Heat flow, geothermal gradient, and the thermal conductivity of sedimentary rocks

Understanding the time and place of maturation of source rocks for petroleum requires an understanding of past geothermal gradients. We of course can't go back in time to measure those geothermal gradients, so we have to estimate them. Attempts to estimate past geothermal gradients commonly involve modeling of the flow of heat through layers of sedimentary rock.

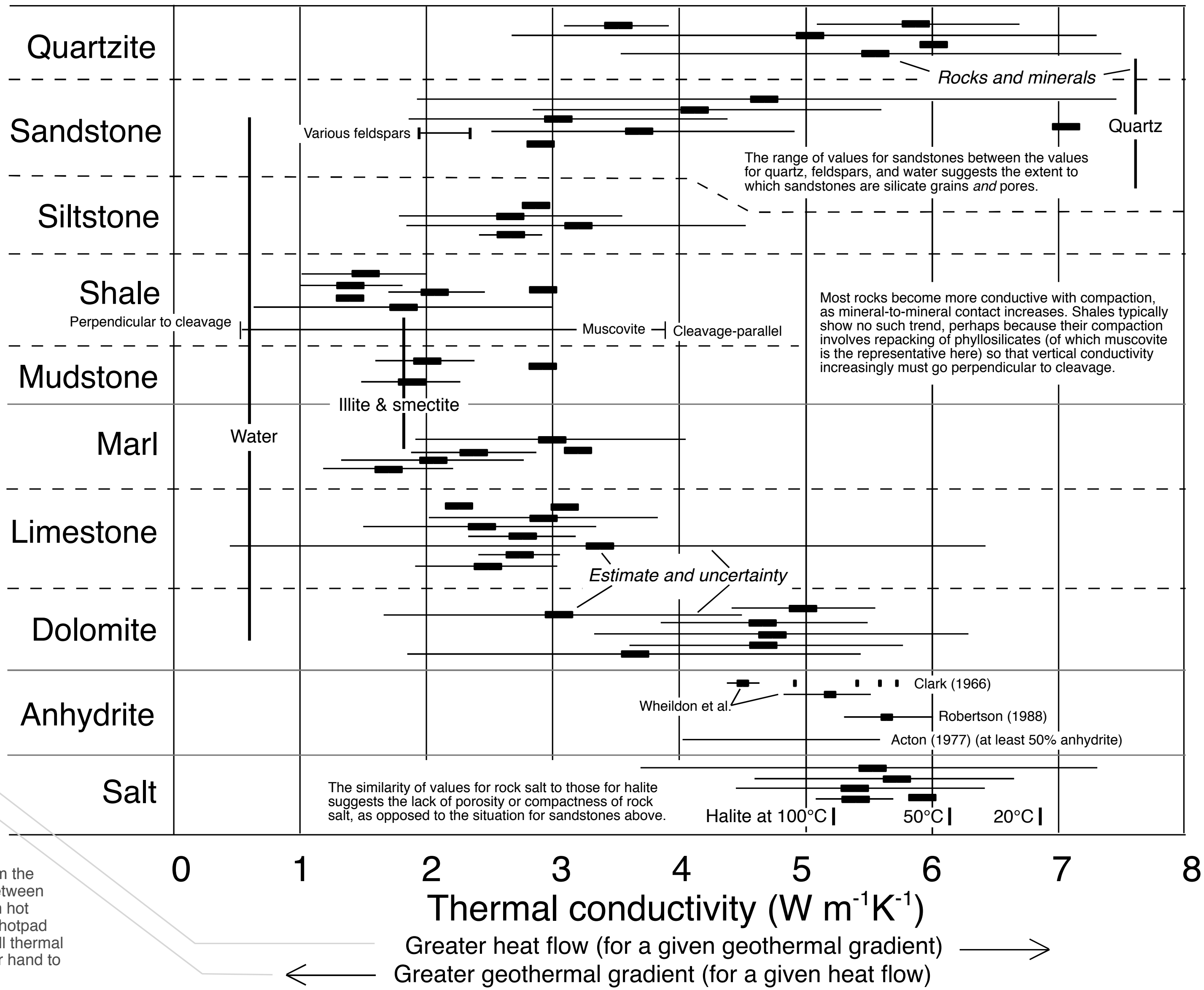
Between the terms heat flow (Q), thermal conductivity (c), and geothermal gradient (dT/dz),

$$Q = c \times dT/dz$$

or alternately

$$dT/dZ = Q \div c$$

If one can make a reasonable assumption about the past heat flow in a sedimentary basin, one can use the thermal conductivity of the strata in the basin to calculate the geothermal gradient at any given time and thus estimate the past distribution of temperatures. The data at right show that shales have small values of thermal conductivity, whereas more quartzose siliciclastics and purer carbonates have greater values. Values are greatest for halite.



If the relationship at right between thermal conductivity and geothermal gradient isn't intuitively obvious, consider this example: when you take a hot item from the oven, you want a steep thermal gradient between that item and your hand (you want that item hot and your hand cool). To do that, you put a hotpad (an insulator and thus an object with a small thermal conductivity) between the hot item and your hand to enforce the desired large thermal gradient.

Data for rocks are from results listed in Table 4.2 of Beardsmore and Cull (2001) *Crustal Heat Flow* (Cambridge University Press); Data for pure substances are from the same and from p. 254 of Bjørlykke (2010) *Petroleum Geoscience* (Springer).

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