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Experimental Study of Shale Rock Self-Heating

Francesco Restuccia, Nicolas Ptak, and Guillermo Rein
Department of Mechanical Engineering, Imperial College London, London, United Kingdom (g.rein@imperial.ac.uk)

Self-heating phenomena due to spontaneous exothermic reactions in oxidative environments are common for many porous materials, even at low temperatures. Combustion of shale outcrop formations has been reported in recent years, with self-heating a potential initiating cause. This work studies experimentally and for the first time the self-heating behavior of shale rock, a porous sedimentary rock. Using field samples collected from shale outcrop at Kimmeridge Bay (UK) and the Frank-Kamenetskii theory of criticality, we determine effective kinetic parameters and thermal properties for different shale particle size distributions and upscale the results to field formations of different thicknesses. We show that for fine particle sizes, with diameter below 2mm, spontaneous ignition is possible for rock formations of thickness between 25m and 5.4m at ambient temperatures between 16ºC and 44ºC. For the same temperature range, the required thickness is between 375km and 15km for coarse particles of diameter below 17mm. This shows that shale rock is reactive, with reactivity highly dependent on particle diameter, and self-ignition is possible for small particles in outcrops or formations accidentally exposed to oxygen.