Reservoir Potential of the Chinook Formation, Upper Cretaceous (Campanian) in the Alberta Deep Basin, Alberta, Canada*

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Abstract

The Alberta Deep Basin is one of the most productive areas of the Western Canadian Sedimentary Basin (WCSB) which contains Upper Cretaceous production from the Dunvegan, Cardium and Chinook formations. The Chinook Formation in the Chicken Field was relatively recently recognized as a new shoreface shallow marine sandstone unit in the Smoky Group of the Late Cretaceous accumulations, and the proven play fairway trends northwest - forming a linear feature across the area. However, no reasonable depositional model appears yet to be available for understanding the uppermost Cretaceous sandstone reservoirs in the basin. The objectives of this study are (1) to build a geological model using wireline logs integrated with other exploration databases available (e.g. seismic profiles, cored samples, etc.), and (2) to evaluate the reservoir quality. This work may help locate an infill drilling location.

Study Area

The study area (Figure 1) is a group of Sections located in western central Alberta (Townships 61 and 63, Ranges 6 and 9W6) in the Alberta Deep Basin which is the westernmost portion of the WCSB. The lands lie in the matured basin which has been explored and drilled for more than two decades (since the1980s), and overlapped mostly with the Chicken Field.

Geological Setting

The Fold and Thrust Belt formed during the Jurassic to Eocene, as the North American Plate collided with terrains to the west, causing the Rocky Mountains. The deformation caused tectonic loading, depressing the western edge of the North American Craton and generating a new huge, crescent-shaped foreland basin, including the Alberta Deep Basin (ADB), which is a dominant structural style in the WCSB. The western part of the ADB has experienced substantial uplift followed by erosion and deposition during the Late Cretaceous, forming prolific sedimentary units including the Smoky Group (Figure 2).

The Smoky Group comprises several different Late Cretaceous sedimentary units, including the Chinook Formation. The Chinook Formation is known as a prograding shallow-marine sandstone unit which is encompassed above and below by the Puskwaskau Formation (marine shale) (Price et al., 2010), forming one or more separate parasequences. The shoreface sandstone reservoirs have demonstrated a cumulative gas production of 100 BCF with average initial production rates of 2.8 MMCFG/D per well.

Structural Analysis

The top of the Chinook Formation, mapped on the basis of 92 wireline logs available, shows that the central part of the study area contains a highly deformed zone, deepening toward the southeast. The fold-like structure may have been caused by the Laramide Orogeny which ended a regional subsidence of the existing basin, presumably following an accumulation of the Chinook Formation.

Well Log Correlation

A datum for the stratigraphic correlation uses a maximum flooding surface (MFS) of the Wapiabi (or Wapiti) Formation deposited during Campanian to Maastrichtian (Figure 5), because the flat marker appears to be correlated regionally and extensively. The stratigraphic interpretation is limited down to the Chinook D, because the lowermost unit (Chinook E) is difficult to pick its basal boundary on gamma ray logs (see Figure 4). This well-log correlation was done using geoSCOUT manufactured by geoLOGIC system Ltd.

Reservoir Characterization

The Chinook reservoir lithology is identified by using three different borehole data: Gamma Ray (cutoff: 75 API for clean sands) (e.g. Figure 4), resistivity log (not effectively useful because of "no free water"), and cores (calibration with gamma ray curves). The porosity and permeability are also derived from three different borehole data: neutron-density log (cutoff: 9%), sonic log (cutoff: 220 µs/m), and cores (calibration with logs). The core analysis indicates that the Chinook C has better reservoir properties (i.e. permeability and porosity) than the others (Figure 7).

The distribution of net pay thickness of the Chinook C shows a NW-SE trending geometry, reaching a maximum thickness of 6 m (Figure 8). When infill drilling is considered, the results of the present study will provide a fundamental framework.

Conclusions

The present study uses ninety-two well logs integrated with core data to build a stratigraphic framework of the Upper Cretaceous shoreface deposits of the Chinook Formation and to evaluate its reservoir potential. The structural interpretation indicates that a fold-like feature may have been caused by the Laramide Orogeny which ended a regional subsidence of the existing basin, presumably following accumulation of the Chinook Formation.

The stratigraphic interpretation indicates that the Chinook Formation is a single (or several) parasequence deposited in a shallow-marine environment, consisting of five sedimentary facies (Chinook A-E) units which are interpreted to be shelf (base) to coastal/beach sediments (top); however, the interpretation is limited down to the shelf unit (Chinook D) because defining the basal boundary of the lowermost facies (Chinook E) is challenging.

The well-log based stratigraphic correlation suggests that the shoreface strata within the Chinook Formation have a relatively conformable, subparallel geometry in the strike direction, whereas they seem to be pinched out toward the northeast in the updip direction, forming a NW-SE oriented, elongate sand body which appears to be part of a paleoshoreline in the Upper Cretaceous. This information will be very useful and informative when a drilling program is designed. Furthermore, this depositional model may be significantly improved when integrated with a reservoir analog study on well-exposed outcrops of similar ancient depositional environments.

Acknowledgements

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References

Hartley, K., 2002, Reservoir characteristics of the Upper Cretaceous Chinook Formation in the Chicken Field, Alberta, Bachelor's thesis, University of Calgary, Calgary, Alberta, Canada. Web accessed 31 May 2012. http://www.ucalgary.ca/lib-old/gallagher/deptthesis.html

Price, R.A., C.R. McGregor, and J. Wilson, 2010, Precambrian basement beneath the Western Canada Sedimentary Basin. Web accessed 18 May, 2012. http://www.ags.gov.ab.ca/publications/wcsb_atlas.html

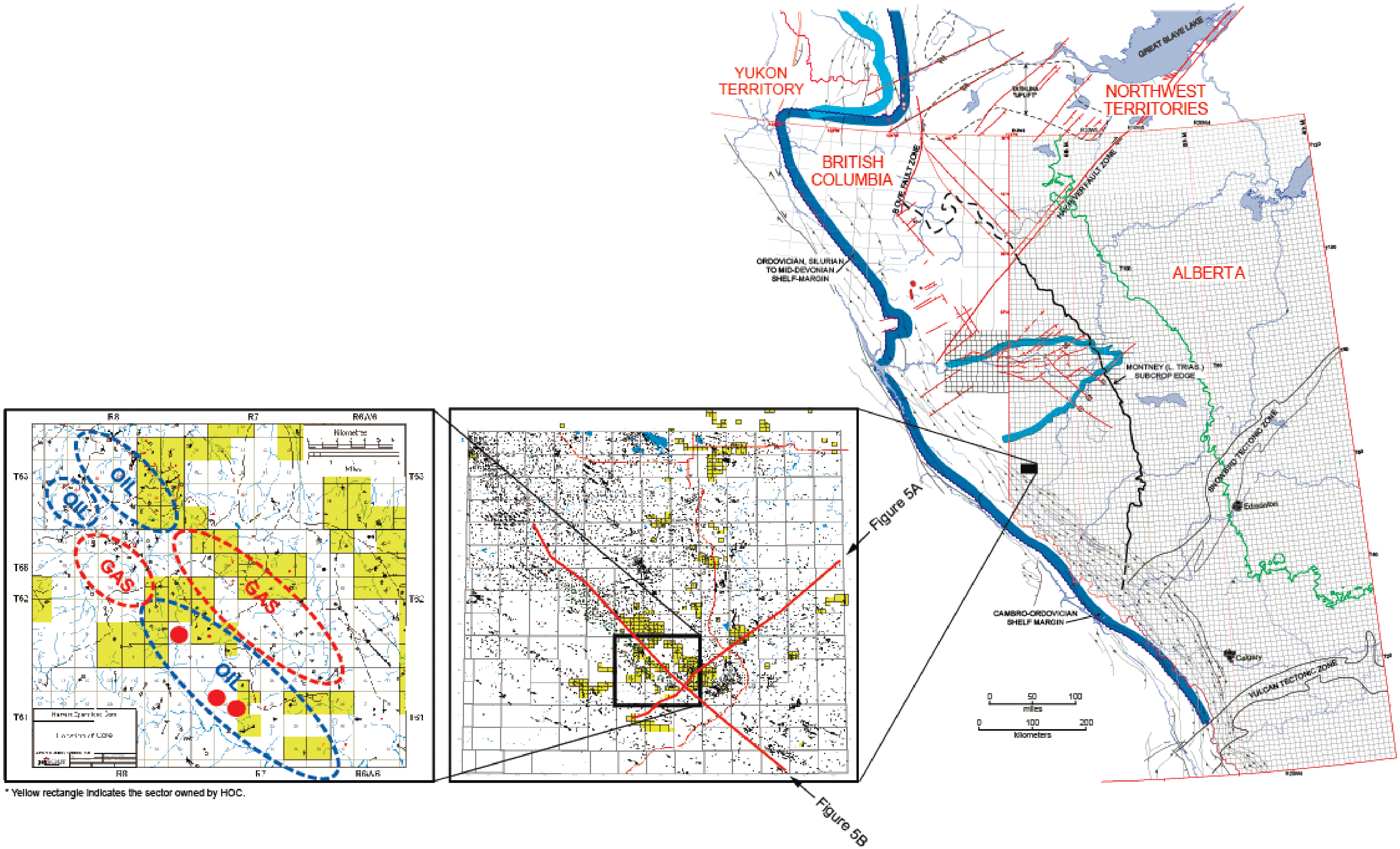

Figure 1. Location of the study area.

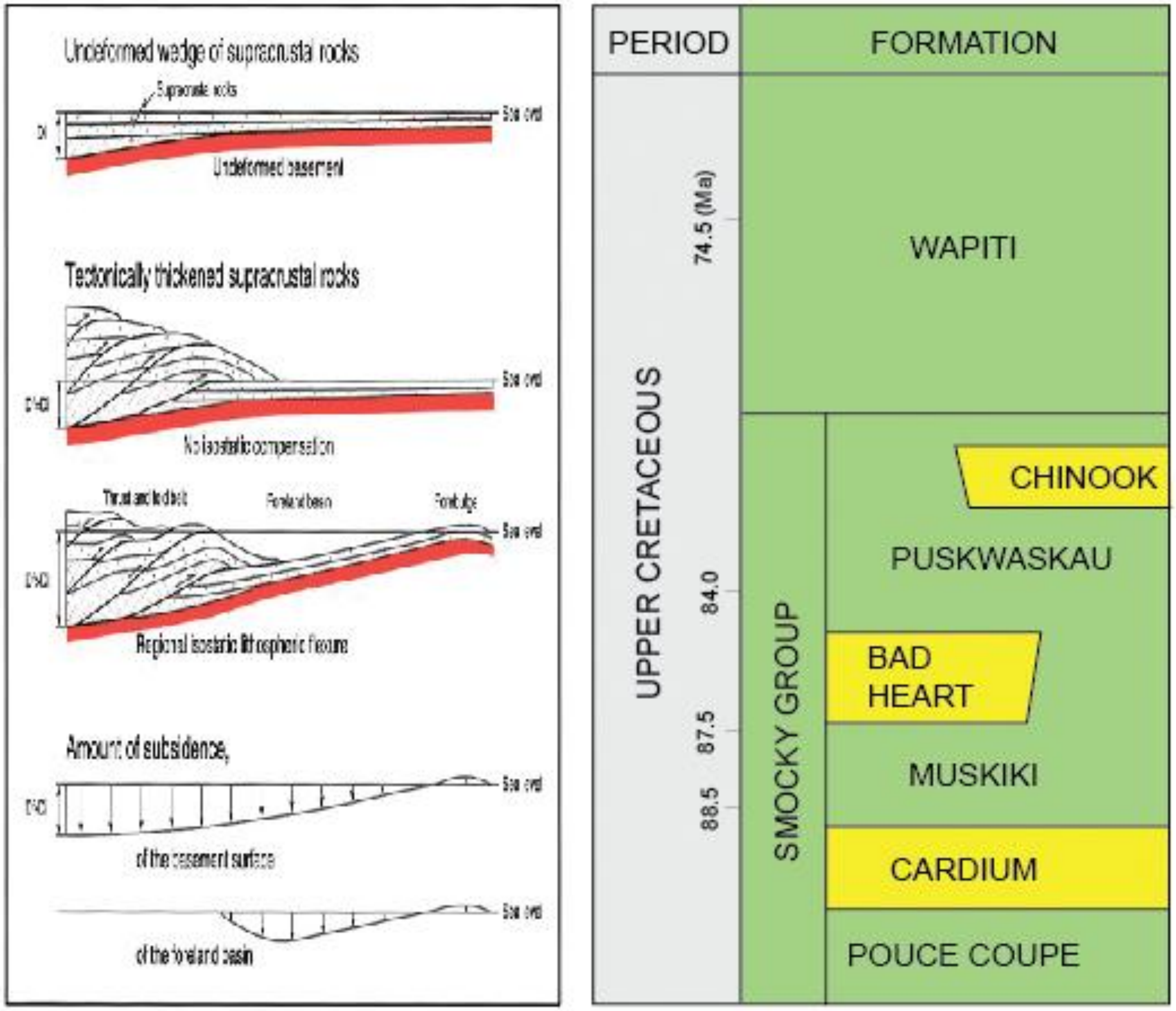

Figure 2. Basin evolution of the Alberta Deep Basin (left panel), and a stratigraphic section of Upper Cretaceous deposits (right panel).

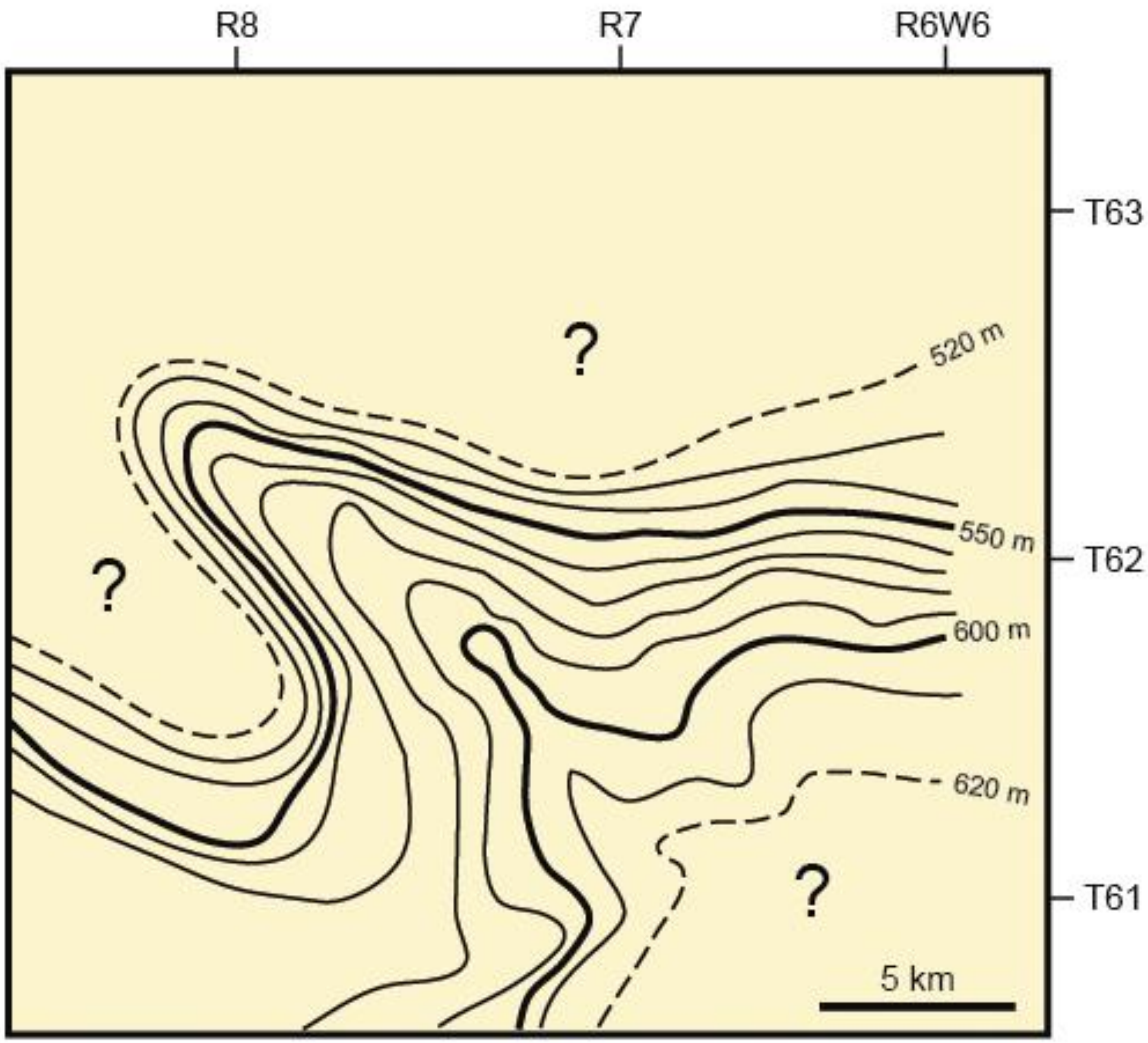

Figure 3. A structure map of the study area.

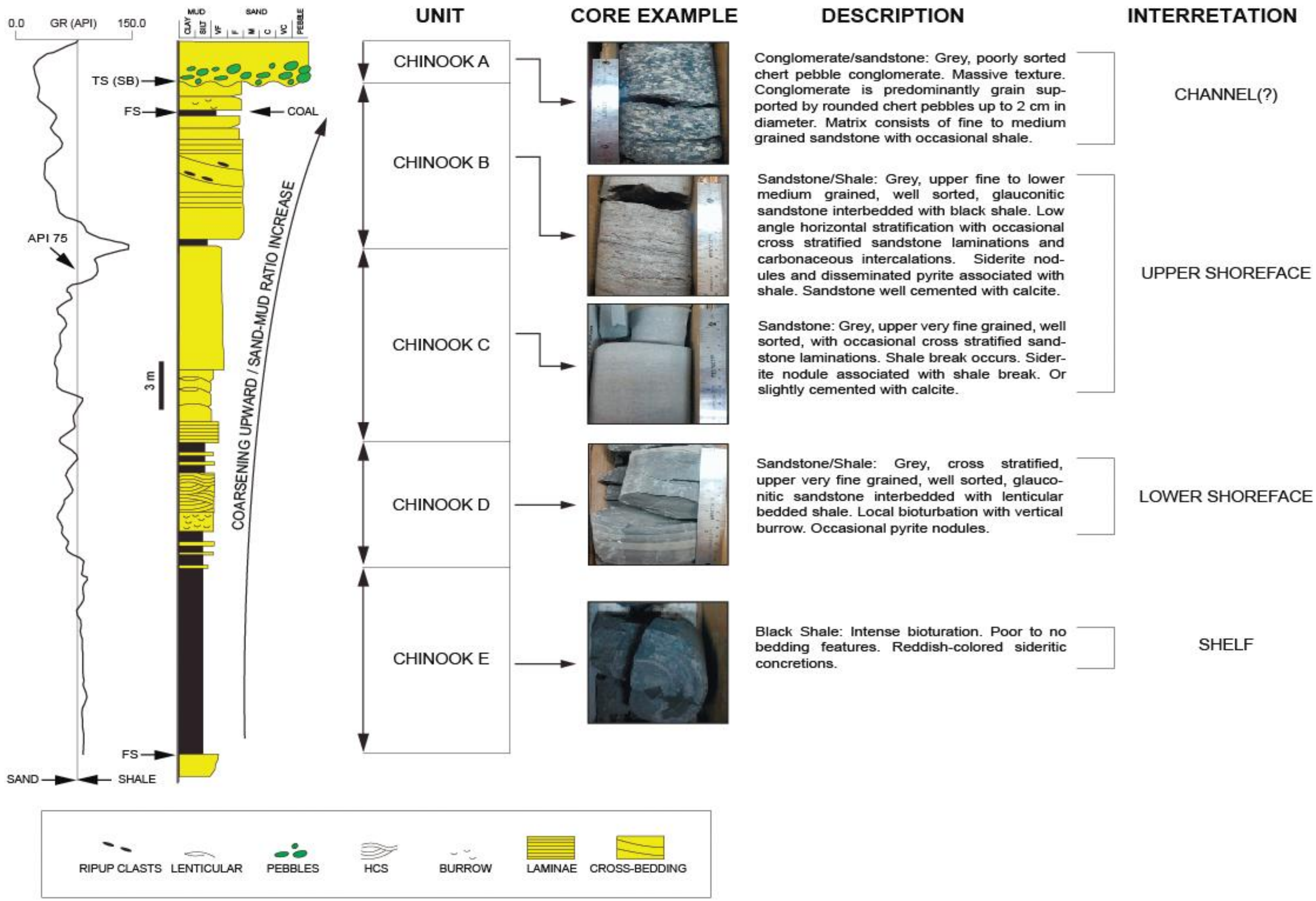

Figure 4. The relationship between Gamma Ray curve and sedimentary facies on core observations (Hartley, 2002). This facies classification is used for the stratigraphic analysis.

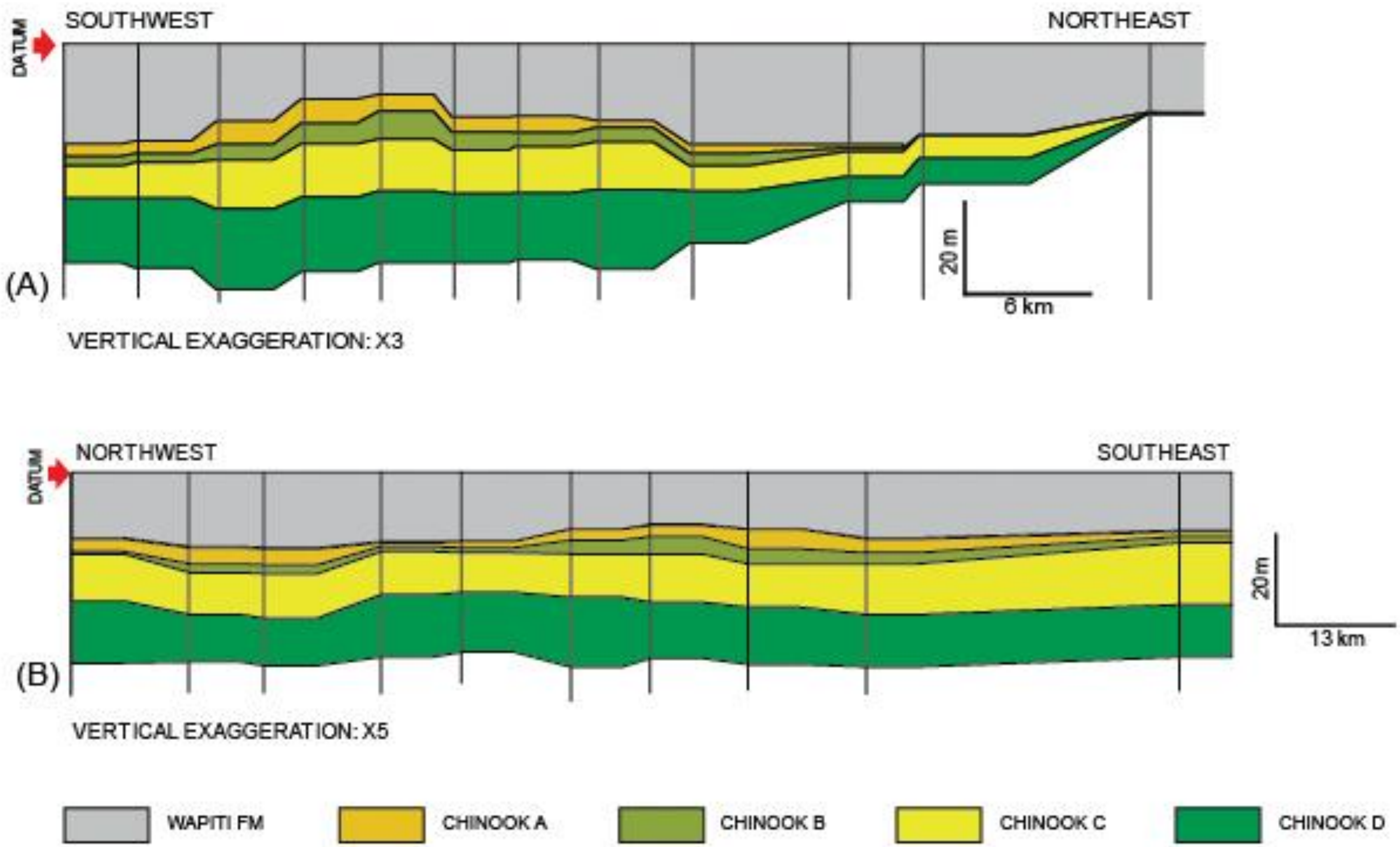

Figure 5. Well log correlations both in depositional dip (A), and strike directions (B). See Figure 1 for locations.

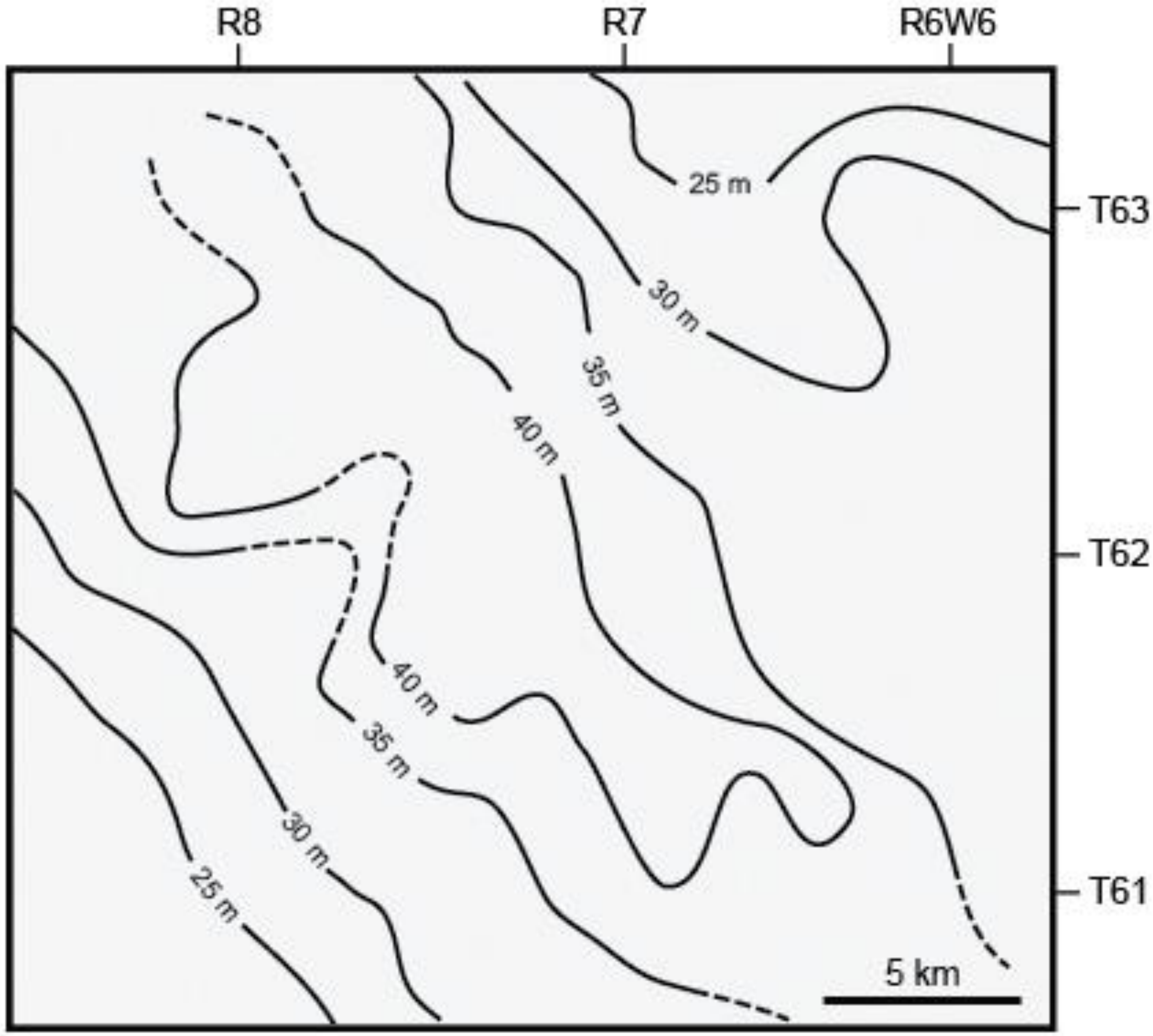

Figure 6. Map of gross thickness containing only four interpreted facies (Chinook A to D).

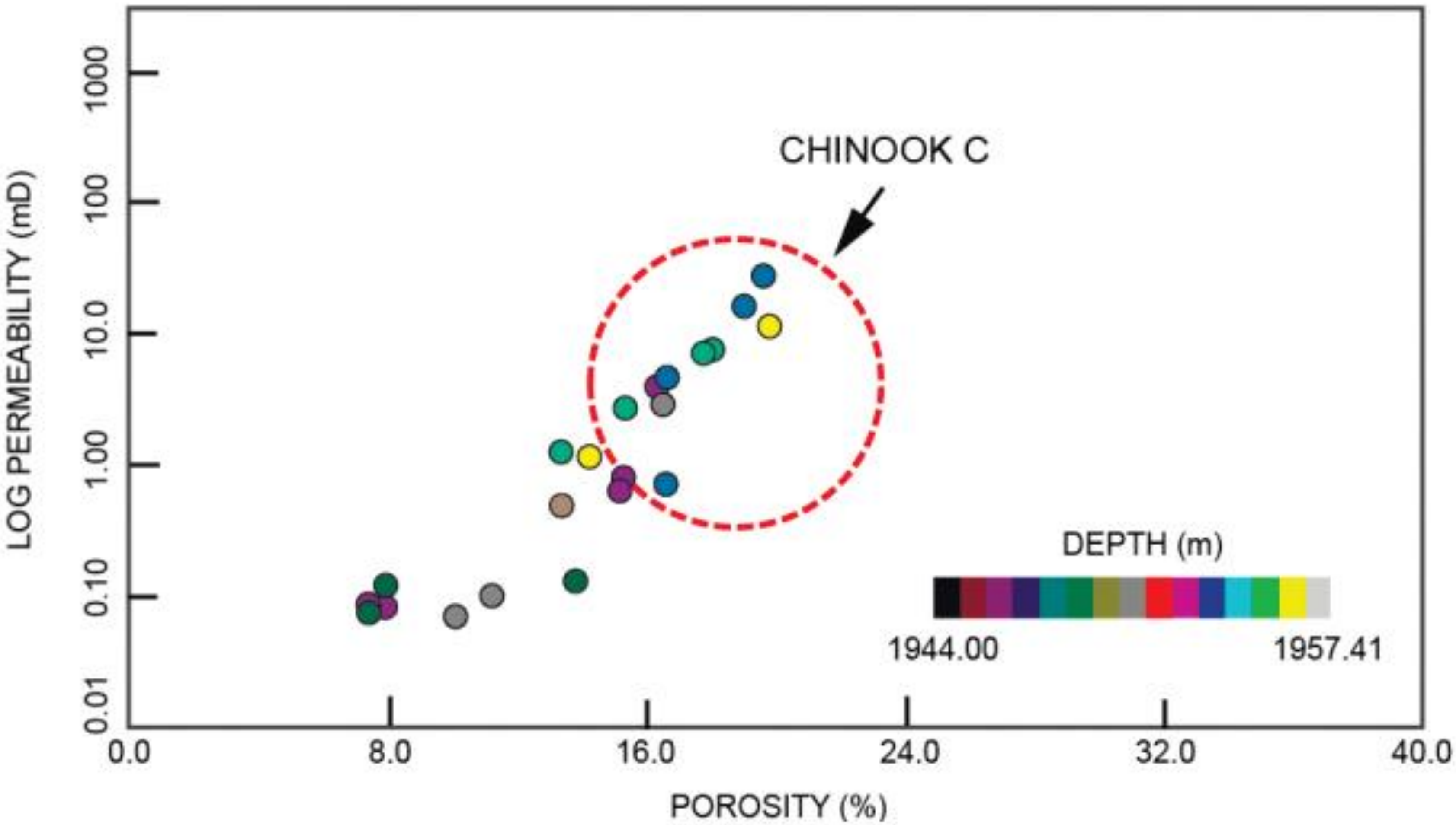

Figure 7. Relationship between permeability and porosity measured from cores.

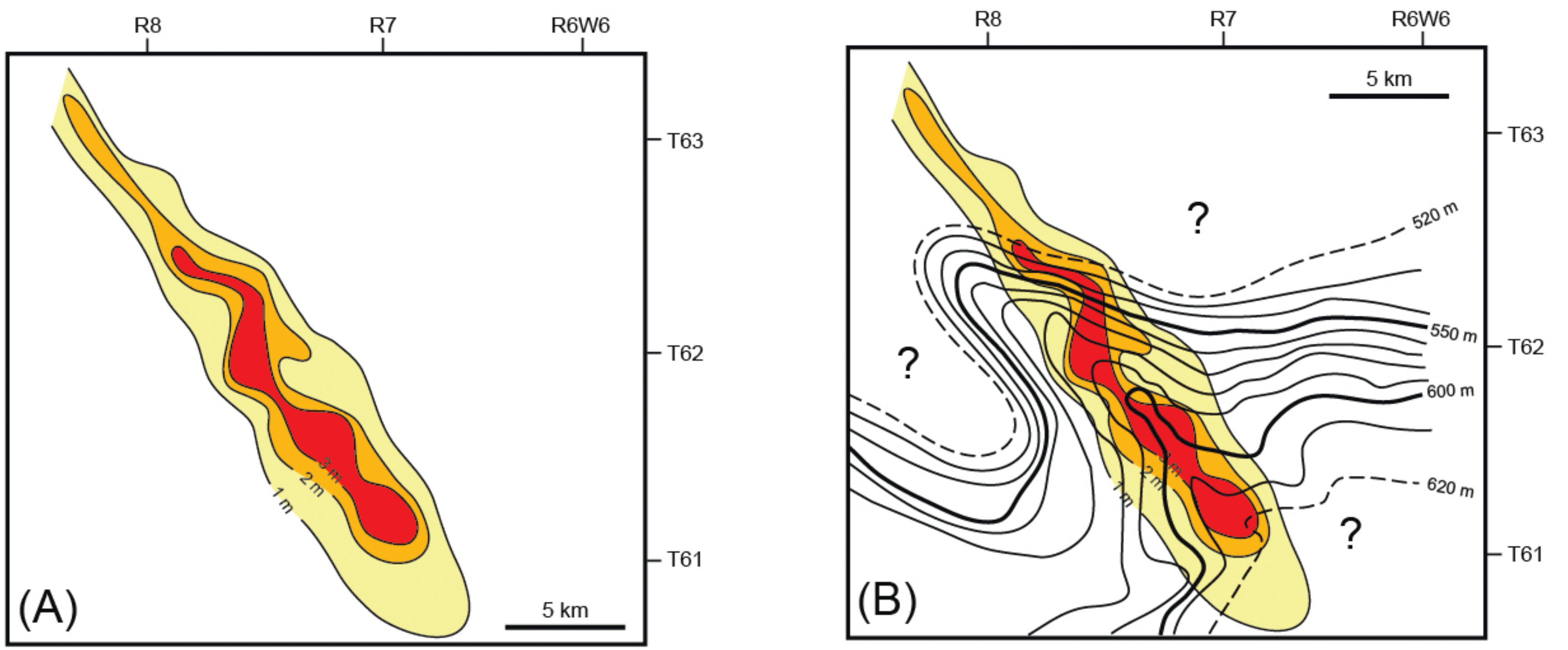

Figure 8. Thickness variation (isopach map) in net pay (A), and a proposed well location on a structure map superimposed on the isopach map (B).