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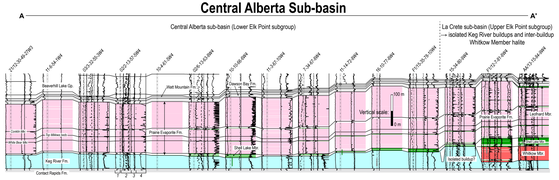
Moving beyond 'salt thickness': a detailed assessment of lithological heterogeneity within salt-bearing evaporite successions in the Elk Point Group of Alberta

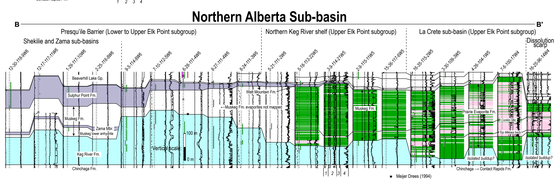
Alberta Energy Regulator | AGS Alberta Geological Survey

Keg River - Praire Evaporite Paleogeography and Evaporite Distribution

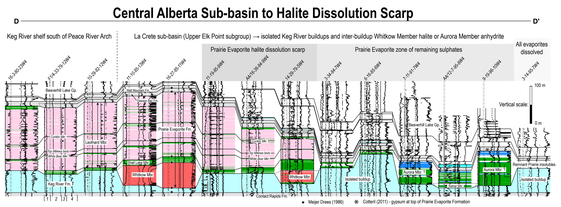
Central Alberta Sub-basin



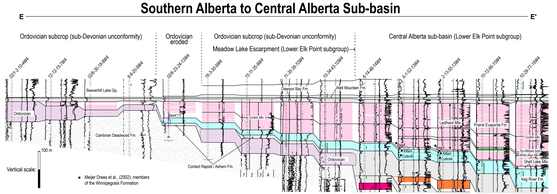
Northern Alberta Sub-basin



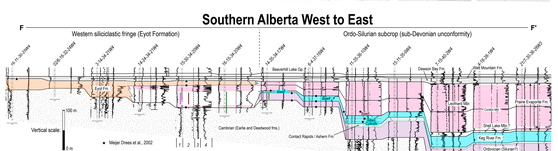
Central Alberta Sub-basin to Halite Dissolution Scarp



Southern Alberta to Central Alberta Sub-basin



Southern Alberta West to East



Logs by track number:

1 Gamma-ray, spontaneous potential, caliper
2 Density/neutron porosity suite, photoelectric
3 Bulk density, sonic
4 Resistivity suite

Net-evaporite pay intervals (Prairie Evaporite):

Prairie Evaporite / Muskeg anhydrite | Whitlow / Telegraph halite | Leofnard salt | Prairie gypsum

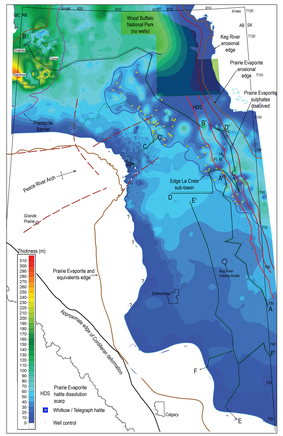


Figure 5. Keg River isopach.

Keg River Controls on Prairie Evaporite Deposition

• The thickness of the Keg River Formation (Fig. 5) has a significant influence on the thickness and member distribution of the overlying Prairie Evaporite Formation (Fig. 6). This influence is particularly evident within the La Crete sub-basin, where isolated Keg River buildups control the distribution of lower Prairie Evaporite salt (Whitkow Member) and anhydrite (Aurora Member) (cross-sections A-A', B-B', and D-D'; Fig. 10).

• Outside of the La Crete sub-basin, the Keg River is shelf-like and lacks isolated buildups. On these shelfal deposits, the lower Prairie Evaporite members are absent (cross-sections A-A', B-B', D-D',and E-E'). Consequently, the thickest Prairie Evaporite deposits and the thickest net salt occurs within the La Crete sub-basin (Figs. 6, 7).

• On the Presqu'ile Barrier, smaller sub-basins (Zama, Shekilie, Rainbow) contain numerous small, isolated Keg River buildups that influence the thickness of Muskeg Formation strata (Figs. 5, 6; cross-section B-B').

Southern Alberta

• In the southern part of the province the salt of the Prairie Evaporite Formation thins onto the sub-Devonian unconformity surface comprising Ordovician carbonates (cross-section E-E'). To the west, salt of the Prairie Evaporite transitions to a western siliciclastic fringe known as the Eyot Formation (Meijer Drees et al., 2002) (cross-section F-F').

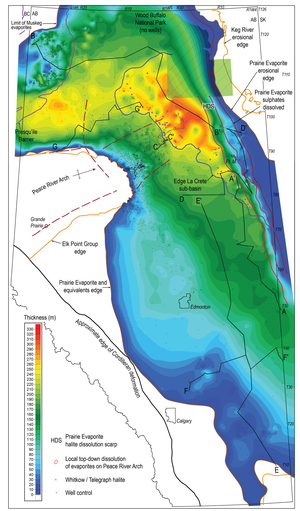


Figure 6. Prairie Evaporite / Muskeg / Eyot isopach.

The Prairie Evaporite–Muskeg Transition

• In central to southern Alberta the upper Prairie Evaporite (Leofnard Member) is predominantly salt parsed by relatively thin non-salt interbeds (cross-sections A-A', D-D', E-E', and F-F'). The Leofnard Member very gradually transitions to anhydrite northwestward where significant salt-anhydrite interbedding is evident (cross-section B-B'; Fig. 10). The distribution of net salt (Fig. 7) and net anhydrite (Fig. 9) display this gradual transition.

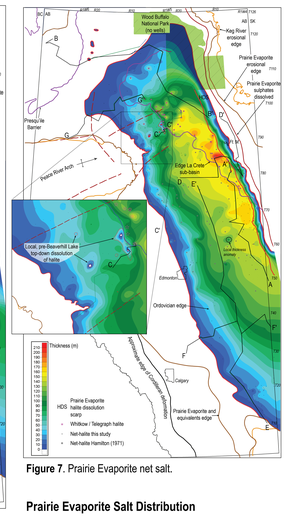


Figure 7. Prairie Evaporite net salt.

Prairie Evaporite Salt Distribution

• Salt distribution in the Prairie Evaporite Formation of Alberta forms an elongated trend to the N-NW to S-SE. In the north it transitions to anhydrite, to the west it transitions to siliciclastics shed from the Peace River Arch or the West Alberta Ridge (Eyot Formation), and to the east the current distribution is controlled by the halite dissolution scarp (Fig. 7).

• The thickest net salt is mapped within the La Crete sub-basin, where Whitkow Member halite is present (Fig. 7).

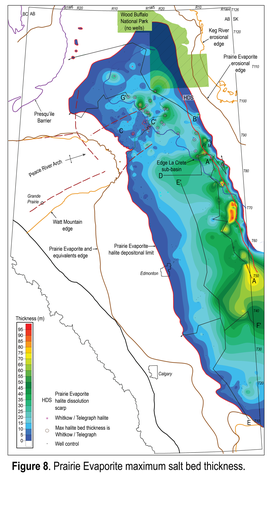


Figure 8. Prairie Evaporite maximum salt bed thickness.

• Figure 8 shows a map of the maximum salt bed thickness in the Prairie Evaporite Formation. Salt beds in excess of 90 m were mapped in east-central Alberta, where non-salt interbeds were not observed on wireline logs.

• In the La Crete sub-basin, the Whitlow Member forms the majority of the thickest halite beds, which formed in the inter-buildup areas of isolated Keg River mounds (see Fig. 10).

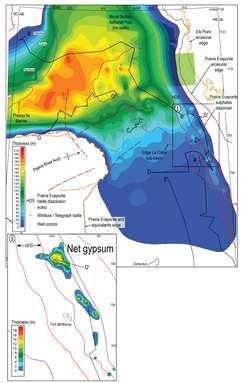


Figure 9. Muskeg / Prairie net anhydrite and gypsum.

Evaporite Karst

• Regional top-down evaporite karst occurs along the well-known halite dissolution scarp (cross-section D-D'). East of this feature, remaining anhydrite experiences gypsification, with cumulative gypsum in excess of 18 m (Fig. 9)—gypsification is also top-down (D-D'). The presence of gypsum is closely tied to distribution of Aurora Member anhydrite within the La Crete sub-basin (Fig. 9).

• Local top-down dissolution of salt occurs on the eastern flank of the Peace River Arch (Fig. 7; cross-section C-C' below). This phase of evaporite karst is pre-Beaverhill Lake Group, as these strata are unaffected by any associated karst subsidence.

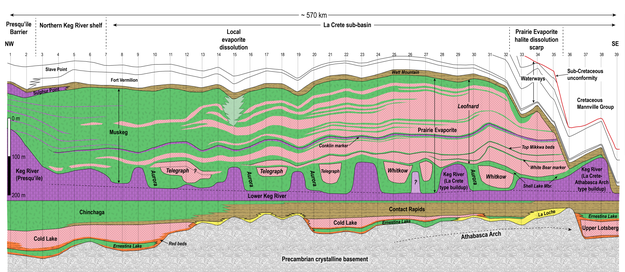
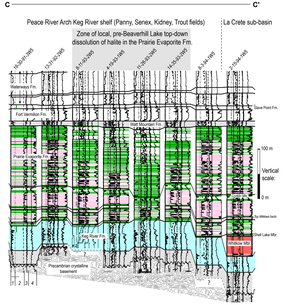


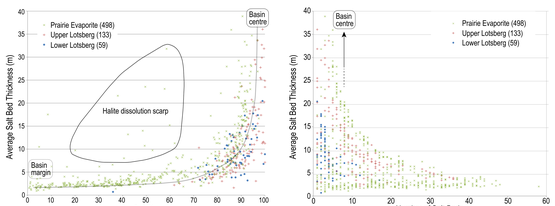
Figure 10. Regional NW to SE stratigraphic cross-section from the Presqu'ile Barrier, through the La Crete sub-basin, to the Prairie Evaporite halite dissolution scarp.



Characterizing Heterogeneities in Elk Point Group Evaporite Successions

• Bedded salt formations contain impurities in the form of regionally extensive non-salt interbeds. Net-evaporite thicknesses calculated by mapping individual salt beds allows for a more accurate assessment of salt potential within the bedded evaporites of the Elk Point Group. Furthermore, this approach characterizes non-salt interbeds on a well-by-well basis. Maximum salt bed thickness is a mappable parameter that points to potentially favourable areas for salt caverns—those locations with thick salt beds uninterrupted by non-salt interbeds.

	Percent Salt			Maximum Salt Bed Thickness			Number of Salt Beds		
	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Prairie Evaporite (498 wells)	0.7%	97.4%	55.2%	1.4 m	93.0 m	21.2 m	1	58	16
Cold Lake (244 wells)	13.9%	96.6%	73.9%	0.6 m	58.4 m	23.3 m	1	17	4
Upper Lotsberg (133 wells)	61.8%	100.0%	88.9%	1.6 m	106.1 m	34.2 m	1	36	11
Lower Lotsberg (59 wells)	36.0%	100.0%	87.1%	0.9 m	40.1 m	18.1 m	1	11	3



• The upper Lotsberg has the thickest individual salt beds, the highest average maximum salt bed thickness, and given its thickness, the lowest average number of non-salt interbeds (table above).

• The Prairie Evaporite displays the greatest variation in average salt bed thickness and non-salt interbeds (graphs above), in large part due to interbedding with Muskeg anhydrite to the northwest and siliciclastics along its western edge.

• The basin-centered evaporite deposits of the Lotsberg and Prairie Evaporite have an expected pattern of non-salt interbeds: Thick and relatively uninterrupted salt beds in the basin centre, with the degree of interbedding increasing toward the margin of the evaporite basins, and by association a decrease in the average thickness of salt beds. Exceptions to this trend occur along the halite dissolution scarp (graphs above).

Comments on Optimal Cavern Placement

• Many factors beyond general 'salt thickness' need to considered for cavern placement in the subsurface of Alberta. Bedded evaporite successions need to be assessed for their degree of heterogeneity, namely the characterization of non-salt interbeds. These interbeds pose challenges for cavern feasibility and stability as their geomechanical properties are vastly different from salt. This is especially true when considering caverns for compressed air energy storage (CAES), which operate under significant pressures.

• East-central Alberta is the location with the thickest cumulative salt deposits, both in the Lotsberg and Prairie Evaporite formations. Thick, potentially contiguous salt beds also occur within this location (e.g., fewer non-salt interbeds). Careful consideration of the local geology should be considered for caverns in the Prairie Evaporite Formation close the halite dissolution scarp.

Acknowledgments / References

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