

Heat Flow in the Caspian – Black Sea Region and its Tectonic Implications*

R. I. Kutas¹

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¹National Seismological Data Centre, Ukraine (kutro@ndc.org.ua)

Abstract

An analysis of the heat flow distribution over the territory of Caspian – Caucasus – Black Sea region shows that tectonics and evolution of the earth's crust are the dominant factors affecting the nature of the geothermal field. The region is characterized by a complex combination of high and low heat flow density. Heat flow density ranges from 20 to more than 100 mW/m². High heat flow (>70 mW/m²) is related to zones of young volcanic activity. In the Lesser Caucasus heat flow varies from 65 to 95 mW/m². The values of 80 to 110 mW/m² are reported for Eocene magmatic arc. High heat flow (60 to 145 mW/m²) can be observed in the central part of the Great Caucasus. Such a high geothermal activity can be explained by extensive Neogene and Quaternary volcanic activity, which was expressed on the surface more to the south by the creation of the Elbrus volcano. Characteristic features are heat flow density anomalies running transversal to the main course of the Alpine units. They are related to deep fault zones, crossing these structures. In the Great Caucasus one of these zones running from Quaternary massif of the Elbrus to Pyatigorsk are associated with outcropping laccolites and the Stavropol arch in the north.

The folded structures of the Great Caucasus, Crimea, and Dobrogea are characterized by intermediate heat flow density (50-75 mW/m²). The mean heat flow is 48 mW/m² in Crimea Highland 52 mW/m² in the western part of the Great Caucasus and 55 mW/m² in the southeastern part. The geothermal feature of these units strong depends on their previous evolution, age of their extension and inversion.

The ancient Georgian crust block which lies between the Greater and Lesser Caucasus is characterized by decreased heat flow values ranging from 40 to 50 mW/m². On the Moesian and Scythian Plates, the heat flow density increases to an average of 50 to 60 mW/m².

Some anomalies of increased heat flow (60 to 80 mW/m²) can be associated with Mesozoic – Cainozoic extension (Karkinit, Indol, Stavropol) and folding (Prikumsk, Kanev – Beresansk, Tarkhankut uplifts) zones. In contrast to the increased heat flow of rift zones the Alpine fore deep show low heat flow values (35 to 50 mW/m²). They depend on the age of the original basement. Low heat flow (20 to 50 mW/m²) found in intermountain depressions and the inner sea basins (Rioni, Kura, Black Sea and South – Caspian) i.e. over subduction sedimentary basins.

Introduction

The Caspian – Caucasus – Black Sea region is distinguished by a complicated geological structure. According to tectonic maps this region includes the margin of the pre Cambrian East-European platform, the Scythian Palaeozoic plate, the Alpine folded areas of the Greater Caucasus, the Lesser Caucasus and the Southern Crimea, old Dzirula Massif, Indol-Kuban' and Terek-Caspian foredeep, the Black Sea, Rioni, Kura, Southern Caspian intermountain depressions. Now there are about 1400-heat flow determinations.

The heat flow density varies from 25-30 mW/m² to 100 mW/m² and in local anomalies to 140 to 150 mW/m². (Figure 1) There are several heat flow density levels defined by evolution and structure of the lithosphere. The pre-Cambrian structures is characterized by low heat flow density — 35 to 50 mW/m². On the Palaeozoic Scythian plate (Figure 2), the background values of heat flow density are 50 to 60 mW/m². A number of anomalies of different form, size, sense, intensity are distinguished against this background. Heat flow values within them increase to 70 to 80 mW/m². Strong regional and local variations of geothermal activity are found in various parts of the Alpine belt and mountainous system. The central part of the Greater Caucasus is generally marked by high heat flow (70 to 145 mW/m²) but on the northwest and southeast flanks of the heat flow values decrease to 40 to 60 mW/m². In the Lesser Caucasus heat flow varies from 65 to 95 mW/m² and 80 to 100 mW/m² is reported for the Armenian Highland. The Crimea Highland is characterized by rather low heat flow, which does not exceed 55 mW/m². Low heat flow density averaging 30-50 mW/m² predominate in the Indolo – Kuban', Terek – Caspian foredeep, and in the Kura, Rioni, Black Sea, South – Caspian intermountain depressions, Sorokin and Tuapse trough before the Crimea and Caucasus orogenies.

Figure 3 shows profile crossing the Central part of the Greater Caucasus Orogen, the Dzirula massif and the Rioni depression. We can see the southward vergent thrusting of the Greater Caucasus, Jurassic sedimentary and volcanic successions related to back-arc basin formation and old Paleozoic basement. Along profile, increased heat flow values (50-60 mW/m²) predominate. Low heat flow is observed in the Rioni depression and high heat flow in the volcanic Elbrus area of the Greater Caucasus.

Figure 4 shows geological situation and heat flow distribution along profile crossing the Lesser Caucasus and the Araks depression to the south and Kura depression to the north. The Lesser Caucasus is characterized high heat flow (65-90 mW/m²). Maxima values correspond to volcanic area of the Armenia Highland. Low-heat flow values are observed in the Araks and Kura depressions with the thickest sediments and old basement. In general deep sedimentary basins are characterized by low heat flow density resulting from rapid sediment accumulation in Pliocene – Quaternary stages.

Conclusions

- There are several heat flow levels in the Caspian – Caucasus – Black Sea region defined by the structure and time of tectonic activity of the lithosphere.
- The surface heat flow density varies from 20 to 30 mW/m² to 100 to 150 mW/m². The increased heat flow values are predominant. Abnormally low heat flow (20-40 mW/m²) is found in sedimentary basins. Zones of young tectonic and volcanic activity are distinguished.
- A characteristic feature is heat flow density anomalies running transversal to the main course of the Alpine units. They are related to deep fault zones crossing these structures (from the Arabian plate to the peri-Caucasus region).
- From an analysis of the heat flow distribution on the map a conclusion can be drawn on the genetic relationship between the heat flow pattern and the tectonic evolution of the Caspian – Caucasus – Black Sea region, its position between the still converging Eurasia and Arabian – Africa lithosphere plates within the wide zone of continent-continent collision.

Selected References

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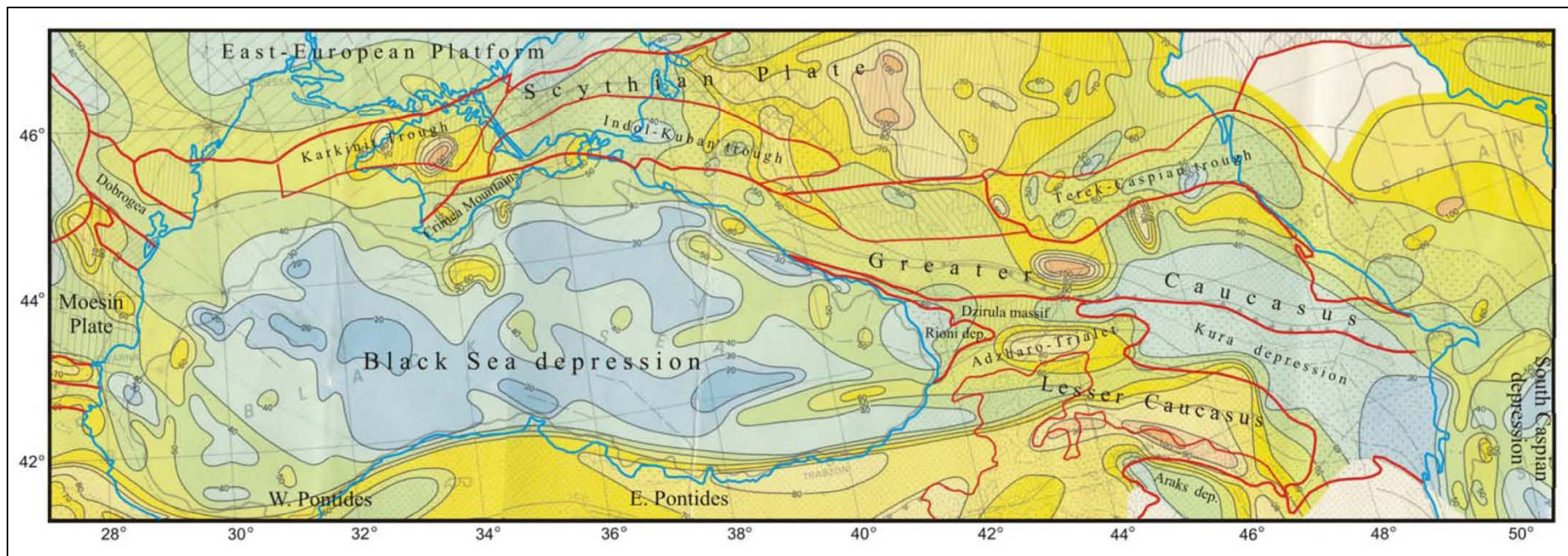


Figure 1. Heat flow distribution in the Caspian – Caucasus – Black Sea region.

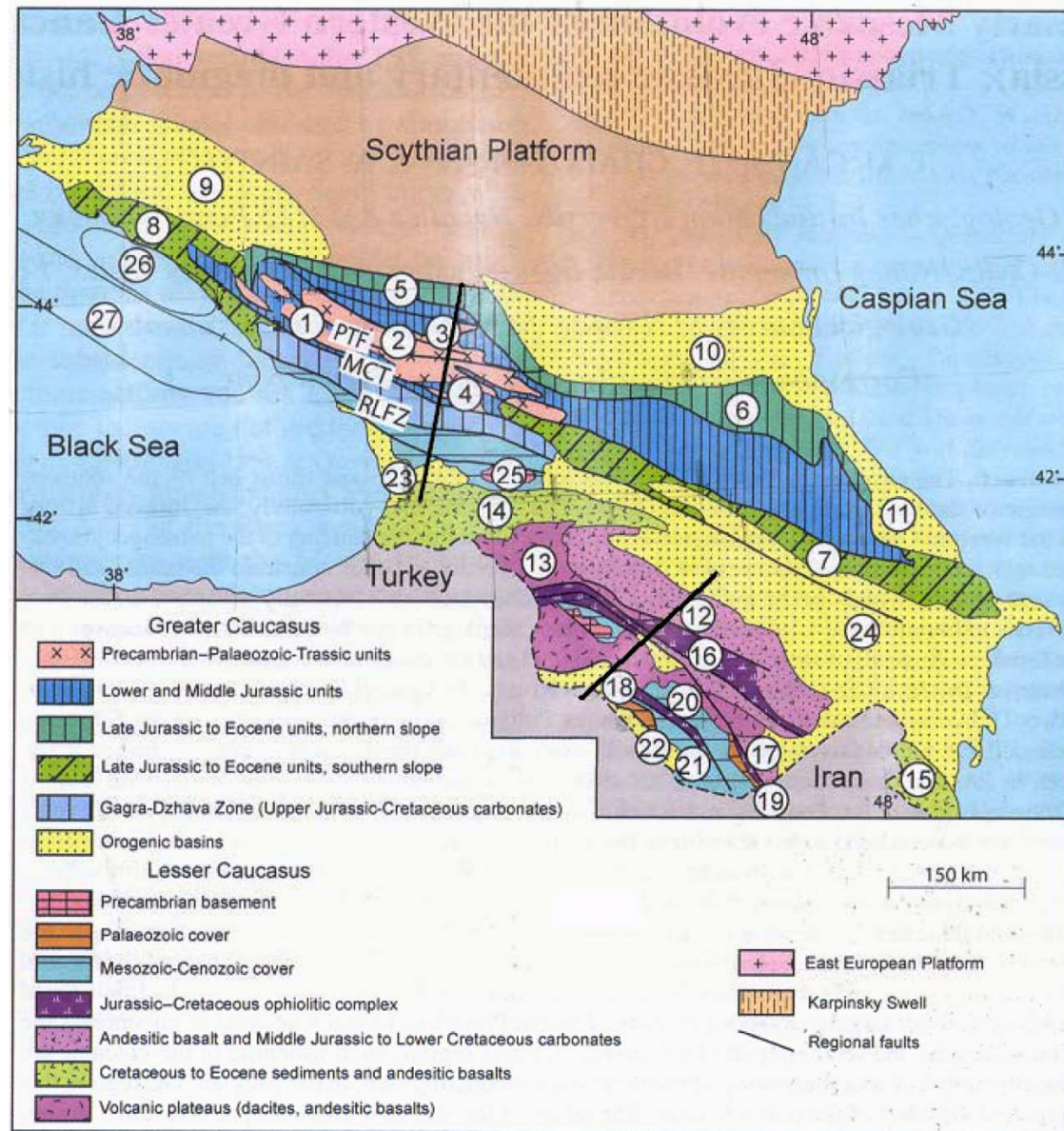


Figure 2. Simplified geological map of the Caucasus and location of cross-section of the Greater and Lesser Caucasus.

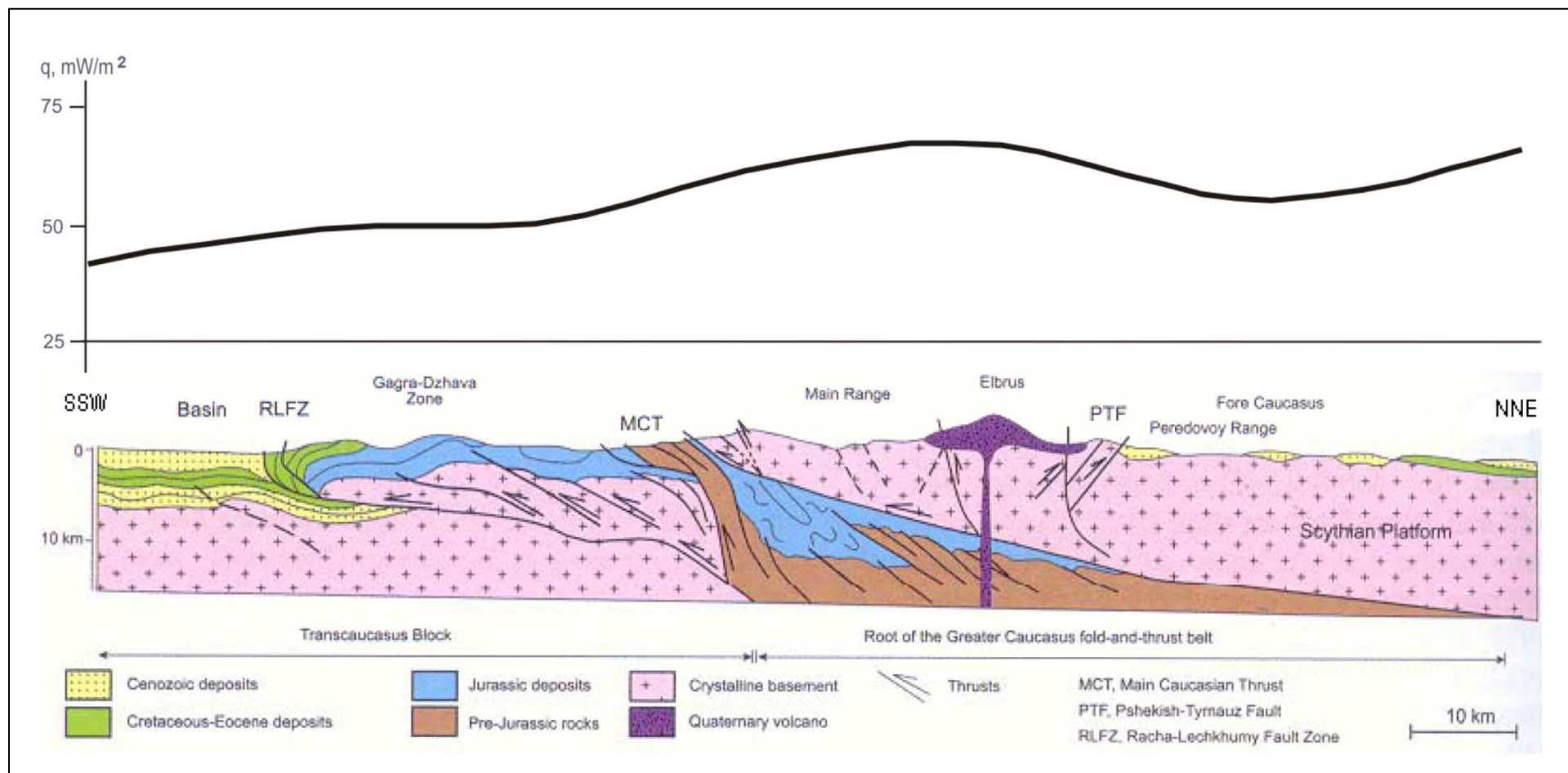


Figure 3. Heat flow density (mW/m^2) along geological cross-section across the Central part of the Greater Caucasus and the Rioni basin (after Dotduyev 1989, McCann et al, 2010).

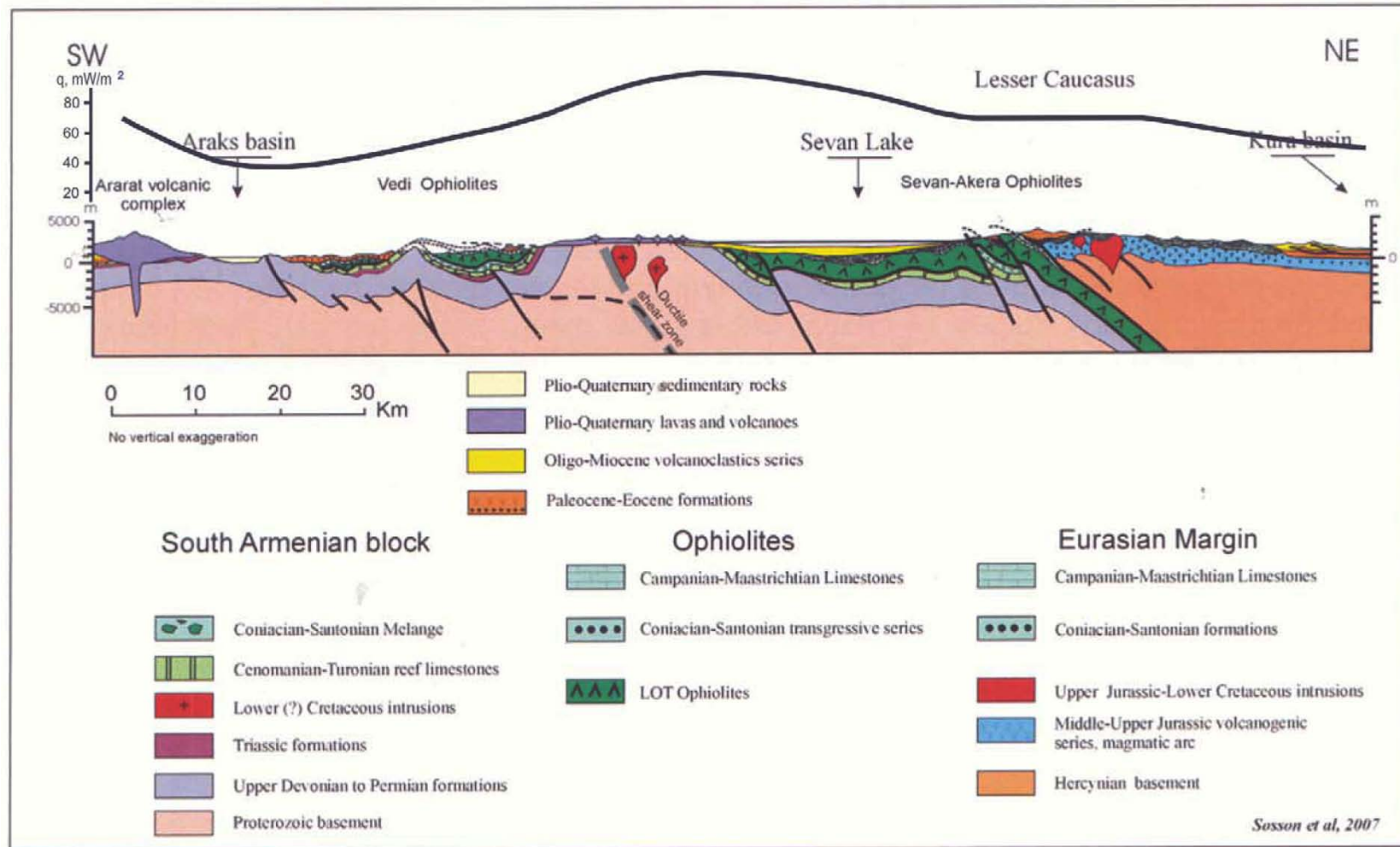


Figure 4. Heat flow density (mW/m²) and geological cross-section of the Lesser Caucasus (after Sosson et al., 2010).