Karst, Evaporite Dissolution and Associated Geohazards in the Oil Sands: Unraveling the Keg River/Prairie Evaporite Transition in N.E. Alberta, Canada

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Abstract

Recent recognition of the profound effect of the underlying Devonian geology on the Cretaceous Oil Sands of N.E. Alberta has led to a renaissance in Devonian investigation in the area. A vast new array of geological and geophysical data is being collected and analyzed. The Canadian Oil Sands Innovation Alliance (COSIA) has formed a Devonian Aquifer Working Group (DAWG) to collaborate in the collection and analysis of much of this new data.

A common stratigraphic nomenclature was required to ensure clear communication between DAWG participants. It quickly became clear that the transitional nature of the contact between the Keg River Formation and the Prairie Evaporite Formation (KR/PET) was going to make definition of that contact extremely difficult.

Gradational contacts in geology are not uncommon and have caused headaches for stratigraphers for centuries. The KR/PET is particularly interesting in that the transition is caused and modified by three distinct geological processes – deposition, diagenesis and dissolution.

During the Middle Devonian, prolific open marine carbonate production throughout the Elk Point Basin resulted in a broad carbonate platform around the margins and numerous isolated reef masses throughout the centre of the basin. At the N.W. margin of the Elk Point Basin, these accumulations coalesced to form an almost continuous barrier reef. The barrier reef became effective in restricting normal marine water circulation and the entire basin began the transition to hyperhaline conditions. The transition to evaporitic conditions varied throughout the basin resulting in significantly different contacts between the marine Keg River and evaporitic Prairie Evaporite.

On the basin margin platform, evaporitic drawdown resulted in regression that is expressed by a thin prograding sabkha deposit. On the basin-centered reefs, exposure resulted in subaerial deposits similar to those found on the modern Cayman Islands. In the deep inter-reef areas, anoxic marine conditions were modified to conditions of elevated salinity because of density segregation. The most complex transitional relationships existed on the reef margins. Evaporitic mudflats developed adjacent to the reefs. The steepness of the reef slope had a big influence on the dimensions of those mudflats. Brine levels in the basins between the reefs undoubtedly rose and fell many times because of the interplay between evaporation and water entering the basin by marine incursion or precipitation in the basin and its catchment area. This interplay resulted in thick deposits of anhydrite and cryptalgal dololaminites that formed on these reef-margin mudflats prior to the basin reaching hyperhaline conditions for the first time.

It is proposed that these reef margin deposits be included in a new member of the Prairie Evaporite Formation called the Vonda Member (Kendall 1975). With all the new drilling being conducted, it is expected that a fully cored type section will be available soon so only an informal definition is proposed here. The Vonda Member will be defined as the oldest unit of the Prairie Evaporite Formation in areas adjacent to reefs. The Vonda Member immediately overlies the Keg River Formation and underlies the Whitkow Member and/or the Shell Lake Member of the Prairie Evaporite Formation. It is probably partially coeval and laterally equivalent to the Ratner Member (Reinson and Wardlaw 1972).

Understanding the original depositional architecture of these deposits is essential for interpreting the dramatic effects of evaporite dissolution and karstification that underlie much of the eastern portion of the Athabasca Oil Sands deposit. The removal of much of the Prairie Evaporite Formation in that area has created additional complexity in operating in-situ recovery projects. Recognition of the contact between the Keg River Formation and the residuum remaining from the dissolution of the Prairie Evaporite Formation has created a number of challenges in dealing with these issues. Examples of the transition in areas of evaporite dissolution will be presented.

References Cited

Kendall, A.C., 1975. The Ashern, Winnipegosis and Lower Prairie Evaporite Formations of the Commercial Potash Areas. Summary Report of Investigations of the Saskatchewan Geological Survey, Saskatchewan Department of Mineral Resources, p. 61-65.

Reinson, G.E. and Wardlaw, N.C., 1972. Nomenclature and Stratigraphic relationships, Winnipegosis and Prairie Evaporite Formations, Central Saskatchewan: CSPG Bulletin 20, 301 - 320.