Microtemperature signals in boreholes as precursors of earthquakes

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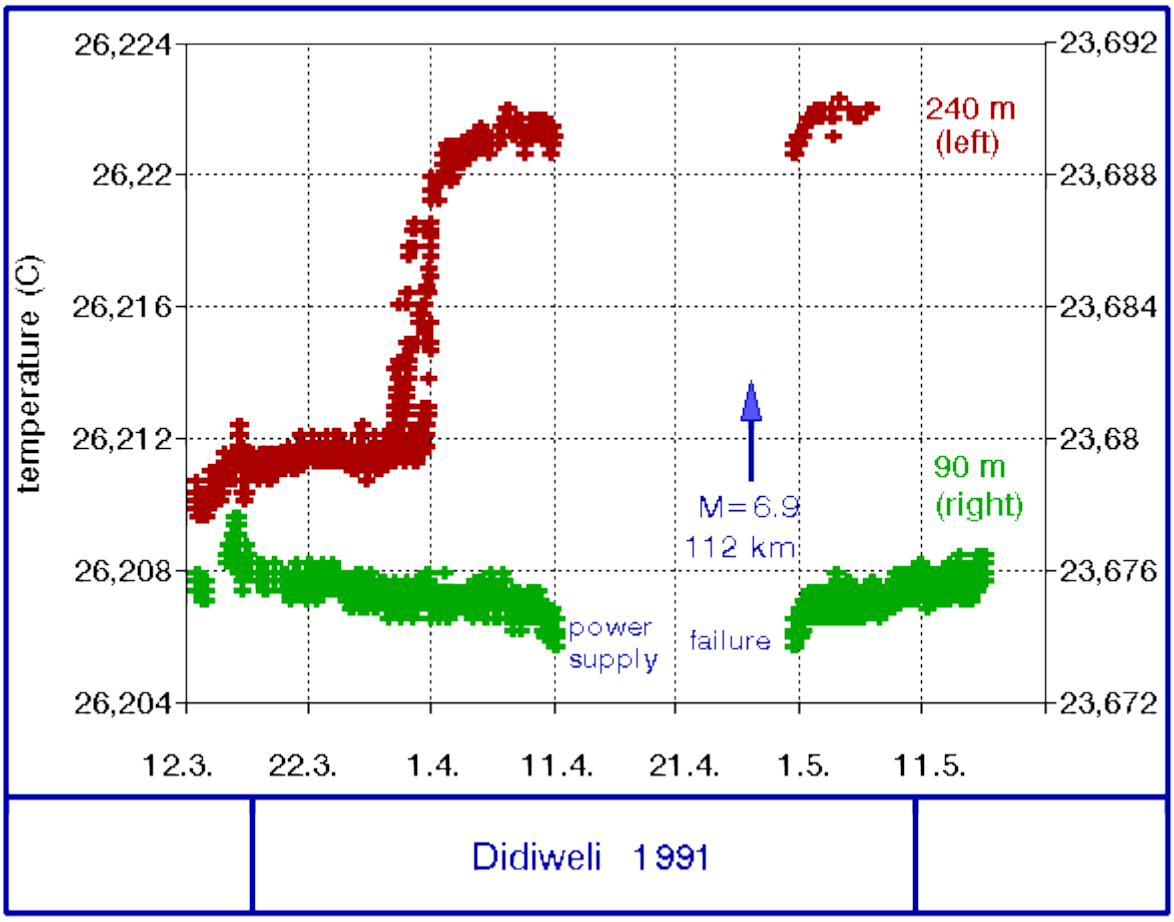
Temperature variations in the uppermost crustal layers result from several external as well as internal effects. These variations superpose the basic and rather stable energy flow from the earth's interior, which is about 40 to 60 mW/m^2 at the surface.

Variations of the surface temperature, caused by diurnal, annual or long-term waves, jerks or other changes, dissipate into the subground to different extents and may be detected by measurements in the subground. Also environmental conditions, e.g. the cutting of forest in medieval times, cause a variation of the subsurface temperature.

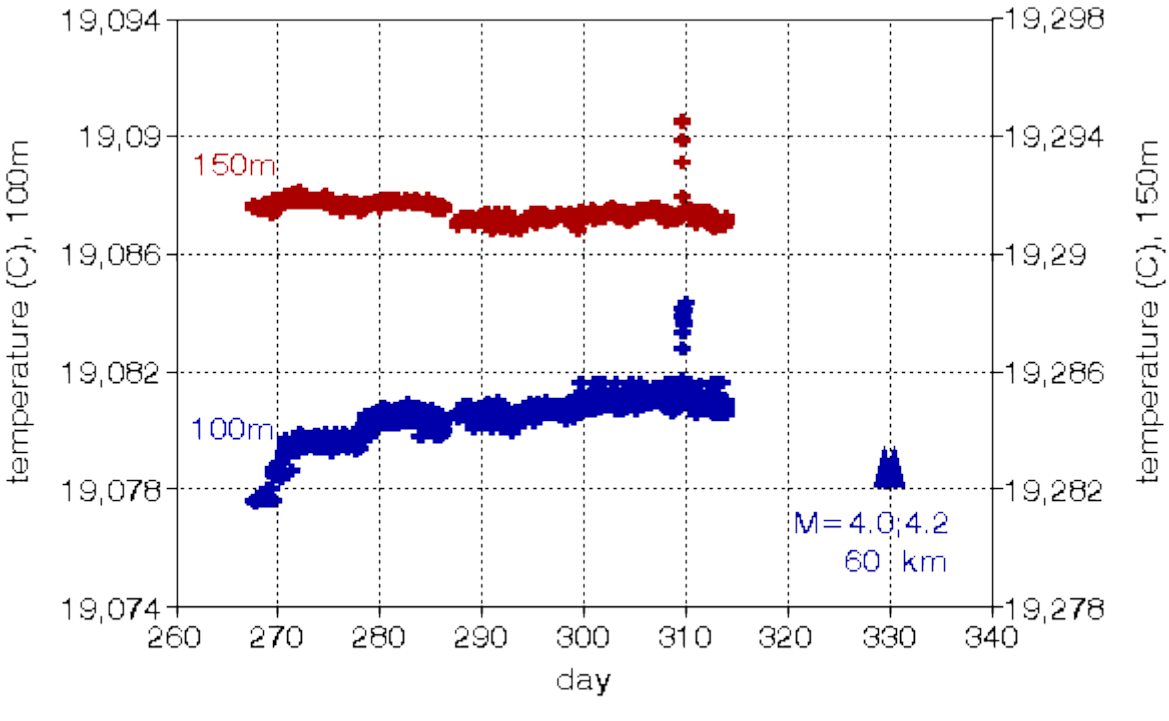
Variations of the nearly stationary heat flow through the mantle and the lower crust, may be barely detectable by measurements over a few years. Nevertheless, local or regional variations in temperature occur. These are due to geodynamical effects. The tides of the solid earth and variations of the tectonical stress can cause, or result in, a differential mass motion between the rock matrix and the pore fluid under specific structural conditions, and these relative motions of the pore fluid with respect to the rock matrix yield a temperature variation at a thermometer which is fixed on the casing of a borehole. This water movement is relatively small and barely exceeds a few centimeters in its vertical component, which means that the expected temperature variations reach amplitudes of milli-Kelvin.

The resolution of the thermometers which are used is approximately a quarter of one milli-Kelvin. The quartz sensors used are very stable in time and do not exceed the resolution within one year. Therefore, they are applicable for long-term registration. The sensor electronics comprises the oscillator, a frequency divider and a chopper for 2-wire-connection. The transduced frequency is measured at the surface with high accuracy of 10-5Hz and stored on computer.

Microtemperature variations are reported (Buntebarth et al. 1997) which were recorded in the Transcaucasus and in Turkmenistan since 1992. The variations are understood as precursory phenomena of earthquake in these regions. It is demonstrated that jerks, excursions and steps occur whose amplitude and/or width of its half value relate to the tectonic activity, i.e. in this case to the subsequent magnitude and distance of the earthquake. Two examples are shown in figs. 1 and 2. Didiweli is located in the Transcaucasus and Firjusa in Turkmenistan.



Didiweli 1991



Firjusa/Turkmenistan **1995**

From the data it can be estimated that the variations of temperature are several milli-Kelvin and that of temperature gradient are several tens of mK/km. The variations occur a few days before the onset of earthquakes of M * 4-5 and a few weeks before strong earthquakes.

Reference:

Buntebarth, G., Belikov, V.M., Ishankuliev, G.A., Kumsiashvili, G.: *Jerks and long-term variations in borehole temperatures in the Transcaucasus and near the Kopet Dagh front in Turkmenistan*, Cahiers du Centre Européen de Géodynamique et de Séismologie, 1997, in print.