Brazilian Equatorial Margin: evidences of magmatic intrusion and alteration of host rock from well data

[1]Aquino da Silva, A.G., [1]Perez, Y.A.R, [12]Vital, H.
Federal University of Rio Grande do Norte, Laboratory of Geology, Marine Geophysics and Environemental Monitoring - GGEMMA, Post-Graduation Program of Geodynamics and Geophysics – PPGG-UFRN, Geology Department
[2]CNPq Researcher

Introduction

The mechanisms of magmatic intrusion is very complex and are commonly associated to pristine unconformities (weak spots) on the crust that ease its emplacement on the form of sills or dikes. When occurring on the Oceanic crust these weak spots may lead to the formation of volcanic islands (such as Fernando de Noronha, on the Brazilian Equatorial Margin-BEM), submarine highs. Alignment of such features are related to Plate motion and the set of volcanos of Fernando de Noronha Ridge are considered a consequence of the westward motion of the South American Plate. Occurrence of magmatic rocks were found on a set of offshore wells at different depths and away of submarine highs. These magmatic emplacement suggests be related to a deep plume-fed mechanism which is the source of all sills found on the wells, as well as the volcanic highs occurring of the BEM. The lateral extents of the sills is greatly influenced by the presence of faults when preceding the intrusion, during which also occurred incorporation of parts of the host rock as xenoliths. On the well logs it is possible to observe changes on sonic slowness for the same lithotype when close to the sills, which indicates rock alteration due to the magmatic intrusion.

Material and Methods

On this research were used information from vertical wells available on the repository of ANP. The wells were drilled by PETROBRAS between 1975 and 2012 on water depths ranging from 40 m to 2200 m. The wells drilled the lithotypes of the offshore portion of Ceará and Potiguar Basins, on the Brazilian Equatorial Margin.

Sonic slowness logs were used to assess the influence of the magmatic intrusions on altering petrophysical properties of the surrounding rocks.

Results

The wells located close to Guaraní Guiot showed the higher number of magmatic intrusions (fig. 1). On W-06 was drilled the longest section of magmatic rocks with 347 m and it was located approximately 48 km from Guaraní Guiot. The wells most affected by the intrusions were drilled on the continental shelf at bathymetries shallower than 50 m, nevertheless, wells drilled on deep water also showed intrusions (bathymetries between 360 m and 1780 m) (Tab. 1).

The shallower intrusion was observed in Well-06 at 583 m, however, in most of the wells the intrusions occurred deeper than 1800 m (Fig. 2).

The intrusions observed at shallow depths also show erratic behavior on the sonic log, suggesting alteration or fracturing.

Comparing sonic slowness of wells W-12 and W-04 it observed that a difference of approximately 35 µs/ft on shales from the same geologic formation and depth below sea floor (Fig. 3).

Table 1 – General information about the wells.

Well Name	MR	Water Depth	TD	Length of sill/dike drilled
W-01	25	-365,0	3547,0	117
W-02	24	-36,6	1784,3	0
W-03	24	-34,1	1457,6	0
W-04	24	-47,0	3015,0	227
W-05	24	-40,6	2911,8	73
W-06	22	-41,0	1609,0	347
W-07	30	-21,0	2366,0	0
W-08	14	-1772,0	3817,5	61
W-12	28	-2130,0	5973,0	0
W-28	14	-1087,0	4504,8	0

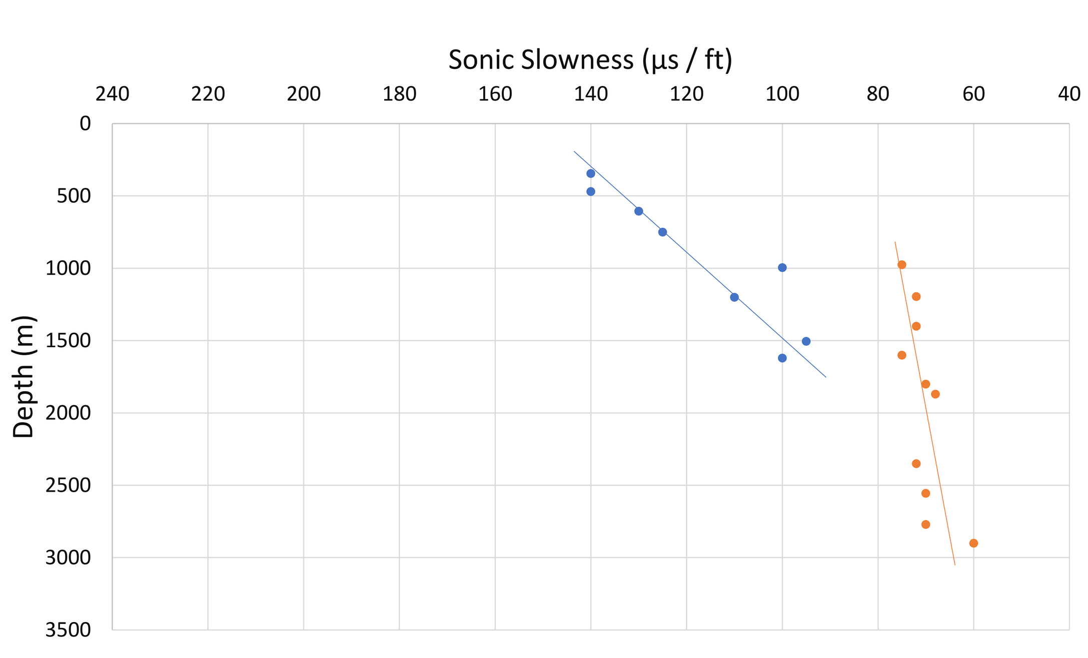

Figure 3 – Graph showing the sonic slowness curve, measured on shales, of the wells W-02 and W-04.

Conclusion

The increase on length of magmatic intrusion drilled and the proximity of the well to Guaraní Guiot suggest their source to be the same. Sonic slowness logs show a reduced travel time of the sonic wave, observed on shales, on wells containing magmatic intrusions. Therefore, the intrusions modified the hosting rock during emplacement due to temperature increase. The erratic behavior of the sonic slowness log on the magmatic bodies are result of fast cooling and water content of the host rock, which caused the intrusion to fracture.

The temperature increase caused by the magmatic intrusion may have implications on organic matter maturation, hence, contributing for hydrocarbon formation.

Acknowledgement

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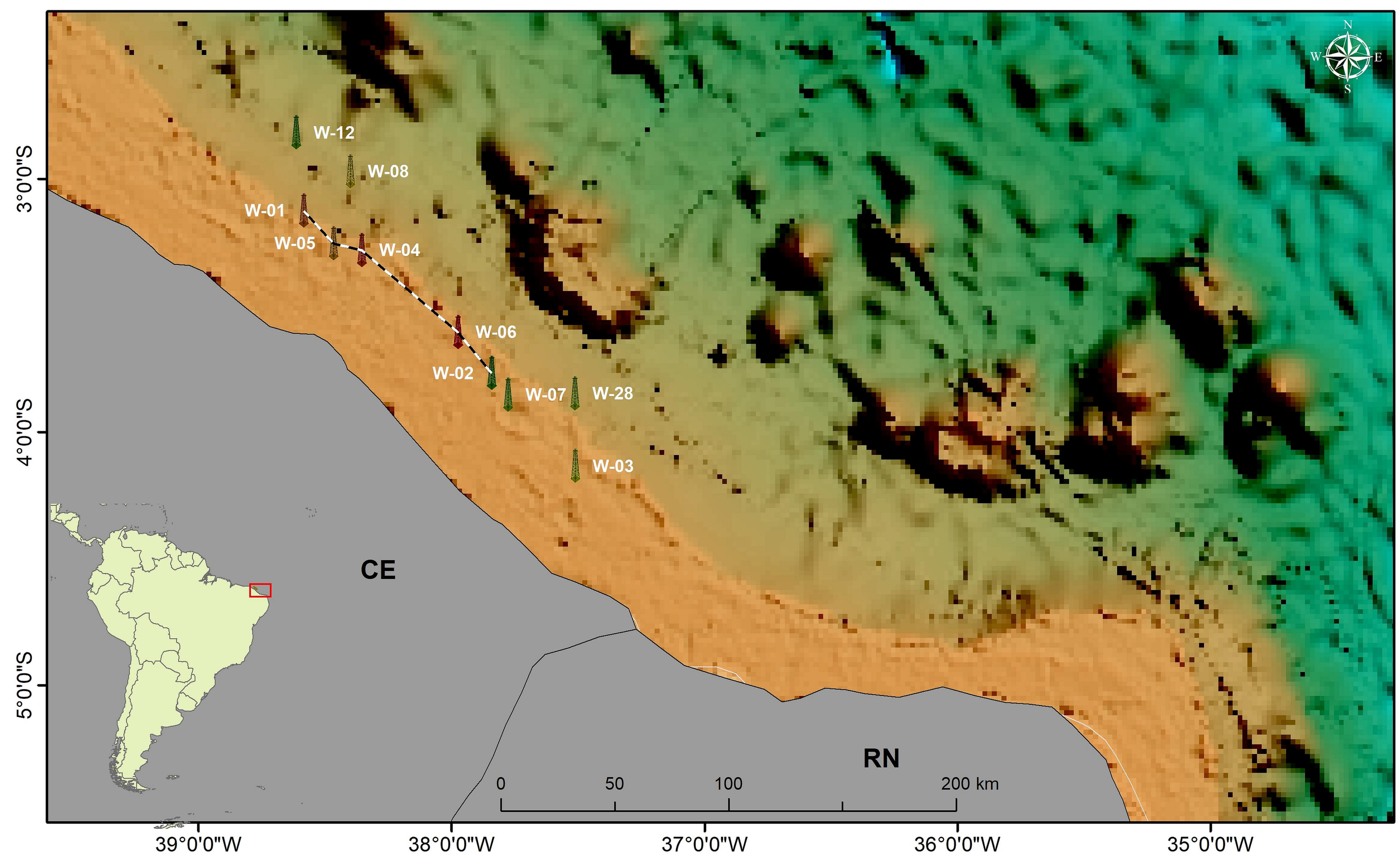
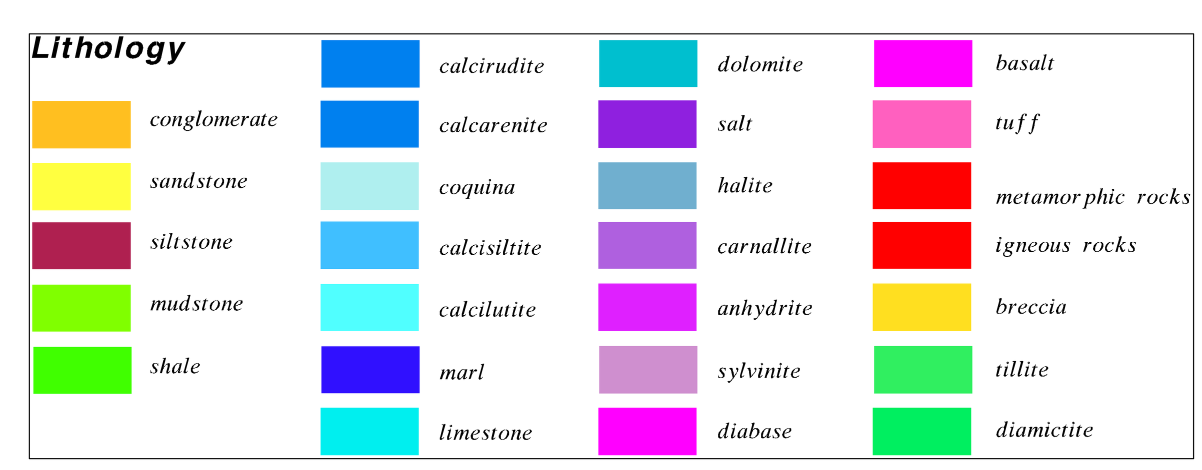
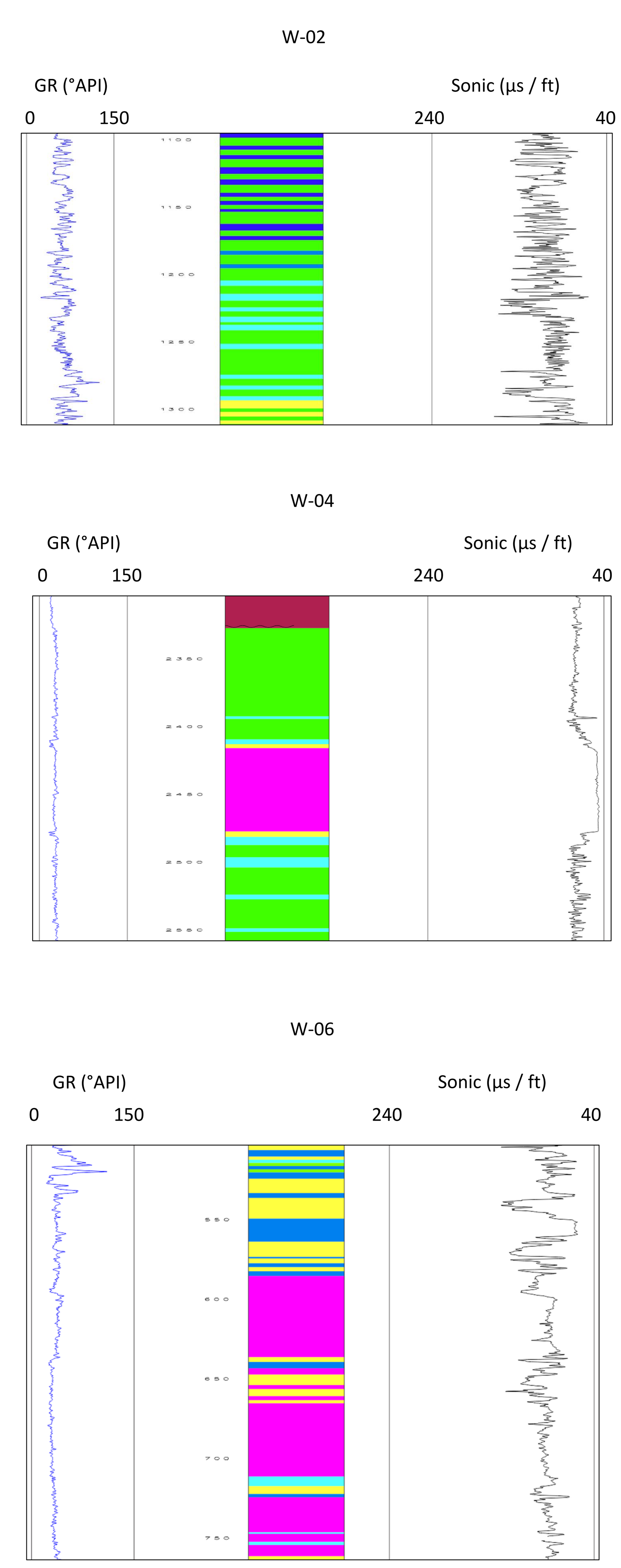


Figure 1 – Location map showing the location of the sea mounds and Guaraní Guiot, the wells used and the transect made using the wells.





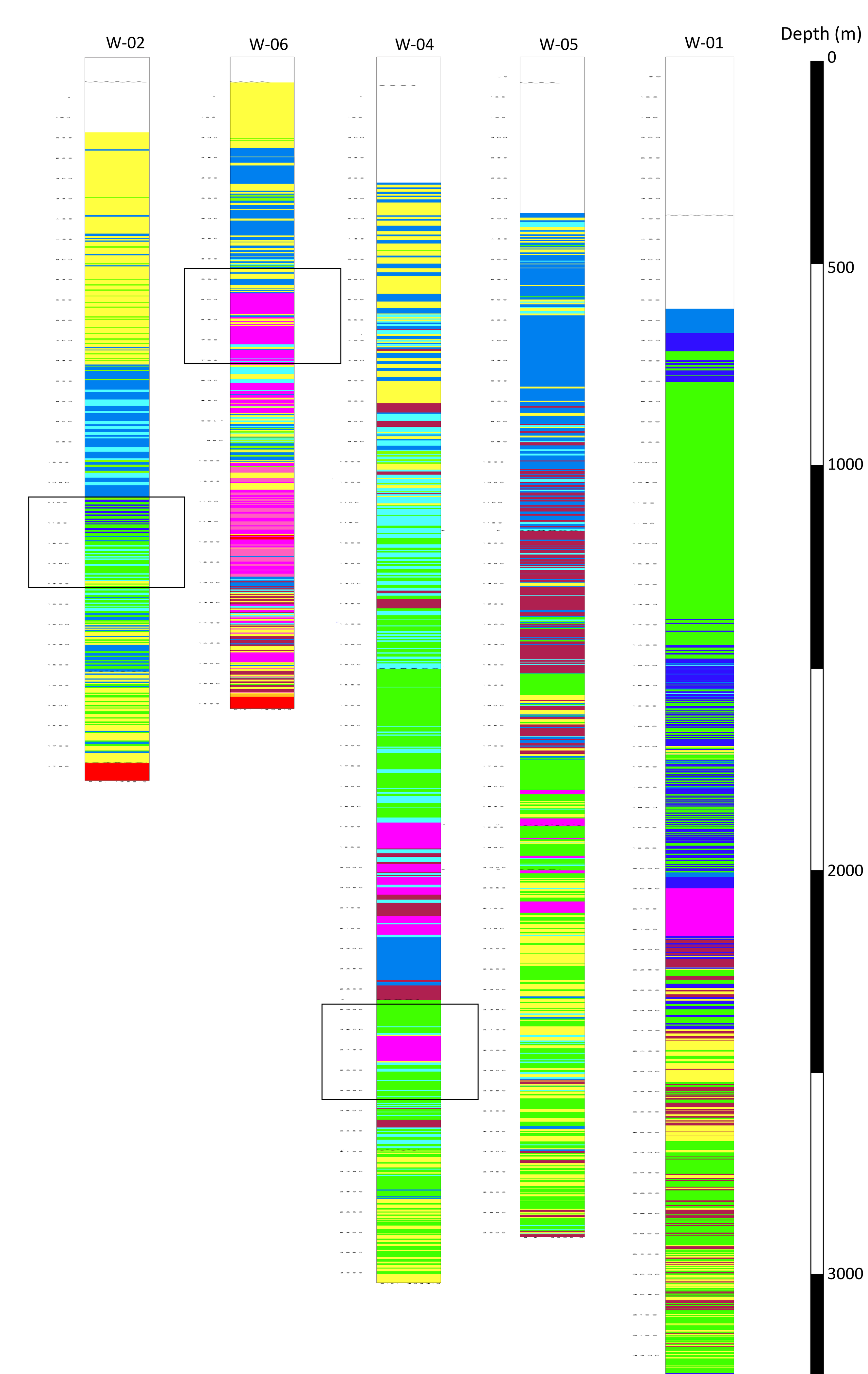


Figure 2 – Simplified representation of the lithotypes drilled on the wells. The black squares mark the location of the zoomed section of in wells: W-02, W-04 and W-06.