Heat Flow and Thermal Maturity in the Williston Basin

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Calculations of thermal histories of sedimentary basins are commonly based on thermal-isostatic models of basin subsidence. This approach is valid in single-event crustal rifting settings, but it can yield inaccurate results when applied to intracratonic settings such as the Williston Basin that experienced multiple subsidence events having no clear link to rift activity. In such cases, thermal history calculations rely on accurate determination of present-day heat flow and estimates of past heat flow that take into account regional tectonic history. However, this also can be problematic where undetected non-tectonic or transient thermal signals affect present-day heat flow. Several observations lead us to suggest that the geothermal gradient in regions near the Pleistocene ice margin may contain a transient signal that causes significant underestimation of present-day heat flow. The observations are: (1) heat flow increases with depth in northern hemisphere periglacial regions; (2) surface heat flow in southern hemisphere shields averages 40 percent more than heat flow in northern hemisphere shields; (3) thermal gradients in thick clastic sediments should decrease with depth due to an increase in thermal conductivity due to compaction, but we observe increases in the gradient in all deep equilibrium temperature logs in the Williston Basin; (4) thermally mature Bakken has been reported in regions outside the expected thermally mature zone. These observations lead us to advance the hypothesis that post-glacial warming in northern hemisphere continents may have been of the order of 10° C to15° C rather than 3° C to 5° C as is generally accepted in terrestrial heat flow research. If this hypothesis is correct, some northern hemisphere heat flow values will require revision by as much as 30 to 60 percent. The implication for the Williston Basin is that the area of thermally mature Bakken Formation may be significantly larger than is currently believed. This hypothesis could be tested in the Williston Basin by coring and measuring thermal conductivities of rocks from the upper two kilometres and by obtaining an equilibrium temperature vs. depth profile in the borehole.

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