

Preparing for experimental CO₂ injection: Geology of the site

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ABSTRACT

We studied the geological properties of three prospective experimental CO₂ injection zones in the study area in Southern Alberta. The primary target is the Basal Belly River Formation, with secondary targets in the Medicine Hat and Second White Speckled Shale formations, which are at depths of about 285 m, 475 m and 710 m, respectively, below the surface.

We correlated well logs in the immediate area of interest with well logs from a well having a lithology log and from wells with Basal Belly River production. We calibrated the gamma ray logs in the top of the Pakowki Formation so that the average values were consistent in all of the well logs. We then used the gamma ray logs to assess reservoir continuity, and sand/shale content in the Belly River Formation above the proposed injection zone and to estimate the sealing properties of this formation.

Based upon our interpretation of the gamma ray logs, it seems probable that the Belly River Formation has sufficient shale content to be a seal in the area of interest.

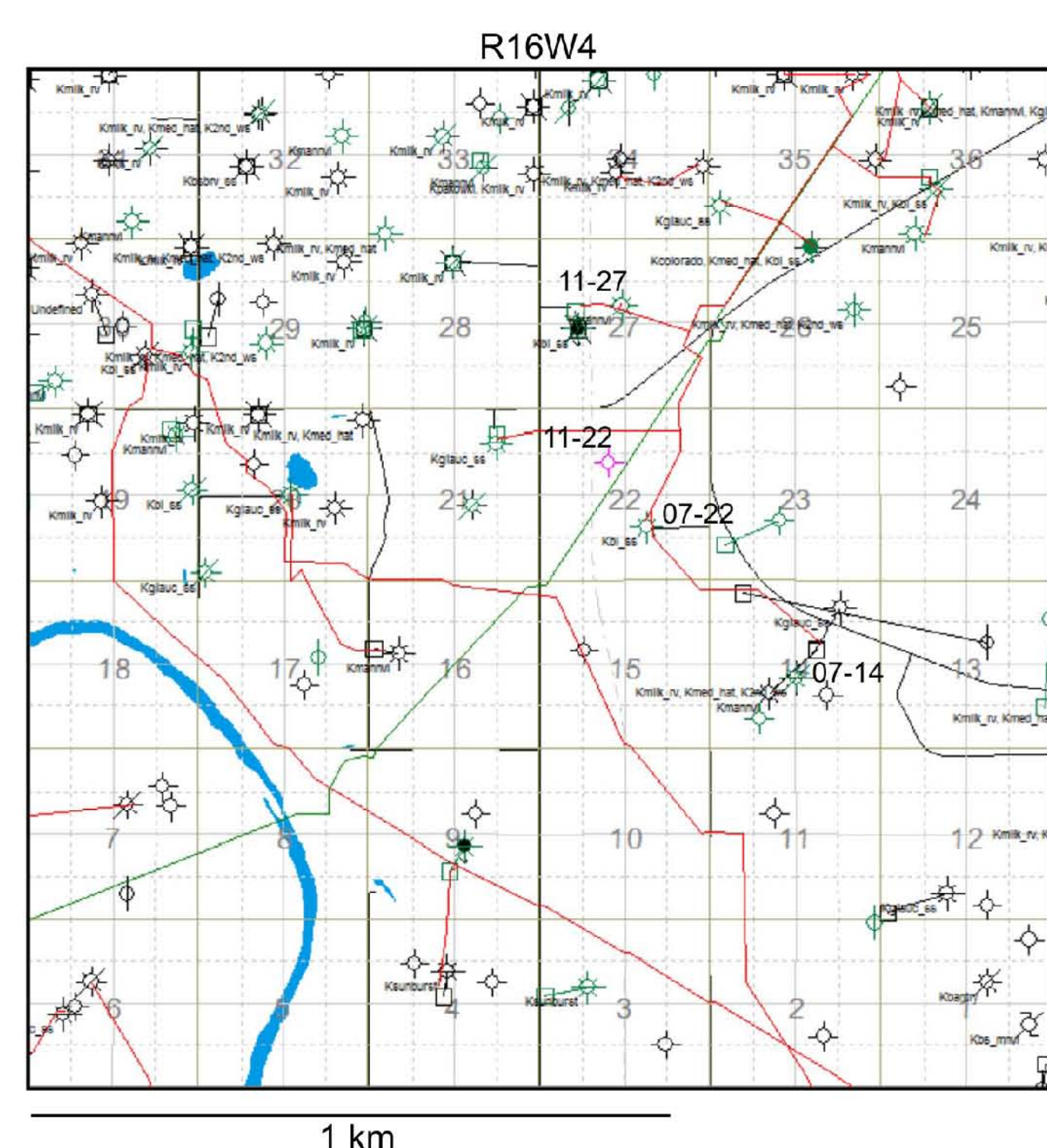


FIG. 1: Wells near Section 22 with producing zones annotated. Red lines denote gas pipelines and green lines denote oil pipelines.

INTRODUCTION

The Containment and Monitoring Institute (CaMI) is a platform for development and performance validation of technologies intended for measurement, monitoring and containment of subsurface fluids, including carbon dioxide.

The program at CaMI's Field Research Station will inject small tonnages (up to 1000 tonnes per year) of CO₂ into the shallow subsurface. The injection targets are water-filled sandstones within Upper Cretaceous clastic reservoir formations, with overlying shales or mixed sand/shale sequences forming the cap rocks.

The site is within the Countess Field, near Brooks in Newell County, Southern Alberta, about 150 km southeast of Calgary. The geological study is centred on well 07-22-017-16W4M, which is a producing gas well drilled in 1997 by PanCanadian Petroleum and now operated by Cenovus Energy.

GEOLOGY

The two boreholes drilled at the location 07-22-017-16W4M encountered gas deeper than our target depths, in the Glauconitic sandstone between 1049-1054 m depth KB (266-271 m subsea) and the Bow Island sandstone at 890 m KB (107 m SS).

Wells surrounding 07-22-017-16W4M have encountered gas in many different formations, as seen in Figure 1, which is a map showing the wells in the immediate area of interest around Section 22 with the producing zones annotated. Gas is found in the Milk River, Medicine Hat, Second White Speckled Shale, Bow Island, Mannville and the Sunburst formations. Although the wells in the south of this map produce only from the deepest Cretaceous formations, wells to the south and east of them have shallower production. Figure 1 also shows gas pipelines (red) and oil pipelines (green). There is an oil pipeline running through Section 22 close to the proposed drilling location of the test well, which is 500 m north of well 07-22-17-16W4M.

The primary target for injection at this site is the Basal Belly River sandstones with sands within the Medicine Hat and Second White Speckled Shale formations as secondary targets.

Basal Belly River

The depth of the Basal Belly River over Section 22 is about 285 m below the surface and the unit is 5-7 m thick. The formation is mostly water-wet. The nearest gas pool producing from the Basal Belly River is at Eyremore, in T19 R18 W4M, which is about 45 km to the northwest. The sand content of the Basal Belly River shoreface sands varies quite a lot and in well 07-22-017-16W4M the sands are quite silty. Figure 2 is a cross-section showing the log character of the Basal Belly River in the area of interest. The Basal Belly River sandstone is about 5-6 m thick here.

Medicine Hat

The Medicine Hat Formation consists of at least three upward-coarsening, very fine-grained sandstone and siltstone successions, 3 to 11 m thick, deposited in a shallow-marine shelf setting. The formation is up to 60 m thick. Figure 3 is a cross-section showing sand-prone zones in the Medicine Hat Formation. Gas was encountered in two 1 m thick sandstones in well 07-14-017-16W4M (red dots).

Second White Speckled Shale

This predominantly marine mudstone unit contains some fine-grained distal marine shoreface sands. A few wells have flowed gas from thin sand zones. Well 102/7-14-017-16W4M has 2 m of net pay in the Second White Speckled Shale at 712 m KB (69 m subsea), where there is a decrease in the gamma ray reading and increase in sonic velocity (Figure 4).

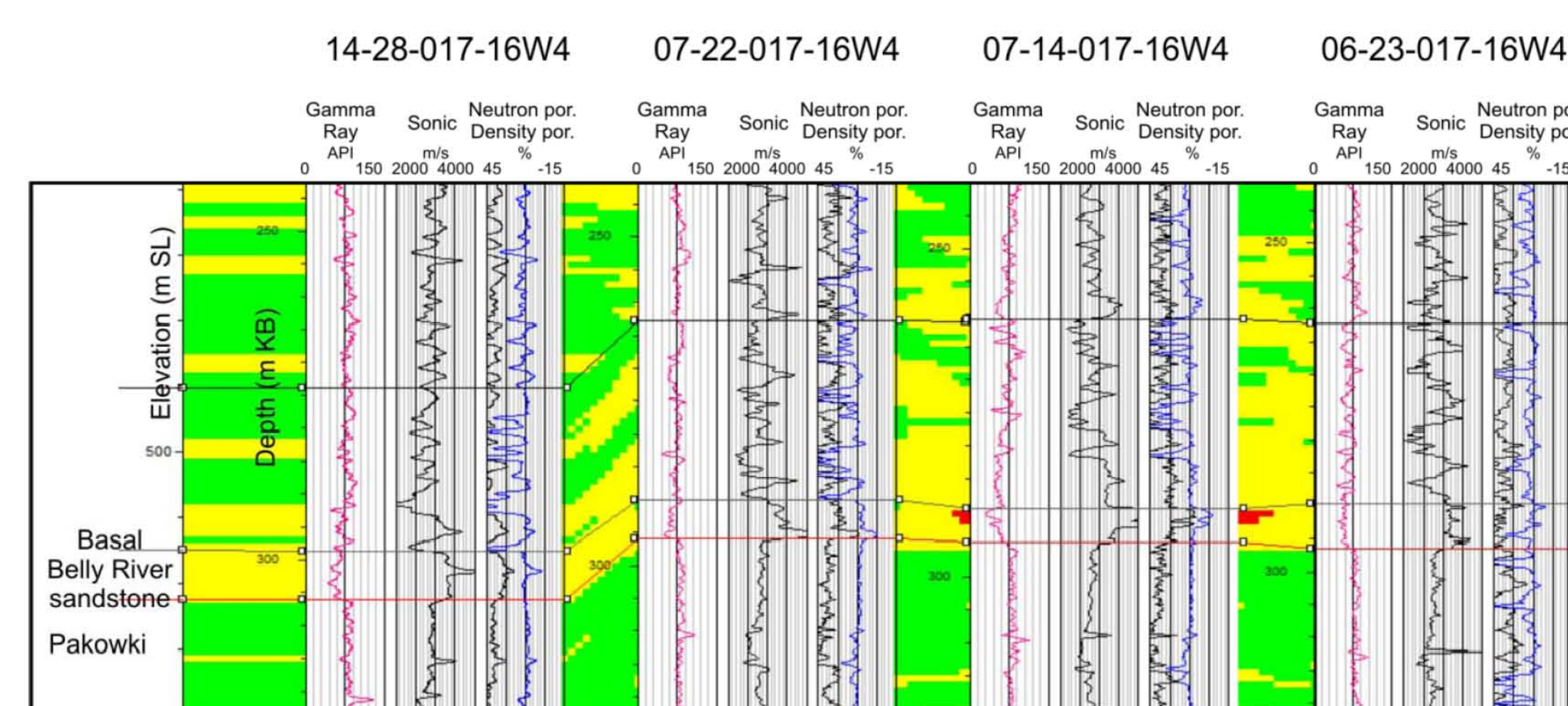


FIG. 2: Cross-section showing the character of the Basal Belly River sandstone around Section 22.

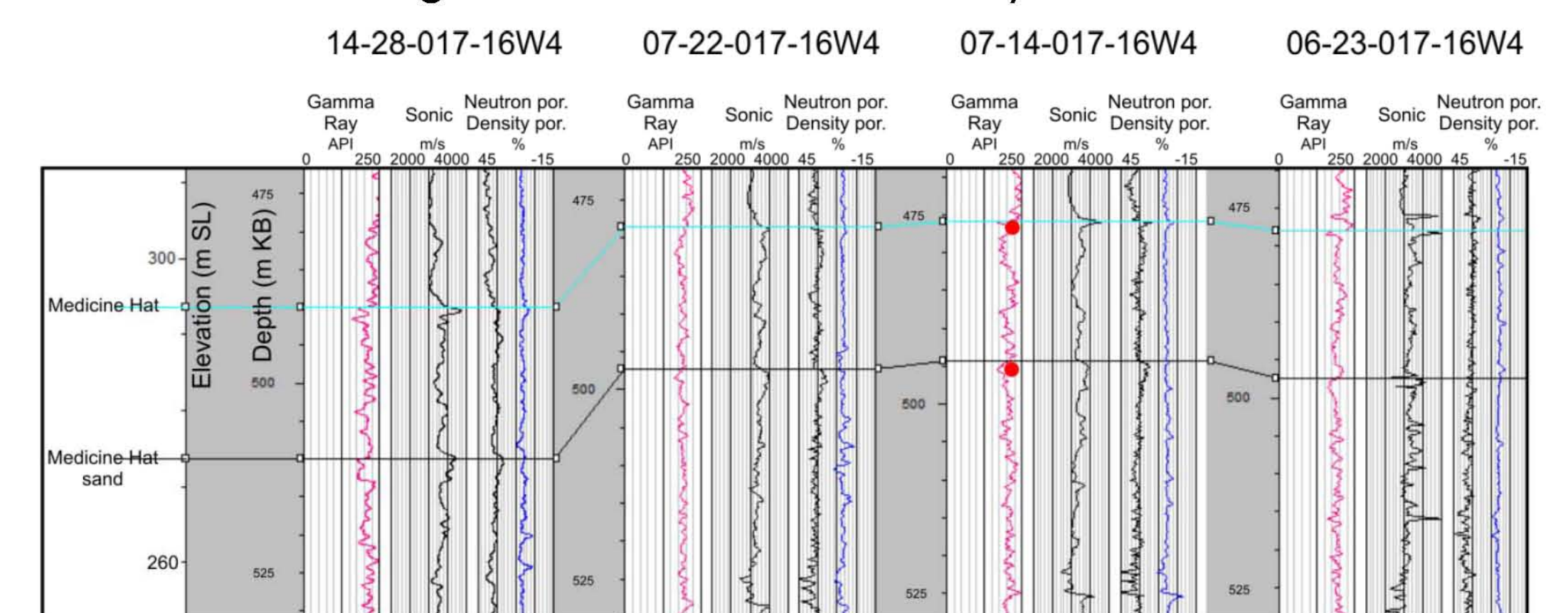


FIG. 3: Cross-section showing the character of the Medicine Hat Formation around Section 22. Gas was encountered in two 1 m thick sandstones in well 07-14-017-16W4M, as indicated by the red dots.

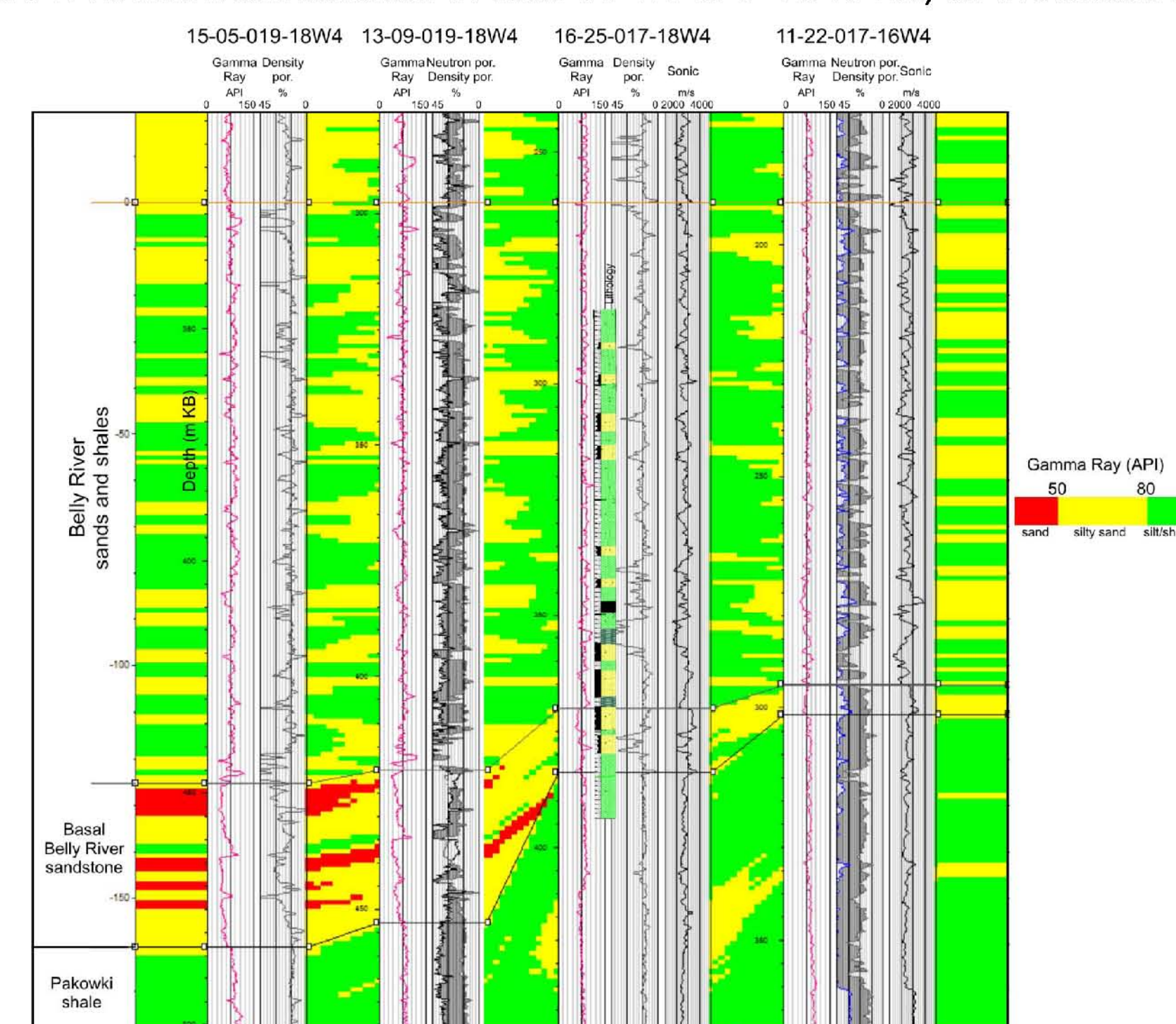


FIG. 6: Correlation of gamma ray logs from well 11-22-017-16W4M with well 16-25-017-18W4M, which has a lithology log, and wells 15-05-019-18W4M and 13-09-019-18W4M, which produce from a thick Basal Belly River sandstone. We estimate that the Belly River Formation above the target injection formation is composed of about 40% silty sand and 60% silt/shale in Section 22, compared to about 37% silty sand and 63% silt/shale in well 15-05-019-18W4M.

Sealing capabilities of the Belly River Formation

Of critical interest in this study area is the capability of the Belly River Formation to form a barrier to migration of injected CO₂ from the Basal Belly River sandstone. We correlated well 07-22-17-16W4M to the nearest well with a lithology log, 16-25-017-18W4M. The wells in the cross-section (Figure 5) are flattened on the top of the Basal Belly River and have been calibrated so that the average gamma ray values in the uppermost Pakowki Formation are equivalent.

The colour background shows the lithology based upon the gamma ray values. It was designed to match the lithology log as well as possible in the Belly River Formation and is divided into the three basic types: sand, silty sand and silt/shale. This correlation implies that the Belly River Formation in Section 22-017-016W4M might be slightly sandier than in Section 25-017-18W4M.

The well correlations were expanded further to include wells from a producing pool, Eyremore, in T19R18W4M, to compare the shale content of the Belly River Formation where it must be a seal to the shale content in Section 22-017-16W4M. The cross-section (Figure 6) is flattened on a correlation approximately at the top of the Foremost Formation. The sand/shale content in the rocks overlying the Basal Belly River appears to be similar in wells 13-09-019-18W4M and 11-22-017-16W4M. Since this section must be a seal at Eyremore, it would appear probable, based upon the gamma ray colour coding, that it is also a seal at Countess. We estimate that the Belly River Formation above the target injection formation is composed of about 40% silty sands and 60% silt/shale in Section 22. In comparison, well 15-05-019-18W4M is about 37% silty sand and 63% silt/shale in the same interval. There also appear to be several shale units that are at least 10 m thick.

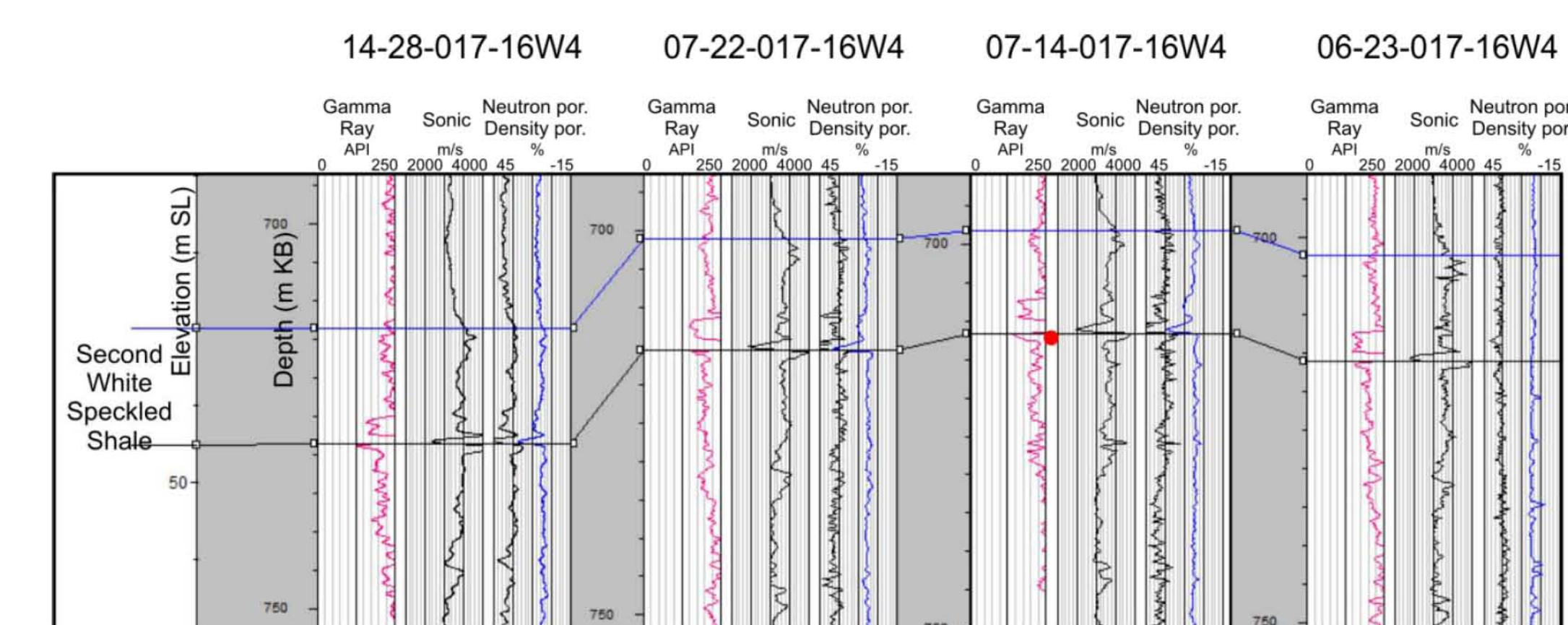


FIG. 4: Cross section showing the character of the Second White Speckled Shale Formation around Section 22. The thin sand unit shows up as a sharp spike on the gamma ray and sonic logs. Gas was encountered in well 07-14-017-16W4M in a 2 m sand (red dot).

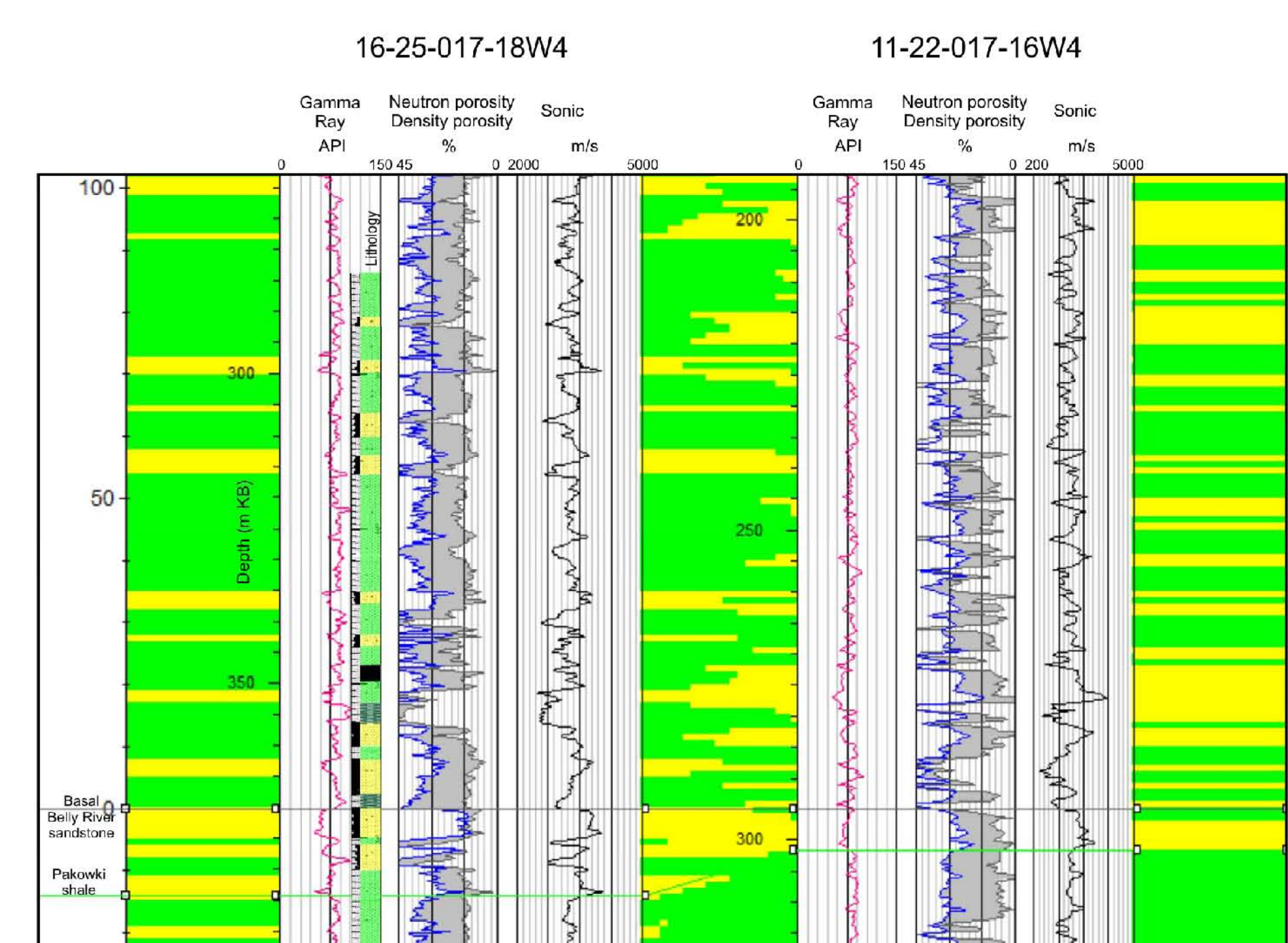


FIG. 5: Correlation of gamma ray logs from well 11-22-017-16W4M with well 16-25-017-18W4M, which has a lithology log. The logs are flattened on the top of the Basal Belly River.

ACKNOWLEDGEMENTS

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