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Influence of sill intrusions on the hydrology and thermal maturity of sediments – Modelling heat flow and organic geochemical alterations

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In a variaty of continetal margins worldwide, sill intrusions had a significant influence on the fluid flow and on the thermal alteration of the sediments. We present concepts of fluid and/or gas flow within the contact aureole of sills. Water exposed to the high temperatures at the contact will inadvertently be converted into the steam phase. This process is of explosive nature due to the enormous expansion of the specific density of the fluid. High temperatures in combination with the available fluid will build up high pressures around the aureole and lead to fluid or gas flow according to the pressure gradient. From the thermal point of view, the major effect of the steam formation is a drastic reduction of the contact temperature at the sill to near the steam point of the fluid. The temperature value depends primarily on the local hydraulic pressure, which is closely related to the depth of the contact below surface. One consequence of the high pressure regime will be the escape of the steam through fractures wherever available. Geologic evidence from known locations points to the creation of so-called pipes. Through such pipes, the fluids and gases will be carried away from the contact, and with it the thermal energy. Our concept is compatible with observations on hydrothermal vents in sedimentary basins, which are known to be associated with sill intrusions.

To demonstrate the effectiveness of the above concept, we employ a derivate of BGR's heat flow model which has been used and proven as a robust analytic tool in a variety of published studies. Our calculations demonstrate the massive temperature depression caused by the steam production in comparison to the case of pure heat transfer by conduction. After sill emplacement steam generation will ensue until the latent heat for steam formation for the given water volume has been supplied by heat flow out of the sill. During this process, the contact temperature will be kept at the steam point of water for the given pressure at the sill depth. As soon as the latent heat is used up, the heat flow from the sill will drop below the capacity to heat the water to the steam point. The contact temperature will thereafter slowly drop, sediments and sill will proceed to cool jointly.

To test our model with observations, we included routines of kinetic modelling of thermal vitrinite alteration, and compared the computational results to data from different settings worldwide. The comparison between modelled and observational data are in very good accordance.