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Solid Earth
Discussions

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

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Dear Dr. Shalev,

Based on my assessment of the reviews and your resubmission, I regret to inform you that significant modifications are still required before possible publication of your manuscript. As the text (p. 5, top) states, "the purpose of this paper is to re-examine the geothermal heat data collected in Israel for the past 50 years and to determine the average geothermal heat flux in Israel". For this reason, documentation of available heat flow measurements with a critical assessment of data quality and thermal properties of near-surface rocks as well as a discussion of heat flow data within the frame of regional tectonics is thought to be the focus of the paper. These data complemented by thermal modeling could further provide an important information on thermal state of the lithosphere, which is critical for thermo-mechanical models of lithosphere deformation.

The reviewers have raised serious questions related both to the overview of heat flow data and to the thermal modeling. This criticism has been only partially addressed in the revised version. For this reason, the revised version of the manuscript cannot be accepted for the publication until all questions raised by the reviewers are fully and properly addressed.

1. Heat flow data

1.1. Ref #1 has asked to provide a table with all the heat flux estimates and relevant information (geographical coordinates, average temperature gradient and thermal conductivity assumed, depth interval). In the revised version, the authors provide borehole data in supplementary table, however no information is given as on the depth of the boreholes. Thus the authors' response that "in the sedimentary cover, borehole data is abundant and temperatures are constrained throughout the sedimentary layers" is not substantiated by the presented data. According to Figures 2 and 3, many boreholes cut less than a half of the sedimentary thickness and even the deepest shown (Helez) does not seem to reach the basement.

1.2. Ref #2 has asked (i) to discuss the inherent uncertainties associated with BHT measurements, (ii) to present uncertainty estimates of the heat flow measurements, and finally (iii) to discuss "what fraction of the variability represents true variations in background crustal heat flow as opposed to inherent uncertainties in the heat flow determinations".

None of these problems is addressed in the revised manus. As pointed out by Ref #2, while in conventional borehole measurements, thermal conductivity is measured together with measurements of equilibrium temperature logs, in BHT measurements thermal conductivity values are assumed, which leads to significant uncertainties in reported heat flow values. Fig. 3 indicates a significant additional uncertainty of the BHT method associated with a large scatter of temperature gradient, at least in some of the boreholes.

Ref #2 also pointed out that "the thermal conductivity values used for formation averages are incompletely documented, with no indication given as to the associated uncertainties". This question has not be addressed in the revised manuscript. For these reasons, uncertainties in the heat flow determinations are still not specified.

2. Thermal model

The presented thermal model and the choice of the model parameters has been seriously criticized by both of the reviewers. Both referees commented on: (i) unjustified choice of zero heat production in the sediments; (ii) unrealistic value of average heat production in the basement (3.7 microW/m3); (iii) incorrect equation used for temperature calculations; (iv) incomplete information on thermal conductivity values. The revised manus addresses only some of these questions. (ii) The high value of average heat production in the basement caused by typo has been changed to 0.37 microW/m3. (iii) The equation has been corrected for a layered medium. (iv) Some information regarding thermal conductivity values has been provided in the authors' response, but not in the revised text. Thermal model as presented in the revised version still causes serious questions.

2.1. One of the major criticisms of both of the reviewers is an assumption on zero heat production in sediments, since its contribution to heat flow can be high and its effect on thermal state of the crust can be important. This critical point has been completely ignored in the revision. Since the manuscript provides no information about regional laboratory data on near-surface heat production, the choice of zero heat production is unjustified. The contribution to heat flow from the sediments can be particularly significant in regions with a thick sedimentary cover (more than 6 km over 50% of the study area!), and can reach 5-10 mW/m2 and more for typical values of heat production in sedimentary rocks (i.e. 10-20% of the values reported in the Supplementary Table). This would significantly reduce estimated temperatures.

2.2. The average value of 0.37 microW/m3 of basement heat production is unrealis-

tic. Such values are typical of the continental middle-lower crust, while average crustal heat production is significantly higher. Numerous geophysical and petrological, global and regional, studies indicate that average heat production in the post-Archean crust is between 0.6 and 1.3 microW/m3 (for overviews see McLennan and Taylor, 1996; Rudnick et al., 1998; Artemieva and Mooney, 2001; Jaupart and Mareschal, 2007, 2010). On the same note, surface heat flow values alone are insufficient to characterize deep crustal (lithospheric) thermal state (p. 4, bottom), since they are controlled not only by mantle heat flux but also by thermal properties of the crust and its heat production, in particular. For example, for the same surface heat flow of 60 mW/m2, temperature at a 25 km depth can be 500 deg C or 350 deg C (for average crustal heat production of 0.4 and 1.0 microW/m3, correspondingly, and crustal conductivity of 2.5 W/K/m).

3. Results

The results of the thermal modeling are shown as a series of four maps for depths 4, 6, 8, and 10 km. Temperatures in Figs. 5-6 are largely within the sediments and, since no heat production in sediments is assumed, are calculated simply as [Qs*depth/1.8]. Only Fig. 8 shows temperatures within the basement. It is not clear, why the deepest slice is for 10 km depth only. What are Moho temperatures and how do they compare with the depth distribution of seismicity? Ref #2 pointed out that "despite the relatively average heat flow in Israel, temperatures at depth remain surprisingly high... The authors should explicitly evaluate their deep crustal geotherms in the context of the observed deep seismicity". This question has not been addressed in the revised manus, and only some comments are provided in the author's response letter.

Furthermore, an x-y plot illustrating a comparison of xenolith P-T arrays with the geotherms constrained in this study would be useful.

4. Other comments

Several minor suggestions have been proposed by the reviewers, such as to include a tectonic map of the region, to indicate the coordinate system used for the maps, to show xenolith locations. These questions have been addressed in the revised version. However, the new Fig. 1 is still insufficient for understanding the tectonic background of Israel; it illustrates some features of the large-scale regional tectonics, but not the tectonics of the study region. It would be useful to show tectonic provinces mentioned in section 2.

The authors are advised to address properly all the questions raised by the reviewers and by the editor. The resubmission should explain how and where each point of the reviewers' comments has been incorporated; in case you disagree with any part of the reviews, please explain why. An annotated version of the revised manuscript should also indicate the changes made to its content.

Sorry for this negative feedback at the moment. Best regards, Irina Artemieva

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