The Global Heat Flow Database: a collaborative and fundamental revision to ensure comprehensible and reliable heat-flow records

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The Global Heat Flow Database

"A database provided by the IHFC since 1963"

**Introduction**
- What is heat flow?

**Motivation**
- Database Status Quo
- Requirements for good data

**The Project**
- Objectives & Community Approach
- The new database structure

**Outlook**
- Data Release 2021
- Data Assessment 2021-2025

**The IHFC:**
A service to the geoscientific community.
What is heat flow?

Heat flow describes the transport of heat from the Earth’s interior due to the temperature difference between the core and the Earth's surface.

Heat flow $q$ can be calculated using the rock thermal conductivity ($\lambda$) multiplied by the temperature gradient ($\nabla T$) for a specific depth interval.

Fourier’s law of heat conduction

$$q = -\lambda \cdot \nabla T$$
Heat flow data: why is it important?

Heat flow represents a fundamental parameter in thermal studies.

- Input as model boundary condition, for calibration or validation
- Geodynamic modelling
- Mineral resources & geothermal energy
- Tectonics modelling
- Geological storage
- Paleoclimate
Status quo & Challenge

- Systematically collected since almost 60 years
- The database reflects changes in methodology, technology and data handling over that period
- Challenge: transformation of a paper-based data compilation with respect of digitization and evolution of database technologies
- Database quality is unclear and in the focus of an community debate for years
- Fundamental revision of the Global Heat Flow Database is required and was initiated by the IHFC in 2020
Requirements for „good“ data

Reproducible, well-documented data

FAIR data principles are created to make research data findable, accessible, interoperable and reusable.

Data support the idea of open science and interoperability
Objectives & Community Approach

**Goal:** An authenticated database containing information on the type and the quality of heat-flow data

**Objective:** Defining a new structure with detailed metadata descriptions to fulfil the requirements of modern research data

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**Surveys**

- **Goal:** Open online survey to learn about the experiences and expectation of the community in respect to the GHFDB
  - **April 2020**

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**Workshops**

- **Objective:** Series of online meetings and digital workshops to develop a new structure for the GHFDB
  - **May – Nov 2020**

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**Writing**

- **Objective:** Collaborative writing of the new specifications.
  - **… – Jan 2021**
The new database structure

1) **A parent-child system** is the key innovation

**parent level** → main location information (e.g., geographical position, and associated metadata)

→ q represents the best location heat flow
→ one location = one parent entry

**child level** → At least one but often multiple child entries (child level) per parent entry

→ Multiple child entries result from either determinations obtained over different depth intervals and/or determinations of different age, status, methodological approaches and/or by different authors.
The new database structure

2) Items depends on data origin → Borehole/Mine versus Probe sensing or both

Number of database fields depends on the measurement type.

<table>
<thead>
<tr>
<th></th>
<th>Borehole/Mine</th>
<th>Probe sensing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mandatory</strong></td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td><strong>Recommended</strong></td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td><strong>Optional</strong></td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

**Parent level**

- **Heat Flow**
  - Heat-flow value q
  - Heat-flow uncertainty
- **Meta data & Flags**
  - Site name
  - Geographical latitude
  - Geographical longitude
  - Primary reference
  - Geographical environment

**Child level**

- **Heat Flow**
  - Heat-flow value q
  - Heat-flow uncertainty
- **Meta data & Flags**
  - Relevant child
  - Heat transfer mechanism
  - Flag in-situ properties
  - Flag temp correction
  - Flag sedimentation effect
  - Flag erosion effect
  - Flag topographic effect
  - Flag climatic effect
  - Flag convection effect
  - Flag heat-refraction effect
  - Additional child reference
  - Date of acquisition
  - Stratigraphic age
  - Rock type
  - Flag bottom-water effect

- **Temperature**
  - Temperature gradient
  - Gradient uncertainty
  - Number T recordings
  - Mean gradient corrected
  - Gradient cor. uncertainty
  - T method (top)
  - T method (bottom)
  - Shut-in time (top)
  - Shut-in time (bottom)
  - T correction method (top)
  - T correction method (bot)
  - Probe lift

- **Thermal conductivity**
  - TC mean
  - TC source
  - TC saturation
  - TC pT conditions
  - TC method
  - TC pT assumed function
  - TC uncertainty
  - TC number
  - TC averaging method
  - IGSN
<table>
<thead>
<tr>
<th>Field name and properties</th>
<th>Field Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>q</code></td>
<td>Heat-flow value (mW/m²)</td>
</tr>
<tr>
<td><code>q_uncertainty</code></td>
<td>Heat-flow value uncertainty (mW/m²)</td>
</tr>
</tbody>
</table>

Example of field descriptions:

Example for one dataset


Example for one dataset
Outlook


Contains 74,548 heat-flow data from 1,403 publications; continental domain: 55%; oceanic domain: 45%

Supporters and collaborators

GLOBAL HEAT FLOW DATA ASSESSMENT PROJECT
1st May 2021 - 2025

- Global collaboration of volunteering scientists and institutions
- Review and update the global heat flow database publication by publication
- Provide a quality controlled, authenticated global database of heat flow

Join us!
assessment.ihfc-iugg.org
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Key challenge

Transforming 80 years of paper-based global research on heat flow data into a authenticated F.A.I.R., open and interoperable database?

1 | Why heat flow?

2 | How we did it – the new structure

3 | Keeping the pace – the Global Heat Flow Data Assessment starts now

Your benefits?