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Solid Earth Discussions

Interactive comment on "The thermal structure of Israel" *by* E. Shalev et al.

E. Shalev et al.

eyal@gsi.gov.il

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Dear Dr. Williams,

Thank you for taking the time and effort to review our paper. We appreciate your constructive comments. We have addressed all of the points you raised and we think that our paper has been significantly improved by taking these comments into account. Please see our answers to your questions below. Sincerely,

Eyal, Vladimir, Yishai, and Zvi.

"The heat flow measurements represent a wide range of qualities, from equilibrium temperature logs with thermal conductivity measurements from the same borehole to uncertain Bottom Hole Temperature (BHT) measurements with assumed thermal conductivity values. The authors need to discuss these inherent uncertainties and present the heat flow measurements with associated uncertainty estimates. The mapped heat flow values are highly variable, and it is not at all clear to the reader what fraction of the variability represents true variations in background crustal heat flow as opposed to inherent uncertainties in the heat flow determinations. The BHT corrections in particular seem arbitrary and poorly constrained. The correction used by the authors was developed for particular conditions in North America basins dominated by sandstone and shale sequences, and, given the numerous contrasting approaches to BHT correction applied around the world, there is no particular reason to believe that this correction is applicable to boreholes in Israeli limestones. Similarly, the thermal conductivity values used for formation averages are incompletely documented, with no indication given as to the associated uncertainties."

Answer: We think that the error in BHT is associated with the drilling mud and technology (not lithology) and therefore the same correction can be applied for different lithologies. Indeed, the corrected BHT was compared to accurate DST measurements (figure 3) and showed a good agreement between the corrected BHT and DST, and that the correction developed for North America applies to Israel as well. In North America this correction has also been applied to different regions with variable lithology, we have emphasized this point in the text. The different methods of measuring the temperature are consistent and the error of each could be a few percent. However, the conductivity estimation could be different in each borehole and lead to an additional uncertainty of the estimated heat flux.

"Following on the heat flow measurements, the authors estimate crustal temperatures using the well-known relationship for temperature in a crust with an exponential decrease in radiogenic heat production with depth. This should be a relatively straightforward process, yet the authors make some unusual choices without justification. For example, they assume zero heat production in the sediments, when the value, even if low, should still be consequential for thermal modeling. In addition, they estimate the mantle heat flow to a geotherm constrained by a very high value of radiogenic heat production obtained from the a table of values for the Sierra Nevada batholith in Turcotte and Schubert (1982). This value should properly be referenced to Art Lachenbruch's original work on heat production in the Sierra Nevada, and both the Turcotte and Schubert table and Lachenbruch's work show the value of 3.7 used in this paper to be at the extreme end of heat production values in that province. The resulting geotherms and mantle heat flow values are not shown by the authors, but there should be some anomalously extreme and unrepresentative geotherms given the choices regarding heat production."

Answer: Indeed, this paragraph was not written well. We were trying to write this paragraph succinctly, but as the reviewer noted this resulted in errors. We have now corrected equation 2. The equation suggested by the reviewer was used for the sedimentary cover and an equation that takes into account the radiogenic heat was used for the basement. We have used radiogenic heat generation of 0.37μW m$-$3 and not what was incorrectly written before (sorry for typo).

"Finally, despite the relatively average heat flow in Israel (which does seem to be a robust result), temperatures at depth remain surprisingly high, exceeding 200 Celsius at 10km over most of the country. The authors should explicitly evaluate their deep crustal geotherms in the context of the observed deep seismicity, which implies temperatures no higher than 400 Celsius at depths as great as 32 km or more."

Answer: The purposes of this study were to present the complete data and to evaluate the regional heat flux. We noted in the text that the seismicity in a large part of the Dead Sea fault is anomalously deep, extending almost to the mantle. This deep seismic activity suggests that the lower crust might be cold and brittle, and thus is consistent with a low heat flow of 40 mW/m2, suggested by Aldersons et al., (2003). The presented results confirm a relatively low heat flux, considerably below the world average value. In our study all measurements were taken down to a depth of 6 km. Below this depth, the temperatures are less reliable and are modeled assuming certain radiogenic heat production and thermal conductivity. Therefore, we present the set of maps with temperature distribution no deeper than 10 km. According to the geotherm estimated by Aldersons et al., (2003), the temperature of 200 C is expected at about 12-13 km depth. The depth extrapolated temperature predicts that 200 C temperatures maybe reached at 9-11 km depth. These relatively small differences maybe attributed to the uncertainty in the chosen values controlling radiogenic heat production. These values are compatible with deep seismic activity. We emphasize this point in the discussion section.

Interactive comment on Solid Earth Discuss., 3, 431, 2011.