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Clay mineral structural changes and mineralogical transformation in the Devonian Duvernay shales.

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The Duvernay Formation is a stratigraphic unit of the late Devonian (Frasnian) in the Western Canadian Sedimentary Basin containing organic-rich and fine-grained sediments deposited along the western shelf of the North American Craton south of the Peace River Arch. Mineralogical analysis and thermal maturity data of core and cuttings (>500 wells) of the shales presents a unique opportunity to illustrate: a) thermal maturity changes and complexity across the basin and b) clay mineral crystal structural changes associated with increasing burial depth. Regional maps and detailed core analyses are compiled to illustrate origin, transport and processes during diagenesis that explains the current findings and illustrates progressive clay mineral structural transformation associated with formation burial/diagenesis.

Current depths of the Duvernay Formation are typically >1200 m and clay mineral content can exceed 50 wt-% with the majority of Duvernay shales having 20-35 wt-%. Detailed clay mineral analysis in these rocks illustrates the dominance of illite with smaller amounts of nanocrystalline or poorly structured illite with no swelling capacity, chlorite and kaolinite. Source rock analyses show a complex thermal maturity of the organic matter with immature material (Tmax <430°C) in the shallow (~1400-2400 m) eastern part of the basin and high maturity (Tmax >470°C) along the deeper (>3300 m) western deformation front. Within these different thermal maturity areas, clay mineral crystallinity in particular illite/nano-crystalline illite changes which illustrates distinct increasing crystallinity towards the west.

This presentation provides insights into regional source rock and mineralogical changes across the Duvernay Formation and provides details of clay mineralogical structural changes (XRD) and organic thermal maturity (Tmax, TOC). Clay mineralogy in the subbasins of the Duvernay allows interpretations about possible original detrital influx, paleo-ocean currents and paleotopographic relief. Maturity trends and clay mineral transformation at local and regional scales provide specific basin model parameters and thermal maturity information associated with both local basement heat flow and regional burial depth.