

Upper Grand Rapids Formation in the Cold Lake Field, Alberta*

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Abstract

The Cold Lake oil sands have been recognized for its huge reserves of heavy oil or bitumen under primary production. These deposits exist primarily in unconsolidated siliciclastic sediments within the Upper Cretaceous Mannville Group of Alberta (McPhee and Ranger, 1998). In this paper, the interval of interest corresponds to a portion of Upper Albian (Lower Cretaceous) strata--the Upper Grand Rapids Formation. These deposits occur approximately 300–400 meters below the surface. This study is focused on the integration of geological data in order to investigate the major controls on production performance.

The study area is located in the subsurface of East-Central Alberta and is representative of a portion of the Cold Lake field. It encompasses 10 km² and is bound by Sections 13, 14, 23 and 24, Township 62, Range 5W4 ([Figure 1](#)).

Wireline well logs from 39 wells that penetrated the Grand Rapids Formation were selected to prepare stratigraphic correlations through the study area ([Figure 2](#)). These detailed stratigraphic sections led to define the stratigraphic architecture and geometry of the evaluated interval in which the reservoir facies corresponds to a sinuous fluvial channel belt as described by Maynard et al. (2010).

This deposit reaches up to 70 ft (21 m) in thickness, with bimodal porosity distribution between 31 to 35%; oil saturation ranges between 25% to 85%; and maximum horizontal permeability is in the range of 176 millidarcys to 5 darcys. The elevation of the reservoir is essentially flat, with low relief ([Figure 3](#)). All wells are producing water, independent of the structure of the reservoir. As a result, oil productivity has been significantly affected by water production, leading to early abandonment (1 to 3 years) before all recoverable oil has been extracted.

This geological examination reveals that the majority of the producers are located along the channel belt. Surprisingly, the best producers are not in the middle of the channel, but in areas with relatively low net-to-gross sand ratio ([Figure 4](#)). Further analysis of production data has resulted in the grouping of these wells in three different categories, according to their production performance ([Figure 5](#)).

The observed behaviour might correspond to preferential water encroachment along the high net-to-gross areas in the channel belt. Thus, further development must consider appropriate locations of the new wells to delay the water intrusion.

Selected References

Maynard J., H.R. Feldman, and R. Always, 2010, From bars to valleys: The sedimentology and seismic geomorphology of fluvial to estuarine incised-valley fills of the Grand Rapids Formation (Lower Cretaceous), Iron River Field, Alberta, Canada: *Journal of Sedimentary Research*, v. 611-638.

McPhee, D., and M.J. Ranger, 1998, The geological challenge for development of heavy crude and oil sands of Western Canada: UNITAR International Conference on Heavy Crude and Tar Sands Proceedings, v. 7, p. 189.

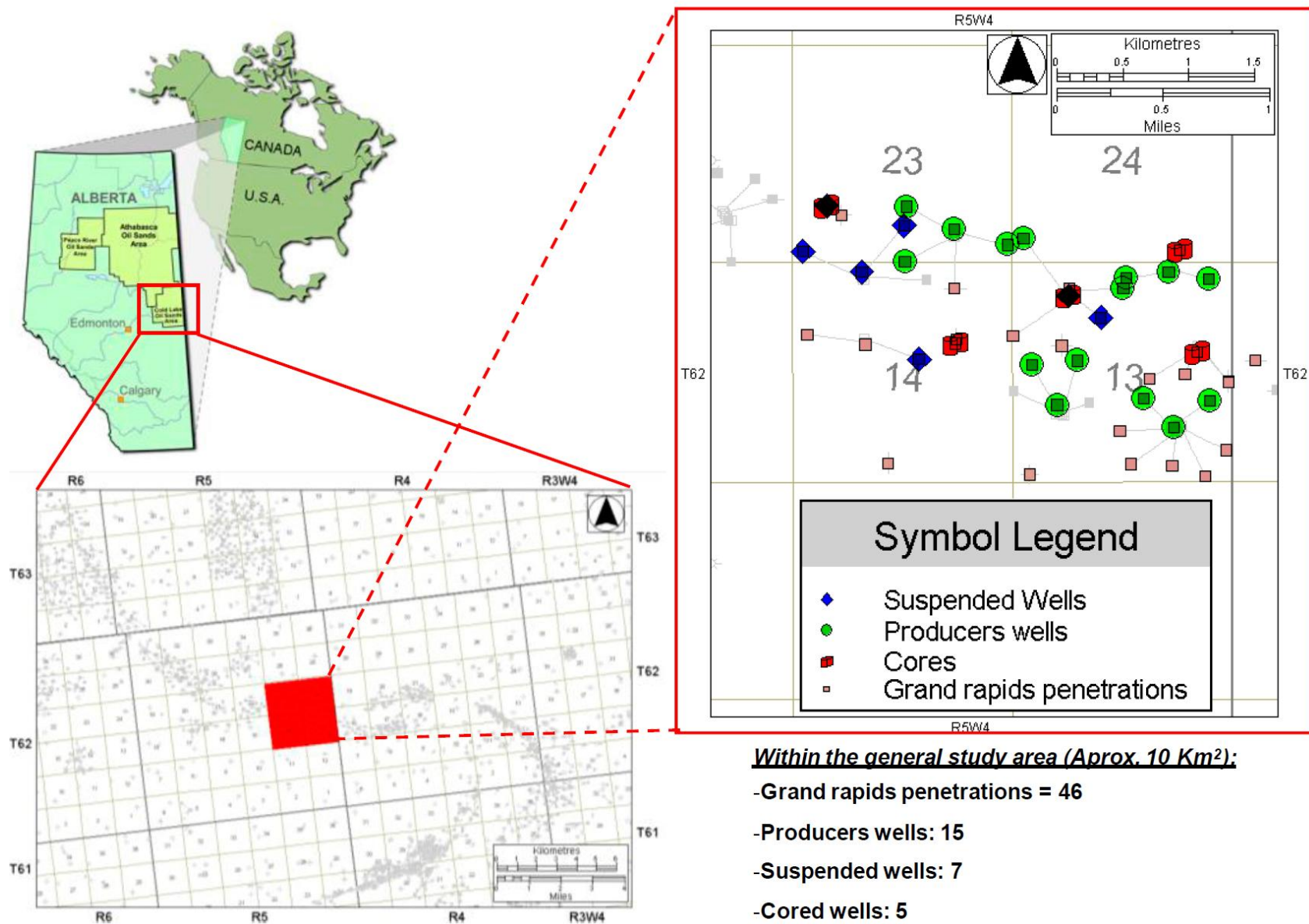


Figure 1. Location of the study area in the subsurface of east-central Alberta, Cold Lake Field. (Alberta Geological Survey, 2011).

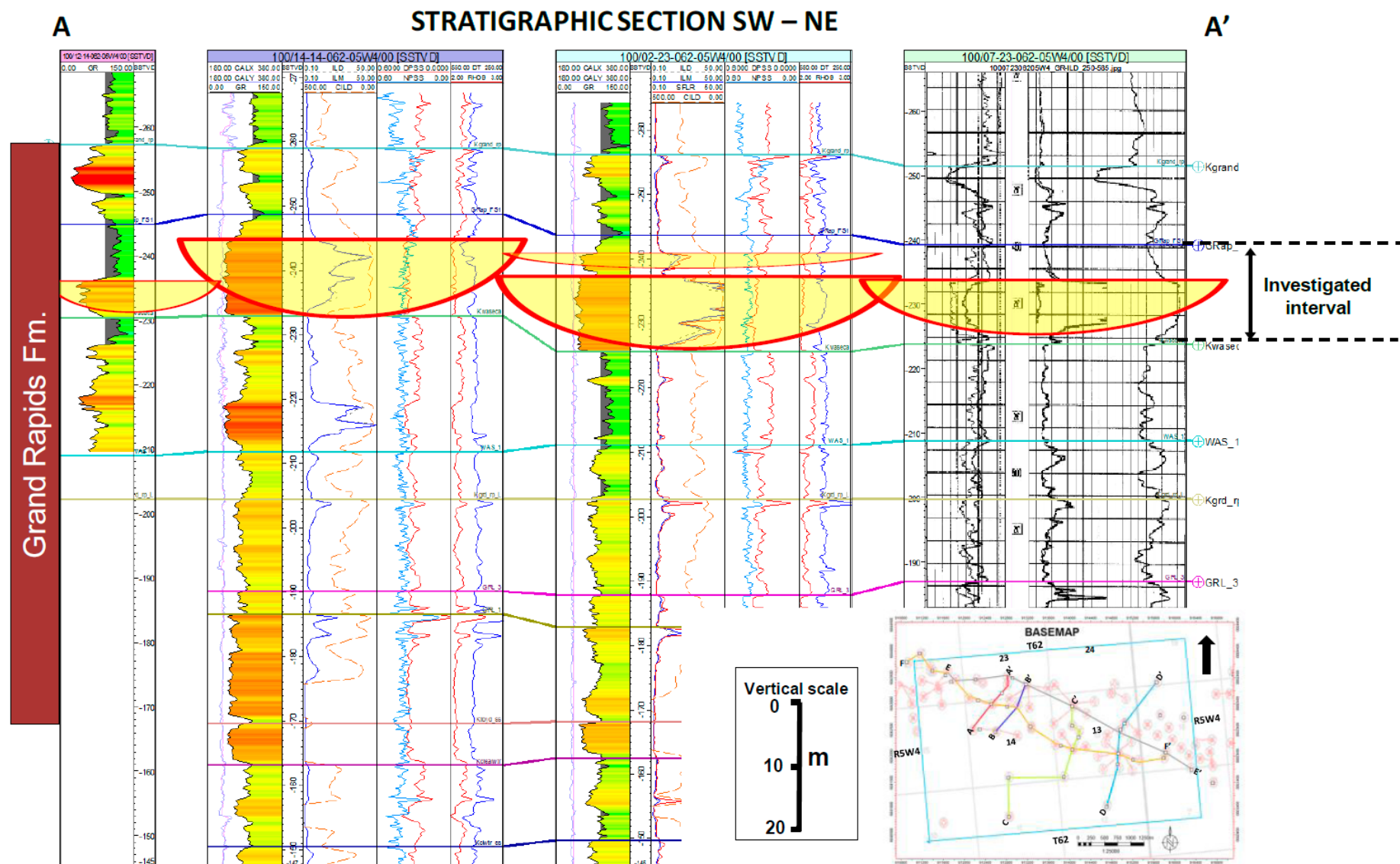


Figure 2..Stratigraphic cross-section A-A' of the Lower Grand Rapids Formation. This section is oriented southwest to northeast. The investigated interval consists of massive-appearing sandstone beds. According to the gamma-ray log patterns and the literature, the depositional setting was characterized by fluvial channels cutting across shoreface deposits. In this section the interval thickness is between 13 to 18 meters, and it decreases along the axis of the basin. Net sand is shown in red and defined as 75 API units or less.

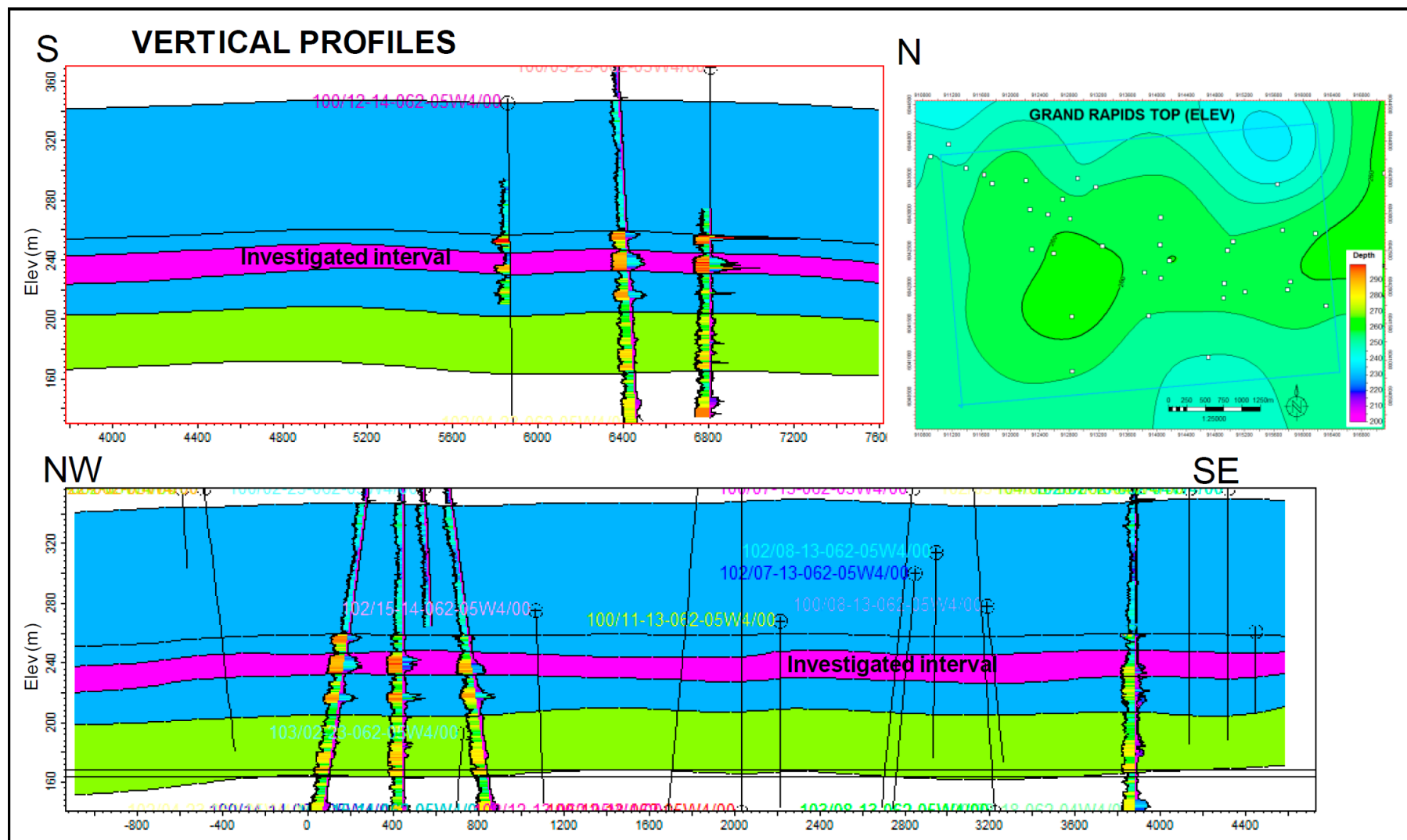


Figure 3. Vertical profiles showing the relative low relief across the study area. GR and ILD logs are shown for several wells.

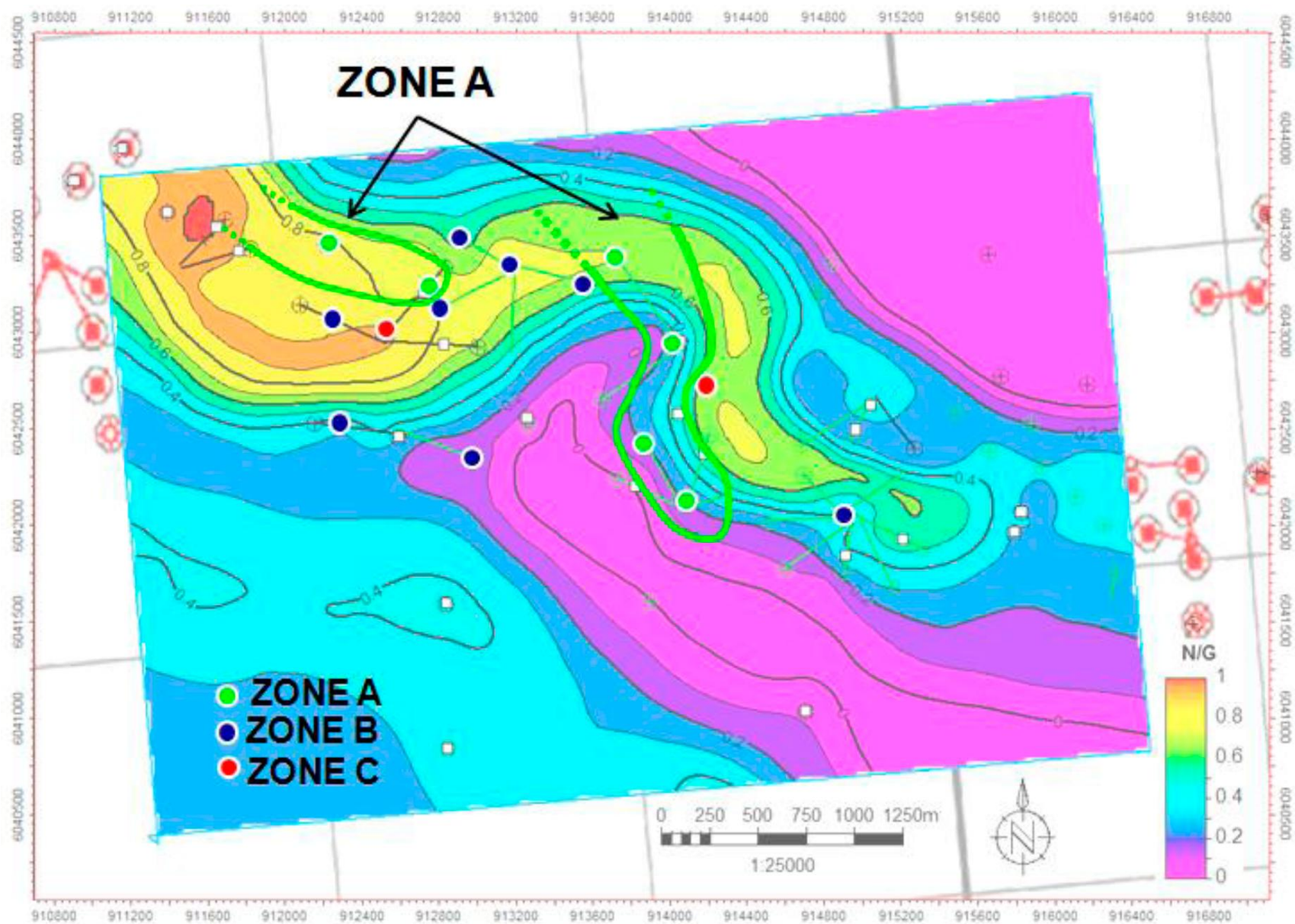


Figure 4. Net-to-gross sand map showing three different zones (units) within the channel facies.

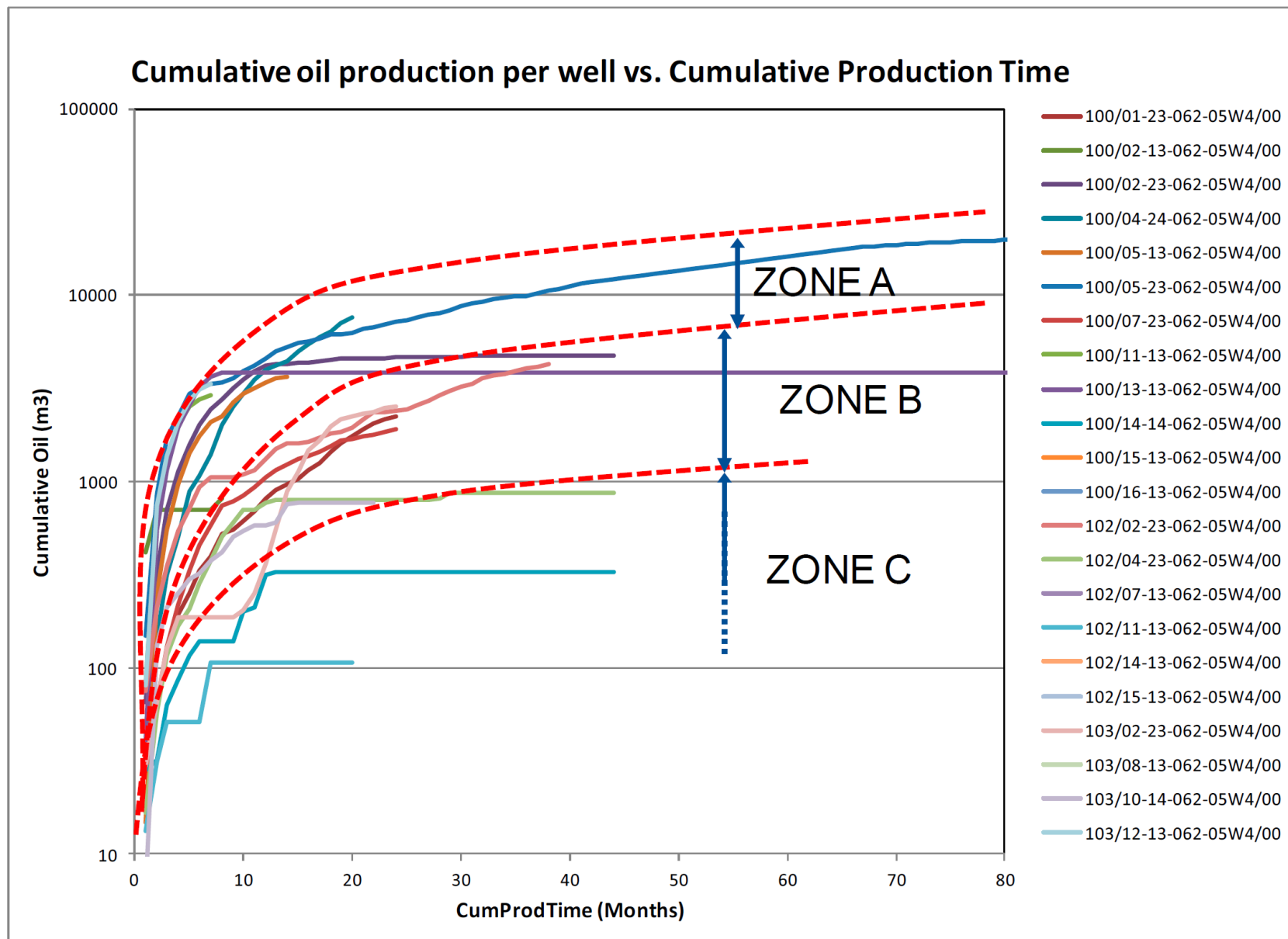


Figure 5. Cumulative oil production vs. cumulative production time for 22 wells, according to the 3 zones.