## 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

enforce the desired large thermal gradient.

Quartzite Rocks and minerals Sandstone Quartz Various feldspars The range of values for sandstones between the values for quartz, feldspars, and water suggests the extent to which sandstones are silicate grains and pores. Siltstone Shale Most rocks become more conductive with compaction as mineral-to-mineral contact increases. Shale's typically Perpendicular to cleavage show no such trend, perhaps because their compaction Muscovite - Cleavage-parallel involves repacking of phyllosilicates (of which muscovite is the representative here) so that vertical conductivity increasingly must go perpendicular to cleavage. Mudstone Illite & smectite Water Marl Limestone Estimate and uncertainty **Dolomite** ■ ■ Clark (1966) **Anhydrite** Robertson (1988) Acton (1977) (at least 50% anhydrite) Salt The similarity of values for rock salt to those for halite suggests the lack of porosity or compactness of rock salt, as opposed to the situation for sandstones above. Halite at 100°C 20°C gradient isn't intuitively obvious, consider 5 0 6 this example: when you take a hot item from the oven, you want a steep thermal gradient between Thermal conductivity (W m<sup>-1</sup>K<sup>-1</sup>) that item and your hand (you want that item hot and your hand cool). To do that, you put a hotpad Greater heat flow (for a given geothermal gradient) —— (an insulator and thus an object with a small thermal conductivity) between the hot item and your hand to Greater geothermal gradient (for a given heat flow)