

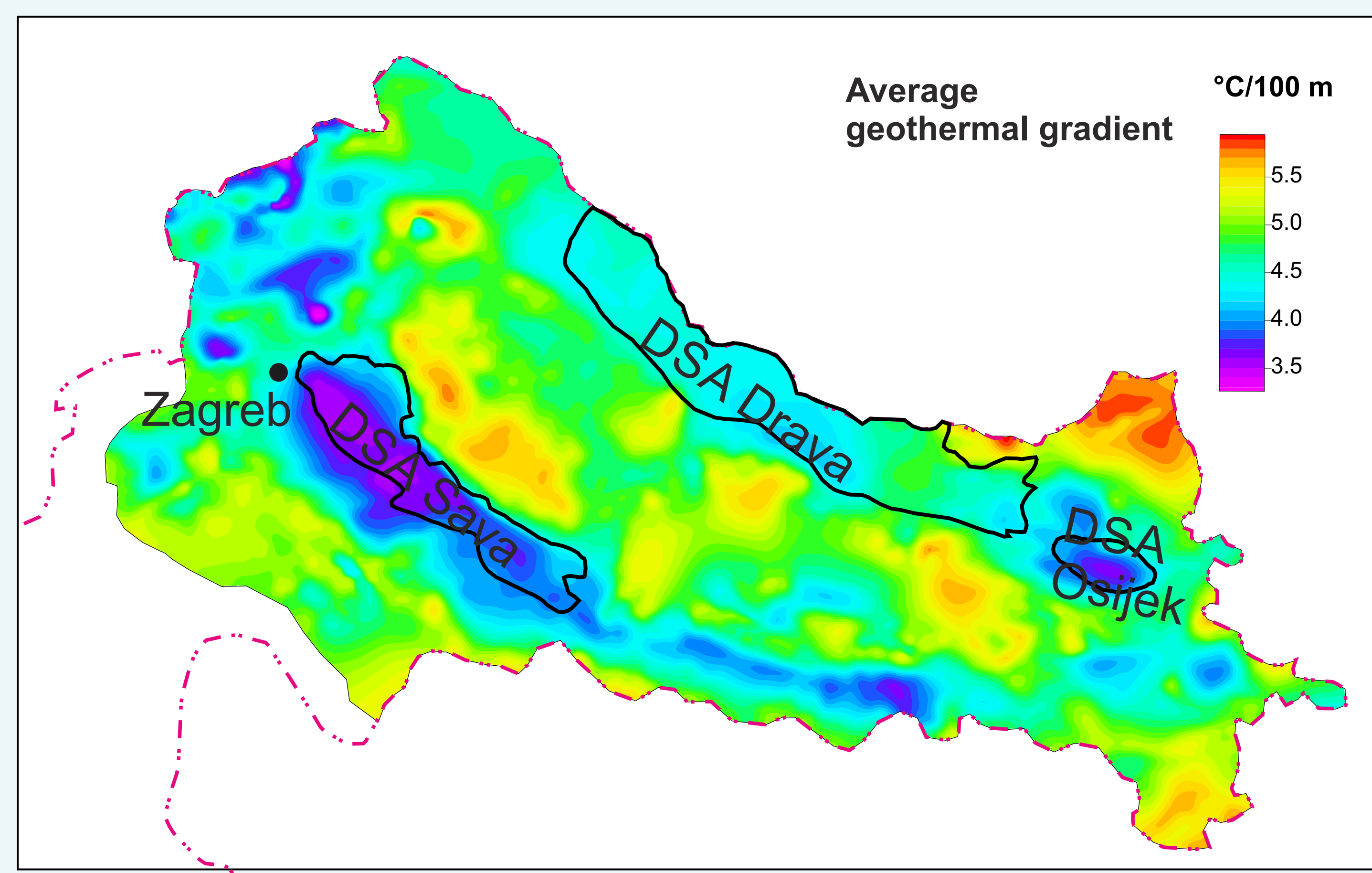
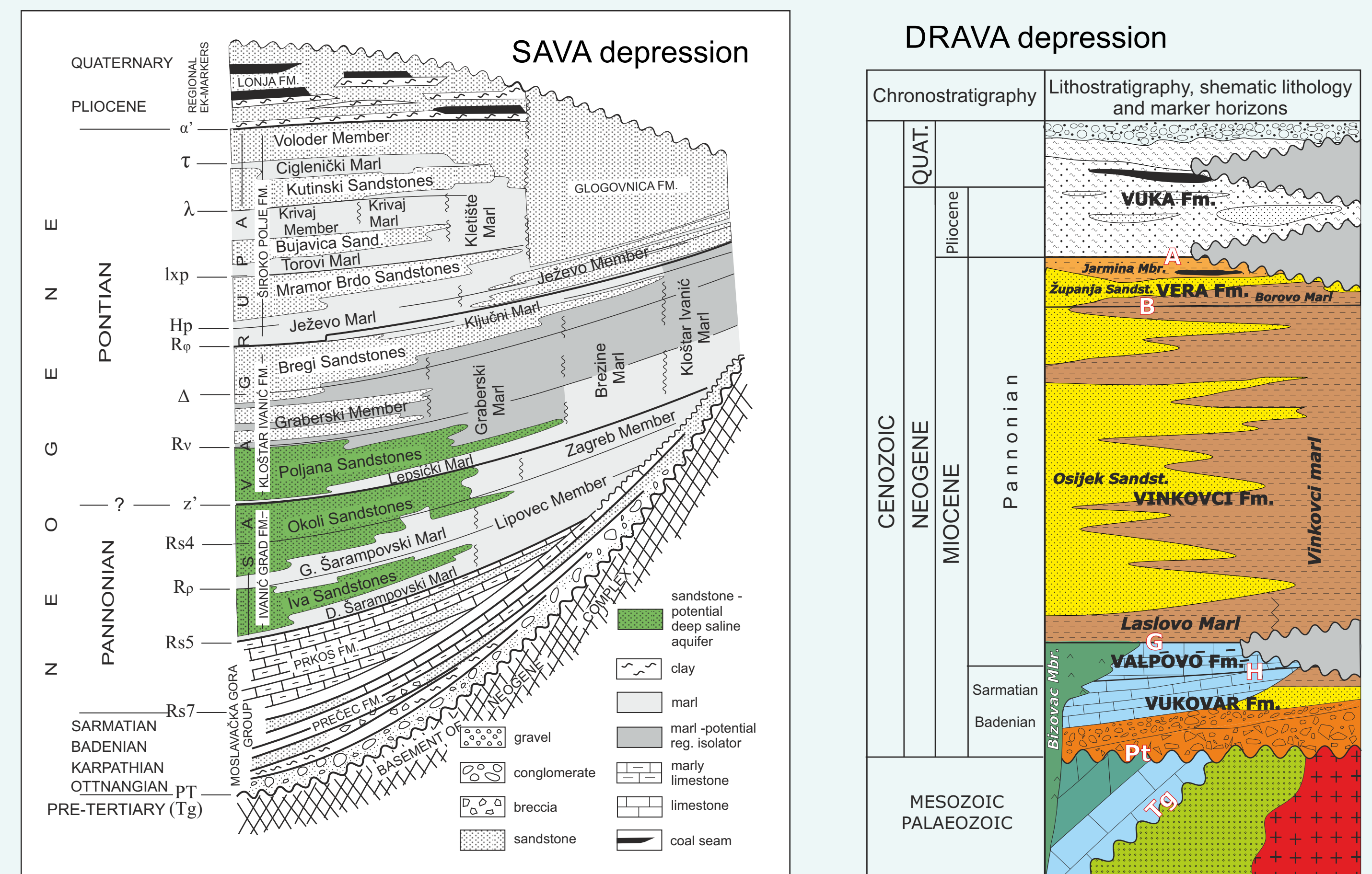
OVERVIEW OF UNDERGROUND ENERGY STORAGE POTENTIAL IN CROATIA



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Apart from the general overview carried out within the ESTMAP - Energy Storage Mapping and Planning project, the potential for underground energy storage in Croatia hasn't been studied yet. Currently, energy storage in Croatia is limited to a single operating natural gas underground storage in one of the depleted gas reservoirs of the Okoli field in Sava Depression, east of Zagreb. Reservoir rocks are turbidite sandstones of Upper Pannonian age with rather favourable petrophysical properties, with anticlinal trap. Since the underground storage of natural gas represents the important step towards the security of natural gas supply, underground storage of the natural gas in a gas reservoir of the Grubišno Polje field in Drava depression in northern Croatia is planned. Since this reservoir has never produced, the first phase of the project involves its partial depletion and the maintaining gas is intended to act as a cushion gas.

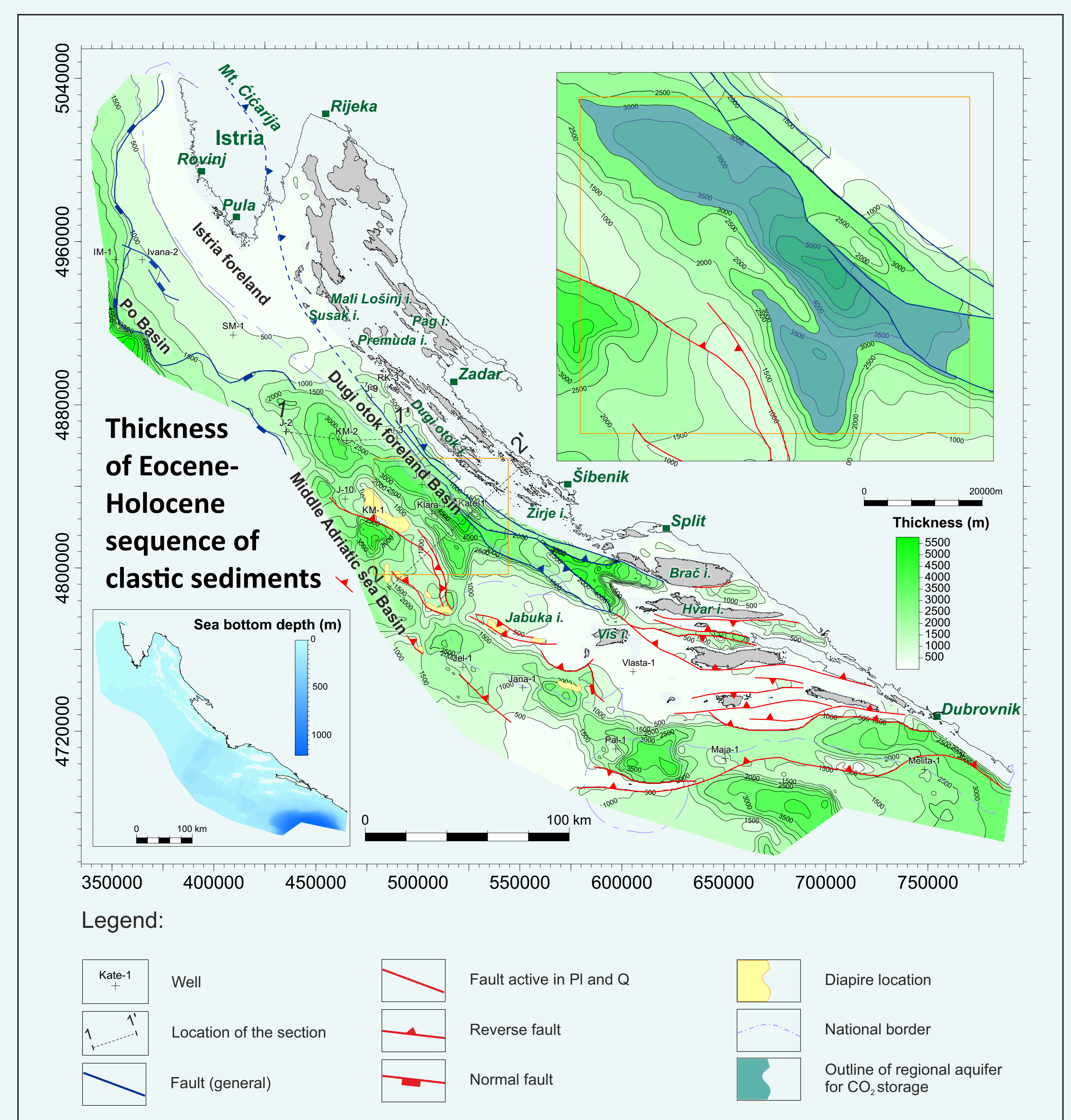


Due to the unfavourable geographical position of salt diapirs, energy storage in salt caverns is not likely to be an option for Croatia. Namely, central part of the Adriatic offshore (area around islands Jabuka, Brusnik, Vis and Palagruža) is characterized by salt tectonics, with presence of different halokinetic structures, including salt diapirs of variable size and time of formation. Energy storage in offshore salt caverns can be ruled out since it is technically and economically unviable. Other offshore storage options, in depleted gas reservoirs and structural traps in clastic and carbonate deep saline aquifers, can also prove to be economically unviable, not only due to the unfavourable location but also because the said structural traps haven't been sufficiently characterized and extensive targeted exploration will be needed before any recommendations can be made.

Generally, underground storage objects in deep saline aquifers can be economically challenging, because they demand significant initial investment, including investment in their identification and characterization, yet it is envisaged that they represent the only option for storage of hydrogen and hot compressed air.

References:
Cvetković, M., Matoš, B., Rukavina, D., Kolenković Močilac I., Saftić, B., Baketarić, T., Baketarić, M., Vuić, I., Stopar, A., Jarić, A., Paškov, T. (2019): Geoenergy potential of the Croatian part of Pannonian Basin: insights from the reconstruction of the pre-Neogene basement unconformity. *Journal of Maps*, 15, 2, 651-661.
Kolenković, I., Saftić, B., Perešin, D. (2013): Regional Capacity Estimates for CO₂ Geological Storage in Deep Saline Aquifers – Upper Miocene Sandstones in the SW part of the Pannonian Basin. *Journal of Greenhouse Gas Control*, 16, 180-186.
Malvić, T., Cvetković, M. (2013): Lithostratigraphic units in the Drava Depression (Croatian and Hungarian parts) – a correlation. *Nafta*, 64/1, 27-33 pp.
Saftić, B., J., Sztanó, O., Juhász, Gy., Ivković, Ž. (2003): Tertiary subsurface facies, source rocks and hydrocarbon reservoirs in the SW part of the Pannonian Basin (northern Croatia and south western Hungary). *Geologia Croatica*, 56/1, 101-122.
Saftić, B., Kolenković Močilac, I., Cvetković, M., Vulin, D., Velić, J., Tomljenović, B. (2019): Potential for the Geological Storage of CO₂ in the Croatian Part of the Adriatic Oshore. *Minerals*, 9, 577, 21 p.
Šimon, J. (1973): O nekim rezultatima regionalne korelacije litostratigrafskih jedinica u jugozapadnom području Panonskog bazena (On some results of regional correlation of lithostratigraphic units in SW part of Pannonian basin). *Nafta*, 3, 119–127.

Regarding other energy storage options, based on general knowledge of geological setting and the current level of exploration focused on regional assessment of CO₂ storage potential, there is a potential for underground storage of hydrogen and hot compressed air in deep saline aquifers within the Sava and Drava Depressions (Pannonian Basin). It should be noted that there is a possibility of conflicts of subsurface use, since it is reasonable to expect that the structures which will be identified as favourable for CO₂ storage are also the ones having favourable properties (size, geometry, petrophysical properties of reservoir rocks ensuring large capacity and high injectivity, efficient cap-rocks) that make them target objects for underground storage of hydrogen and compressed air. Also, having the elevated heat flow, this part of Pannonian basin has a potential for use of geothermal energy (the first medium temperature geothermal power plant in Europe has started operating in January 2019), which also represents another possibly competitive option for use of the deep subsurface.



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