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Structural controls on geothermal activity in the eastern Mediterranean region: example of the Main Menderes area (Western Turkey)

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The eastern Mediterranean region, characterized by active tectonics and volcanism, is a promising geothermal area. During the last five years, geothermal resources have been increasingly exploited with a significant development of geothermal electricity production and direct uses in Turkey. In this country, more than 2000 MWt are being utilized for direct applications and most of this geothermal energy originates from the Menderes Massif. Although the potential of deep geothermal resources has not been systematically investigated yet, many studies based on geological mapping, geophysical surveys and exploration drilling have been carried out by the MTA (Turkish Geological Institute). As a result various interpretations to explain heat source origin or structural control on the locus of hot springs have been proposed in literature.

During the Oligo-Miocene, the Menderes Massif, which includes typical features of metamorphic core complexes, has undergone significant N-S extension. Its recent evolution is dominated by E-W striking low-angle normal faults (detachments) coeval with the N-S opening of several grabens, controlled by high-angle normal faults. Locally, an additional distributed strike-slip tectonics has been recorded. The relatively sparse distribution of recent magmatic centers produced during this evolution suggests that geothermal activity is not driven by magmatic heat sources, at least not within the upper crust. Instead, we suggest that an anomalously hot mantle and crustal scale faults conveying hot fluids to the surface are the primary controls on geothermal systems in this region.

Our findings, based on a detailed study of structural features of several fields, show a variety of structural controls but with several recurrent themes. We suggest, in a first step, that detachments convey deep circulation of hydrothermal fluids of probably meteoric, crustal and mantellic origin. In a second step, fault zone was break into many sections, thus generating a higher fracture density and permeability that hosts significant fluid flow. Finally, fault zone intersections between strike-slip faults and low angle normal faults have probably enlarged apertures that reinforce groundwater flow to the surface. In addition, it seems that lithology could play a critical role in the localization hot spring, as well as in the building of geothermal reservoirs at shallow (kilometric) depths. This approach, which is based on broad compilation of geothermal and structural observations, shows strong similarities between these geothermal fields (heat source, structural and lithological controls), thus it provides a new vision on the existence of large thermal anomaly in this area which is probably caused by mantle processes relating to the Hellenic subduction.