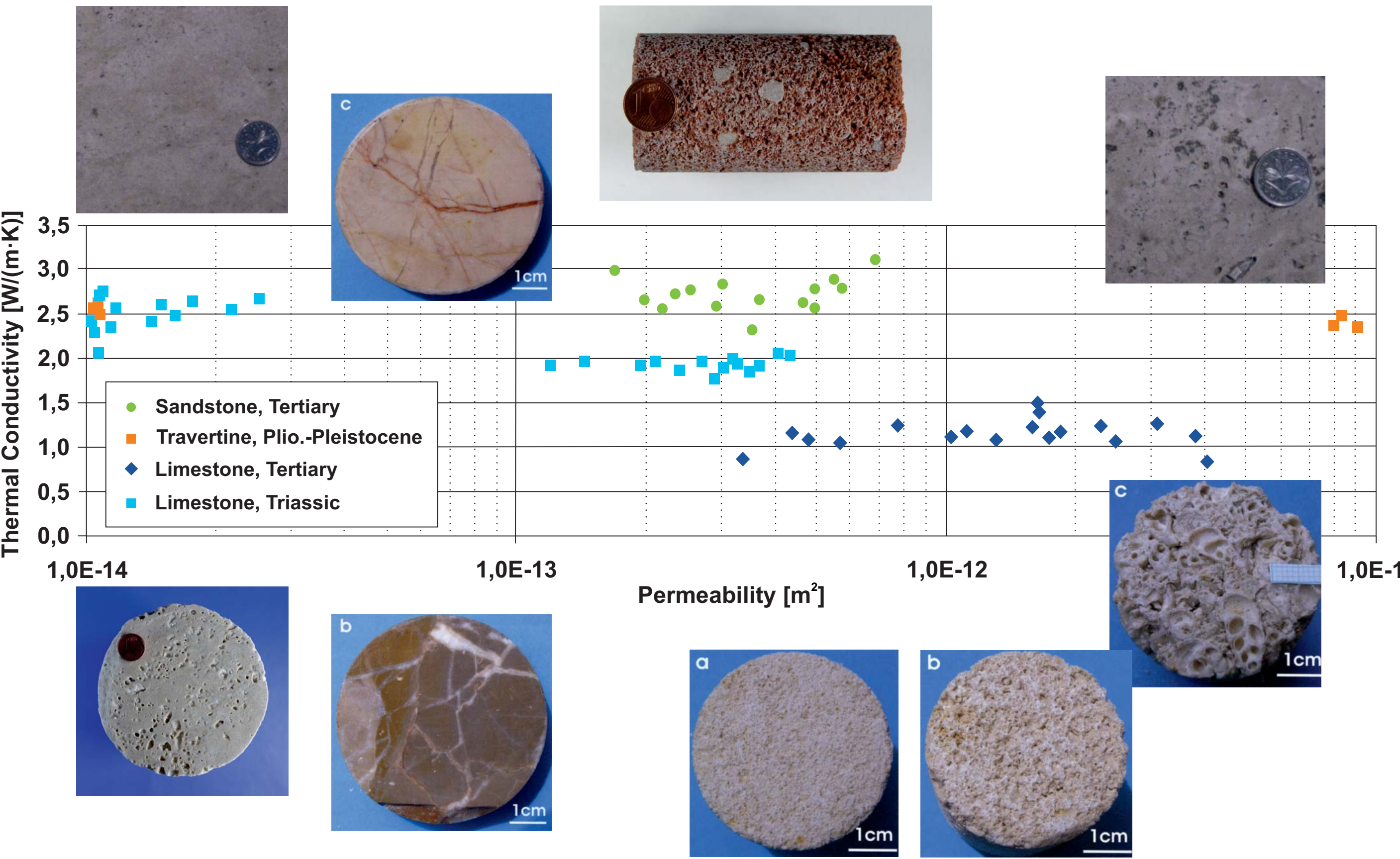
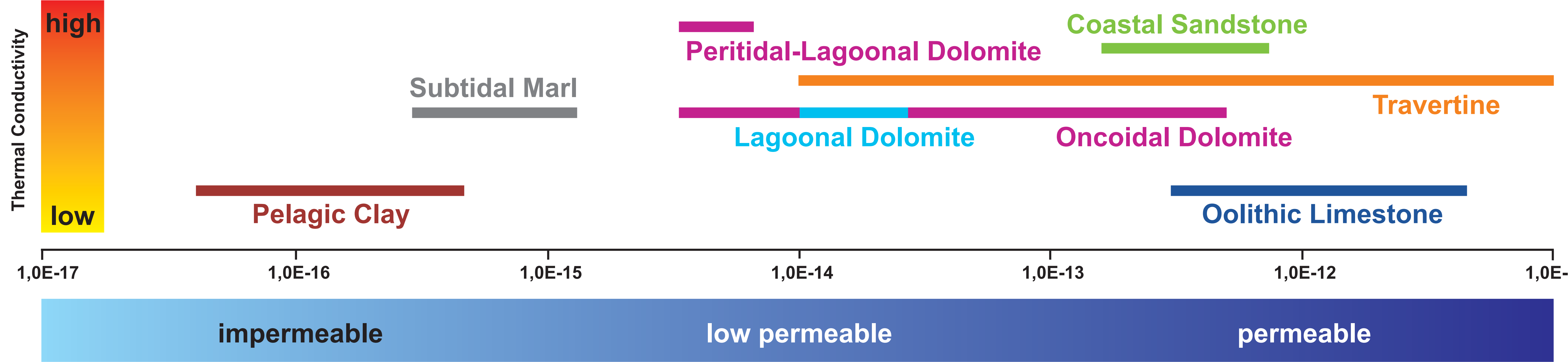
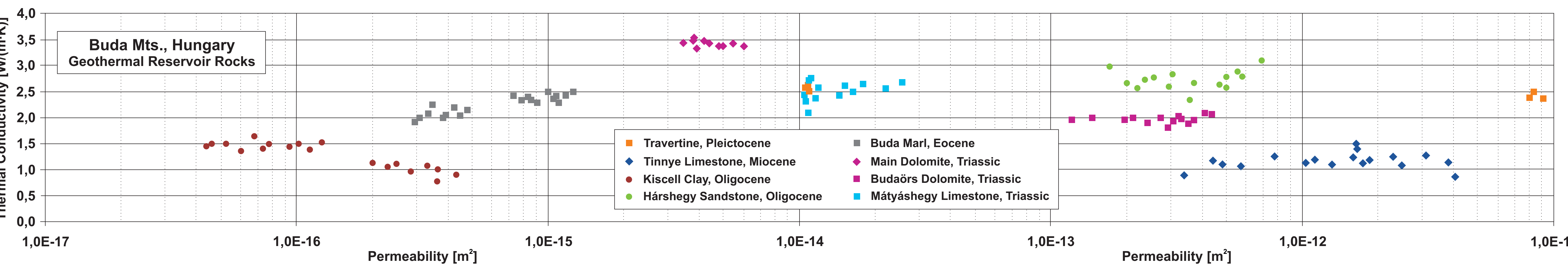


Fig. 2. Hungary's potential geothermal exploration areas (Dövényi et al., 2002).



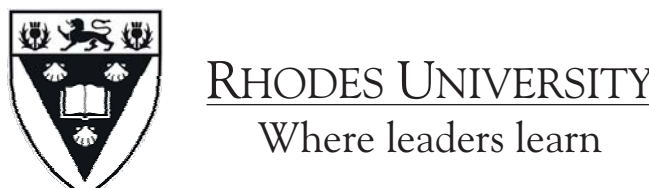
permeable reservoir rocks

Facies and Thermophysical Rock Properties



Results

Field and laboratory analyses reveal distinct stratigraphic horizons of different geothermal potential within the Meso- and Cenozoic sedimentary series of the Buda Mts., Hungary: Upper Triassic limestones (Main Dolomite, Budaörs Dolomite, Mátyáshegy Limestone) show values of thermal conductivity in the range of 2,0 to 3,5 W/(m·K). Matrix permeabilities measured with a gas permeameter span in the range of 10^{-12} to 10^{-14} m². Additionally, these limestones are highly fractured and show a different degree of karstification increasing the fluid migration. Thus, hydrothermal exploration of such limestone reservoirs in geothermal prone depths of about 5 km known from the Zala and Danube basins of NW Hungary is seen very promising. Miocene bioclastic limestones (e.g., Tinnye Limestone) reveal lower values of thermal conductivity in the range of 1,0 to 1,5 W/(m·K). On the other hand, they are characterized by much higher permeabilities (10^{-11} to 10^{-12} m²). Depending on their occurrence in the deep subsurface, they might be considered as reservoir rocks. Marls and travertines show values of thermal conductivity in the range of 2,0 to 2,5 W/(m·K). Matrix permeabilities of marls are low (10^{-15} to 10^{-16} m²), whereas travertines are characterized by the highest permeabilities up to 10^{-11} m². Both, marls and travertines are not considered as deep geothermal reservoir rocks: marls due to their low permeabilities, and travertines due to their occurrence in the shallow subsurface. Clastic sediments of Palaeo- and Neogene age are grouped into impermeable and low heat conducting clays (e.g., Kiscell Clay), and permeable, high heat conducting sandstones (e.g., Hárshegy Sandstone). Thus, hydrothermal exploration of permeable sandstone reservoirs in geothermal prone depths known from different basins in Hungary (e.g., Central Great Plain) is also seen very promising. Based on these preliminary results, further outcrop analogue studies will serve as a powerful tool to predict such subsurface thermophysical properties and thus, finally lead to a better understanding of deep geothermal reservoirs in the Pannonian Basin.



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