

Sequence Stratigraphy and Reservoir Architecture of the Blasillo Field (upper Miocene),
Salina del Istmo Basin, Southeastern Mexico.

By

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The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

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Salina del Istmo Basin, Southeastern Mexico.

Thesis directed by Professor Paul Weimer

ABSTRACT

The Blasillo Field is a mature field located in the Salina del Istmo Basin in the southern part of the Gulf of Mexico. An analysis of 71 wireline logs and 930 square km of 3D seismic data was done to evaluate the potential for infill drilling based on an improved understanding of reservoir geometry. Reservoirs are primarily upper Miocene turbidites deposited in bathyal water depths. Average porosity is 19 % and permeability is 215 mD. The field dips to the south along the flank of shallow allochthonous salt feature. The field has a combined structural/stratigraphic trap with three-way closure with an updip pinchout of the reservoirs.

The field is divided into 14 sequences, each separated by regional continuous shales. Seismic and log trends indicate transport from the south to southwest to the north and northeast. Five distinct wireline log lithofacies are recognized. Reservoir sands were primarily single to multistory channel-fill complexes varying from erosional to mixed erosional-aggradational channels. Lateral accretion packages are present within the producing zones indicating migrating channels.

To date, development wells have been drilled at 400-m spacing. Results of the

study indicate considerable potential for infill drilling. The depositional systems interpreted are considered semi amalgamated and could present barriers between the reservoirs levels and constitute areas of opportunity to drill infill wells closer to the pre existing wells. Considerable exploration potential is still present in the regions below the shallow allochthonous salt. Pre-stack depth migration processing will be necessary to image the potential traps.

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INTRODUCTION

Petroleum production in southeastern Mexico was established during the early 1900's in the Sureste basins (Salina del Istmo, Comalcalco, and Macuspana basins) (**Figure 1**). The Salina del Istmo is present in the western part of the area, and encompasses approximately 15,000 km², with about half of it onshore. The Cenozoic basin is composed of thick siliciclastic succession that produces light to medium oil from fields associated with salt-related traps. Fifty-two fields have been discovered in the Salina del Istmo Basin, and all but one field produces from Cenozoic reservoirs. Six of these fields have produced more than 100 million of oil (Guzman and Marquez-Dominguez 2001).

The Blasillo Field is located in the Salina del Istmo Basin in the southern part of the Gulf of Mexico (Figure 1). This onshore field was discovered by the Blasillo-2 well in 1966. The field consists of upper Miocene highly channelized deepwater sands that dip basinward (south) away from a shallow salt feature. The field was discovered with 2-D seismic data. Reservoir sands have porosities of 18-24% and permeabilities of 215 mD (average); oil gravity is 35 API. Today, 105 development wells have been drilled in the field. Since its discovery, the field has been produced through several distinct stages of development drilling. Today, the field is being evaluated for infill drilling by using recently acquired 3D seismic data, with the known production history and drilling technology.

Blasillo Field is a mature field with more of 30 years of production. Pemex, the field's operator, wants to extend the production of the field by (a) additional infill drilling and (b) later secondary recovery to help to achieve these goals. The objectives of this

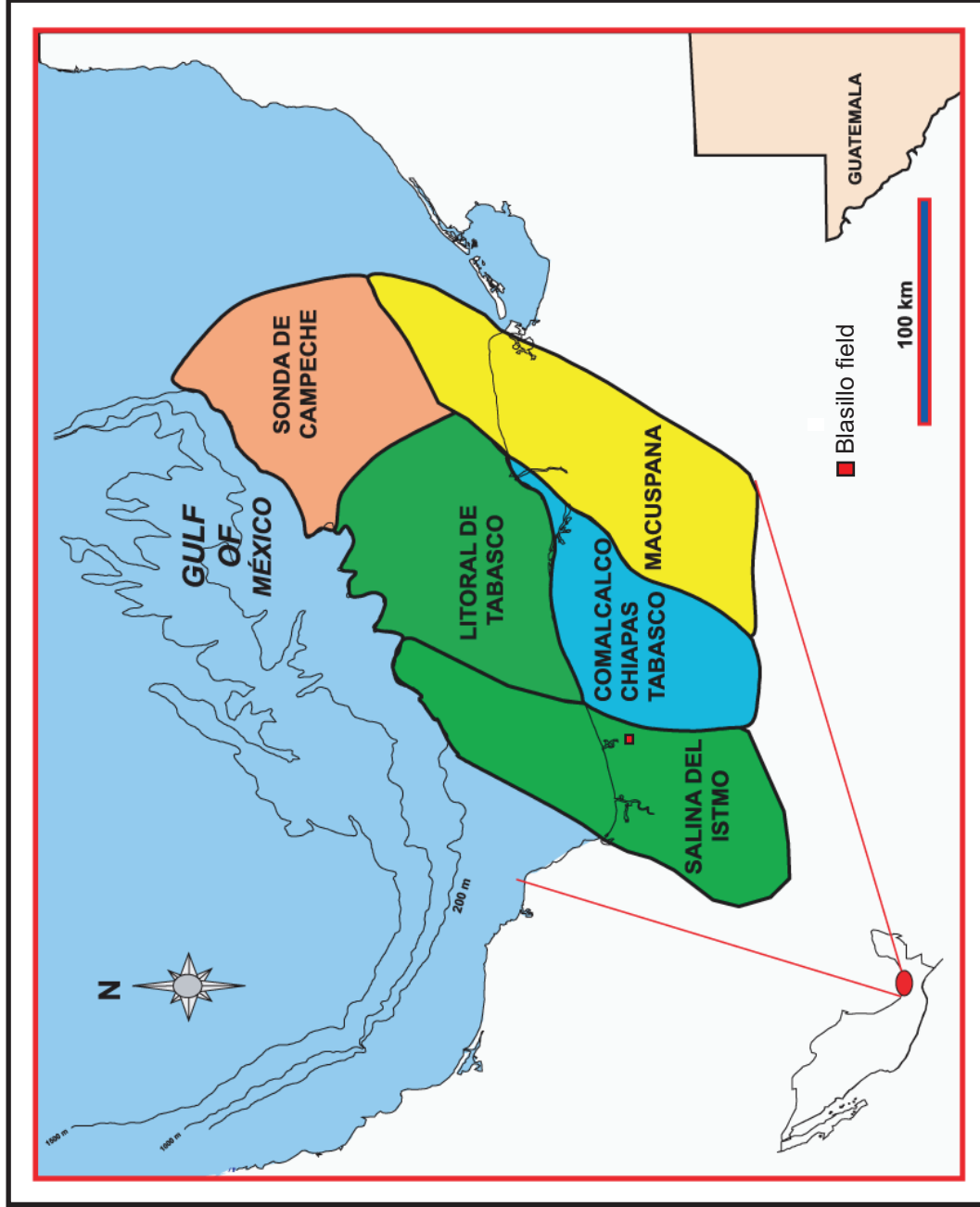


Figure 1. Location of the Blasillo field in the Salina del Istmo basin, onshore in the Southern part of Mexico and flanking Basins (Modified from Guzman and Marquez-Dominguez, 2001).

thesis were to: (1) establish the stratigraphic framework for the reservoir interval in the Blasillo Field by combining the extensive well log information with newly acquired 3D seismic information; (2) propose a geological model for the reservoir interval that focuses on the lateral relation between the wells; (3) understand the relationship of the known salt body adjacent to the field with the reservoir sedimentation in the field; and (4) identify potential zones of bypassed pay that could be the target of infill wells.

BASIN SETTING

The Salina del Istmo Basin is a Cenozoic basin that covers 9800 km² (3784 mi²) on the coastal plain of the southern Gulf of Mexico (**Figure 2**). The main geologic elements that bordered this basin are the Comalcalco Basin (east), the Sierra de Chiapas fold belt (south), the Veracruz Basin (west), in the coastal plain, to the north by the Pescadores Basin in the Gulf of Mexico (Sosa Patrón et al., 2009).

Tectonic setting

The Salina del Istmo Basin contains up to 7 km of Cenozoic strata deposited in the foreland basin and divergent margin settings (Oviedo et al., 1996). Three main tectonic events controlled the evolution of the basin: (a) compression initiated during the Late Cretaceous in the Sierra de Chiapas with major folding in the middle Miocene and thrusting with emplacement of salt canopies; (b) regional uplift and erosion of the Sierra de Chiapas during the Plio-Pleistocene, which provided large volumes of sediments causing a rapid northward progradation of the shelf margin into the present-day Gulf of Mexico and loading of the salt canopies; and (c) subsequent evacuation of the salt towards the Gulf of Mexico forming extensive salt-withdraw basins (Oviedo et al., 1996).

The main structural features in Salina del Istmo Basin are several allochthonous salt bodies. Some salt bodies are up to several kilometers in length. In the study area, salt bodies are interpreted to be close to each other and sometimes are in contact (**Figure 3**). A time-structure map of the top of the allochthonous salt from the 3D seismic data shows four main salt bodies; the top of salt bodies vary from 3.0 seconds to less than one second TWTT (**Figure 4**). The edges and base of the salt bodies are

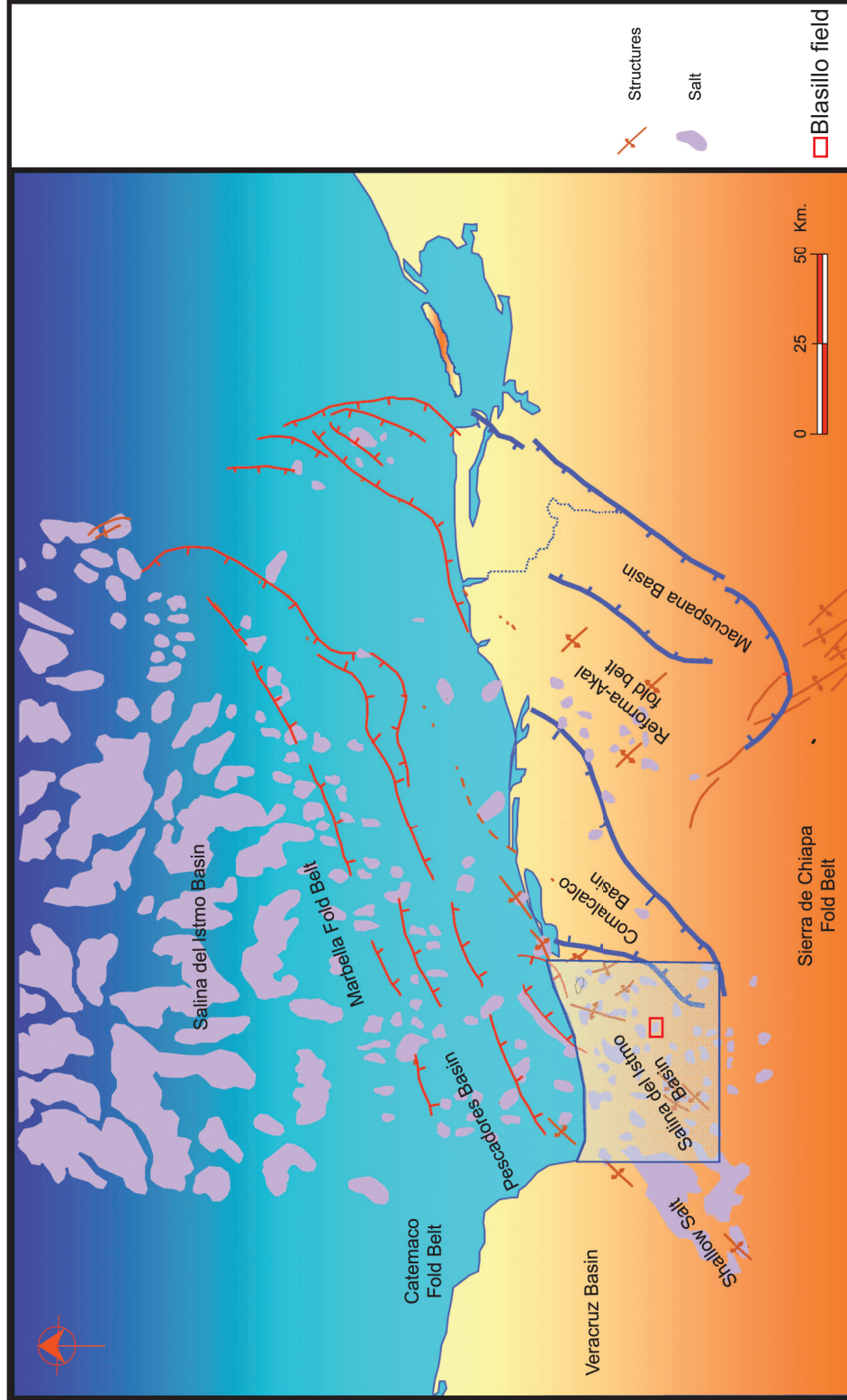


Figure 2. Tectonic setting of the Salina del Istmo Basin. The main elements that bordered this basin are the Comalcalco basin (east), The Sierra de Chiapas Fold Belt (south) and the Veracruz basin (west) in the coastal plain and by the Pescadores basin in the Gulf of Mexico. Several salt bodies are present in the onshore part of the Salina del Istmo basin. The length of some bodies is several kilometers which is equal or greater than some of the bodies found in the off shore (Modified from Sosa Patrón et al., 2009)

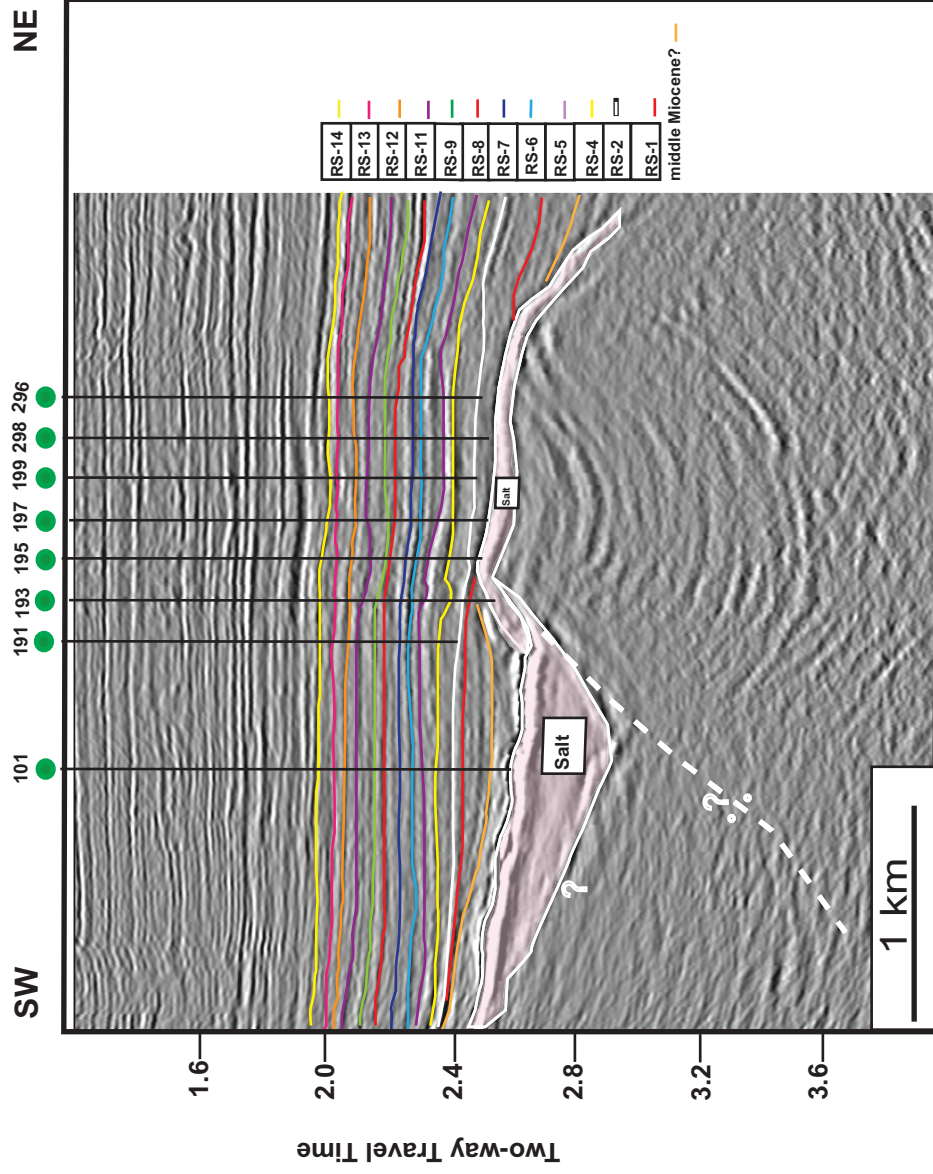


Figure 3. Seismic profile showing the section of correlation X1. The main production zone from the Blasillo field from RS-8 to RS-2. production zone is located in the flank of a salt body (pink). High amplitudes from top of the salt through RS- 8 are interpreted to correspond to stacking and lateral migration of channel complexes. Below the salt body in the right side there are reflections interpreted as strata that present a deformation pattern. See Figure 38 for location of profile.

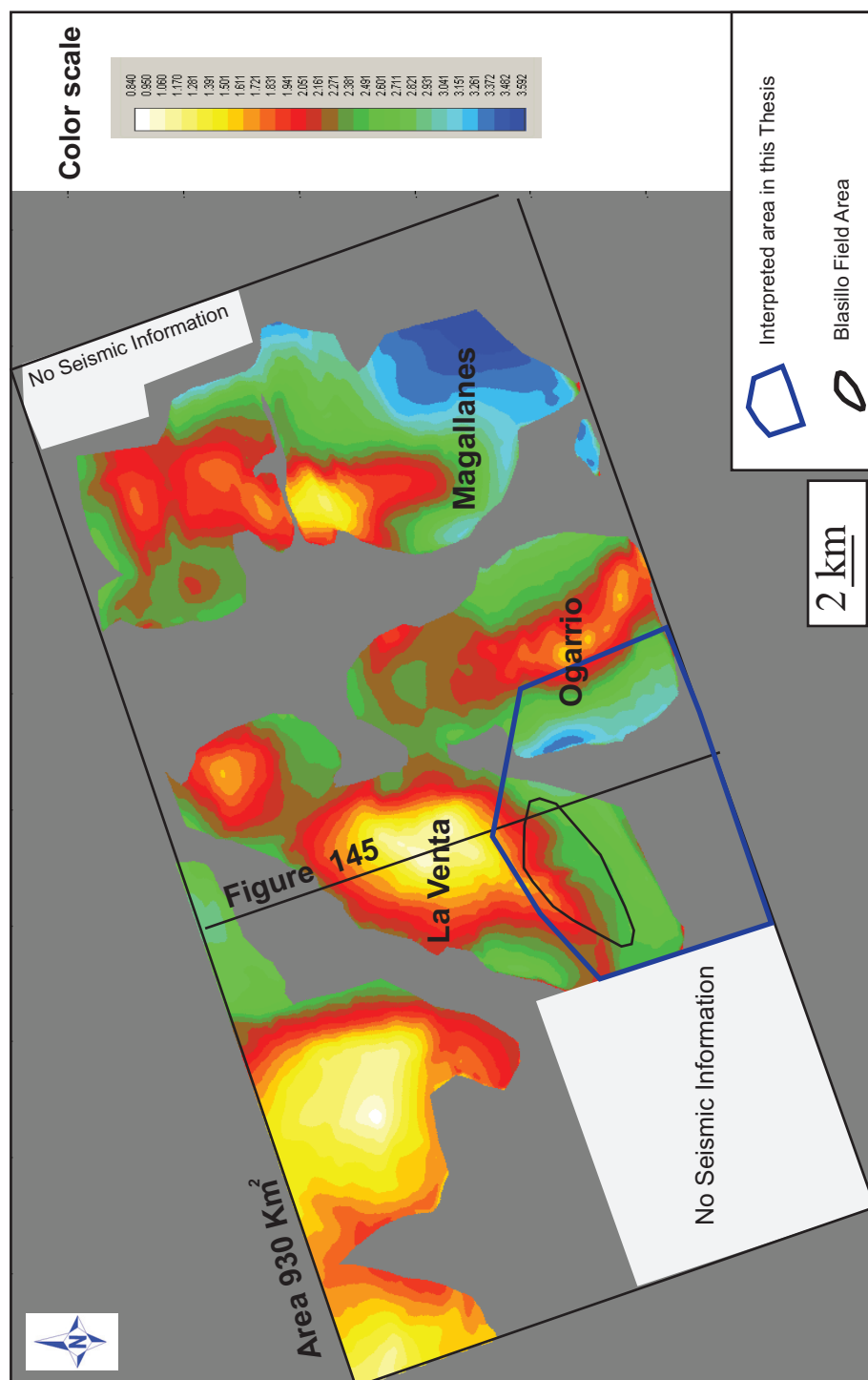


Figure 4. Figure shows the 3D survey with a time-structure map of the top of salt in the 3D survey in the Blasillo Field Area. White areas correspond to no seismic information. Black line shown location of seismic interpretation and the Blasillo Field are shown in blue and black colors.

difficult to interpret on time-migrated seismic data.

Petroleum production in the Salina del Istmo Basin has been from fields whose traps developed related with these salt bodies. Fields produce from reservoirs that overlie the salt bodies (La Venta Field) and from along the flanks of these bodies (Blasillo Field) (**Figure 4**).

DATA SET

An integrated development data set was used for this thesis including wireline logs, 3D seismic, VSP, core, and biostratigraphic information collected in wells.

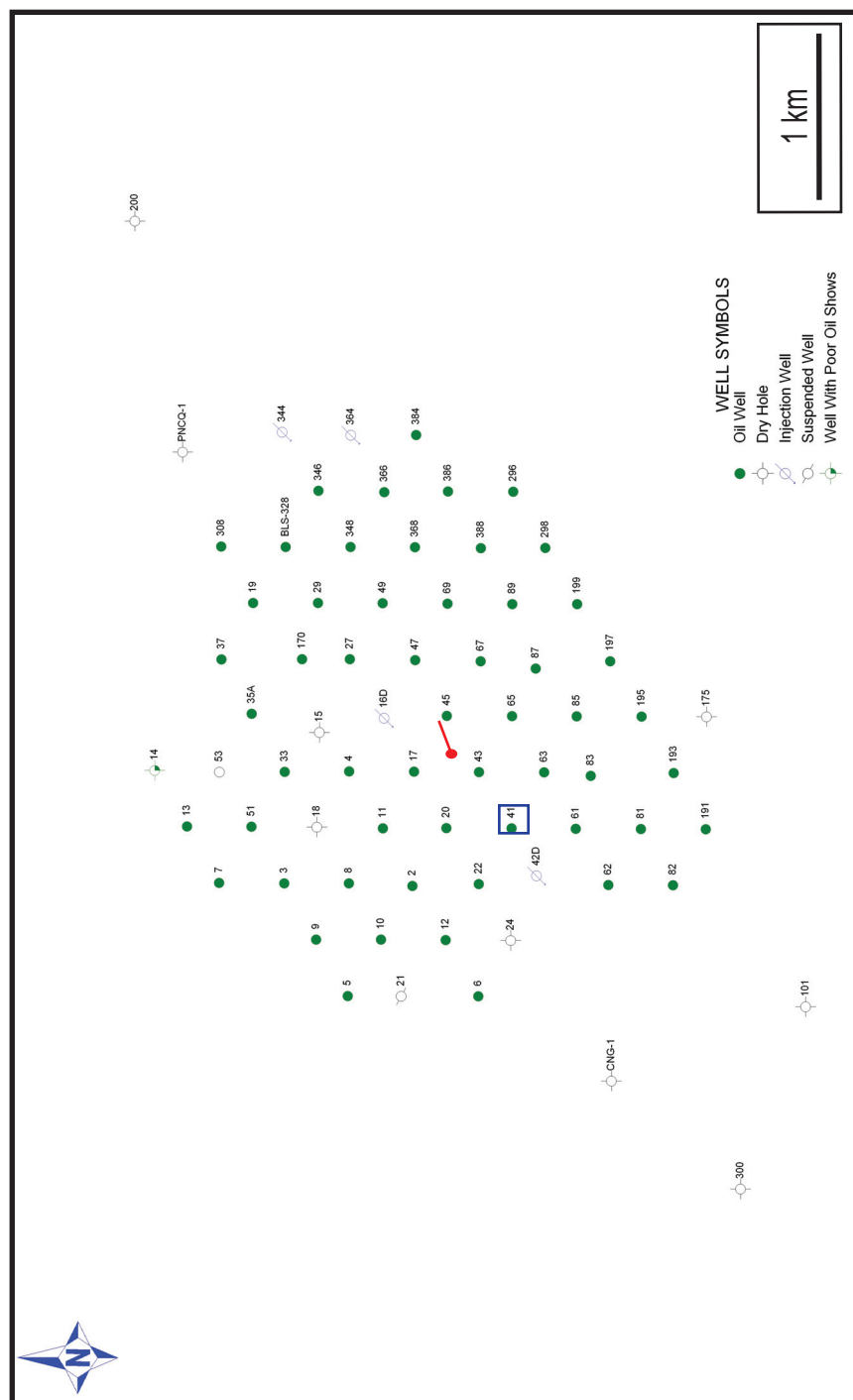
Wireline logs from 71 wells were used in this thesis. The wells have a regular spacing of approximately 400 meters (**Figure 5**). The set of curves used in this work are SP (normalized) and Resistivity logs (AT 90, RI, NL, ILD, LN).

A 3D seismic survey was acquired in 2005 across the Blasillo Field and covers 930 Km² (**Figure 4**). The onshore survey was acquired by Pemex through the Comesa Company with the objective of having good resolution at +/- 4500 m of depth. The prestack time migrated processing version was interpreted for this thesis. The bin size was 25 x 25 meters. The original survey was recorded in time to 8 seconds twtt; however, for this thesis; the data cube was clipped to 6 seconds to reduce the file size for interpretation. The sound source was dynamite, and the data were processed by Veritas-Comesa. The polarity is SEG normal (American polarity).

The results from one vertical seismic profile (VSP) from the 529 well were used. The time-depth curve provided by this survey was used to generate the synthetic seismograms, and time-depth curves for the different wells of the field.

Only one core was available for this thesis, the Blasillo 523 well, which was collected in a deviated well. The cored interval was 2836-2845 meters in depth. This core is from the reservoir zone and is considered to contain key sedimentologic elements that help to establish the geological model of the field in this zone. The core description is presented with photographs.

Biostratigraphic data are available from the 523 well; these data provide



information about the ages of the reservoir sediments and nature of the benthic biofacies.

METHODOLOGY

The data interpretation and integration required several related tasks, which included developing initial sections for log correlations, detailed correlations, and generation of lithofacies, isopach, net-to-gross and net sand maps. Seismic interpretation was done and synthetic seismograms were generated for all wells to tie them to the seismic data.

Section of correlation

Twenty wireline log sections were constructed to develop the basic stratigraphic framework of the reservoirs. The interpretation was done using IHS Petra software and the sections were labeled X, Y and Z (**Figure 6**). The sections labeled Z have a NE-SW orientation, the sections labeled X have a SW-NE orientation, and the sections labeled Y have a north-south orientation. In total, 23 log tops were identified and correlated, where possible (**Figure 7**).

Synthetic seismogram

Sixty-one synthetic seismograms were generated to tie those wells to the 3D seismic data. Two analyses of frequency were made in zone of the reservoir interval. One analysis (18 Hz) was done for the interval of the production zone (**Figure 8**). A second analysis was made for the entire interval of the wells (25 Hz) (**Figure 9**). The seismic wavelet with 18 Hz frequency yielded the best seismic-to-well-ties, and was the primary wavelet used to construct the synthetic seismograms. With the lack of complete set of logs for the older wells to generate the synthetic seismogram and to have a time-depth relation, Resistivity logs (NL, LN, RI, RT, ILD, etc.) were used to create the synthetic seismogram. A representative example of a synthetic seismogram

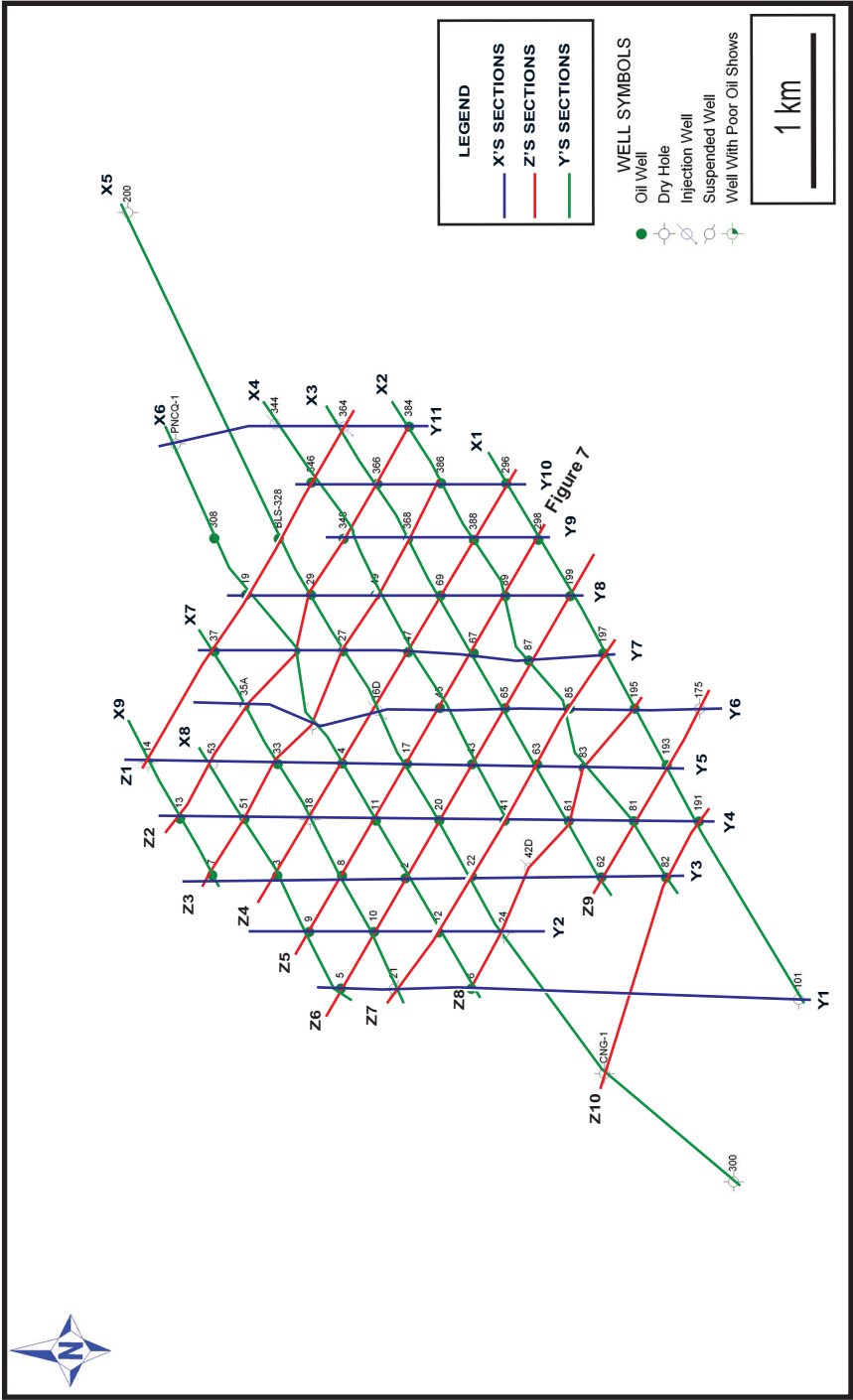


Figure 6. Basemap with the wells position and orientation of the section built in this study. 10 sections in color blue are labeled in a SE- NW direction(X'S), 11 sections in red are labeled in a S-N orientation (Y'S) and 9 section in green are labeled in a SW-NE direction (X'S). Location of Figure 8 is shown.

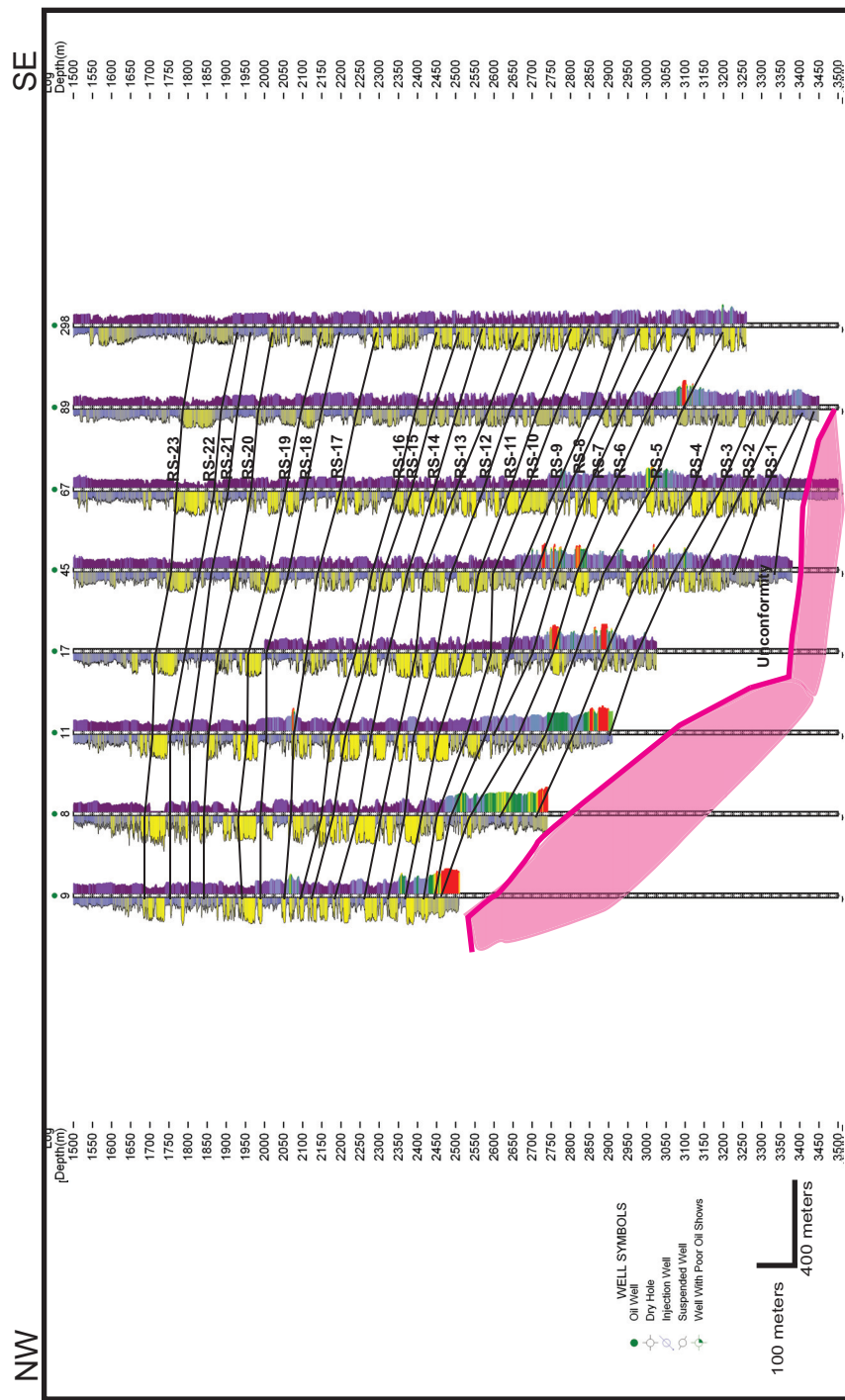


Figure 7. Sandstones bodies onlap against the flank of the salt. The Surface RS-9 is truncating the lower surfaces this concept is interpreted in a similar way in the seismic information. See Figure 6 for location of section.

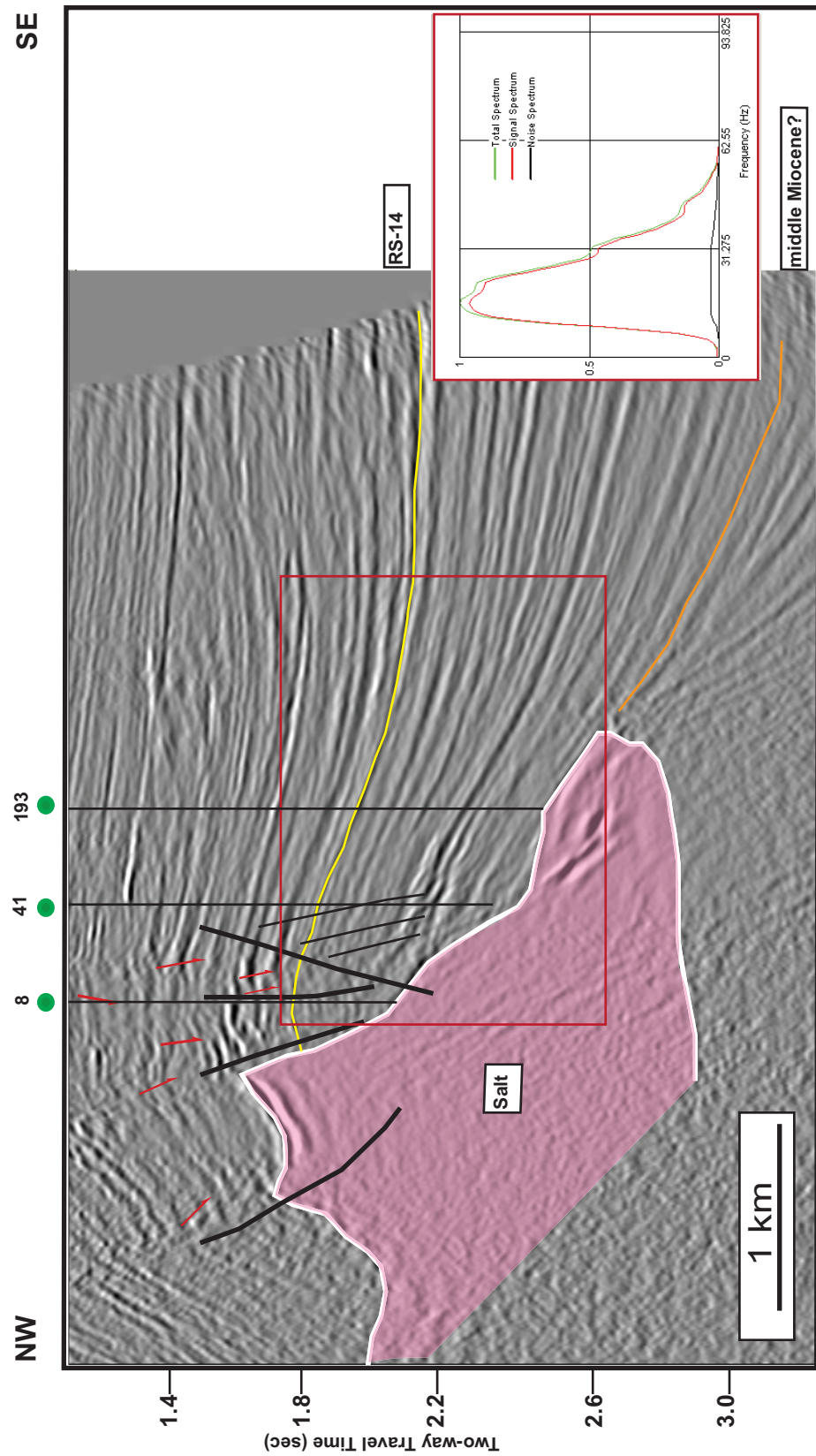


Figure 8. Seismic profile showing in red square the window of frequency analysis in the interval of study the frequency for this interval is interpreted to have a value between 15 and 18 hertz. See Figure 38 for location of profile.

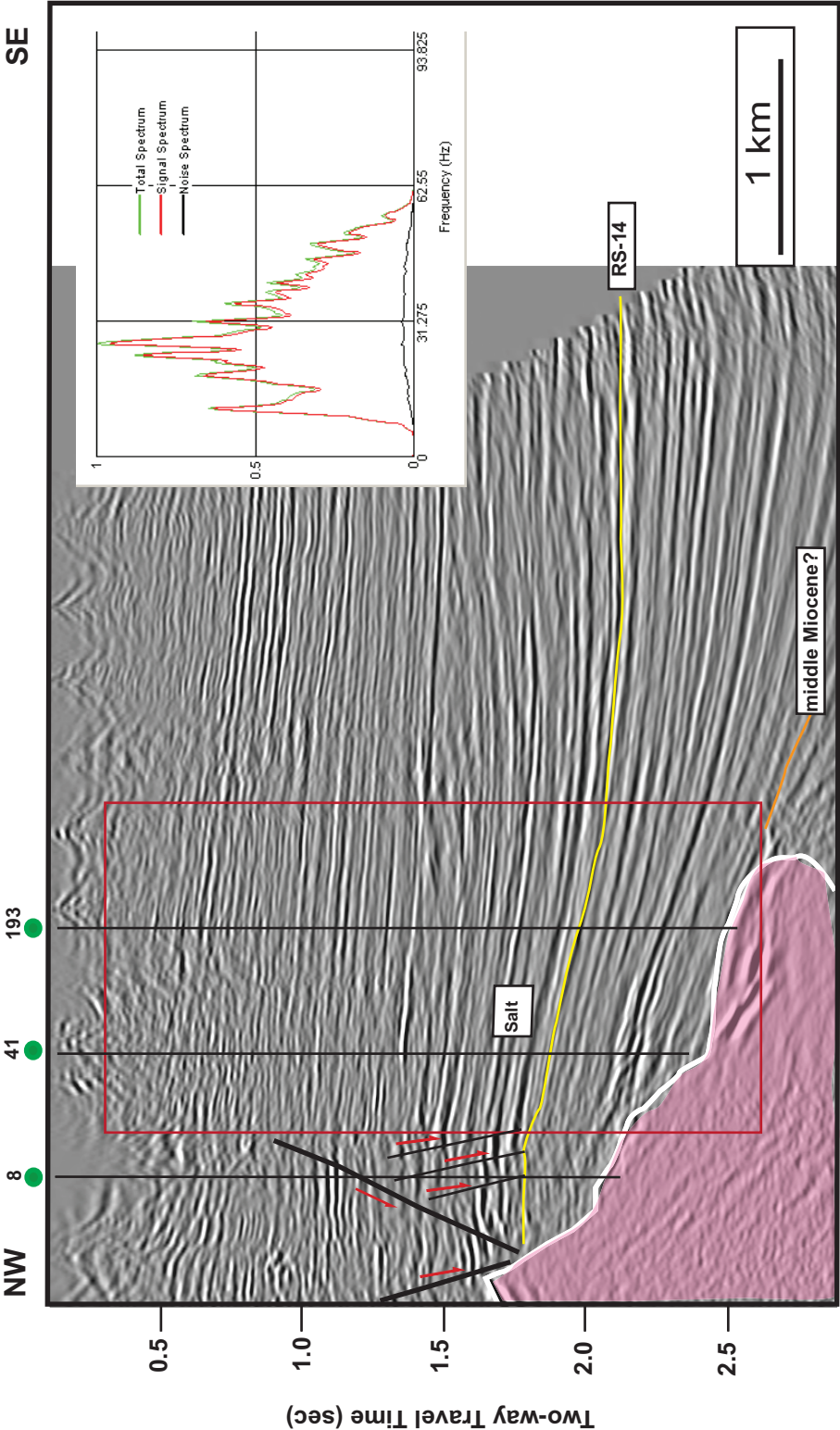


Figure 9. Seismic profile showing in red square the window of frequency analysis in the interval of the wells the frequency for this interval is interpreted to have a value between 23 and 28 hertz according to the two maximum peaks showed in the graph. See Figure 38 for location of profile.

is shown in **Figure 10**.

A well correlation using the synthetic seismograms is shown in **Figure 11**. A representative seismic profile with time-based gamma ray logs is illustrated in **Figure 12**.

Seismic Interpretation (Time-structure maps)

Seismic interpretation was done using SMT software. The surfaces correlated with wireline logs were exported from Petra to the seismic volume. Surfaces were then tied to the seismic reflections and analyzed. The seismic interpretation was done on every fifth line, and using random lines, a second round was made to smooth the interpretation and it was made every 10 lines. The method used during the interpretation of this study was following the concepts used by Vail (1987) for seismic stratigraphic interpretation. As result of the seismic interpretation, time-structure maps were generated for each sequence except Sequences 3 and 10. The seismic information was used to guide where was possible and clear, the top position of one marker that could be adjusted to improve the log correlation.

Maps

Five kinds of maps were generated to evaluate various aspects of each sequence: isopach, net-to-gross, net sand, lithofacies, and seismic amplitude extractions. Isopach, net-to-gross and net sand maps were generated for each zone using Petra software. Lithofacies maps were generated for each sequence to complement the wireline log cross sections. The SP curve for each well is shown in map view. The maps were displayed and then interpreted using five SP log shapes: blocky (orange), coarsening upward (blue), fining upward, (yellow), serrate (green), no

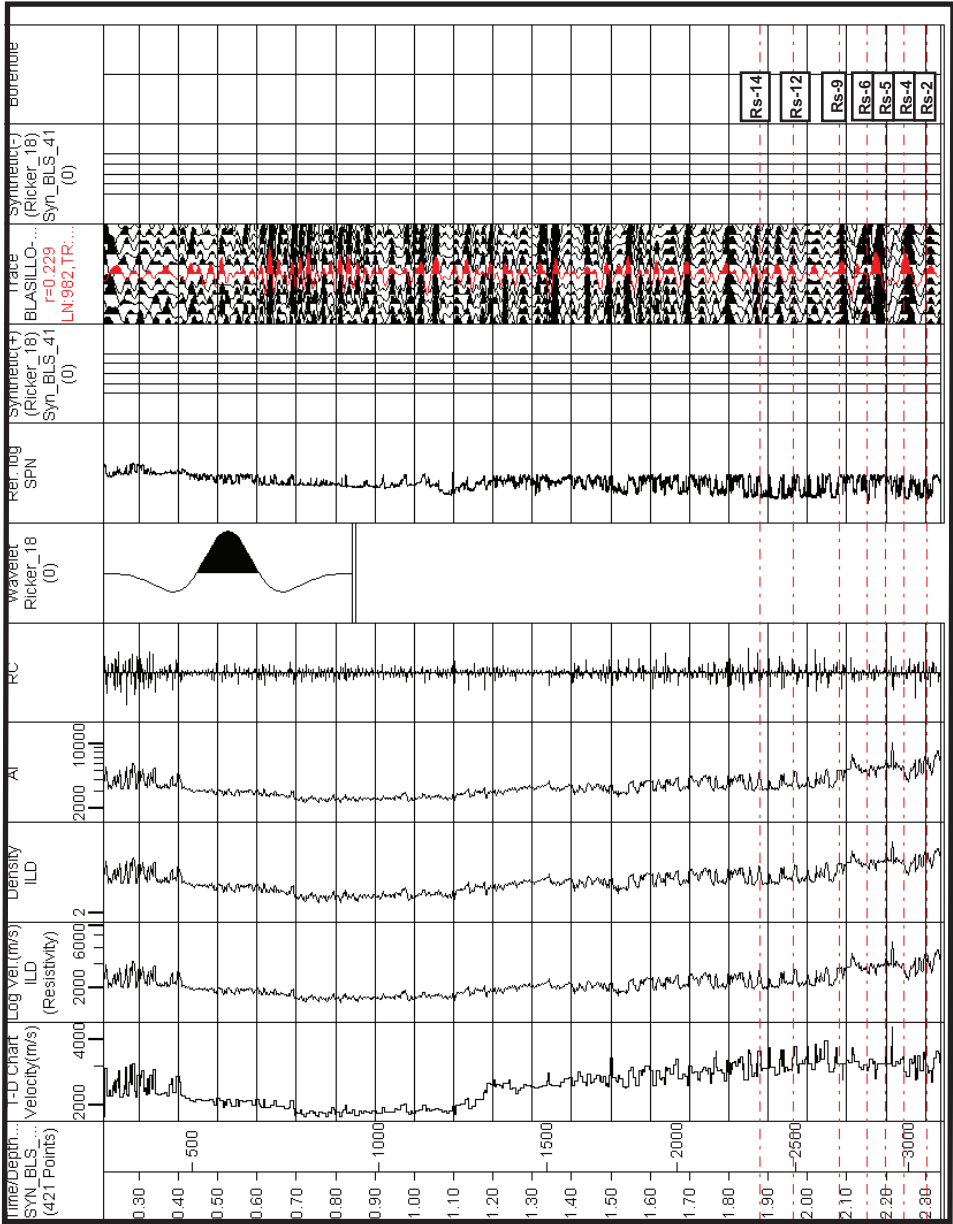


Figure 10. Shows a synthetic seismogram for the well 41 with the markers coming from the log correlation to establish the relationship with the seismic. Peaks of the seismic are interpreted related with shale intervals, a wavelet model with a frequency of 18 hrz was used to constructed the seismogram. See Figure 5 for location of well.

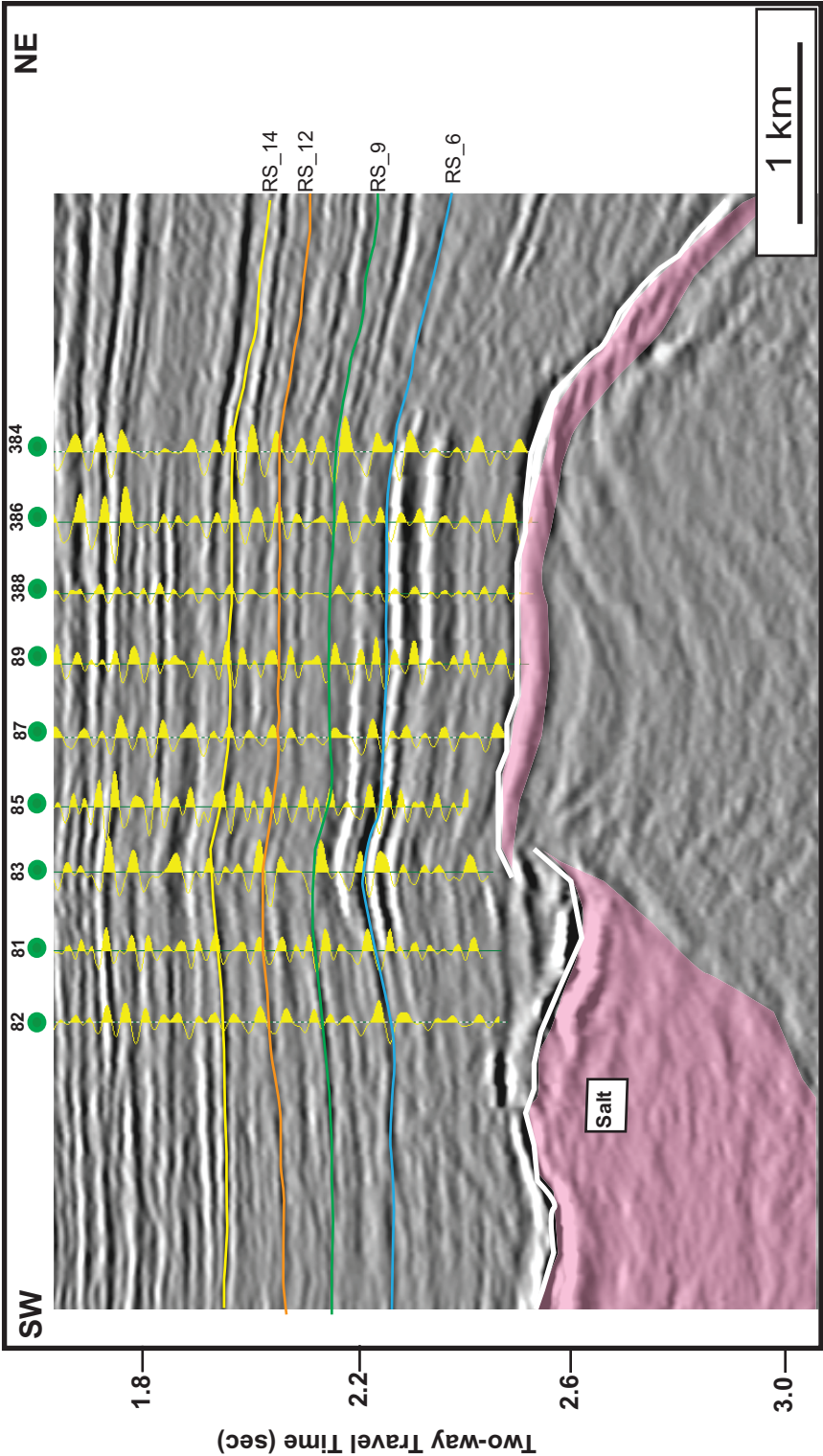


Figure 11. Seismic profile showing a section of correlation X2. This figure shows the synthetic seismograms from the wells in this section 18 Hertz was the frequency used with a modeled wavelet of Ricker to built them. See Figure 38 for location of profile.

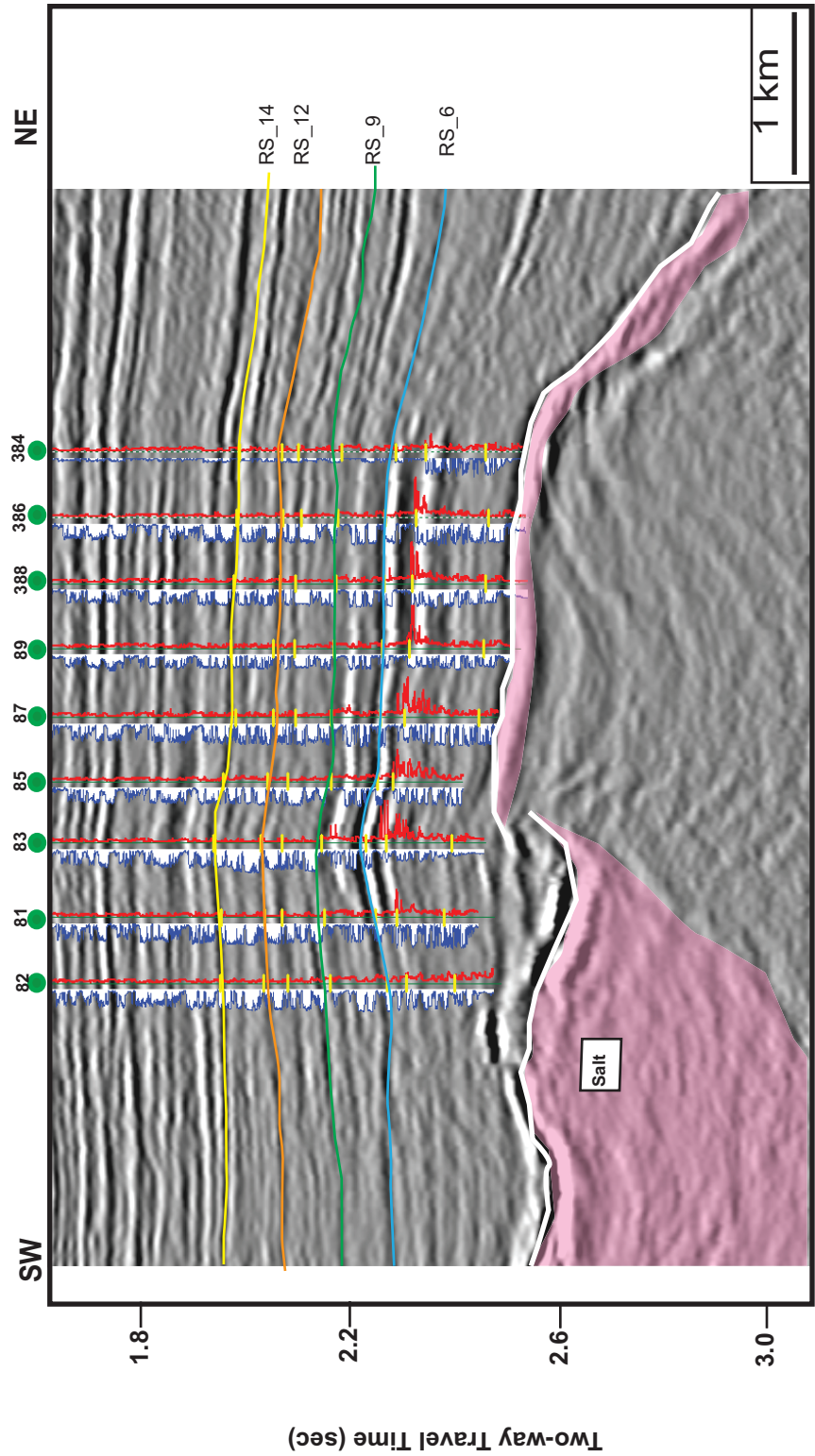


Figure 12. Seismic profile showing section of correlation X2. This figure shows the wells with picks and correlation of horizons used to guide the correlation. See Figure 38 for location of profile.

expression (brown). The relation and interpretation of the different signatures will be discussed further below.

In addition, several seismic amplitude extraction maps were generated for each sequence using gated windows of 10, 20, 30, 40, 50, 60, and sometimes 80 milliseconds above and below of each key surface. Each of the maps was then evaluated to ascertain which map might best indicate depositional trend within a sequence. Only one RMS amplitude map is shown below to illustrate the interpretation of each sequence. However, the other maps were analyzed to have a better understanding of the main sediment supply directions and the shape of the systems identified in this thesis.

REGIONAL STRATIGRAPHY

The Blasillo Field is present in a minibasin that is surrounded by several shallow allochthonous salt features (**Figure 4**). The field sits on the southern flank of a shallow salt feature (**Figure 3**).

To understand the overall depositional setting and stratigraphic evolution of the basin, a seismic profile was flattened along a shallower upper Miocene reflection (**Figure 13**). The lower to middle Miocene strata are dip away from the shallow salt body and possibly, also underlie the salt. A prominent sequence boundary sits at the top of the middle Miocene sediments. The upper Miocene sediments progressively onlap and pinch out higher along the salt, indicating the downbuilding of the salt through the time, and rotation of sediments such that they now dip to the south. Overlying the surface RS-14 (lower Pliocene-Plio/Pleistocene), there is a clear change in the sedimentation, shallow to marginal marine sediments prograded into the area as evidenced by the prominent clinoforms that show progradation to the north-west (**Figure 13 A, B**).

Based on detailed correlations within the extensive wireline log data base, fourteen discrete shale intervals were recognized in upper Miocene sediments of the Blasillo field (RS 1-14) (**Figure 14**). These shales are 5-15 meters thick and separate the major sand reservoirs.

The biostratigraphic data from the 523 well help to place age dates and benthic biofacies on the reservoirs sands. The extinction datum for *Discoaster quinqueramus* (5.5 Ma) is at 2350 depth, and rest in the RS-14 shale. Benthic biofacies indicate the underlying sandstones were deposited in upper bathyal water depths. No other

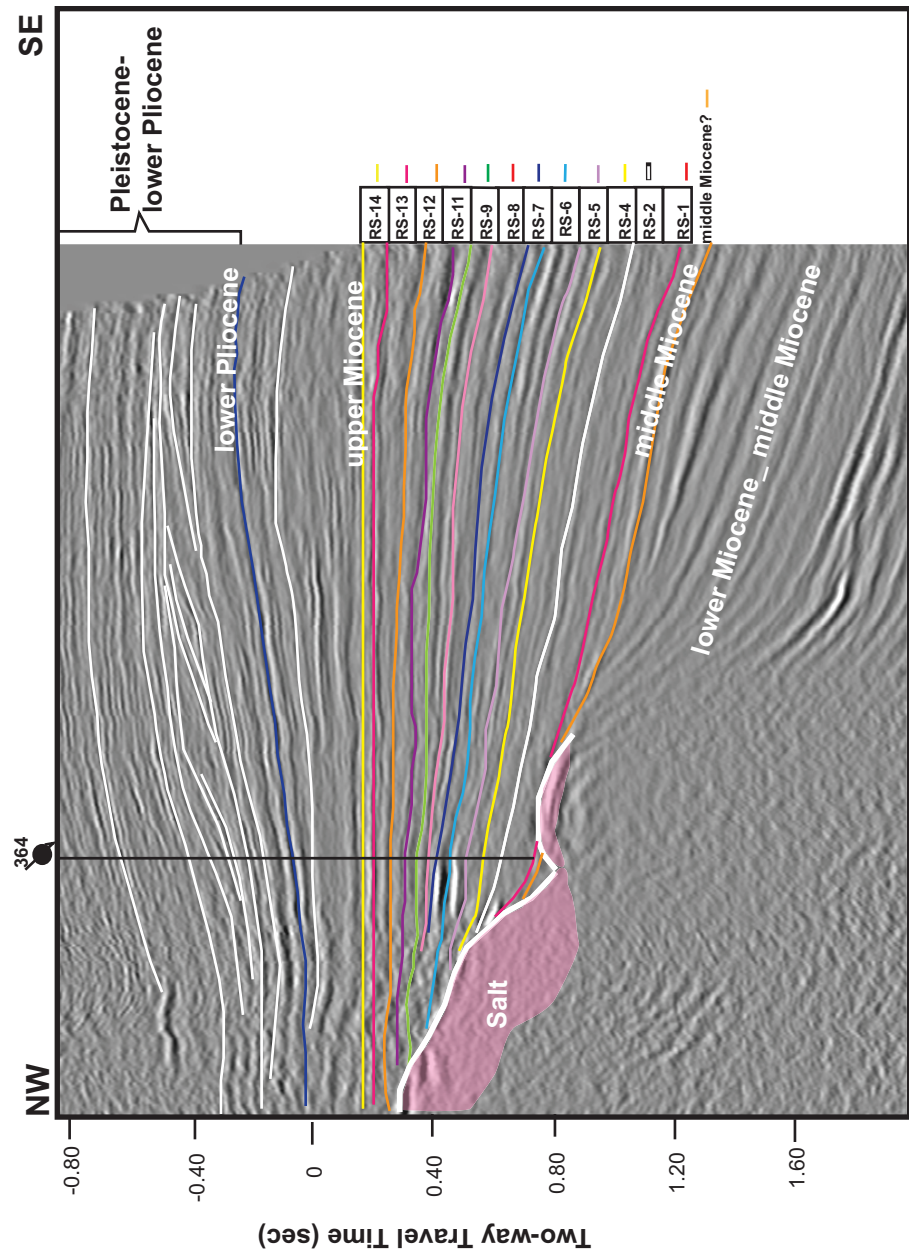


Figure 13 A. Seismic profile across the Blasillo field flattened on the surface (RS-14). Below the salt body reflections are interpreted related with strata. The middle Miocene?, is close to the salt body, almost all the surfaces of the study interval are pinching out against the salt body but RS-7 and RS-8 are eroded before to reach the salt body. Above the flattened surface RS-14 interpreted as the top of the upper Miocene, is possible to distinguish a set of clinoforms which are prograding to the nw. See Figure 38 for location of profile.

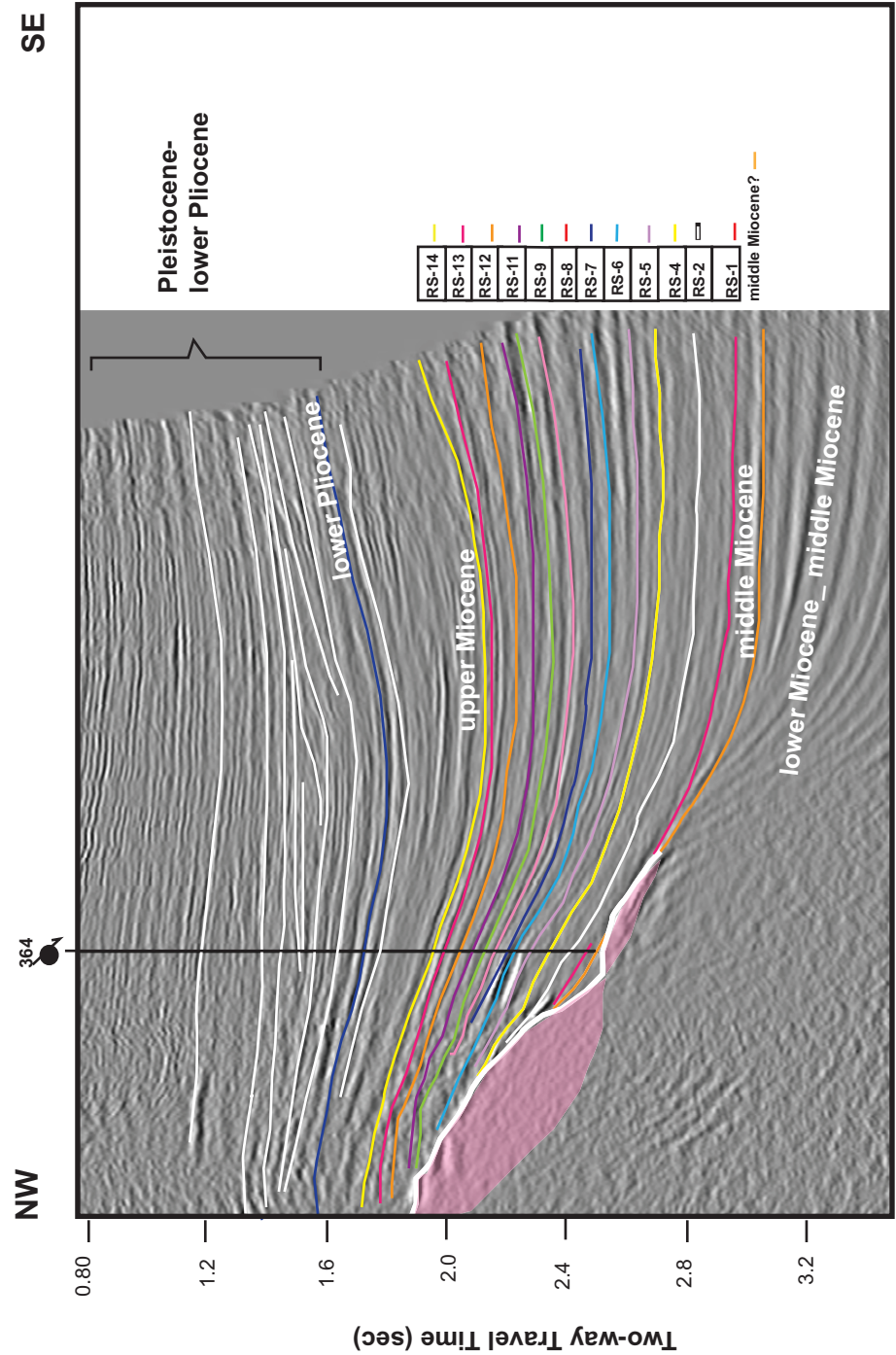


Figure 13 B. Seismic profile across the Blasillo field. Section unflattened. See Figure 38 for location of profile.

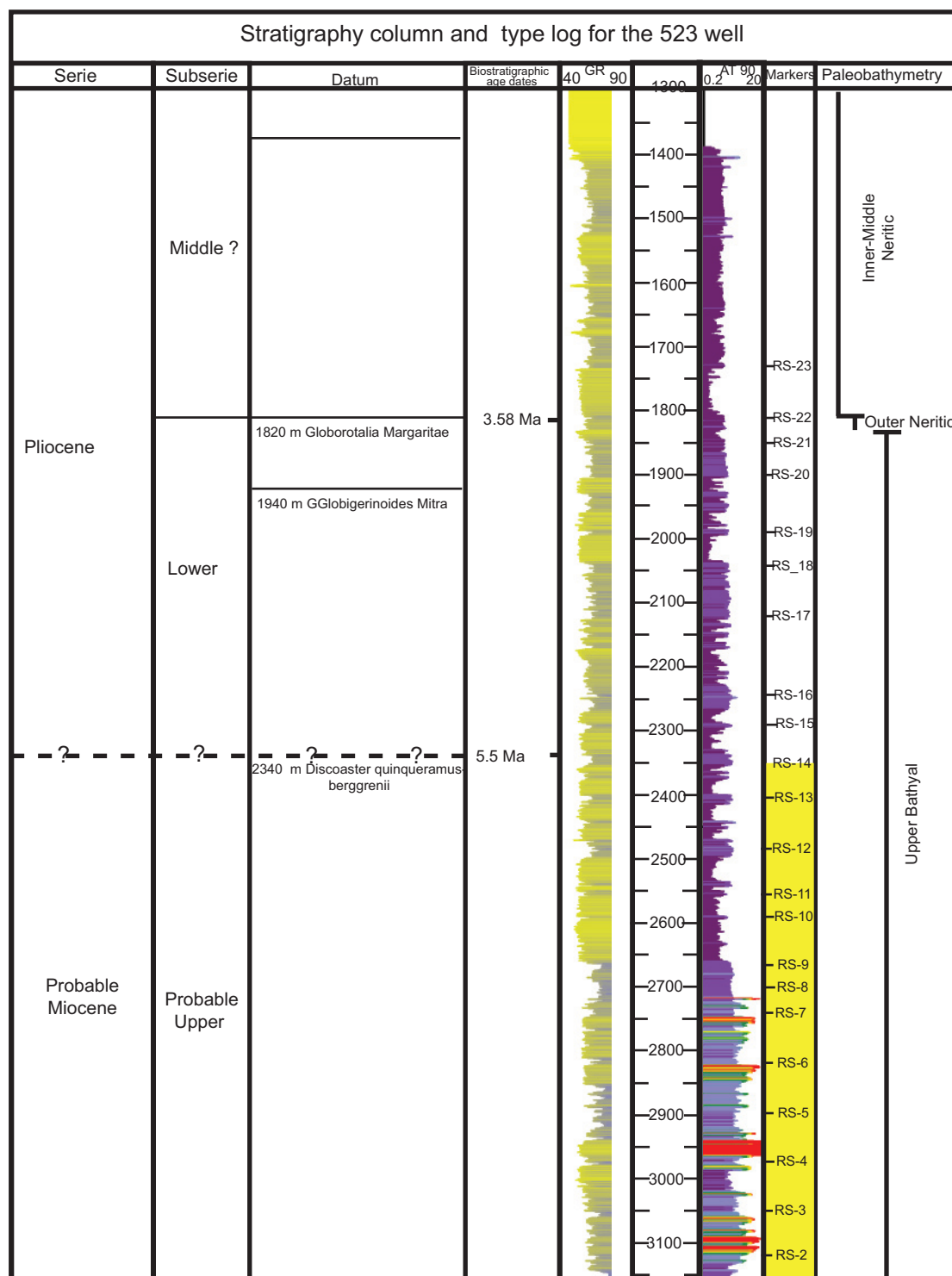


Figure 14. Stratigraphic column and Paleobathymetry for the field is provided by data from the well 523. An probable upper Miocene is reported in the well the top is close to the Top of the interval studied, sediments were deposited in upper Bathyal paleo water depth according to the well data. Change in the net to gross ratio is evident above The RS-9. Yellow area correspond to the markers from the interval studied, shallower markers were interpreted but are not included in this study. See Figure 5 for well location.

Modified from Pemex 2006

extinction datum is noted below this well (**Figure 14**). The age date for the top of the middle Miocene is correlated from a well of a near field (Ogarrio) (**Figure 4**).

For the seismic interpretation, twelve depositional sequences (1-14) were recognized in the upper Miocene (**Figure 15**). A comparison of the results of this study with the onlap chart derived from the north Gulf of Mexico (**Figure 16**) indicates that are many more sequences identified in this study than recognized in the northern Gulf of Mexico. Therefore, the precise frequency of each sequence is unknown.

A vertical seismic profile through the field shows vertical changes in the seismic reflections indicating changes in the stacking patterns of the channel complexes (**Figure 15**). These changes are most apparent between surfaces RS-1 and RS-9. Channel complexes are interpreted to change upward from erosional to erosional/aggradational patterns forming cycles of different orders (**Figure 15**).

The biostratigraphic zonation developed for the Neogene sediments in the northern Gulf of Mexico is shown in Figure 16. Six depositional sequences have been identified in the upper Miocene that correspond to the reservoir interval in the Blasillo Field. However, due to the lack of biostratigraphic resolution in the Blasillo field, it is difficult to know how the fourteen depositional sequences identified in this study correlate to those six third-order sequences in Figure 16. A proposed correlation is shown in **Figure 17**.

Only one core is available from the Blasillo Field, from the 523 well. The cored strata are in sequence 6 (RS-5_RS-6) and are primarily sandstones (**Figures 18-35**). The core has several distinct erosive and sharp contacts overlain by sandstones. Conglomerates are present in one zone. The general grain-size trend in the core is

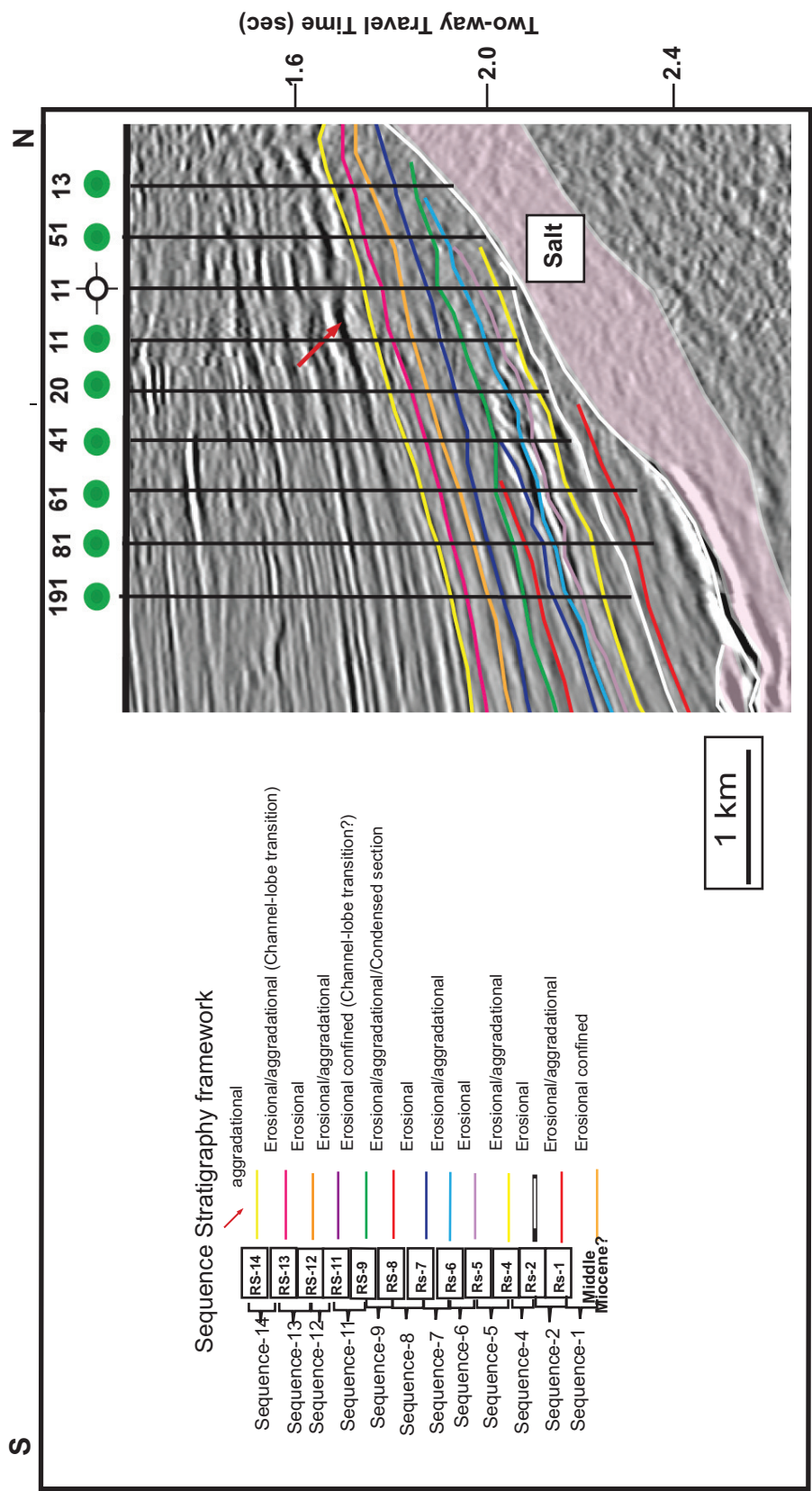


Figure 15. Seismic profile showing the interpreted sequences and the interpreted sequence stratigraphy framework. Fourteen sequences are interpreted as the main framework base in the log data, two of these sequences (3 and 10) are included in the sequence 4 and 11 in the seismic profile because they are below seismic resolution. Each sequence presents changes in the vertical stacking pattern interpreted changing from erosional to mixed erosional/aggradational, channels making a cycle each of this hemi-cycles are interpreted as a higher order sequence (4th order?). In the top above the RS-14 an interpreted aggradational feature is present and could be related with the end of the sequence. See figure 38 for location of profile.

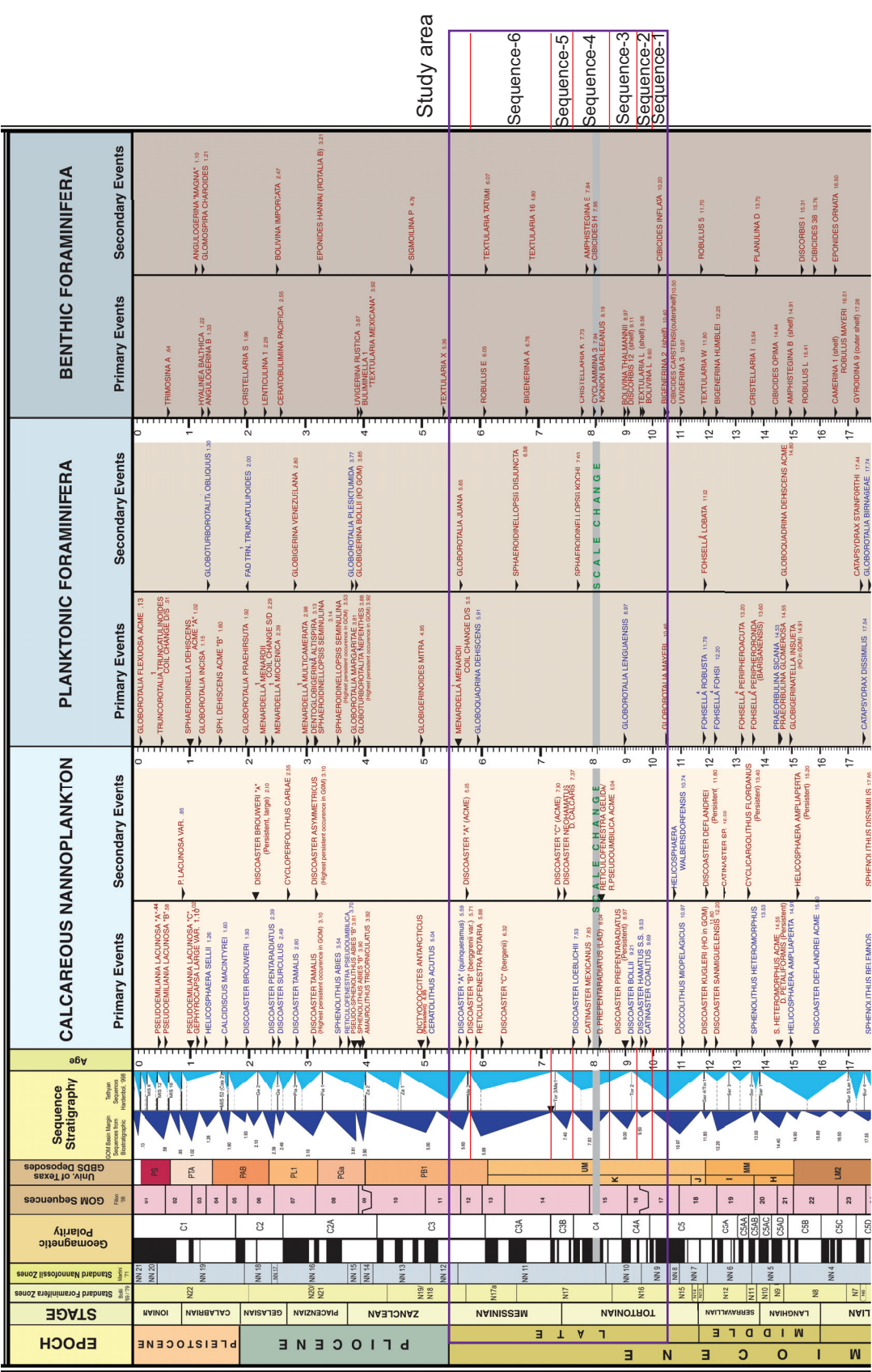


Figure 16. Biostratigraphic zonation middle Miocene through Pleistocene. The purple rectangle shows the interval studied. Candidates for 3 rd order sequence boundaries are shown by red lines to the right. Figure is adapted from Art Waterman. Modified from: http://www.paleodata.com/downloads/PDNeogene_ver1003.pdf

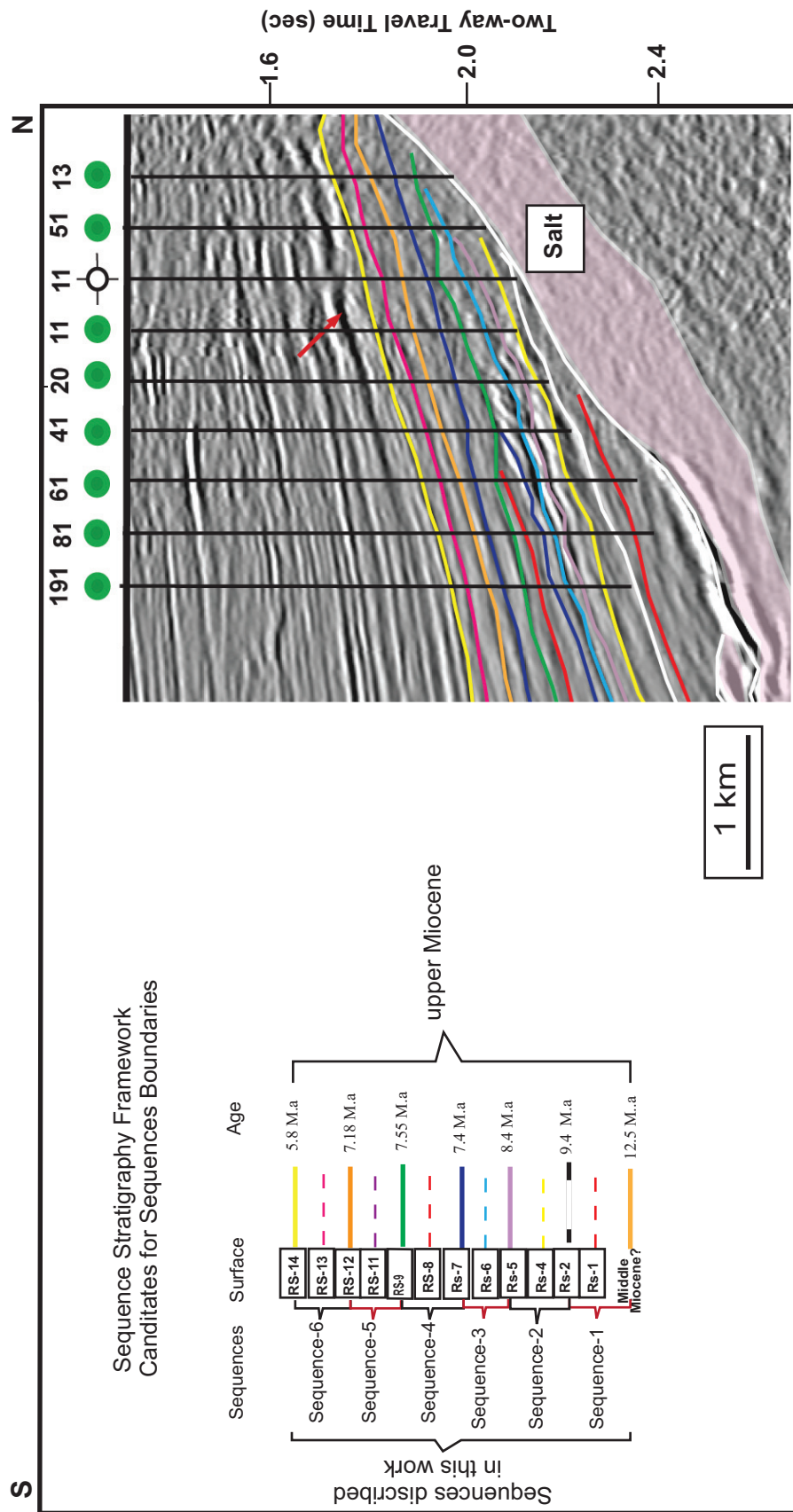


Figure 17. Interpreted sequence stratigraphic framework and interpreted seismic profile. Six main sequences are interpreted in the upper Miocene. The sequence boundaries identified for each sequence are shown in bold lines. Internal interpreted higher order sequences are shown in dashed lines. The sequences boundaries ages, proposed as candidates, are interpreted from the Paleodata Chronostratigraphic Chart. See Figure 38 for location of profile.

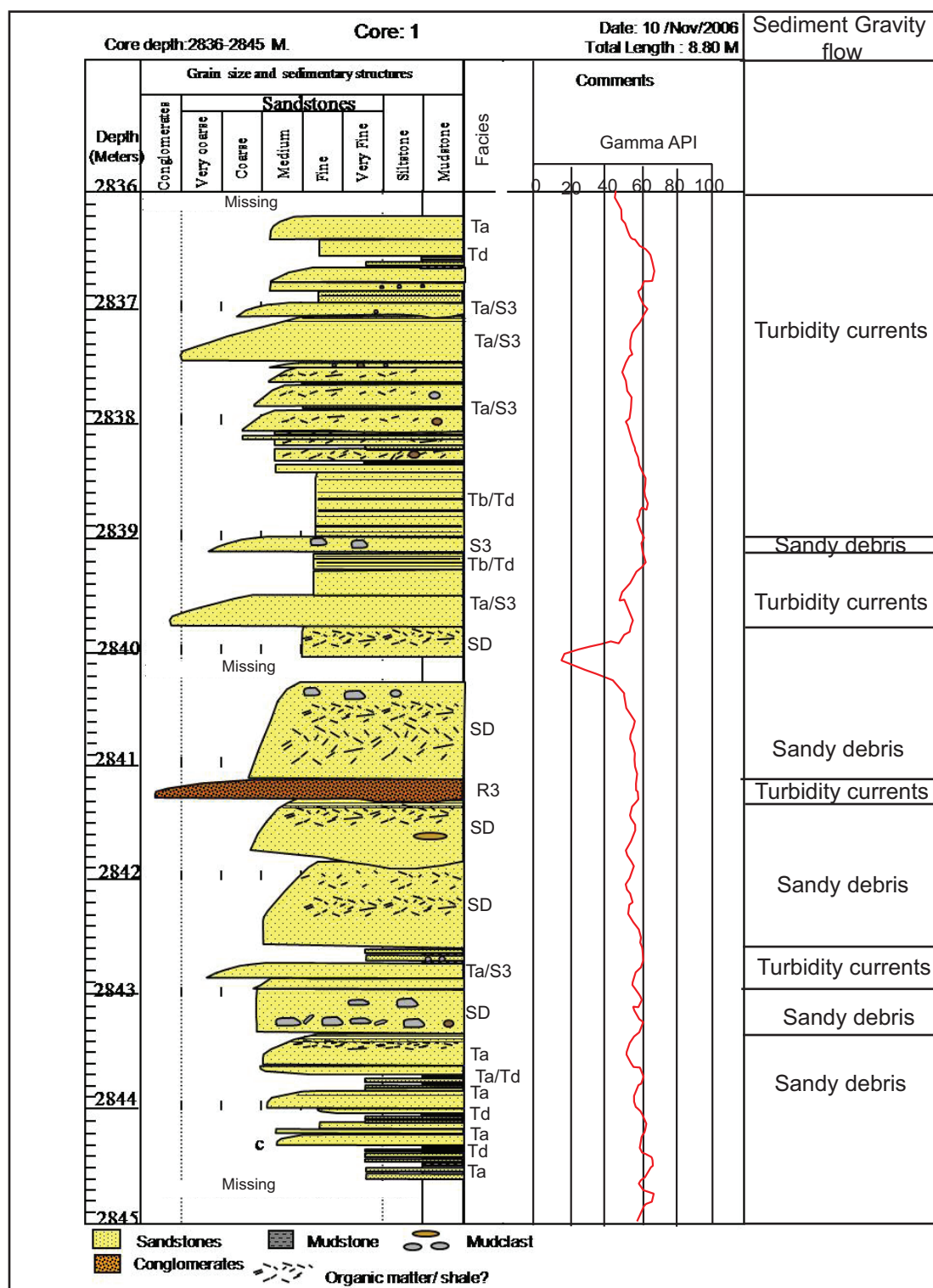


Figure 18. Description of the core of 523 well. Changes of lithology and grain size are noted. Different processes are interpreted to be involved in the mechanism of transport of these sediments. Interpretation of different facies are shown. Gamma ray log is presented in red. (Modified from Pemex 2006).

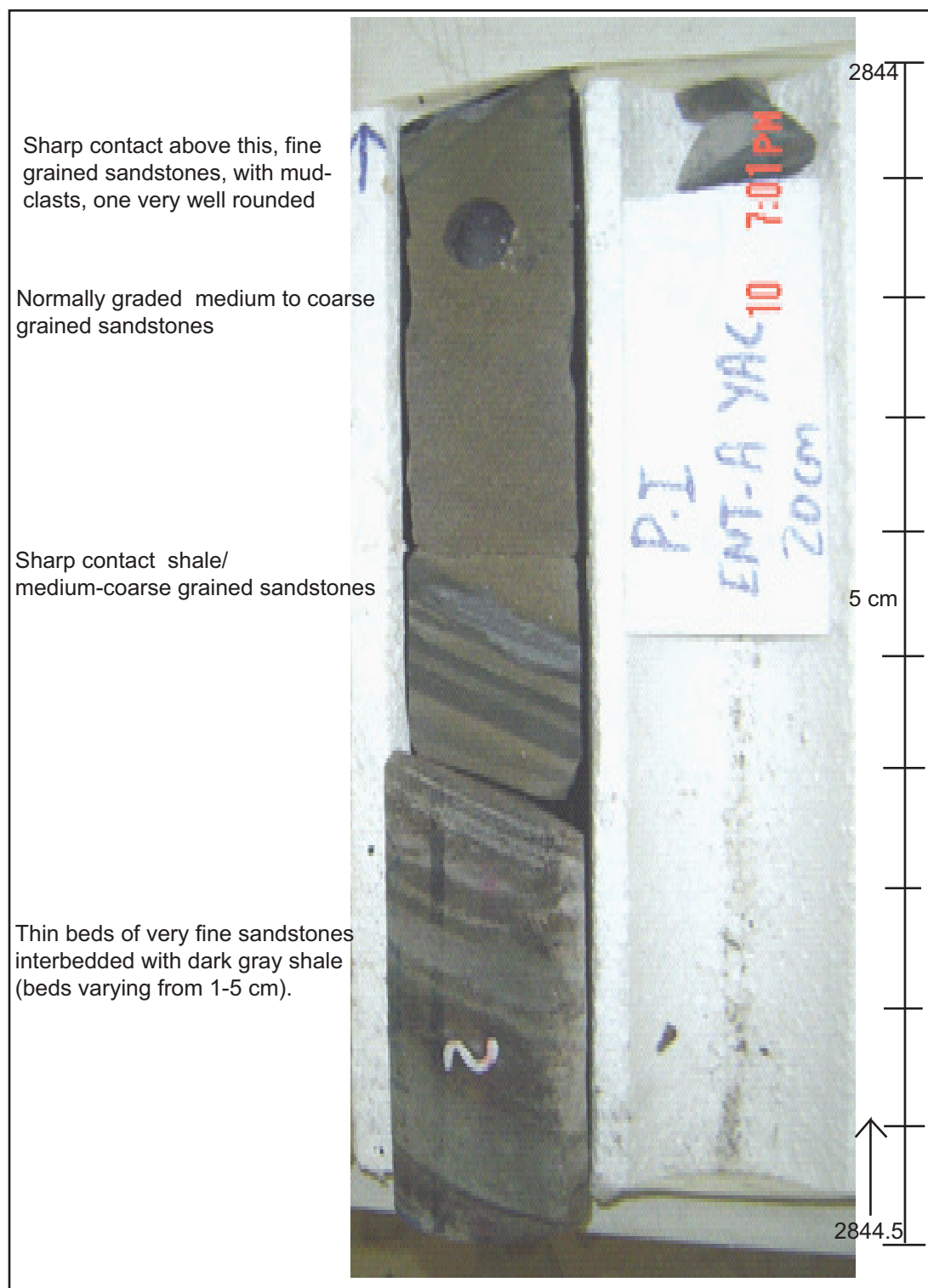


Figure 19. Core photography and descriptions of the Interval 2844-2844.5 meters from the 523 well, Blasillo field. The well is deviated (Modified from Pemex 2006).

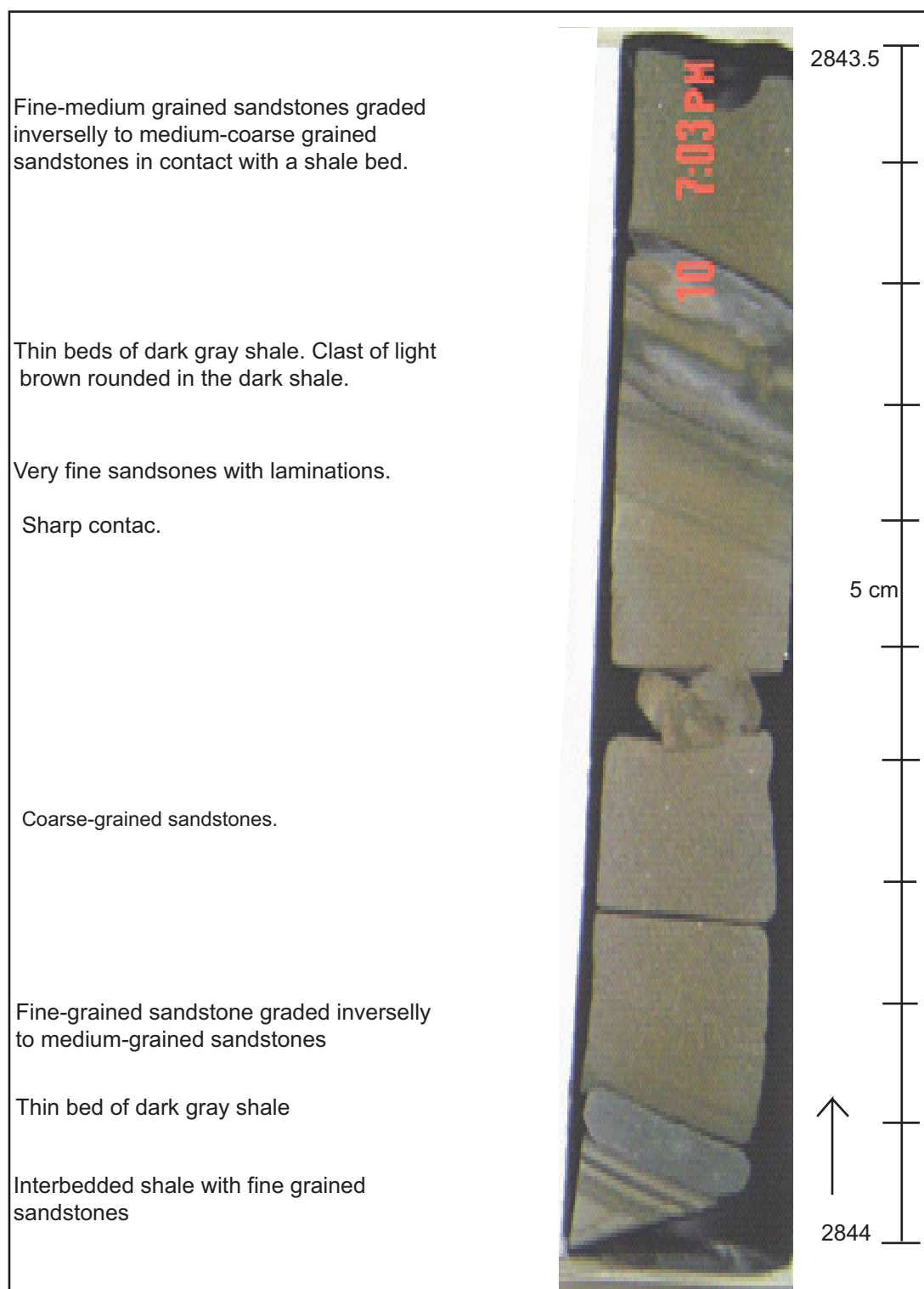


Figure 20. Core photography and descriptions of the interval 2843.5-2844 meters) from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

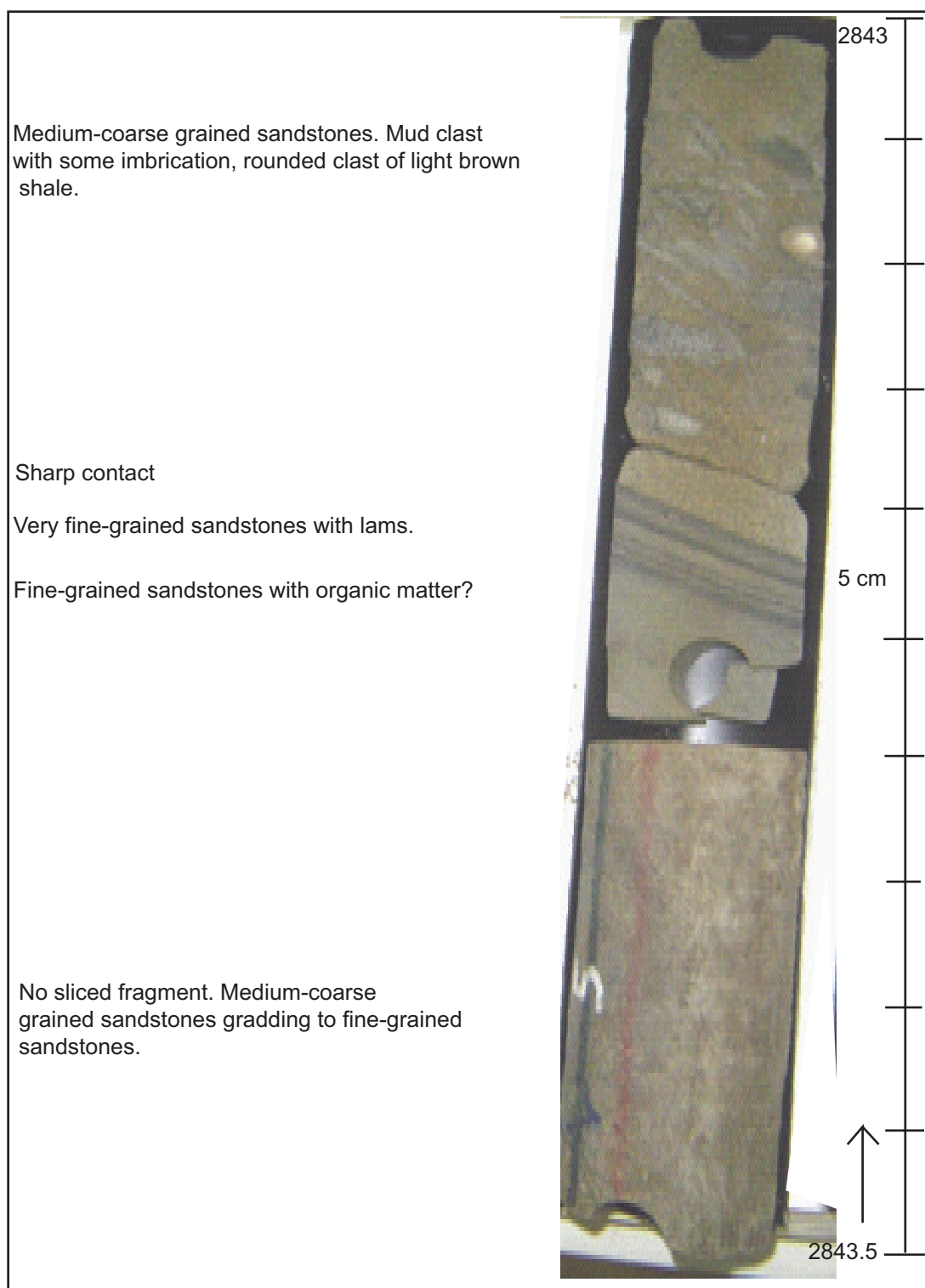


Figure 21. Core photography and descriptions of the interval 2843-2843.5 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

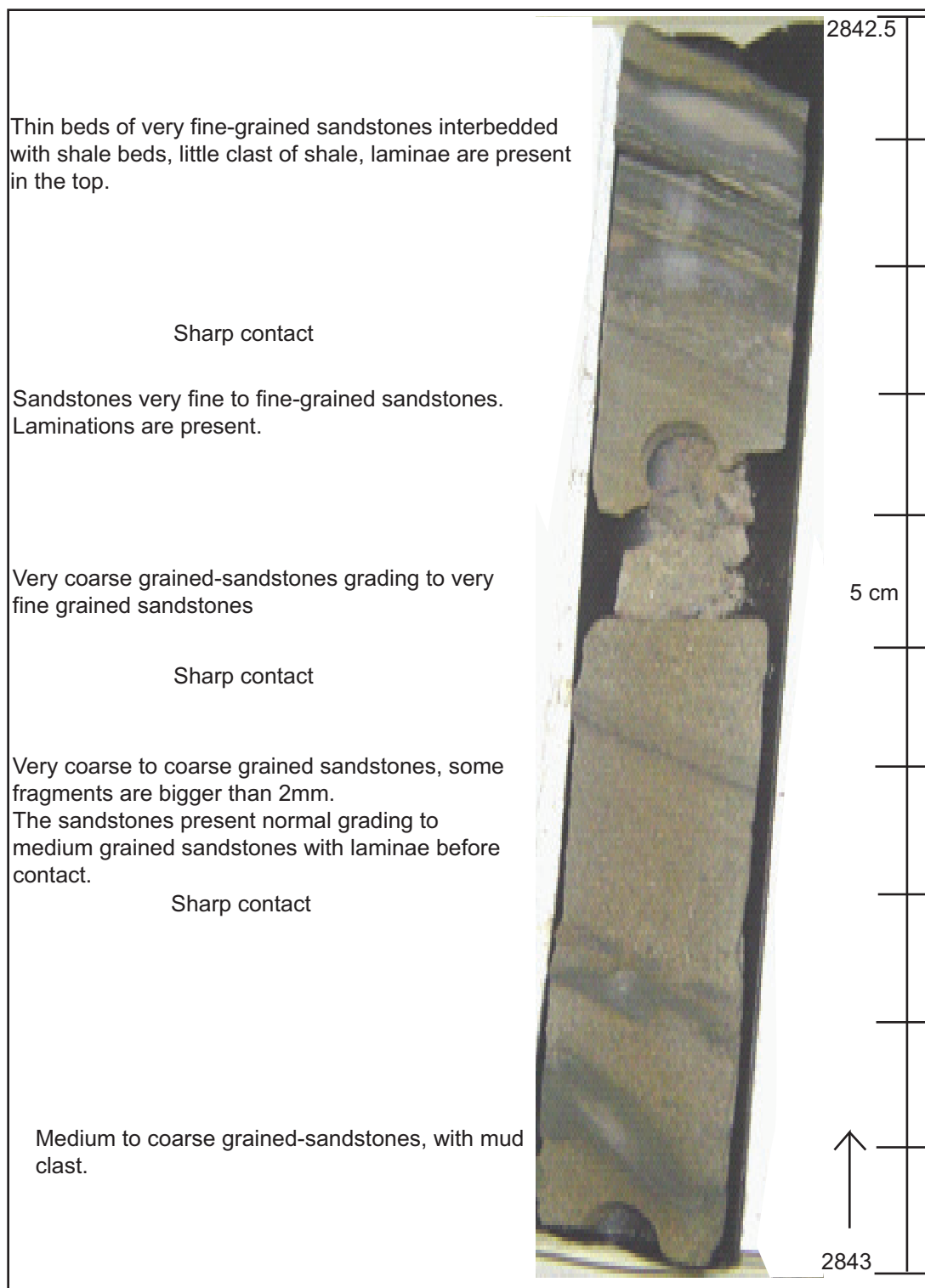


Figure 22. Core photography and descriptions of the interval 2842.5-2843 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

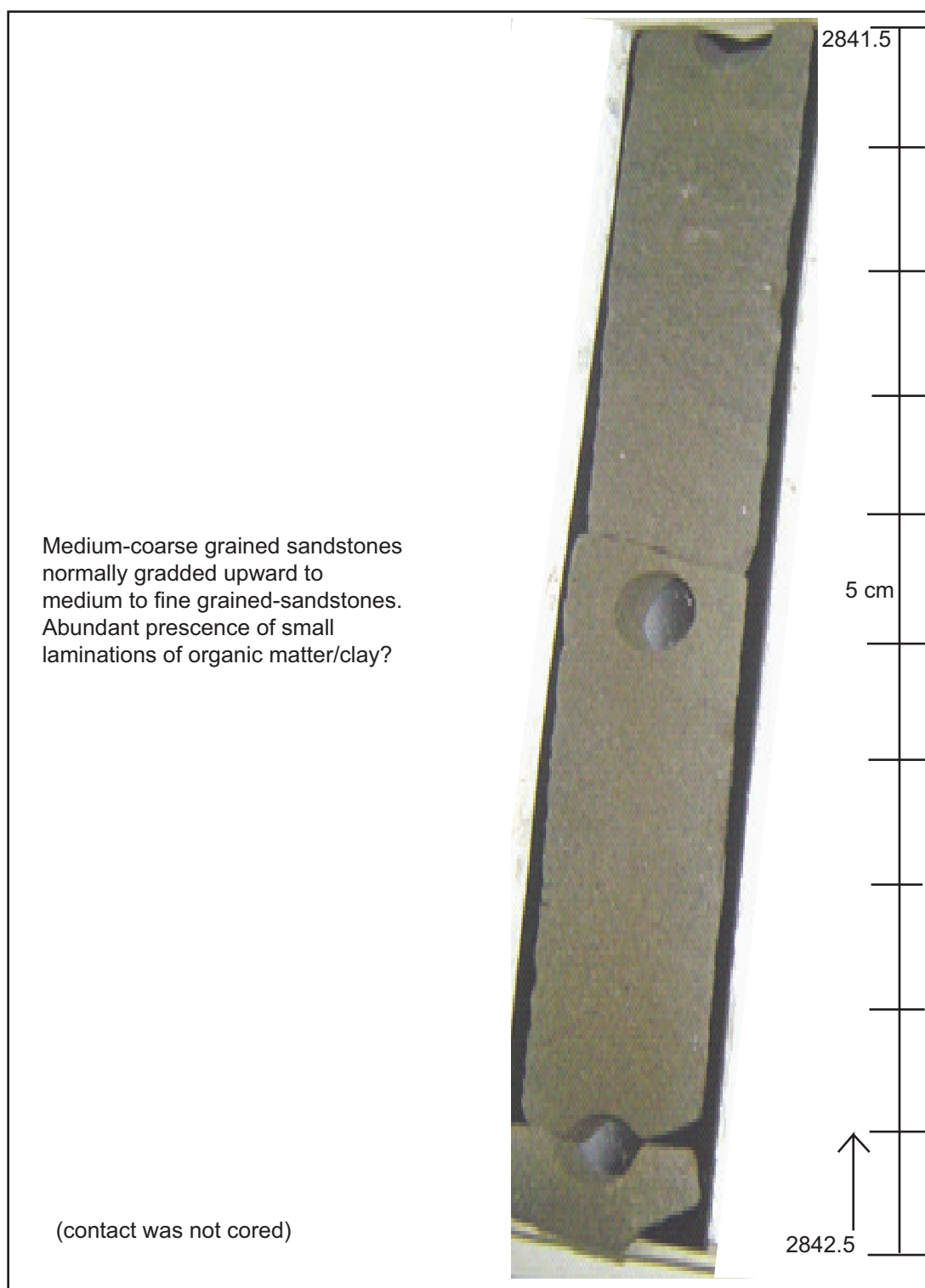


Figure 23. Core photography and descriptions of the Interval 2842-2842.5 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

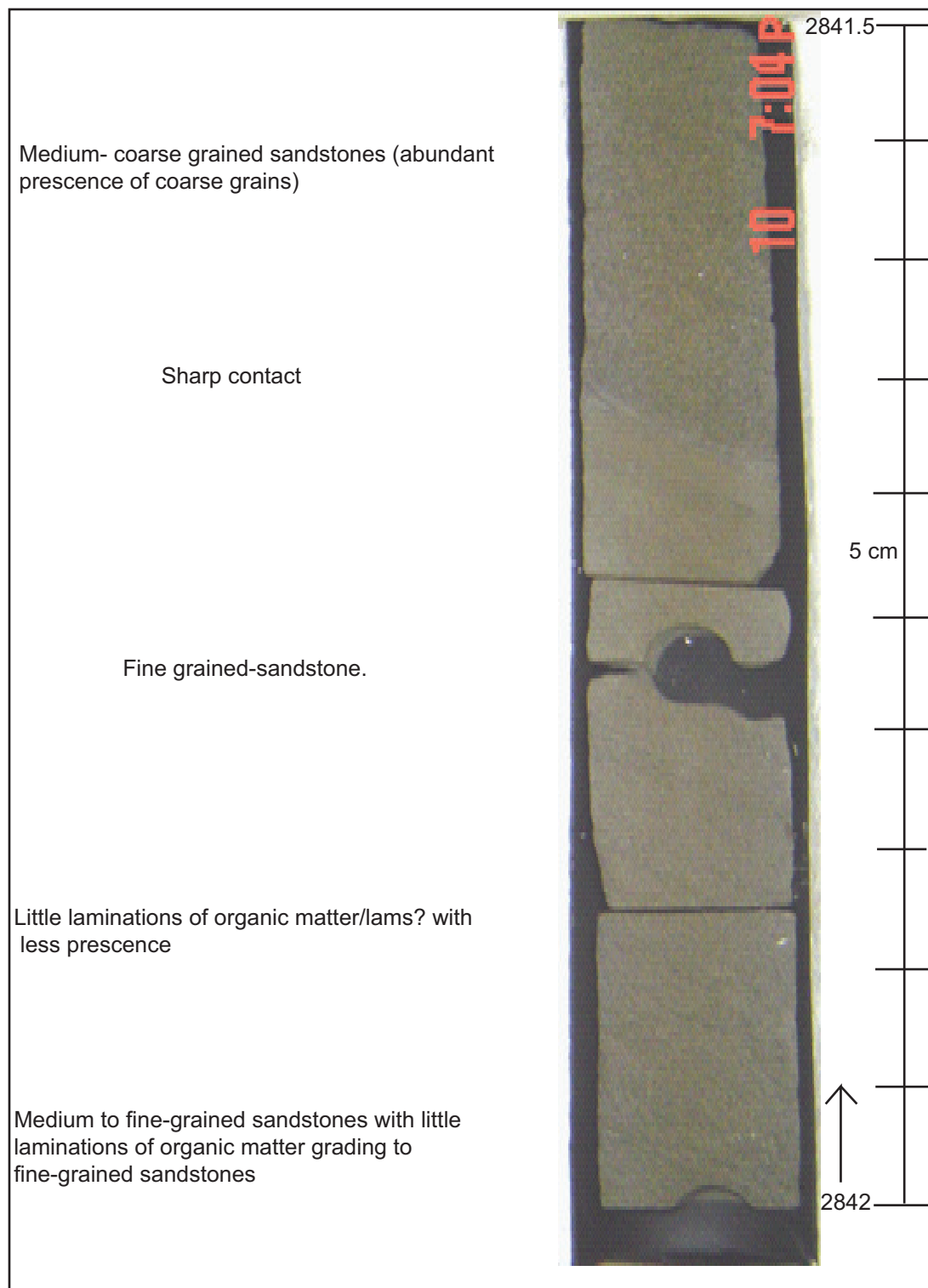


Figure 24. Core photography and descriptions of the Interval 2841.5 -2842 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex_2006).

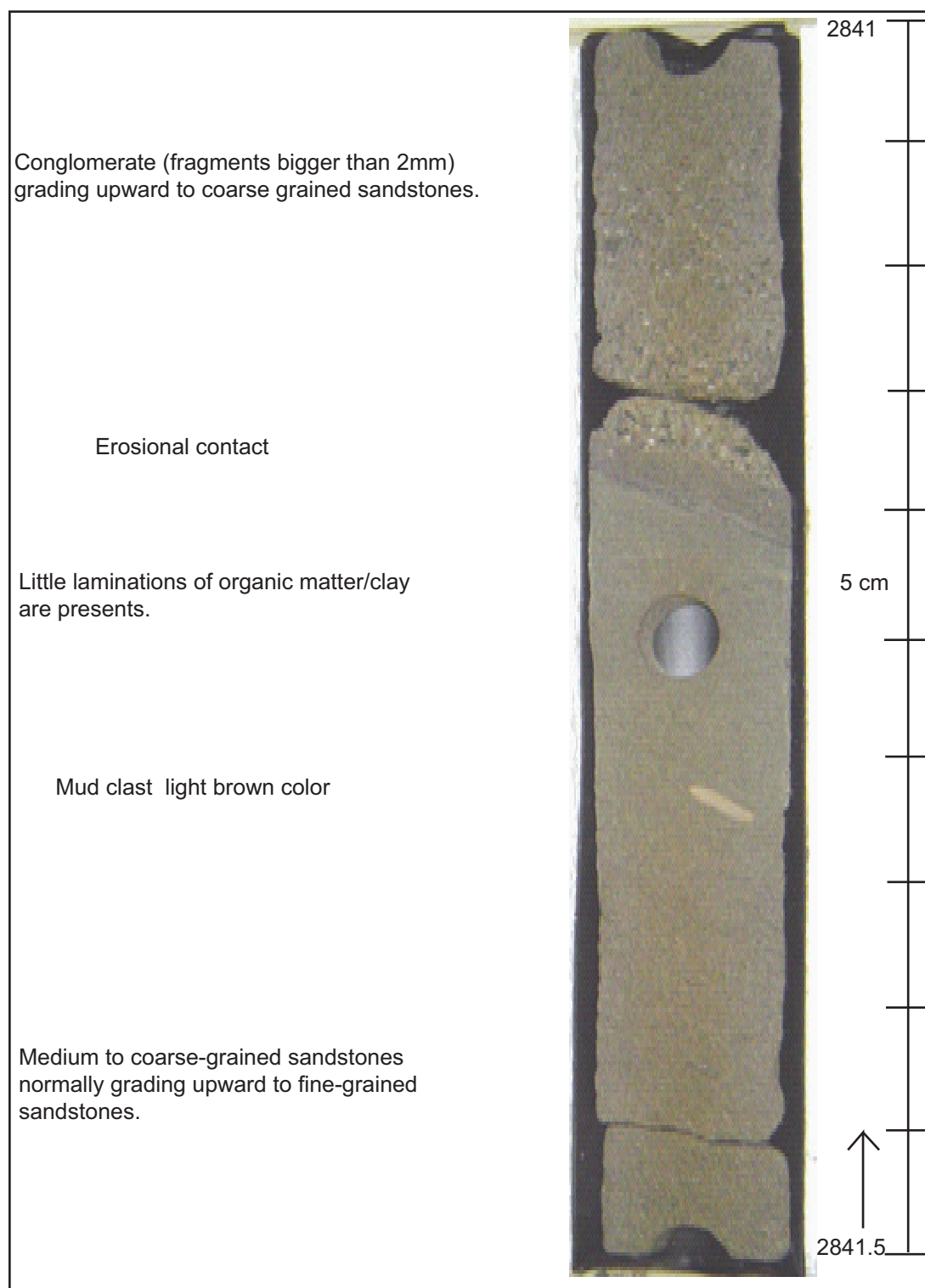


Figure 25. Core photography and descriptions of the interval 2841-2841.5 meters from the 523 well, Blasillo field. Wel is deviated (Modified from Pemex 2006).

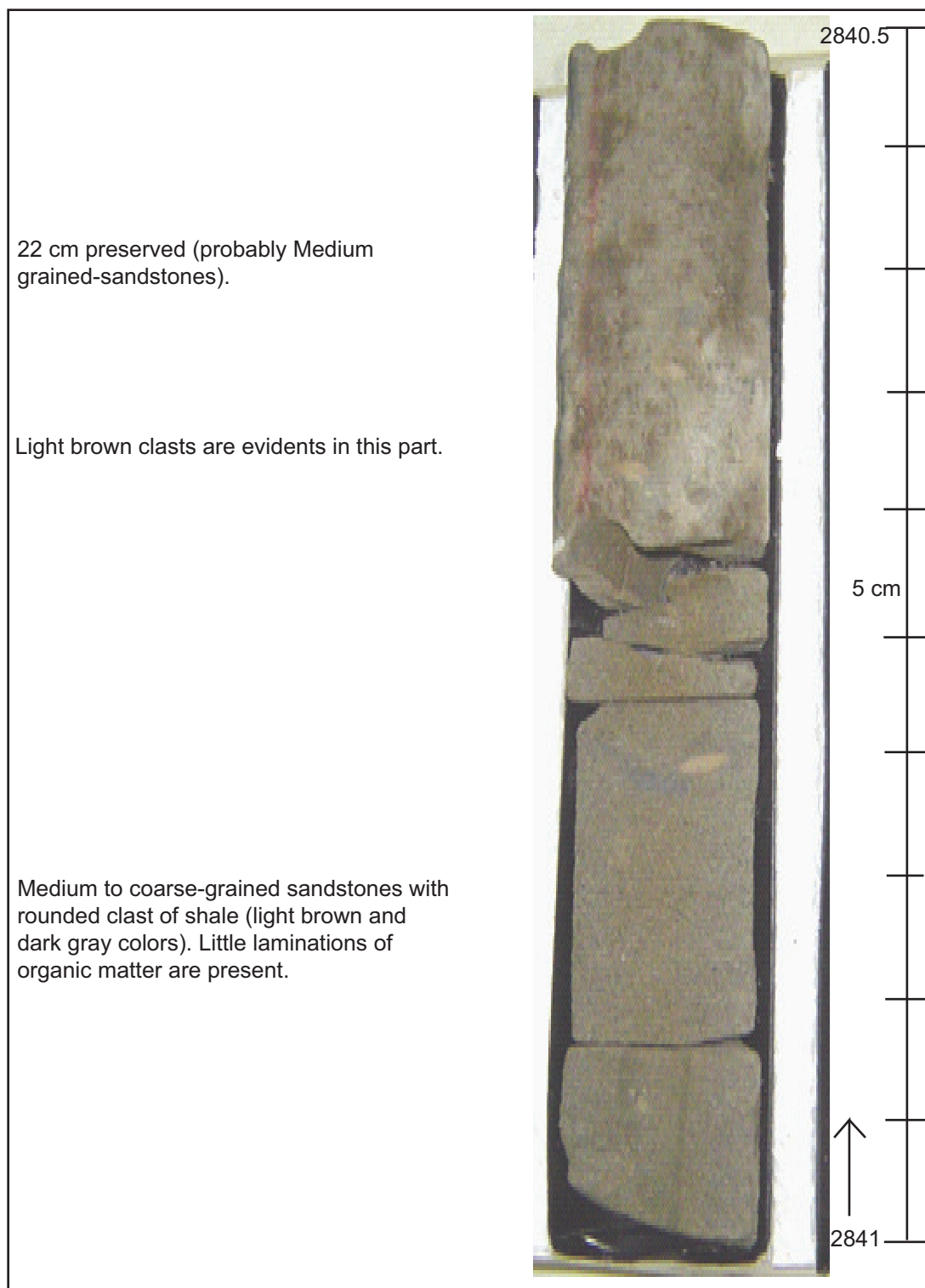


Figure 26. Core photography and descriptions of the interval 2840.5-2841 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

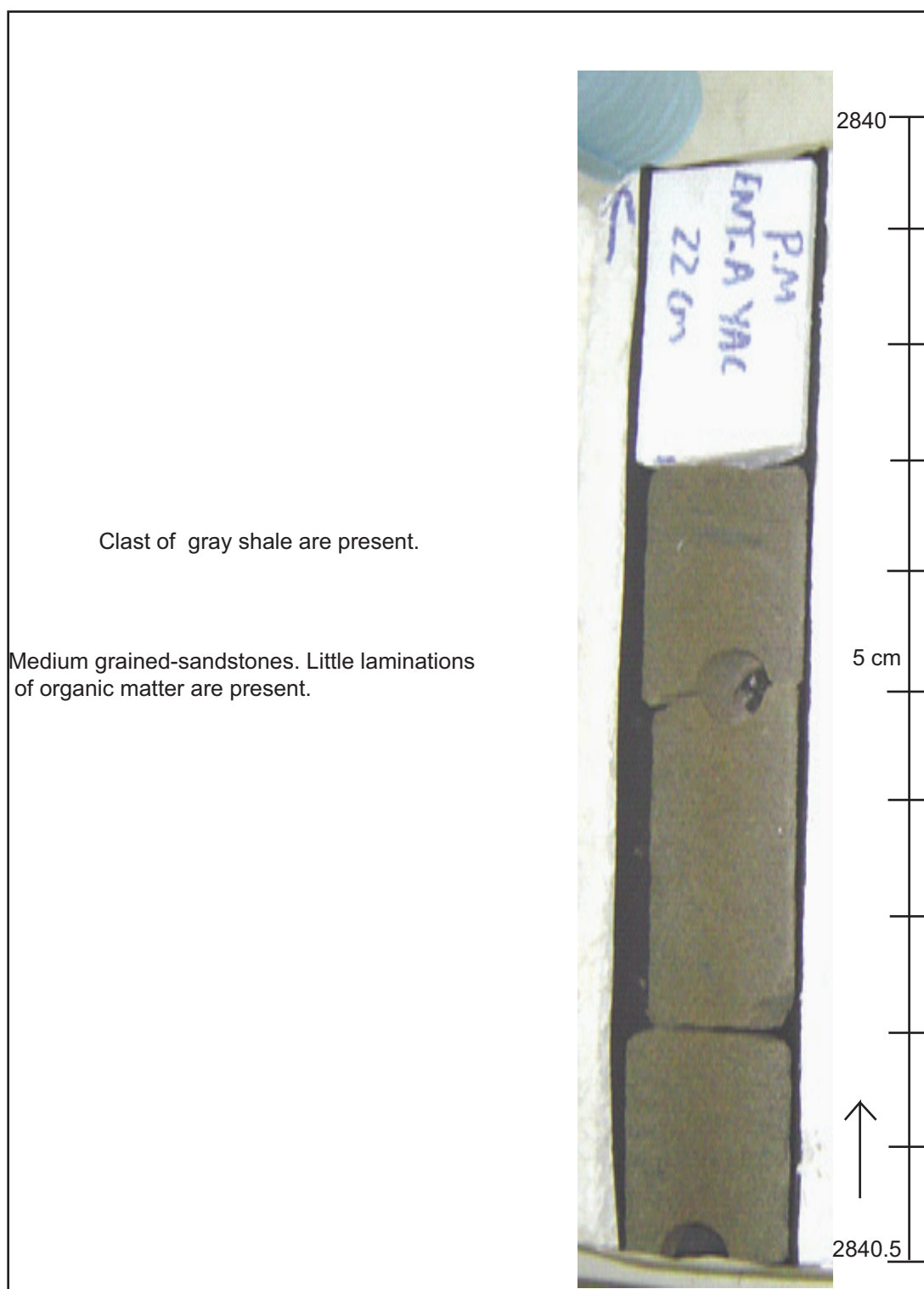


Figure 27. Core photography and descriptions of the interval 2840-2840.5 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

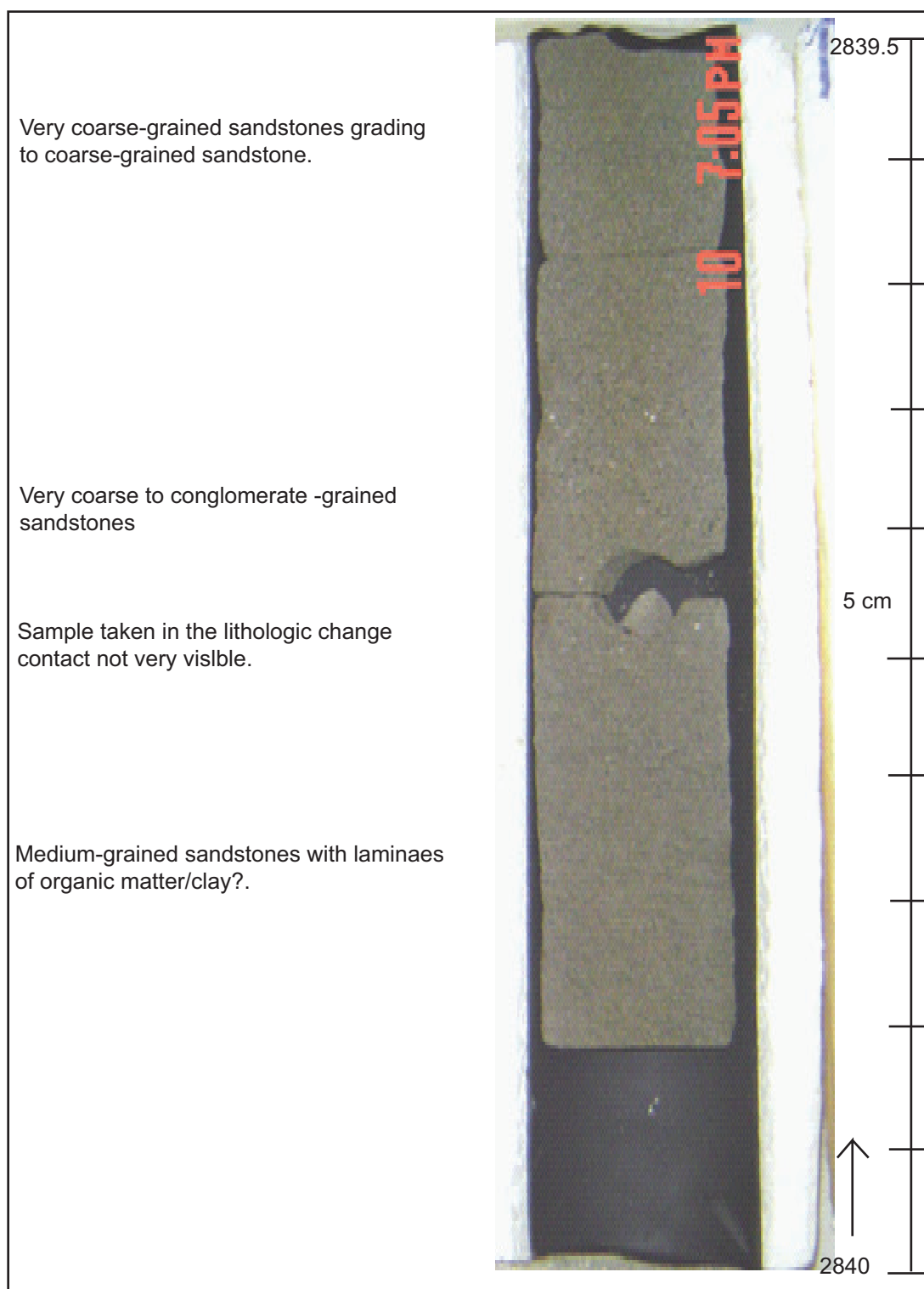


Figure 28. Core photography and descriptions of the interval 2839.5-2840 meters from the 523 well, Blasillo field. Wel is deviated (Modified from Pemex 2006).

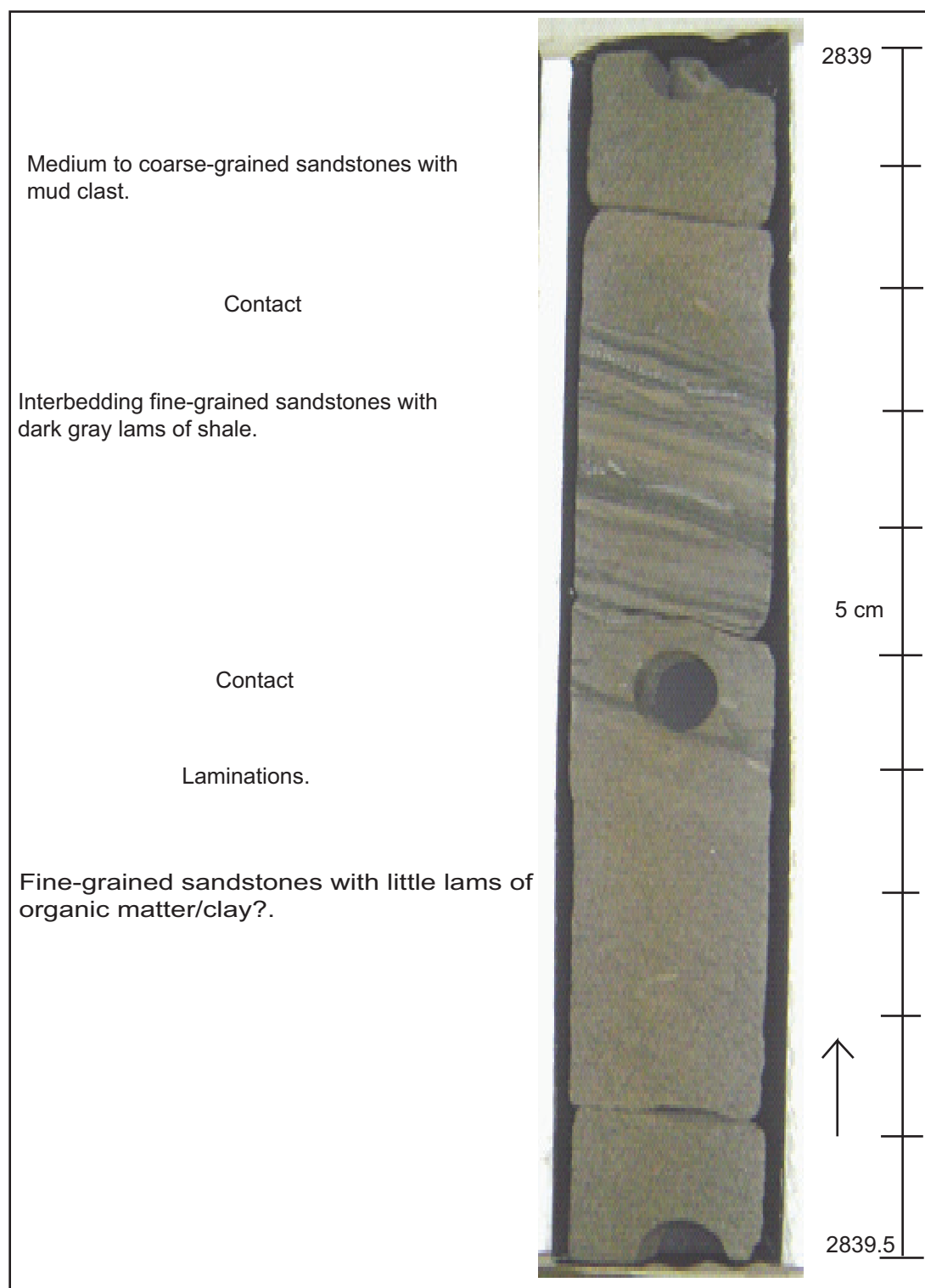


Figure 29. Core photography and descriptions of the interval 2839-2839.5 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

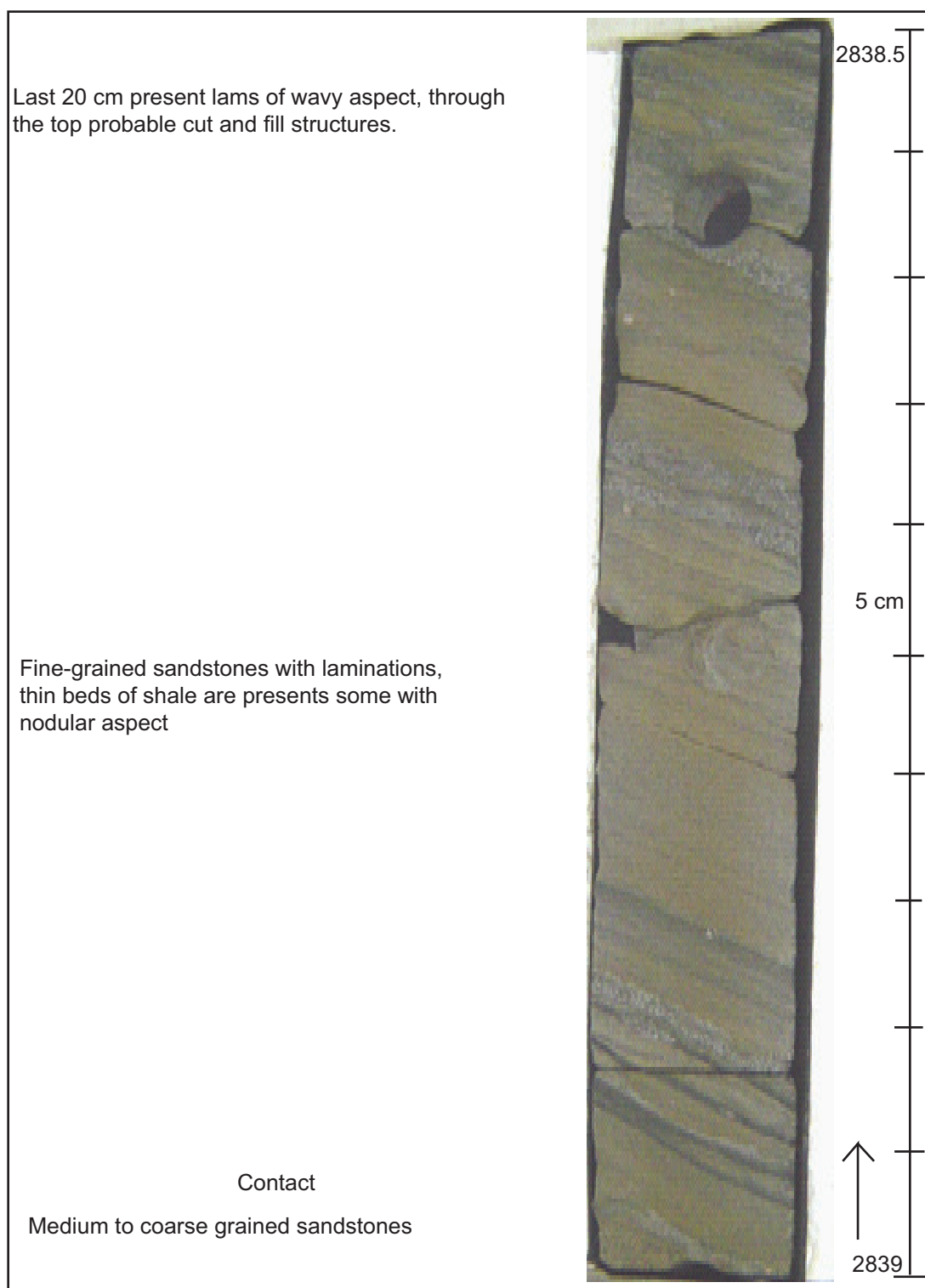


Figure 30. Core photography and descriptions of the interval 2838.5-2839 meters from the 523 well, Blasillo field. Wel is deviated (Modified from Pemex 2006).

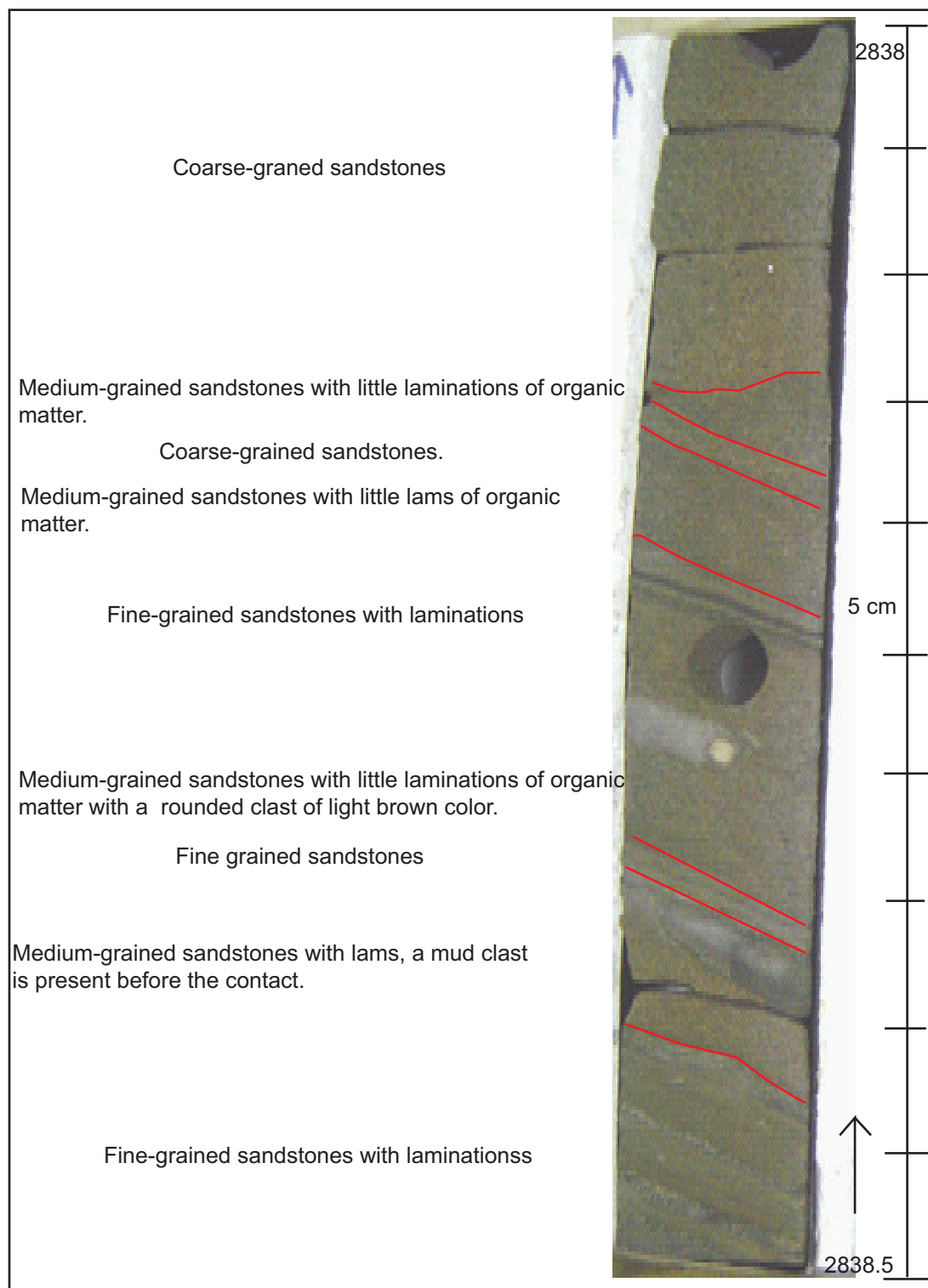


Figure 31. Core photography and descriptions of the interval 2838-2838.5 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

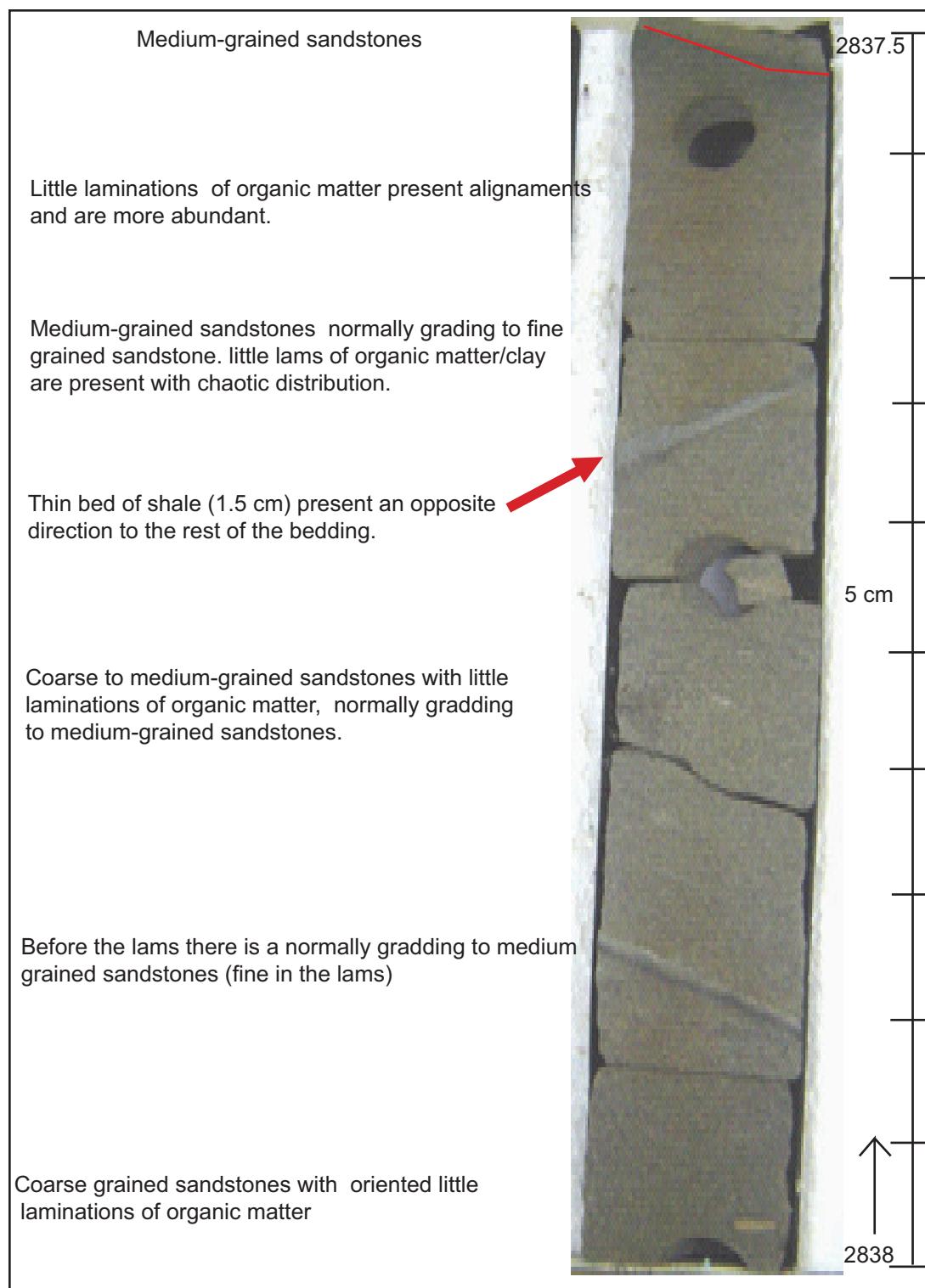


Figure 32. Core photography and descriptions of the interval 2837.5-2838 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

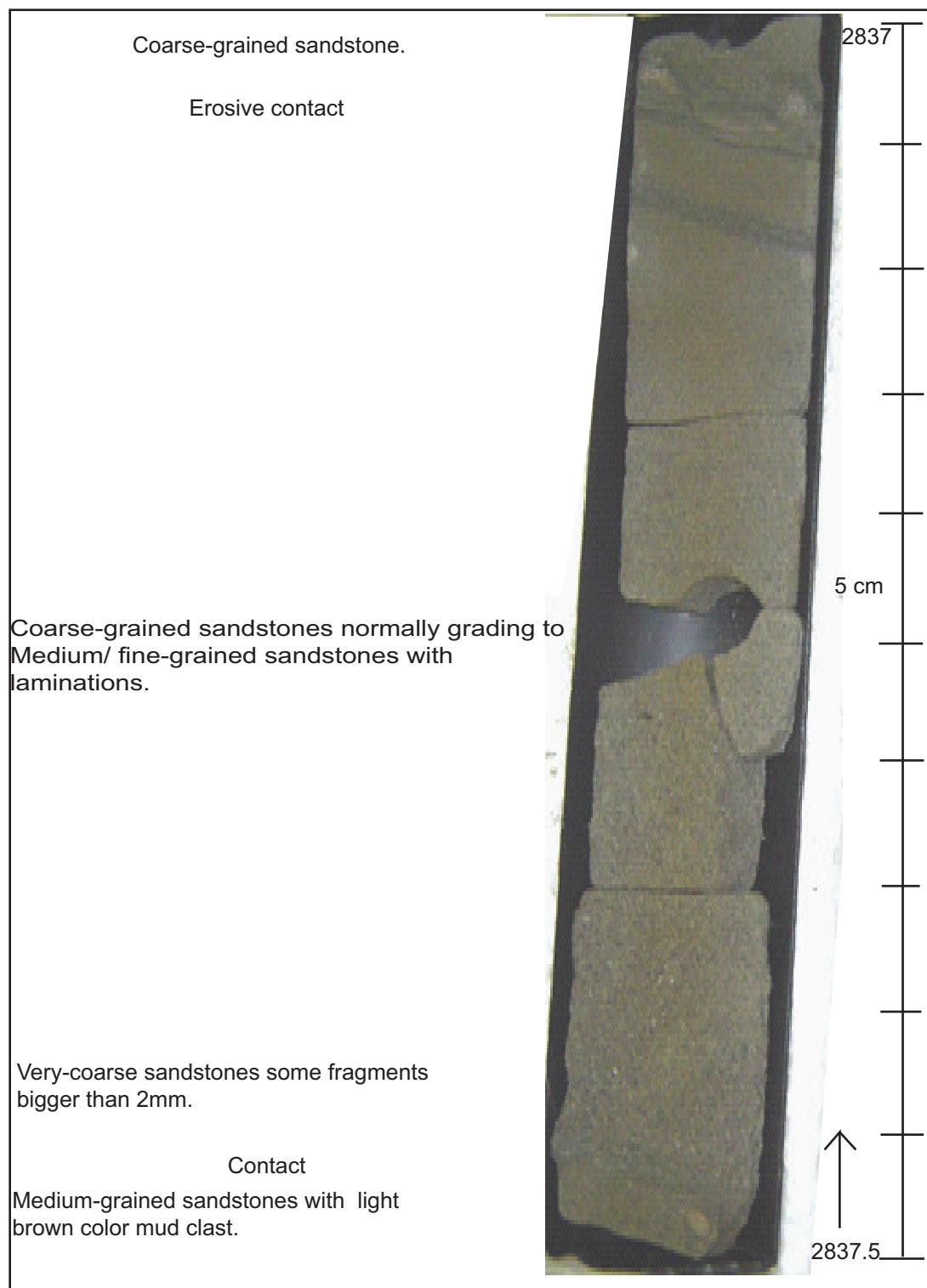


Figure 33. Core photography and descriptions of the interval 2837-2837.5 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

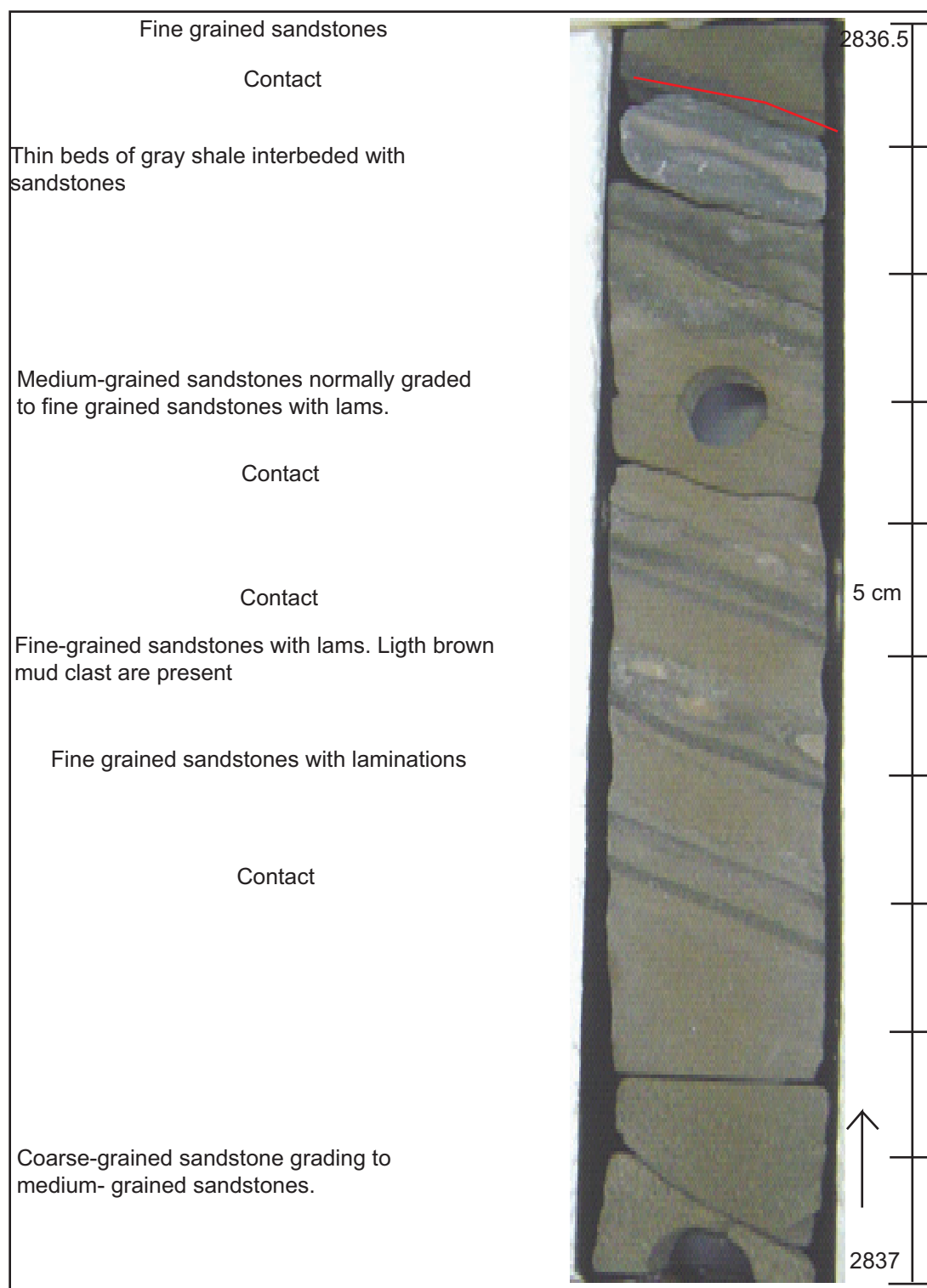


Figure 34. Core photography and descriptions of the interval 2836.5-2837 meters from the 523 well, Blasillo field. Wel is deviated (Modified from Pemex 2006).

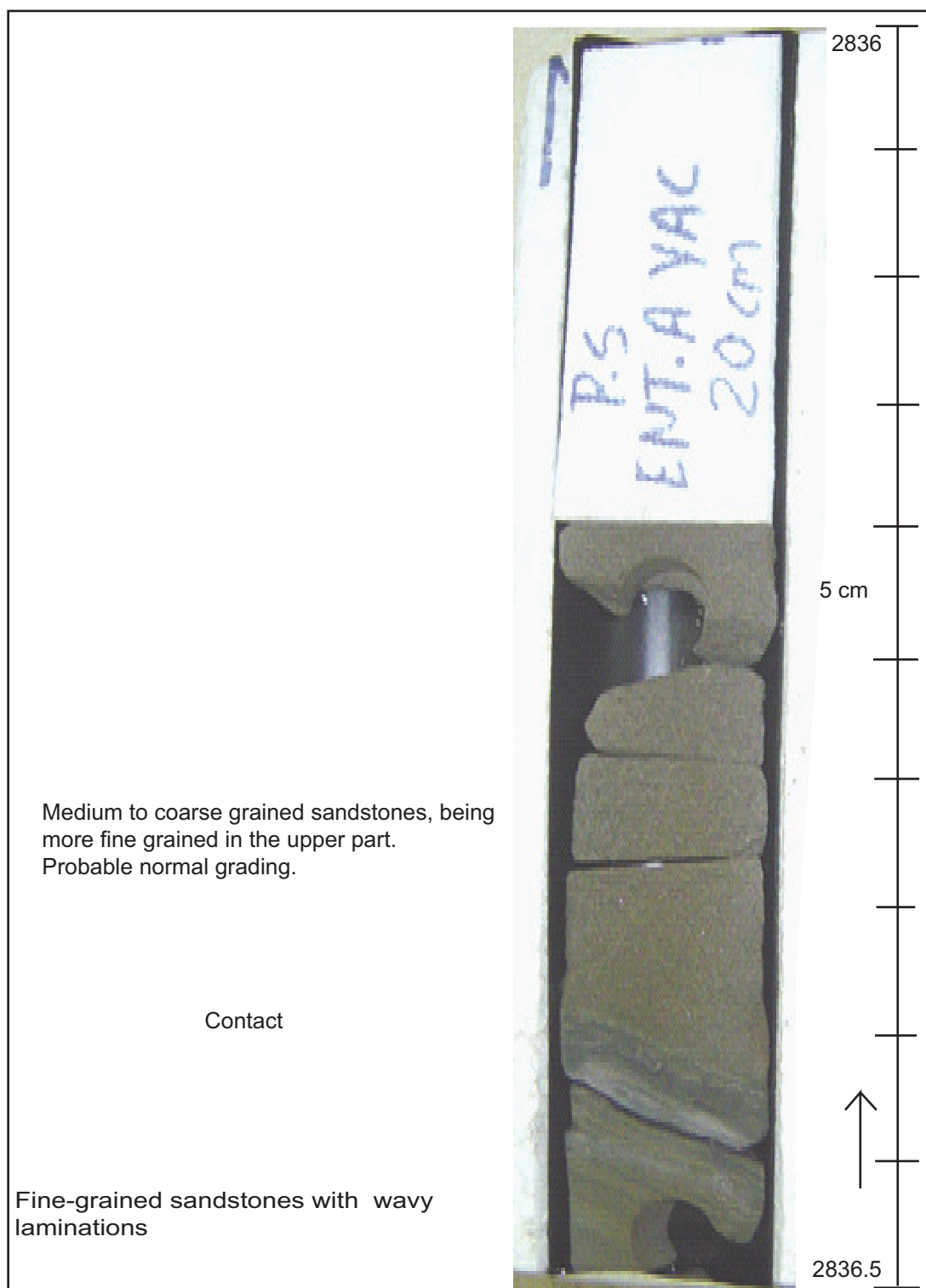


Figure 35. Core photography and descriptions of the interval 2836-2836.5 meters from the 523 well, Blasillo field. Well is deviated (Modified from Pemex 2006).

fining upward signature in the lower part, interbedded shale are present and floating mudclasts and organic matter are present (**Figure 18**). The strata in this core are interpreted to have been deposited by different kinds of sediment-gravity flows, specifically debris flows, and high and low density turbidity currents. Debris flows deposits are represented by SD facies (Sandy debris) and are associated with the thicker sandstones beds. High density turbidites are represented by R3, S3, Ta/S3, and R3 facies. Low density turbidites are represented by Ta,Tb,Td facies (**Figure 18**).

Five main log signatures are identified from SP curves: blocky, fining upward, coarsening upward, serrate and no expression (shale) (**Figure 36**). In this Blasillo field, the SP log is considered to be a good indicator of grain size trends and sand/shale ratio; interpretation of different lithofacies are made in base of these log signatures using the lateral and vertical relation of the log signatures. Interpretations of depositional facies of each sequence are interpreted based on the log patterns and lithofacies associations in combination with the use of RMS amplitude maps.

Most of the reservoir sands in the Blasillo Field have been interpreted as deposits in deepwater channel systems deposited in upper bathyal water depths (**FIGURE 37A**). Deepwater channels systems have been characterized by three broad categories: (Mutti and Normark, 1987,1991; Clark and Pickering, 1996; Morris and Normark, 2000; in Weimer 2006) (**FIGURE 37B**).

(1) Erosional channels (including slumping) which have no, or few, associated overbank-levee deposits;

(2) Aggradation channels with flanking of levee-overbank strata to create an intervening depression in which channel and levee strata interfinger; and

SP Log Signature	Name	Interpretation
	Blocky	Channel axis amalgamated, semi-amalgamated channels
	Fining upward	Margin of the channels
	Coarsening upward	Channel fills Interchannel fill
	Serrate	Interchannel fills Levee/Splays
	No expression	Overbank/Slope deposits

Figure 36. Lithofacies identified in base of the SP log signature used to interpret the lithofacies maps.

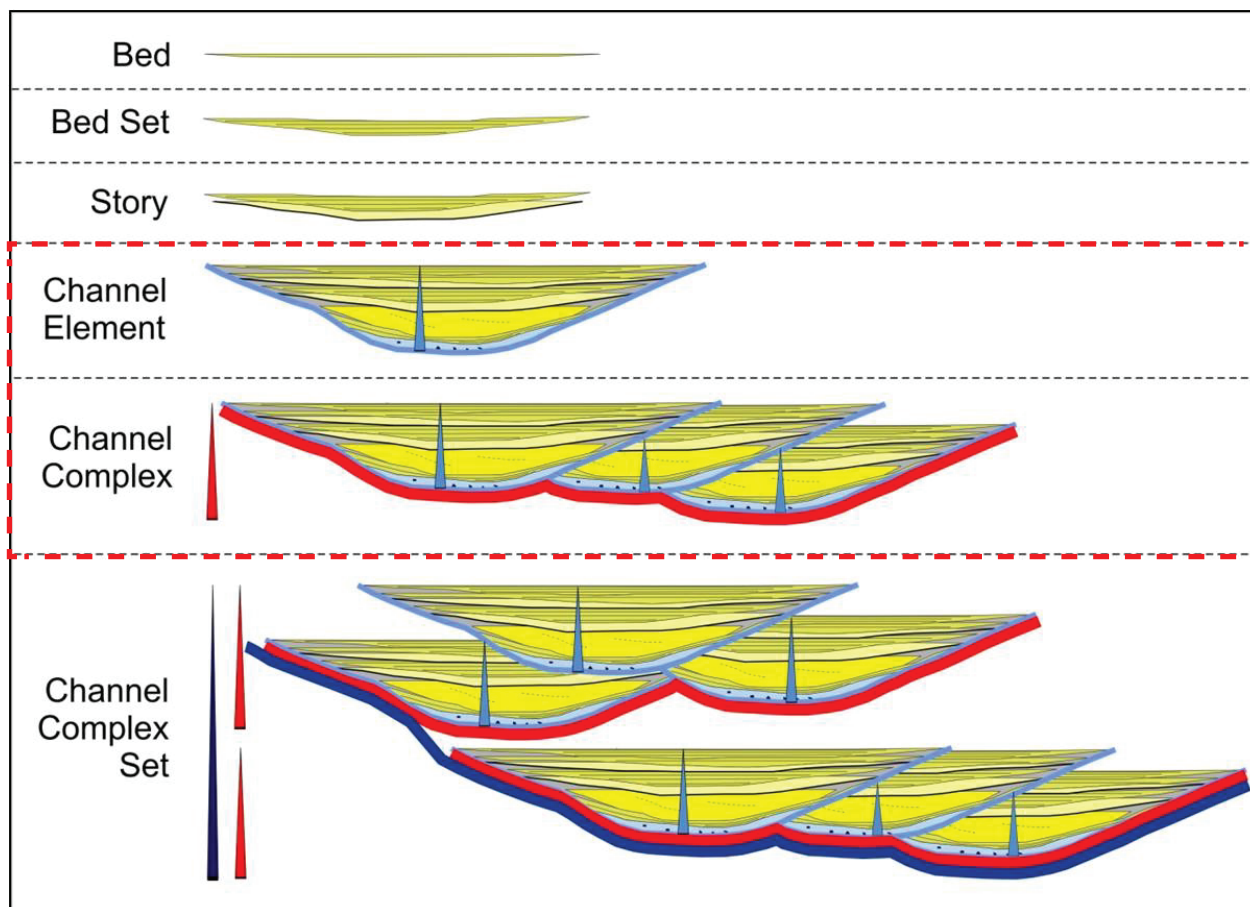


Figure 37A. Hierarchy of the different relationships and complexity that could be found in deepwater channels. in this thesis the main systems interpreted are related with channel fill and channel complex fills (dashed area). Figure 37A after Sprage et al., 2002.

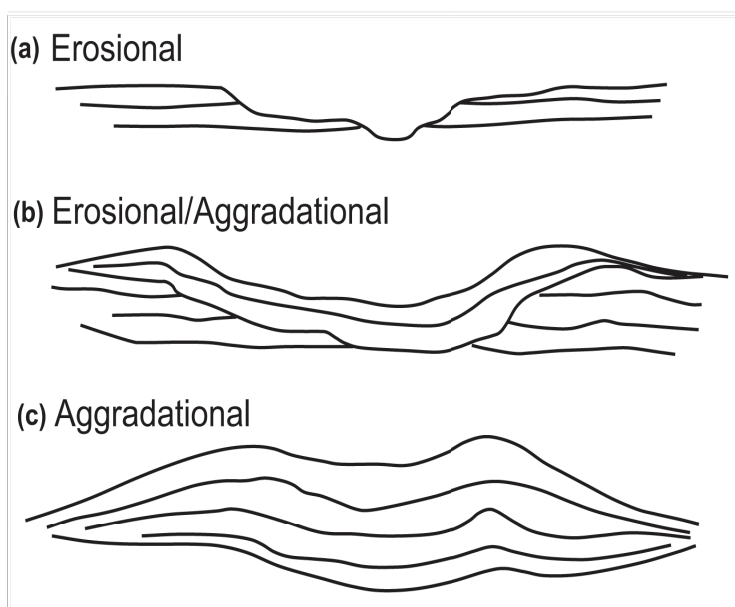


Figure 37 B. Three broad Channel classification. a) originet by erosion b) originated by aggradation c) mix of erosional and depositional processes. (Taken from Weimer and Slatt 2006).

(3) mixed erosion-aggradation channels, which are created by changing sedimentary processes.

GEOLOGICAL DESCRIPTION

Introduction

The fourteen depositional sequences interpreted in this thesis are going to be systematically described here. 14 sequences (Sequence 1 to 14) are going to be presented starting from the lower section. Fourteen sequences are interpreted in this study based in the log data. Because two sequences are below seismic resolution there are twelve sequences base in seismic information.

Sequence 1 (middle Miocene _RS-1)

The sediments in this sequence were the first to be deposited above the allochthonous salt body. A minibasin is located in the south of the field (**Figure 38**). Toward the northwest, the sequence pinches out against the salt body (**Figure 38**).

Time-structure map: A time-structure contour map of the top of the horizon -RS-1 shows the presence of the salt body (salt weld) that separates the structurally highest position of the field from the minibasin. The horizon dips to the south. Two set of faults are present. The first set (F1) is present in the east of the study area, strikes SE-NW, and dips primarily to the northeast (**Figure 38**). The second set in the area (F2), strikes W-E and dip to the south in the east side (**Figure 38**). A minibasin is located in the south from the field, the values in time from this horizon decreases in both flanks of the minibasin NW and SE part of the map (**Figure 38**).

Isopach map: A total of 16 wells penetrate this sequence. The isopach map shows thickness variation from 50 to 80 meters (**Figure 39**), with greatest thickness to the

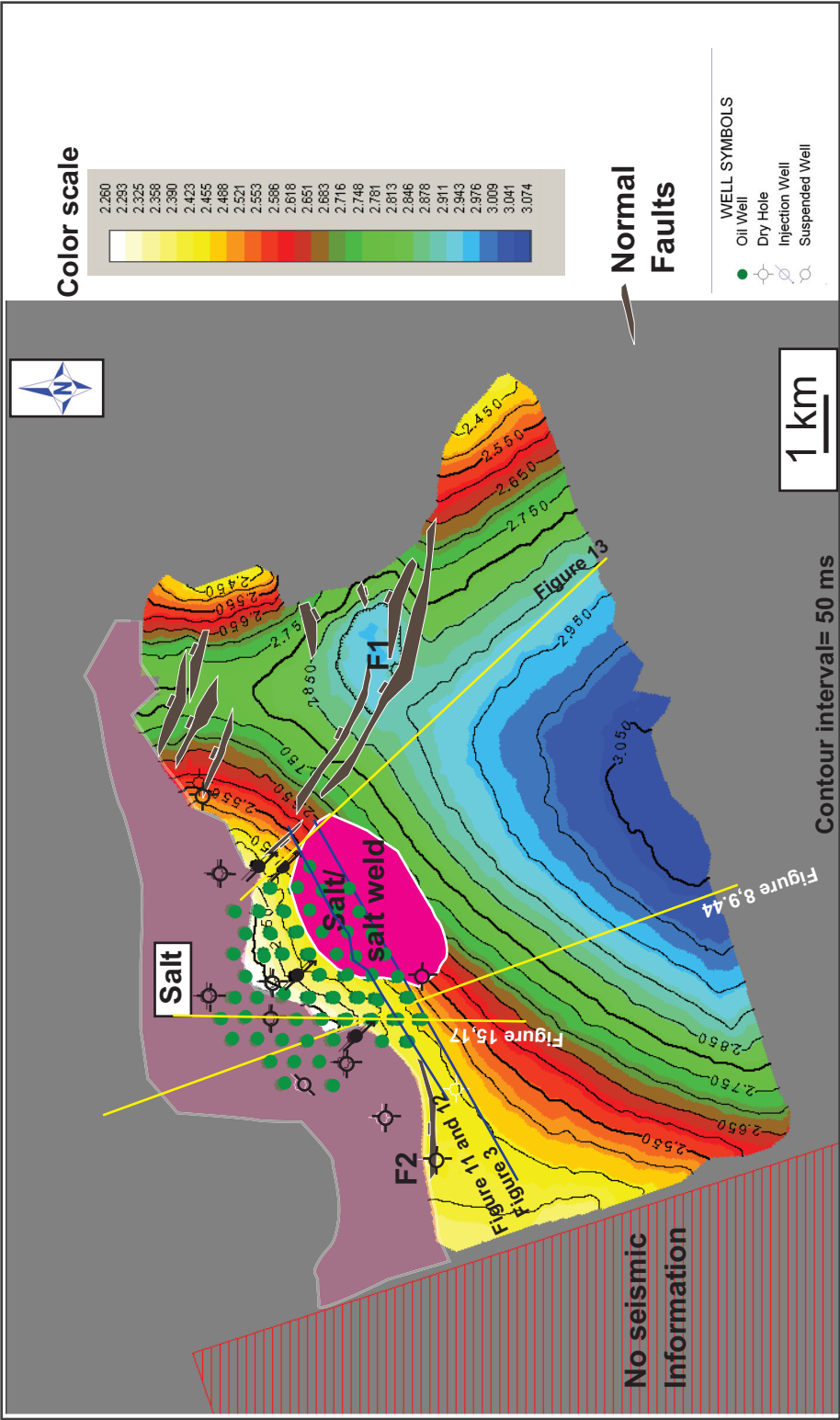


Figure 38. Time-structure contour map (in secs) of the surface RS-1 interpreted in the study area. A salt body is interpreted in the north part of the map (pink), the presence of a second salt/salt weld body separates the highest position of the surface from the minibasin leaving the wells between this two bodies, two set of faults with a SE-NW (F1) and W-E(F2) orientations with different dips are interpreted. Wells are shown by green dots. Location of Figures 8,9,13,15,17,44 and are shown in yellow lines. Location of Figures 3,11 and 12 are shown in a blue lines.

southwest (well 101). Two thinner areas (less than 60 meters) are present to the north and south/southeast (**Figure 39**).

Lithofacies: Two log cross sections illustrate the sequence in strike (**Figure 40**) and dip views (**Figure 41**). The strike section (X1) includes three wells that penetrate Sequence 1, all with blocky SP log patterns (wells 101, 193, 195) (**Figure 40**). In the dip section (Z5), only three wells penetrate this sequence (**Figure 41**). The Well 45 has a fining upward signature, similar to the two adjacent wells but with thinner sandstones. The last well that cut this sequence has no expression in the log (shale) (**Figure 41**).

In map view, the SP log pattern of this sequence shows five main log patterns: blocky, serrate, coarsening upward, fining upward and no expression (shale). The fining upward pattern shows a trend that can be correlatable in the north part of the map (**Figure 42**).

Net-to-gross map: The net-to-gross map of this sequence shows one area with low values located to the north-northeast, and another area of higher values, located in the southwest part (**Figure 43 A**).

Net-sand map: The net-sand map of sequence 1 shows a similar trend to the net-to-gross map; lateral variations in thickness can be observed from the northeast to the southwest (**Figure 43 B**).

Seismic Facies: Seismic facies in vertical profile is characterized by a low amplitude expression and moderate to high continuity of the reflections (**Figure 44**).

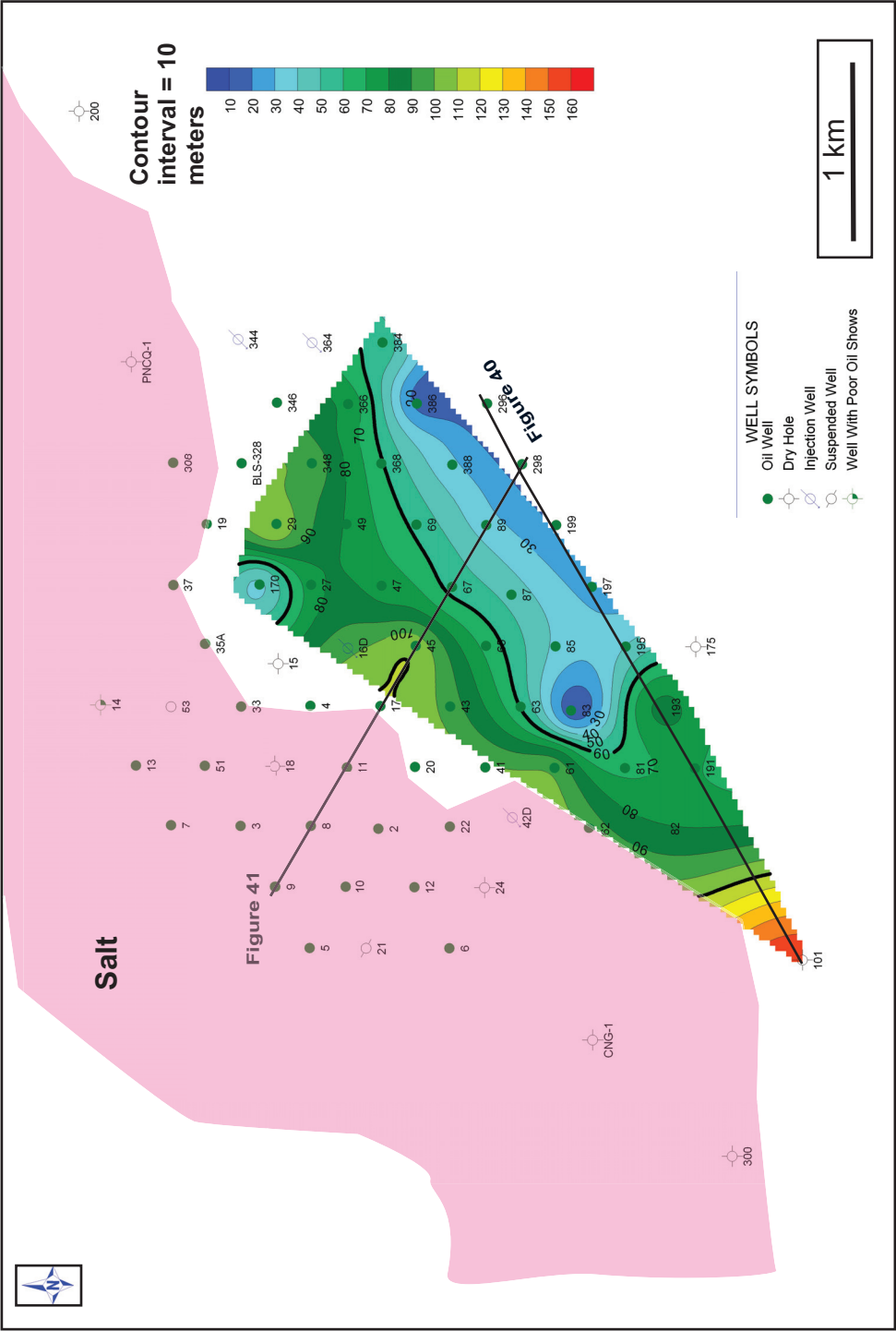


Figure 39. Isopach map of the Sequence 1 in the Blasillo field. Contour interval is 10 meters. Wells are shown by green dots. Location of Figures 40 and 41 are shown.

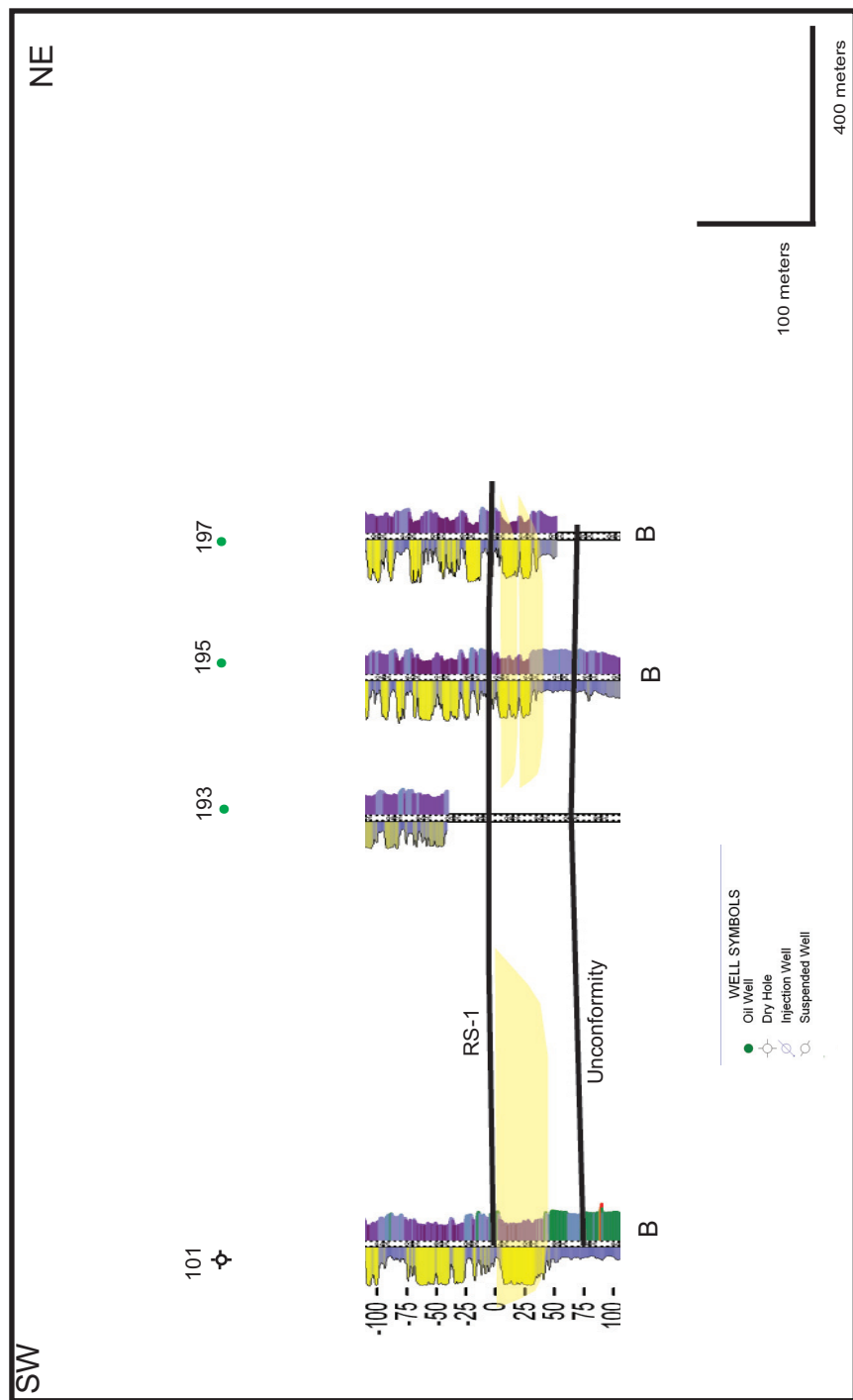


Figure 40. Wireline log cross section showing the Sequence 1 (top of the middle Miocene to RS-1). RS-1 is the datum. SP resistivity curves are shown. Blocky and fining upward are the main log signature in this section. An interpretation of the sandstone distribution is shown in yellow. See Figures 39 and 42 for location of section.

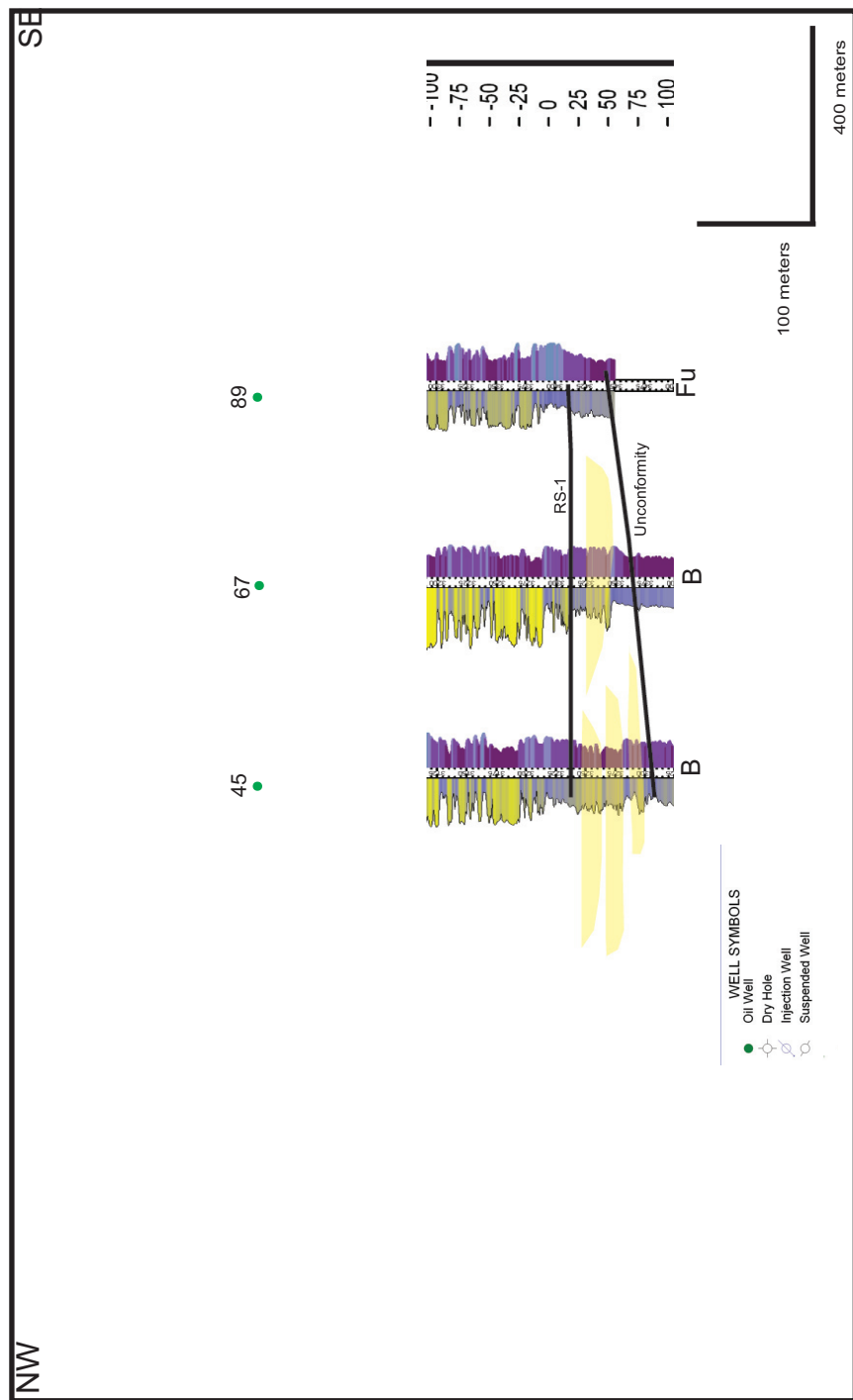


Figure 41. Wireline log cross section showing the Sequence 1 (middle Miocene to RS-1). RS-1 is the datum. SP and Resistivity curve are shown. Fining upward is the main log signature in the well from this section. An interpretation of the sandstone distribution is shown in yellow. See Figures 39 and 42 for location of section.

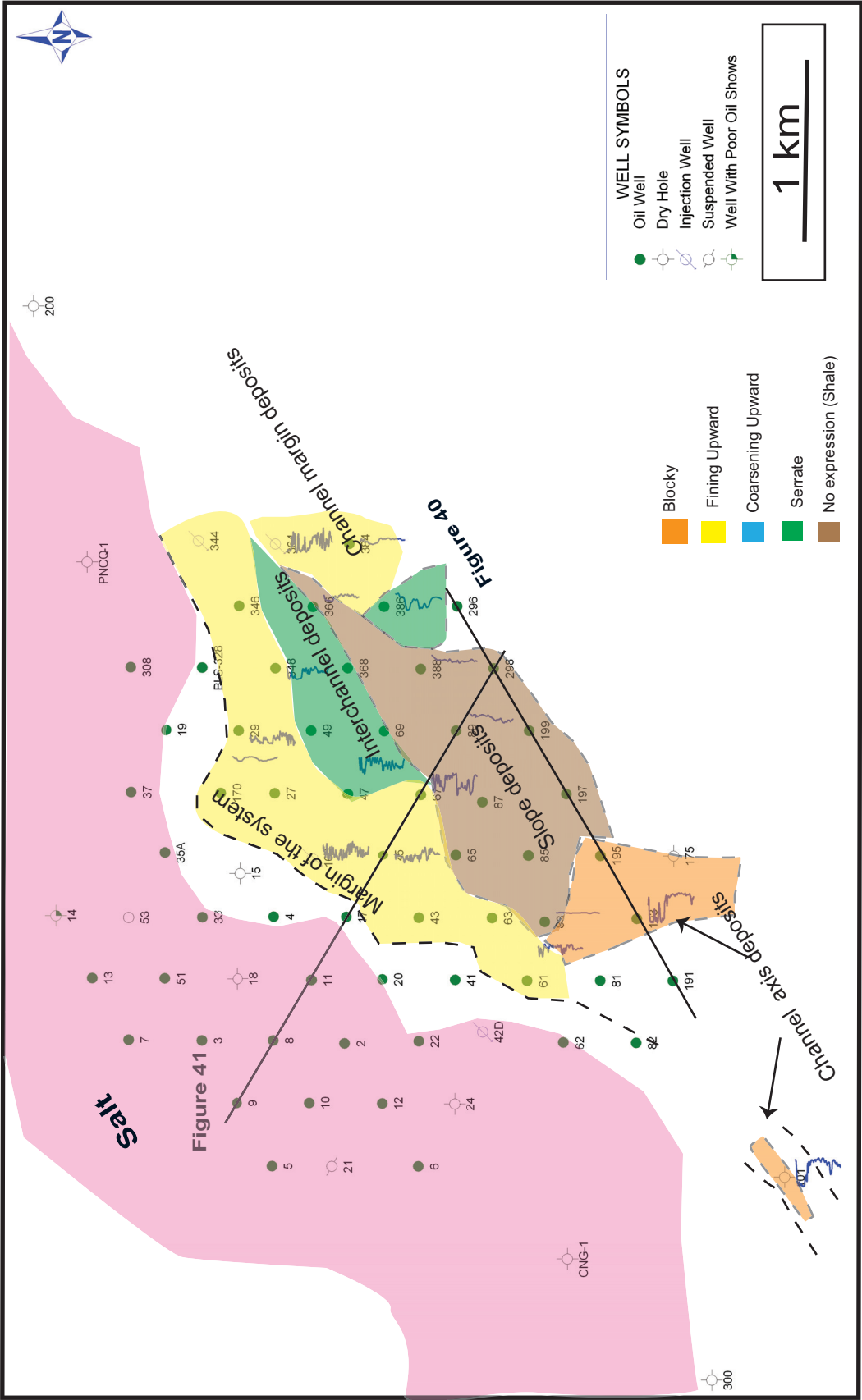


Figure 42. Lithofacies map for Sequence 1 (middle Miocene- RS-1) showing the SP logs. The main SP log pattern is fining upward, some thin sandstones signatures are related with a blocky signature, and some spike log signature are interpreted as serrate. The overall interpretation from this sequence is related with channel complex fill in a confined area. Locations of Figures 40 and 41 are shown.

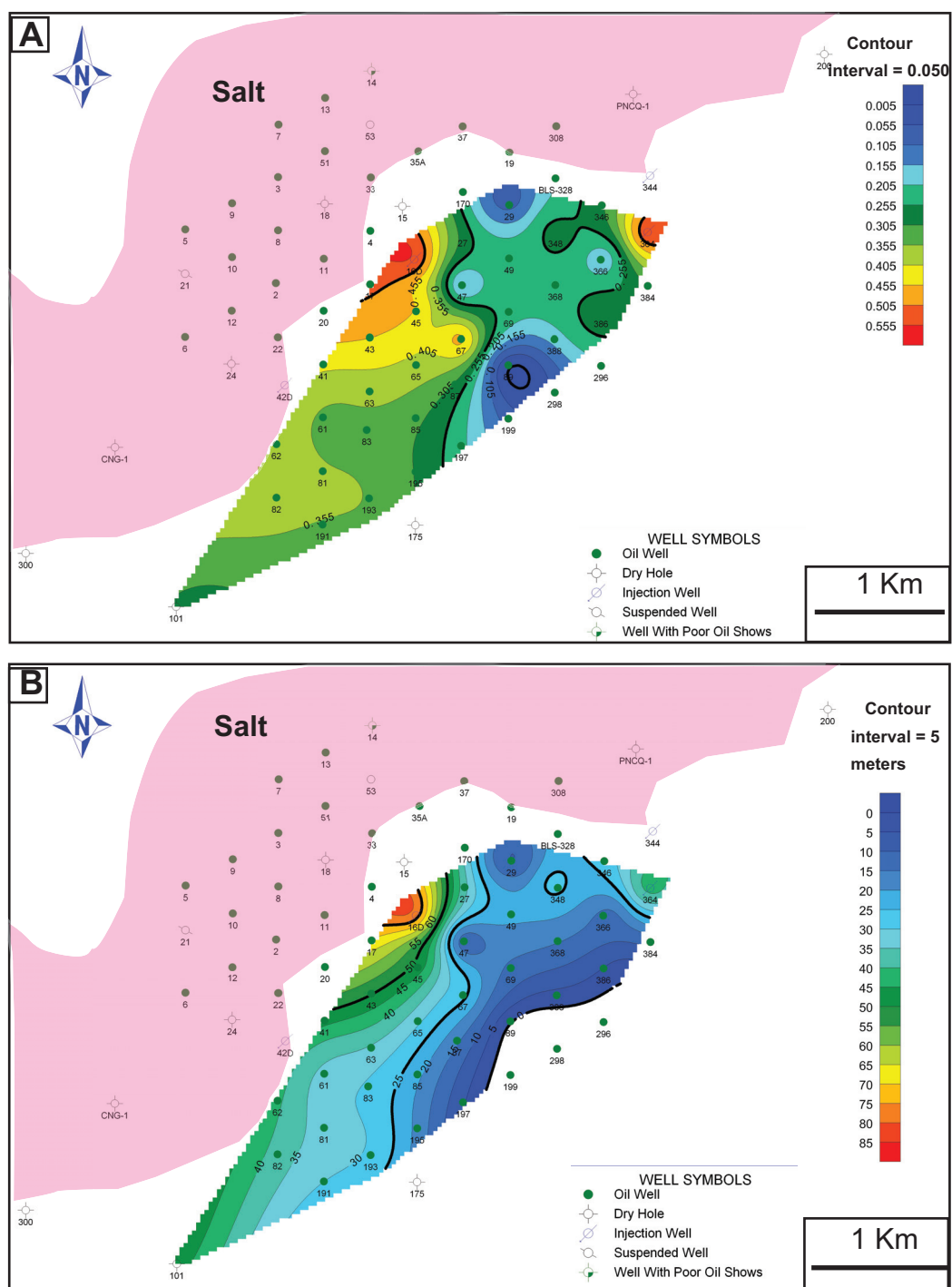


Figure 43. (A) Net-to-gross ratio map from Sequence 1. Contour interval is 0.05.
(B) Net-sand map from Sequence 1. Contour interval is 5 meters.

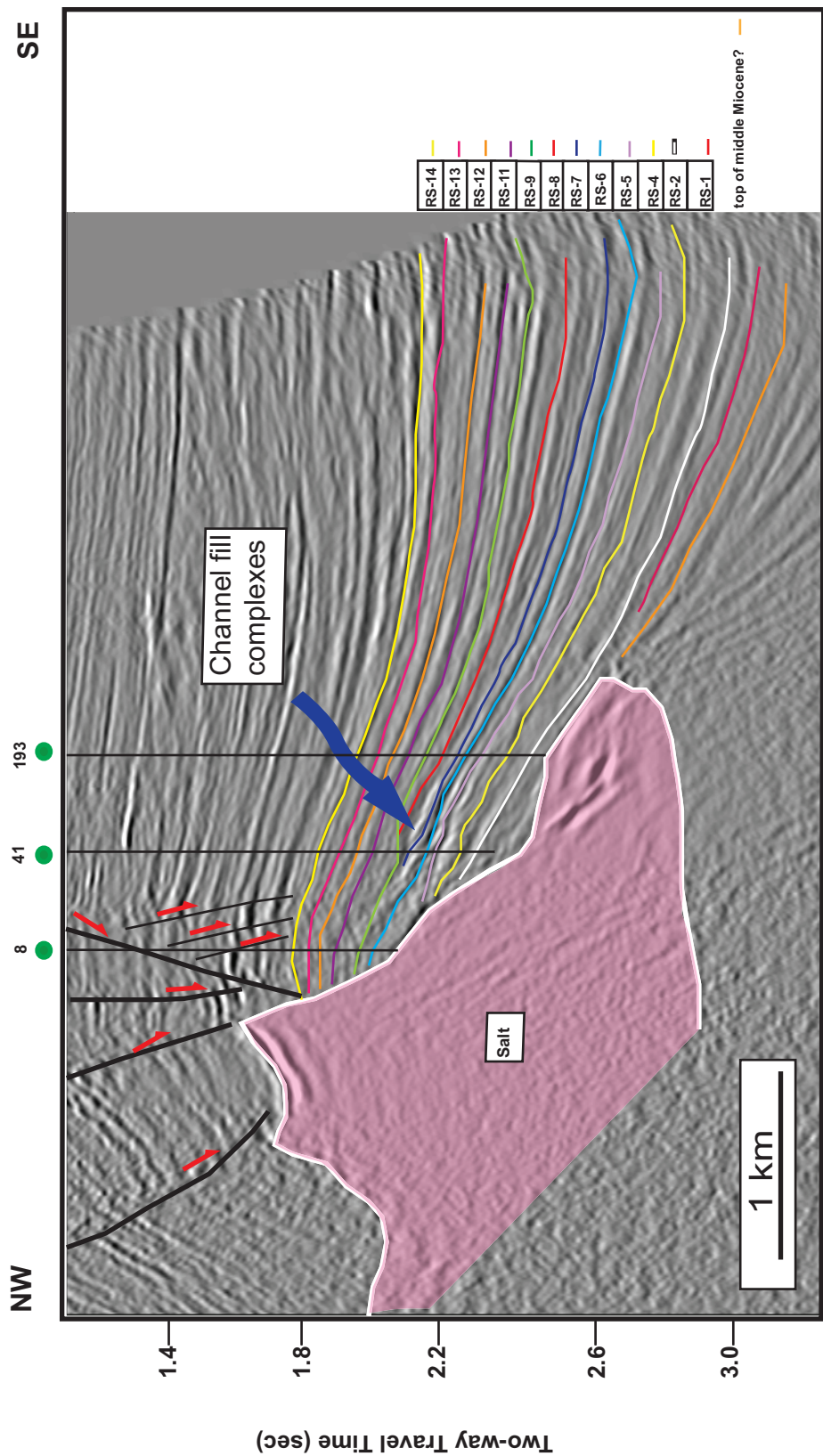


Figure 44. Seismic profile showing the interpreted sequences (top of the middle Miocene-RS-14) in the main production zone from the Blasillo Field. Producing zone is located in the flank of a salt body (pink). High amplitudes from horizon RS-9 through RS-2 (blue arrow) are interpreted correspond to lateral migration of channel complex fills. See Figure 38 for location of profile.

An RMS amplitude map extracted from a gated window 20 ms above the top of middle Miocene shows different amplitude trends south of the field area; this trends primarily from a south-east direction, with additional trends coming from the south and southwest (**Figure 45 A, B**).

Interpretation: Amplitude map of this sequence shows a series of channel systems trending north-northeast forward the field; some of these channel systems seem to have sinuosity. In this map the effect of the salt or weld salt can be observed. Maps of Net to gross and net sand map help to interpreted trend of the systems in the western part of the map.

Sequence 2 (RS-1_RS-2)

This sequence presents lateral facies changes, showing more characteristics fining upwarp and blocky log patterns. Changes in the lateral relation are interpreted to correspond to channel complex fills.

Time-structure map: The time-structure contour map of the top of the Sequence 2 has similar overall shape than Sequence 1. Wells in the highest position are flanked by salt. Two different set of faults are present: The first set (F1) is present to the east, strike SE-NW, and dip primarily to the northeast (**Figure 46**). The second set (F2) is located to the west, strike W-E, and dip to the north.

Isopach map: Sequence 2 was penetrated by 35 wells. The isopach map of Sequence 2 shows the area of greatest thickness in the north in part of the field (**Figure 47**). The thickness varies between 95 to 125 meters, increasing the thickness to the north; a

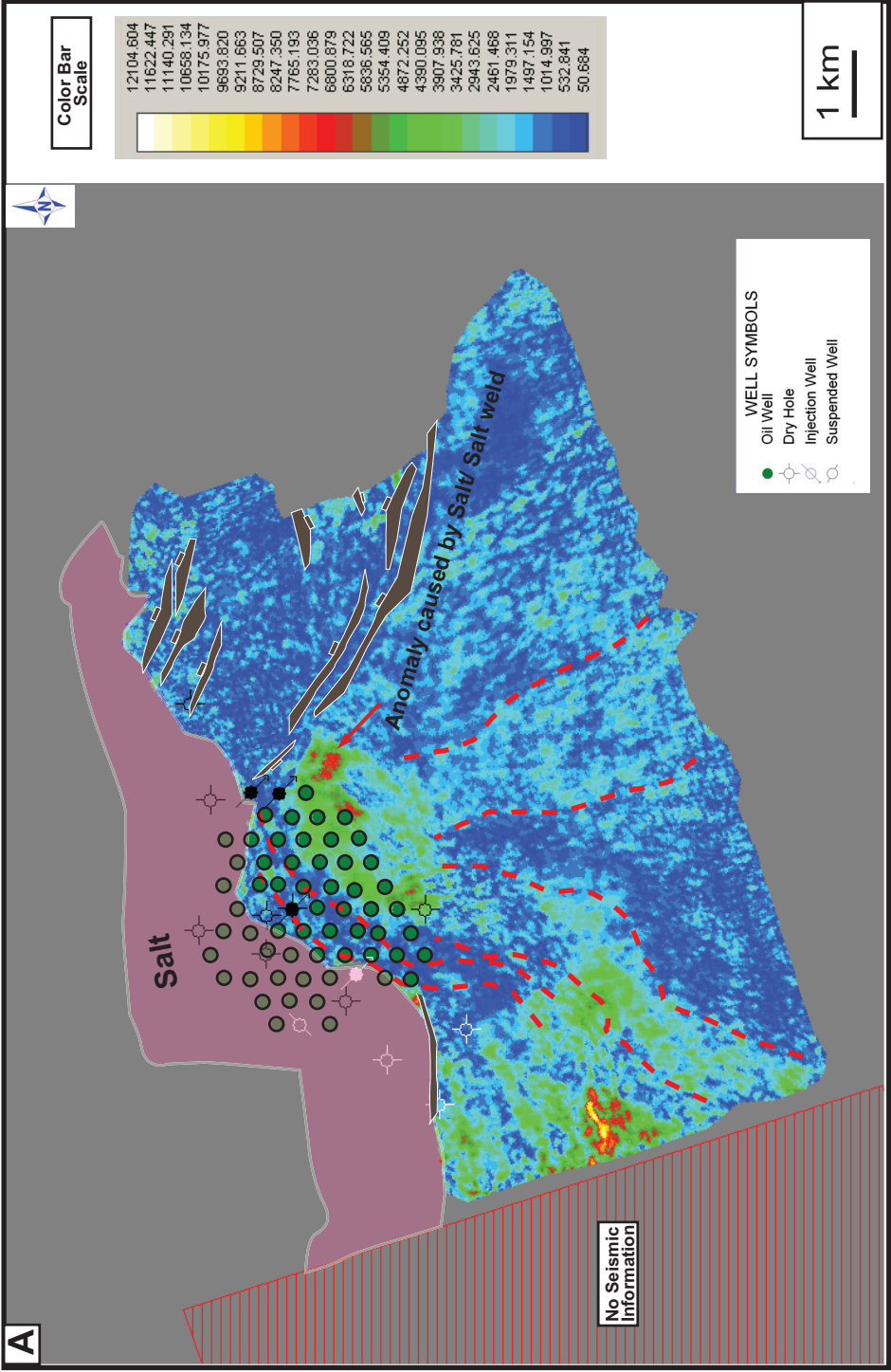


Figure 45. RMS amplitude extraction map from a window 20 ms below the horizon RS-1. A) With well location plotted. B) With not wells plotted. Three sedimentary pathways coming to the field are identified from the south and southeast part of the map. Patterns are not very clear but some of the pattern present a sinuous path, the systems are interpreted as channel complexes. Seismic amplitude shows that the system is made for not very wide channel fills.

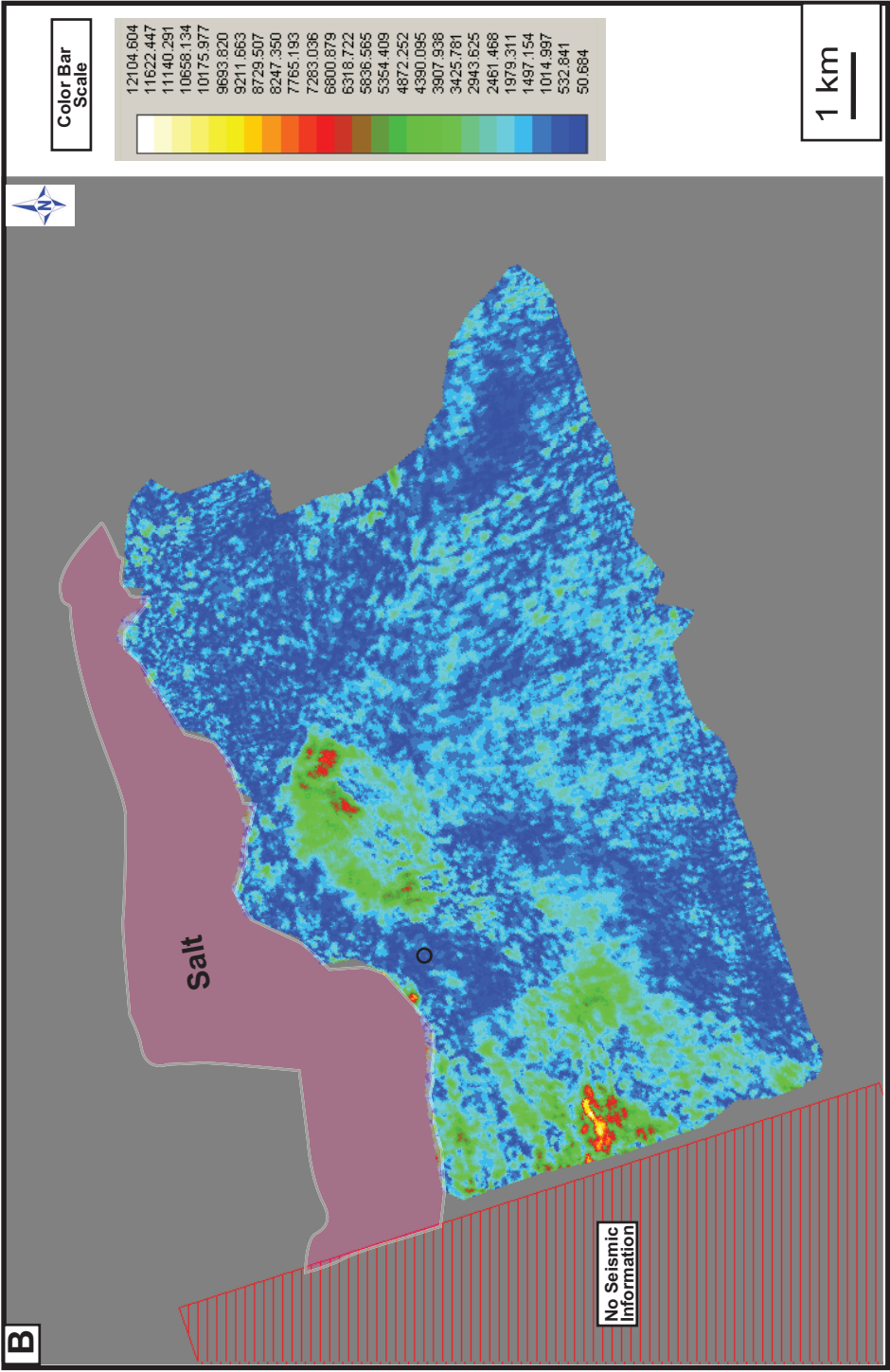


Figure 45 B.

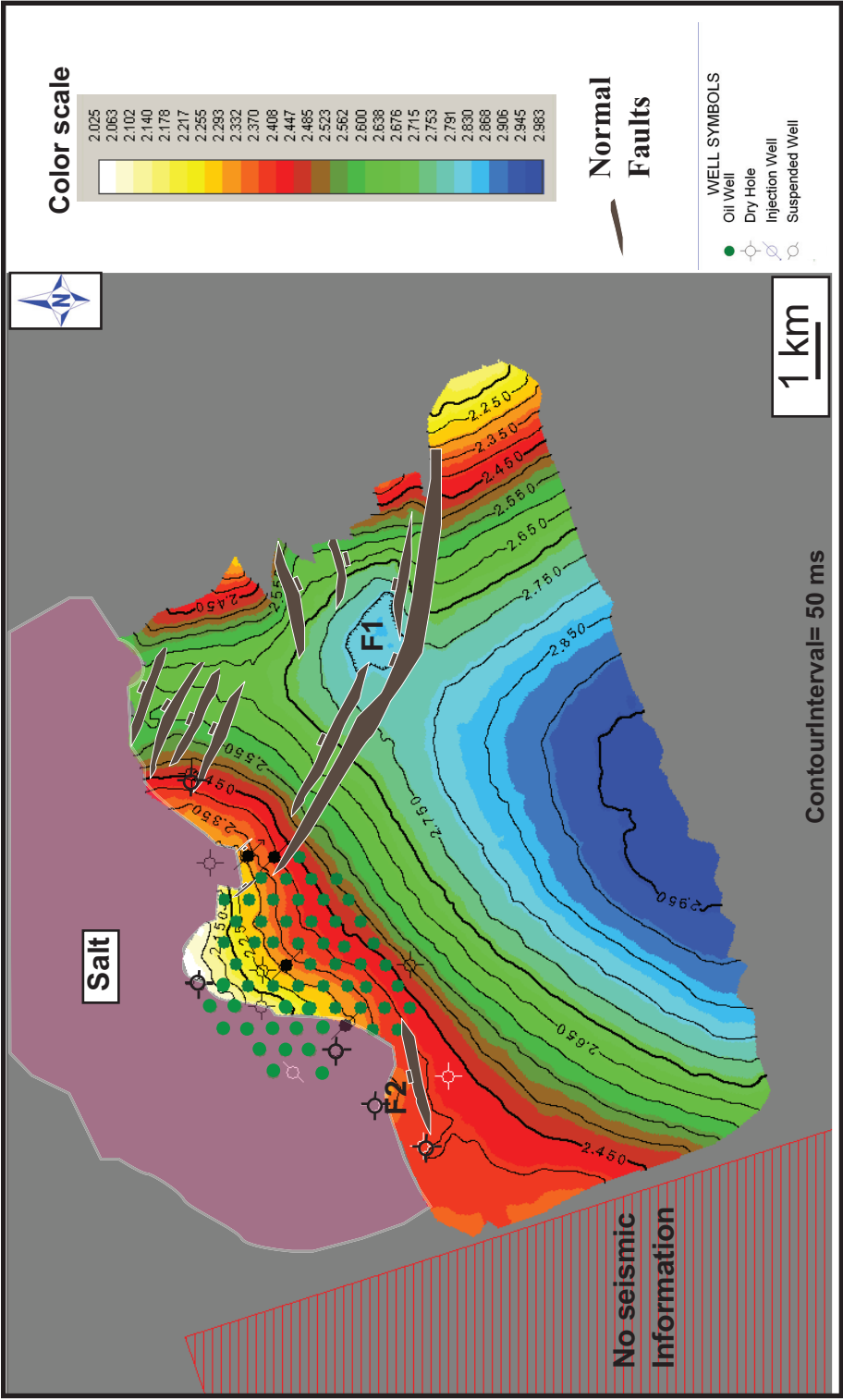


Figure 46. Time structure contour map (in secs) of the Surface RS-2. A salt body is present in the north part of the map (pink). Two sets of faults are interpreted in this sequence with SE-NW and W-E orientations, the first set (F1) strikes NW-SE and dips to the northeast. The second set (F2) strikes SW-NE and present different dips in the east side dips to the south and in the west side to the north. Wells are shown in green dots.

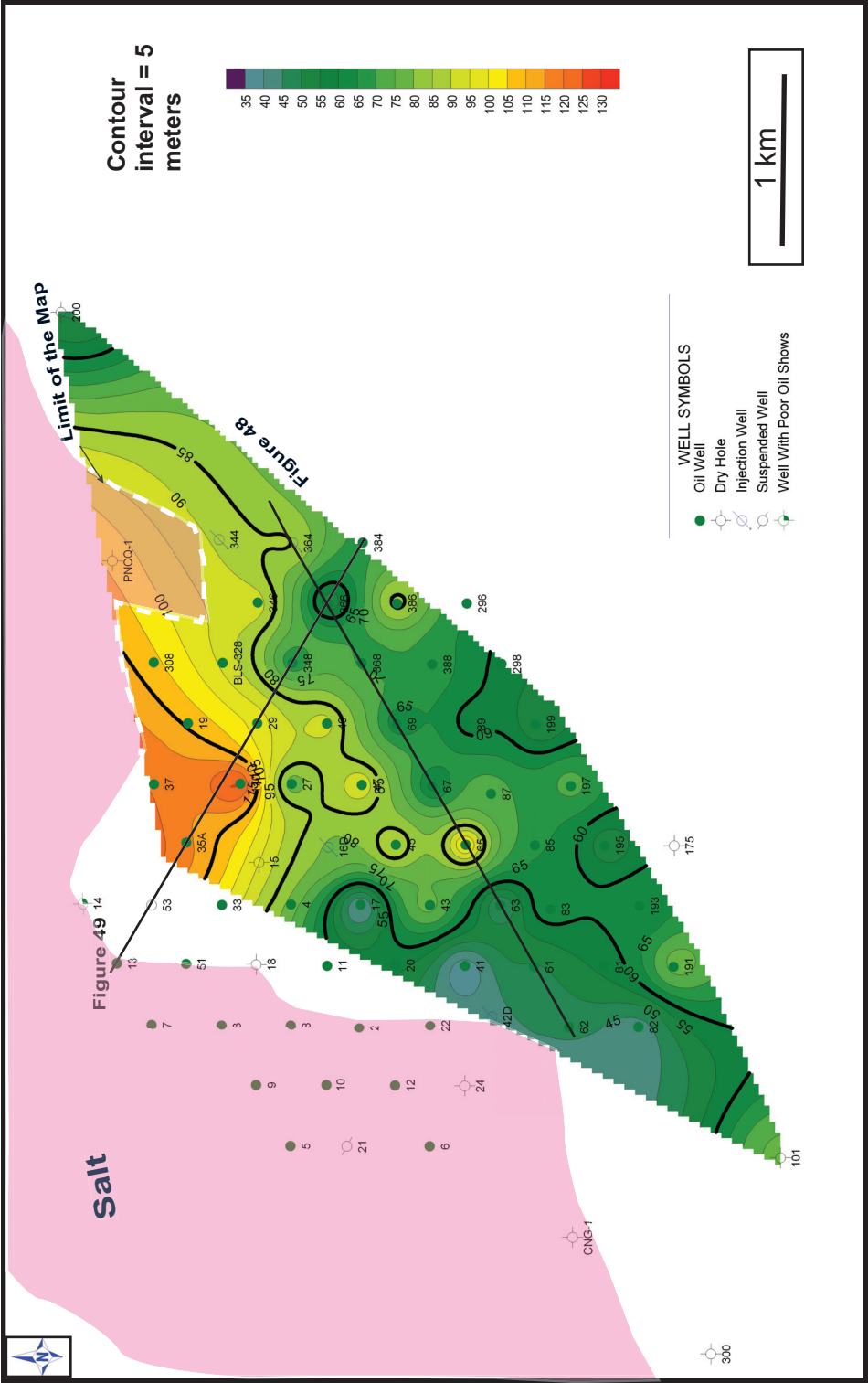


Figure 47. Isopach map of the Sequence 2. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 48 and 49 are shown.

zone with minimum thickness of 40 meters is located in the SW part of the field (**Figure 47**).

Lithofacies: Abrupt lateral changes in sand store units are present, indicating the channelized nature of the deposits. The strike and dip oriented wireline log sections (**Figure 48 and 49**, respectively) illustrate the lateral variability and architecture of the channel-fill strata.

On the strike profile, three distinct blocky patterns are present (wells 65, 69, 368), which change laterally to serrate/blocky pattern (well 364), and fining up to coarsening up patterns (**Figure 48**). The interpreted lateral continuity of the different sand store bodies extend up to 500 m in width. Individual sand units are up to 50 m thick (**Figure 48**).

The dip oriented profile has similar log patterns. Continuity of sand bodies is greater (**Figure 49**) and local thickness increase. Two discrete channel-fill deposits are present at different levels.

In map view, the SP log pattern for Sequence 2, shows that the blocky and the fining upward signature are common and show distinct SW-NE trend (**Figure 50**). Coarsening upward signature is located on edges of the map. Serrate signature is less common in the field (**Figure 50**).

Net-to-gross map: The-net-to gross map for Sequence 2 shows the distribution of the higher values in three zones of the map (northwest, northeast, and southwest), although these zones are not connected (**Figure 51 A**). Zones with lower values are located in the north and northeast part of the area (**Figure 51 A**).

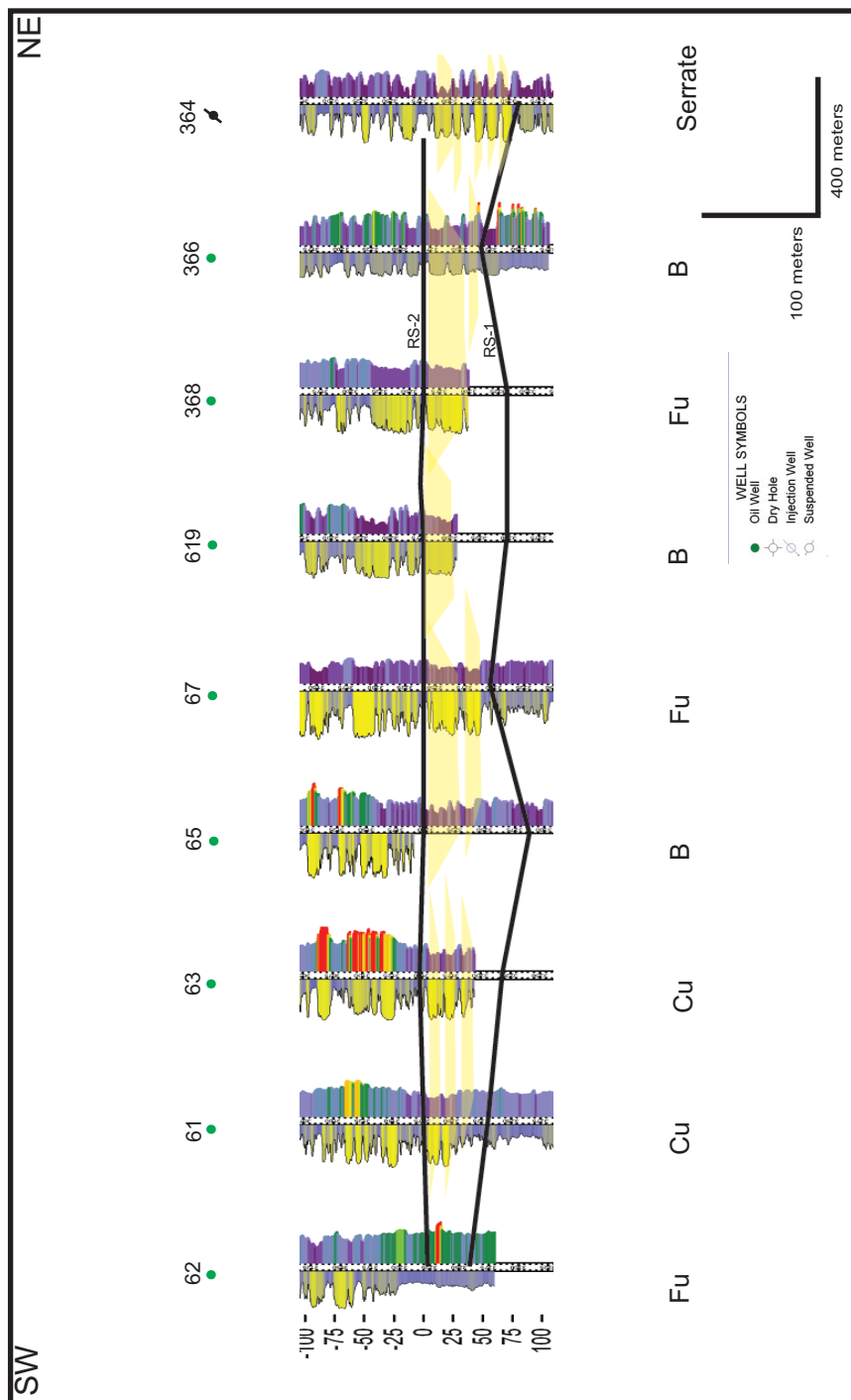


Figure 48. Wireline log cross section showing the Sequence 2 (RS-1 to RS-2). RS-2 is the datum. SP and Resistivity curves are shown. Lateral changes in the log signature are evident from one well to another. In this section fining upward and blocky are the representative log signatures. An interpretation of the sandstone distribution is shown in yellow. See Figures 47 and 50 for location of section.

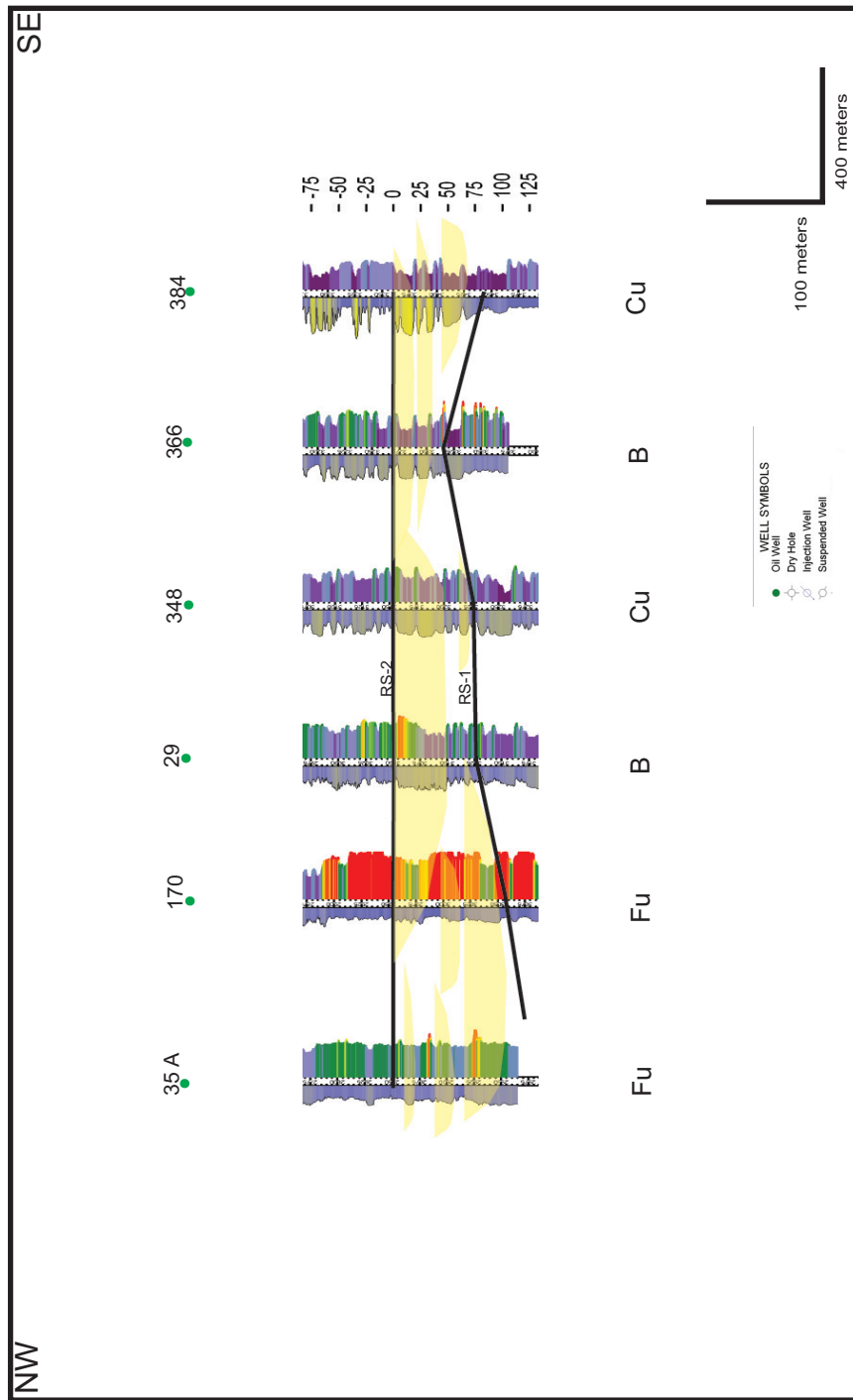


Figure 49. Wireline log cross section showing the Sequence 2 (RS-1 to RS-2). RS-2 is the datum SP and Resistivity curves are shown. Blocky, fining upward and serrate are the most characteristic log signatures in this sequence. An interpretation of the sandstone distribution is shown in yellow. See Figures 47 and 50 for location of section.

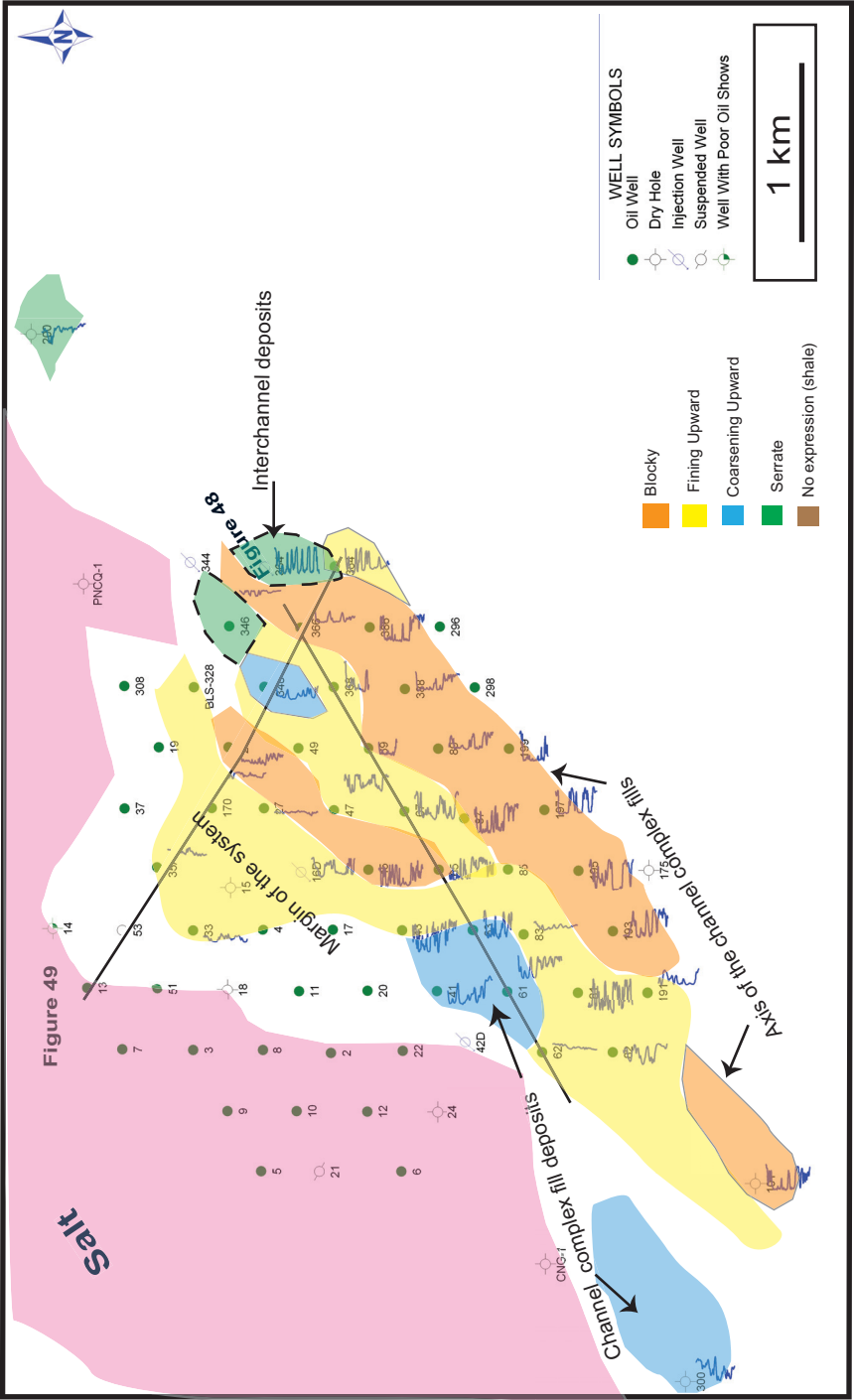


Figure 50. Lithofacies map for the Sequence 2 (RS-1_RS-2) showing the SP logs. The main SP log pattern is blocky followed by the fining upward, serrate is the less represented in this map. The blocky pattern is interpreted as the central part of the system where channel complex fills have semi amalgamation. Fining upward and coarsening upward signature are in the margin of the system. Location of Figures 48 and 49 are shown.

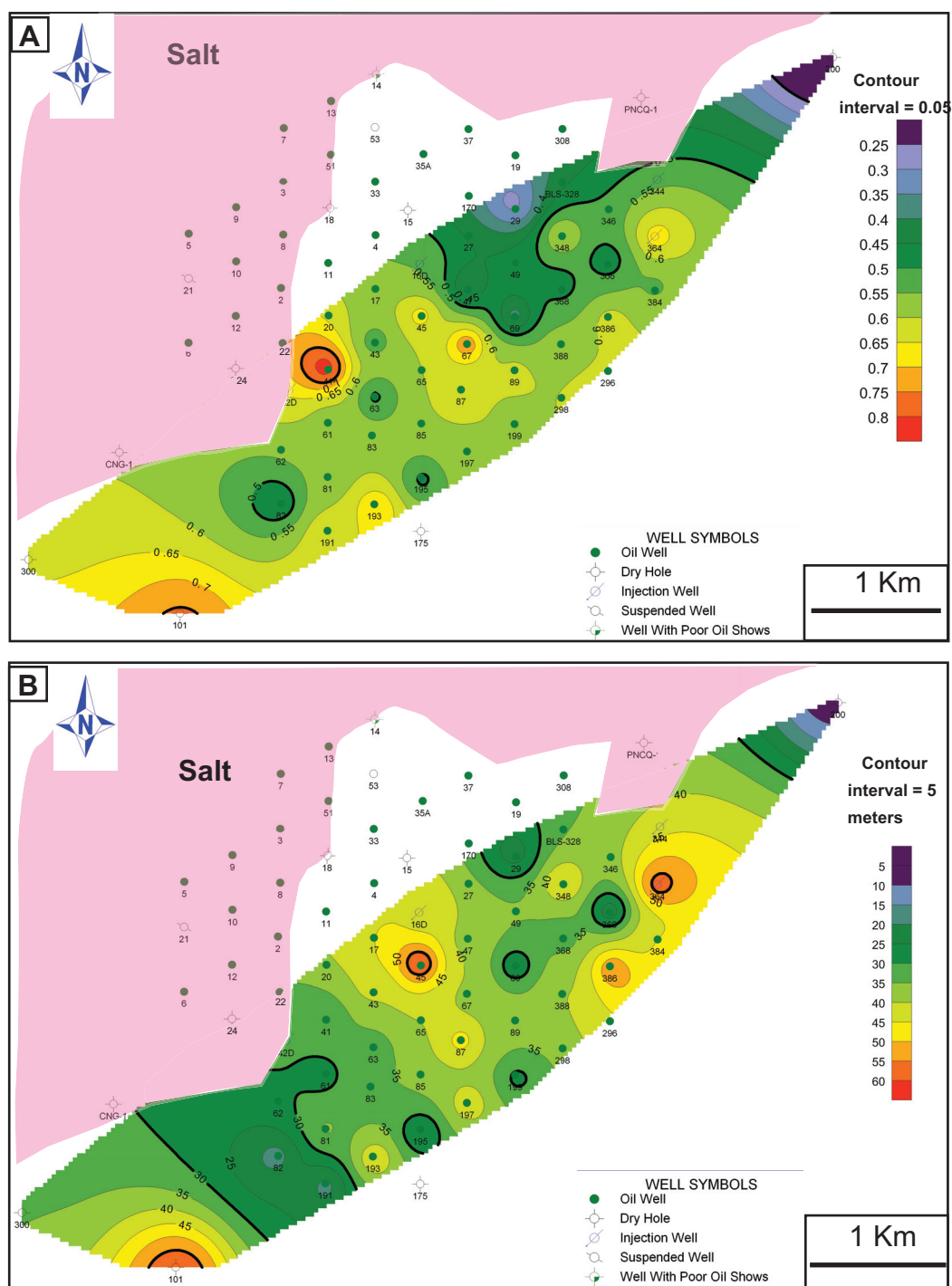


Figure 51. (A) Net-to-gross ratio map from Sequence 2. Contour interval is 0.05.
(B) Net-sand map from Sequence 2. Contour interval is 5 meters.

Net-sand map: The net-sand map of this sequence shows that most of the area in the field has values between 30 and 40 meters. Three discrete areas are present that exceed 50 meters, and zone of lower values is located in the northeast part of the field (**Figure 51 B**). The areas of greater and less sand generally correspond to the SP curve signatures.

Seismic Facies: Two general seismic facies in vertical profile are present: The first one is present in the deeper portion of the sequence far from the salt body. It consists of low amplitude, parallel to sub-parallel reflections and moderate to high continuity. The second facies is characterized by low amplitude relatively low to moderate continuity and are present close to the salt body (**Figure 44**).

An RMS amplitude map from the sequence 2 derived from a gated window 30 ms above the surface RS-1 shows three different trends of slightly amplitude values (green) trending toward to the field area (**Figure 52**). These amplitudes trends have a slightly sinuous pattern outlined by dashed red lines (**Figure 52 A, B**).

Interpretation: The integration of all the above data indicates the reservoir consist of a series of complexly stacked channel systems. Channel complexes are interpreted to the south and southwest. The north trending channel system shows some evidence of sinuosity and appears to deliver sand almost across the entire field. The zone of amalgamated channels is located in the southern part of the field. The log patterns are interpreted as amalgamated channels complexes clearing a erosional/aggradational phase.

Sequence 3 (RS-2-RS-3)

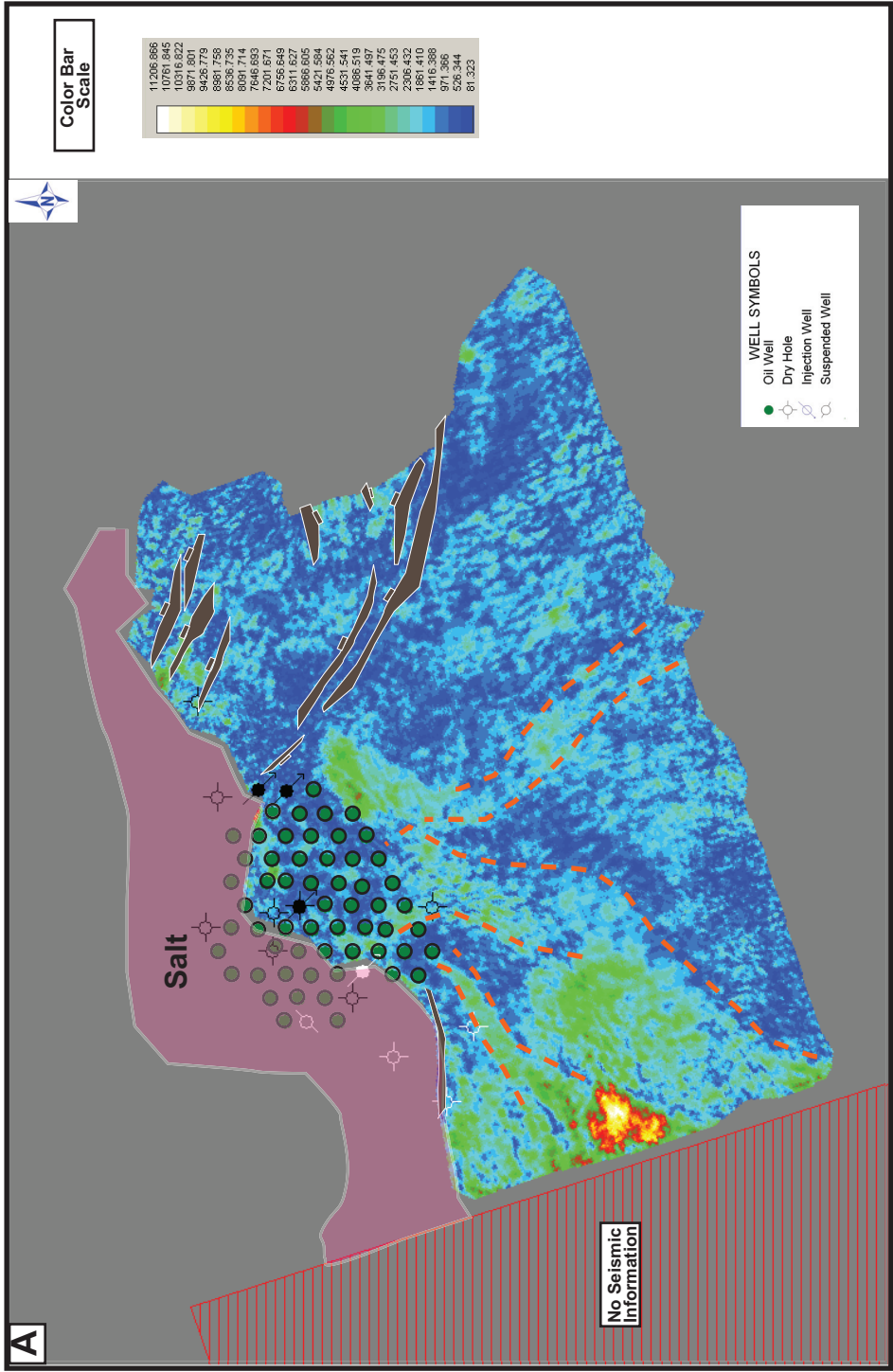


Figure 52. RMS amplitude extraction map from a gated window 30 ms above the Horizon RS-1. **A)** With well location plotted. **B)** With not wells plotted. Shows three different trends of amplitude coming to the field area. One is coming from south direction and another trend is coming from the southwest, the third trend is coming from the southeast systems interpreted as channel complex fills that present sinuous patterns.

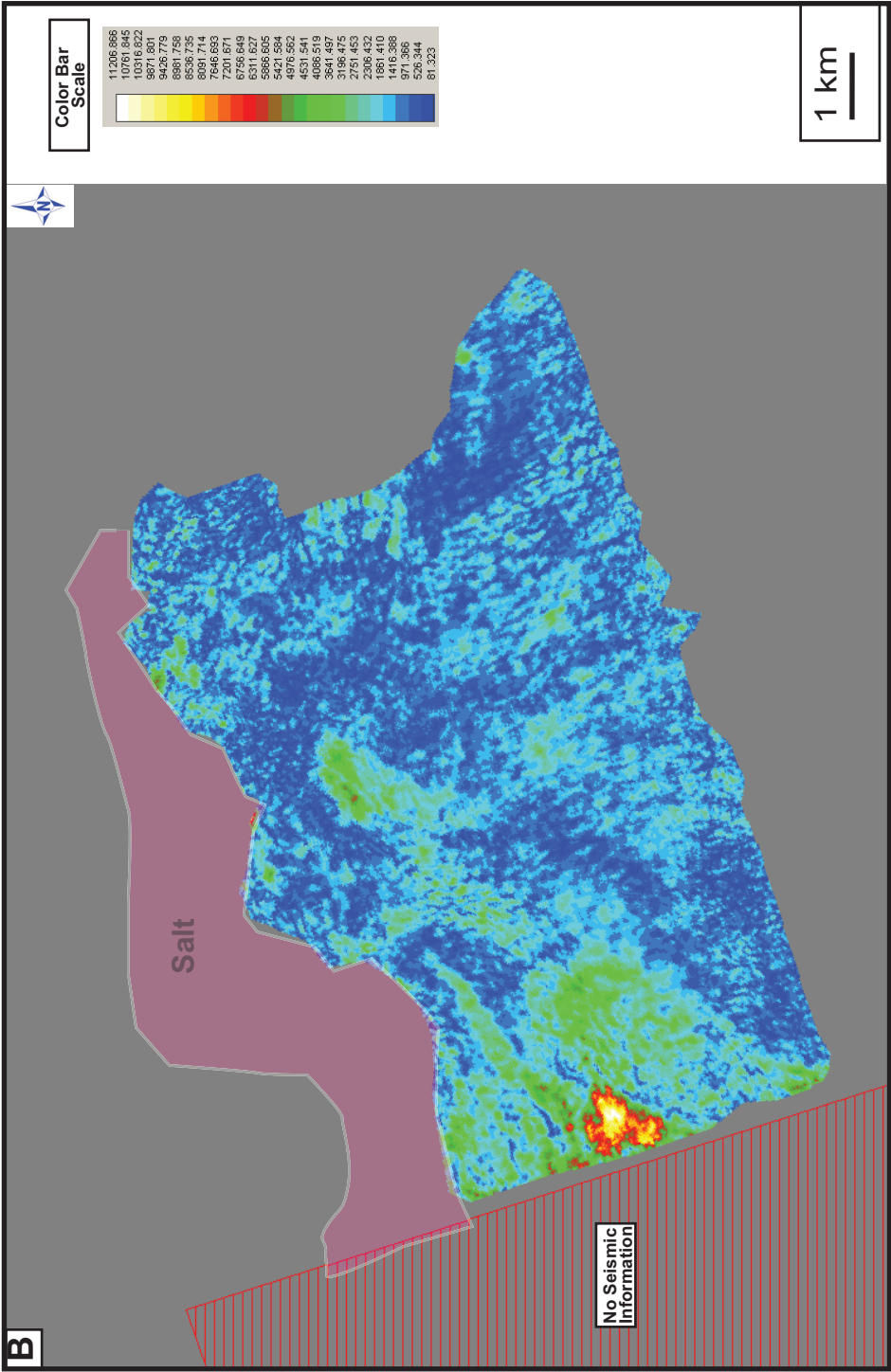


Figure 52 B.

Sequence 3 is evaluated entirely on the wireline logs because there was no seismic used to construct the time-structure map.

Time-Structure map: The structure map for this sequence was generated based on the RS-3 surface from the well data. The structure of the area shows a regional dip to the southeast from 2550 meters in its shallower position to 3350 meters in its deeper part. Note that this is a small portion of the area covered by the 3D seismic, i.e. the area penetrated by the wells. A comparison of this map with those structure maps generated from the 3D seismic volume shows the dip of the area where the wells are located are the same (**Figure 53**).

Isopach map: Forty two wells penetrated this sequence. The isopach map of this sequence shows thickness variation of 70-100 meters with greatest thickness to the north part of the field. Two zones of lower thickness (less than 55 meters) are present to the southwest and northeast. The map shows a trend of higher values with a north-south orientation (**Figure 54**).

Lithofacies: Two log cross sections illustrate the Sequence 3 in strike view (**Figure 55**) and dip view (**Figure 56**). In the strike oriented cross section, the thickest sands are present in the well 67 (blocky) and well 368 (fining upward) (**Figure 55**). Most of the thicker sand units cannot be correlated between adjacent wells (400 m spacing), whereas the thinner sands in wells 63 and 65 (both coarsening upward) can be traced at least 400 m. Three to four discrete channel-fill deposits of at least 25 meters thick are present (**Figure 55**).

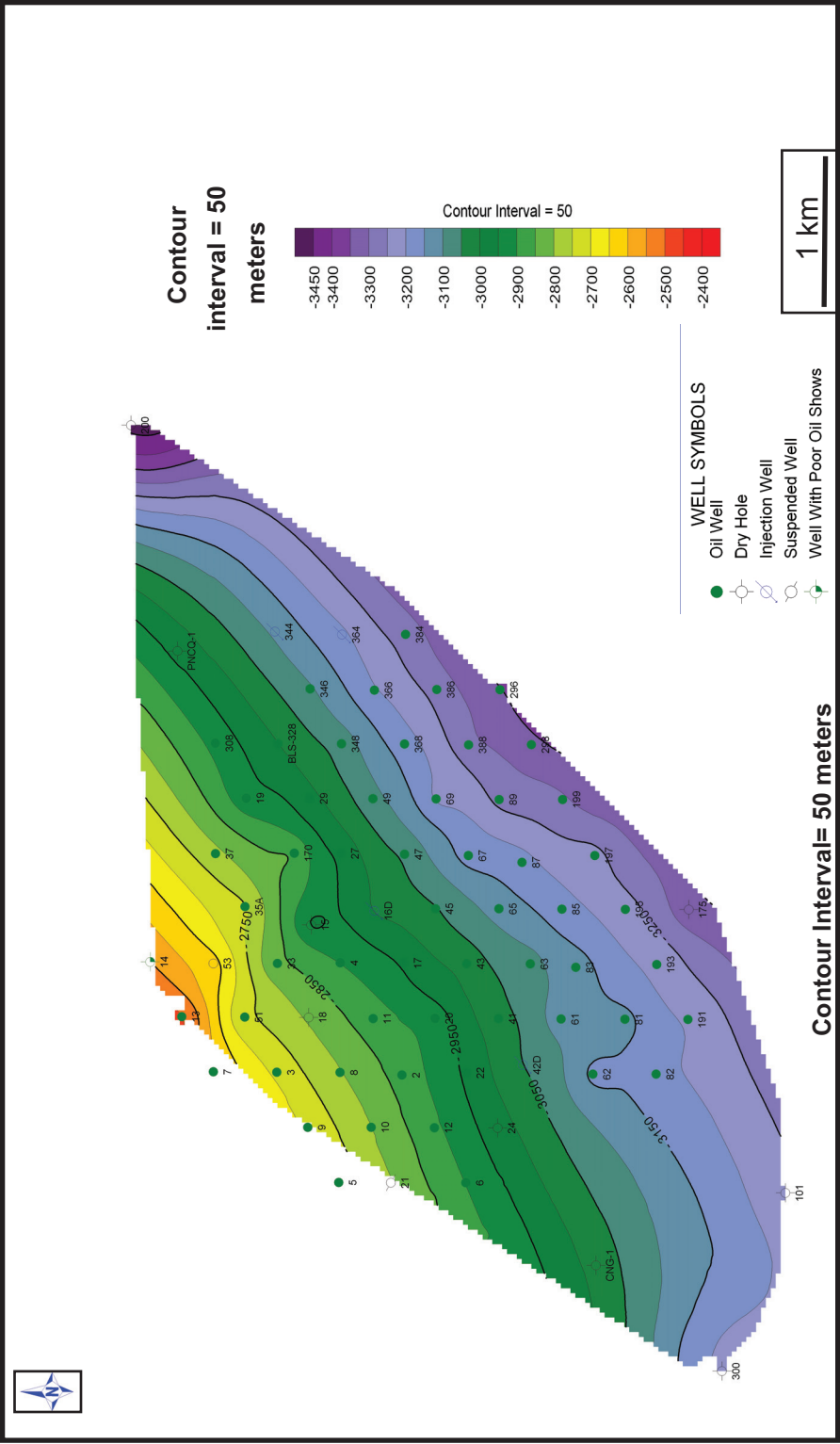
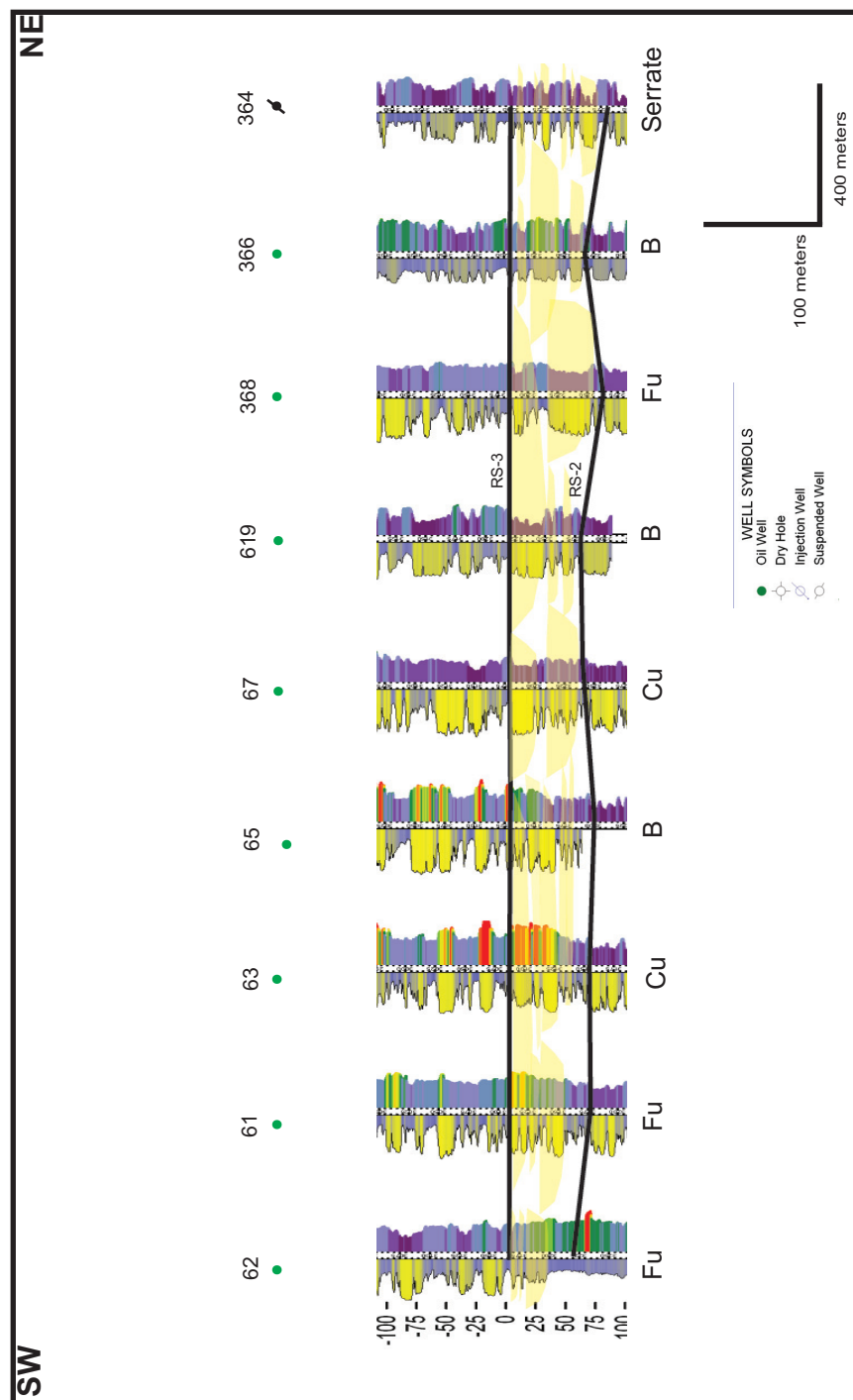


Figure 53. Structural map from the surface RS-3. Shallower position is related with 2500 meters and the deeper position is close to 3350 meters.





The dip oriented cross section illustrates at least three distinct of channel fill intervals that can be correlated between wells (**Figure 56**).

The map of the SP log pattern of Sequence 3 shows that the coarsening upward and blocky signature as the most common lithofacies, and are present in the middle part of the Blasillo field (**Figure 57**). Fining upward and serrate patterns are present on the flanks of blocky and coarsening upward signatures (**Figure 57**).

Net-to-gross map: The largest values are present in the central portion of the field (**Figure 58 A**). These values decrease abruptly to the north, east, and west where they are less than 0.375.

Net-sand map: The sequence has a maximum sand thickness of 60 meters (well 87) with a gradational change to the north and southwest, until reach values lower than 15 meters in the extremes (**Figure 58 B**). The net-sand map shows in the central area a similar distribution to the net-to-gross map. More than 40 meters of net sand is present in the central part of Blasillo field which decrease laterally to less than 25 meters.

Seismic Facies: The description of the seismic facies profile in this section involves Sequence 3 and 4. Two seismic facies in vertical profile are present. One facies consists of low amplitude parallel reflections with moderate to high continuity. These are localized in the minibasin and far from the well zone and another with moderated to high amplitude with low continuity close to the salt in the area of the wells (**Figure 44**).

Because the resolution of these sequences is made with wirelog correlations there is not an RMS amplitude map representative for this sequence.

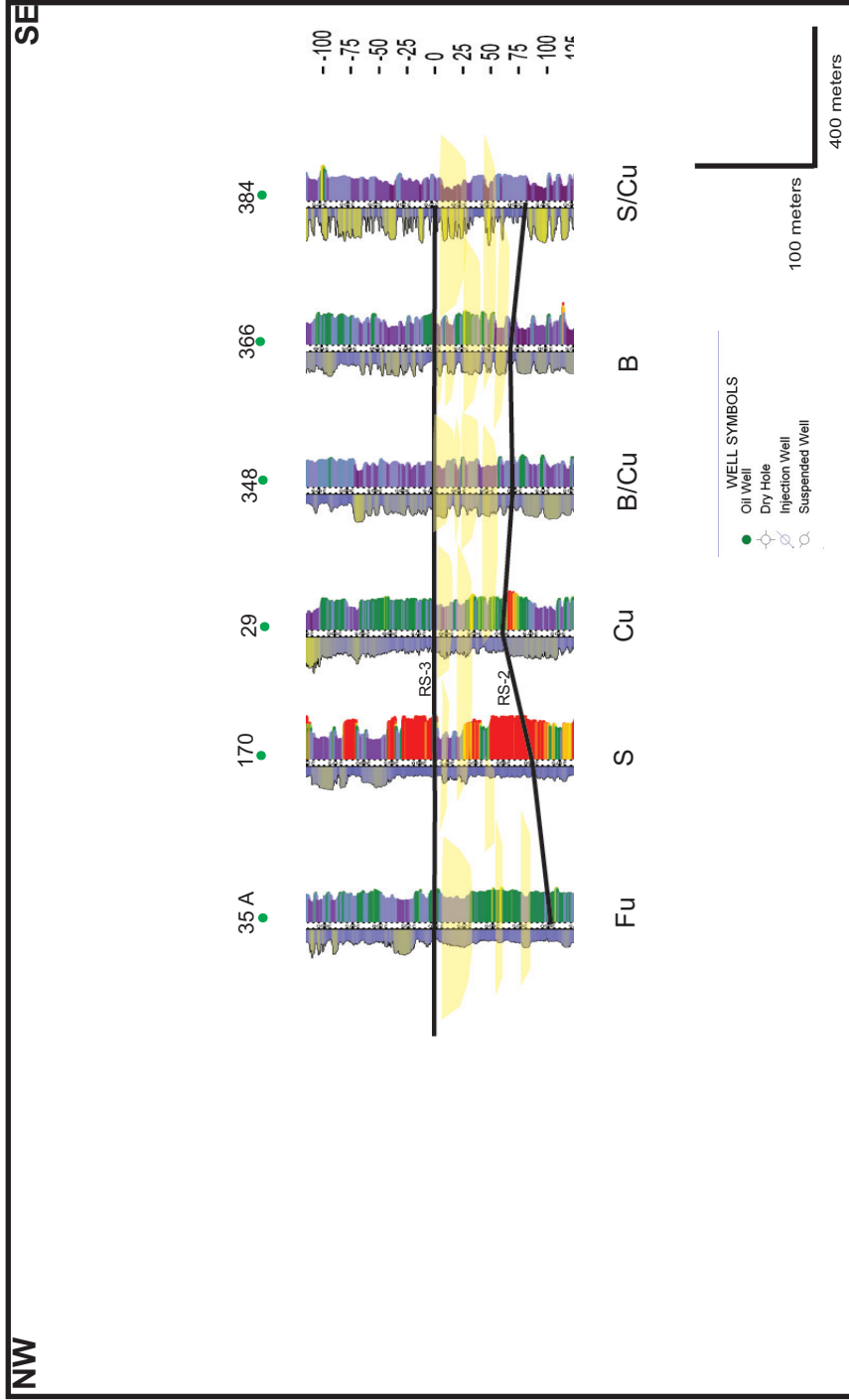


Figure 56. Wireline log cross section showing the Sequence 3 (RS-2 to RS-3). RS-3 is the datum. SP and resistivity curves are shown. Sandstones bodies look mudier, serrate, blocky, coarsening upward are the more characteristic log signature in this sequence. An interpretation of the sandstone distribution is shown in yellow. See figures 54 and 57 for location of section.

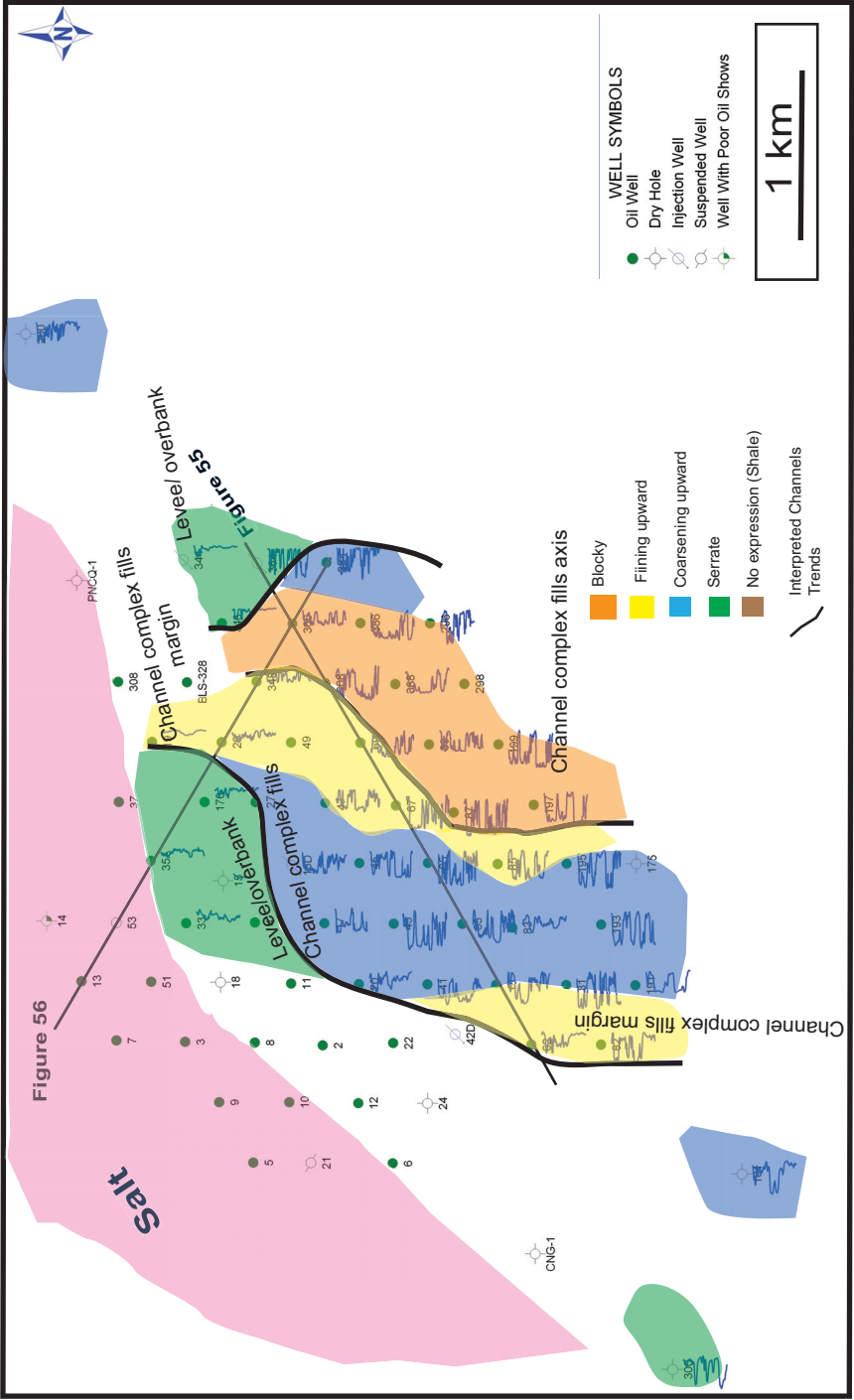


Figure 57. Lithofacies map for the Sequence 3 (RS-2_RS-3) showing the SP logs. The main SP log pattern is coarsening upward, interpreted as channel fill complex deposits. Blocky pattern corresponds to the zones where channels are more amalgamated and the fining upward are close to the margin of the system, coarsening upward pattern is associated with channel fill-interchannel deposits and serrate with levee/overbank? (an alternative interpretation could be isolated channel fill) deposits. Location of Figures 60 and 61 are shown.

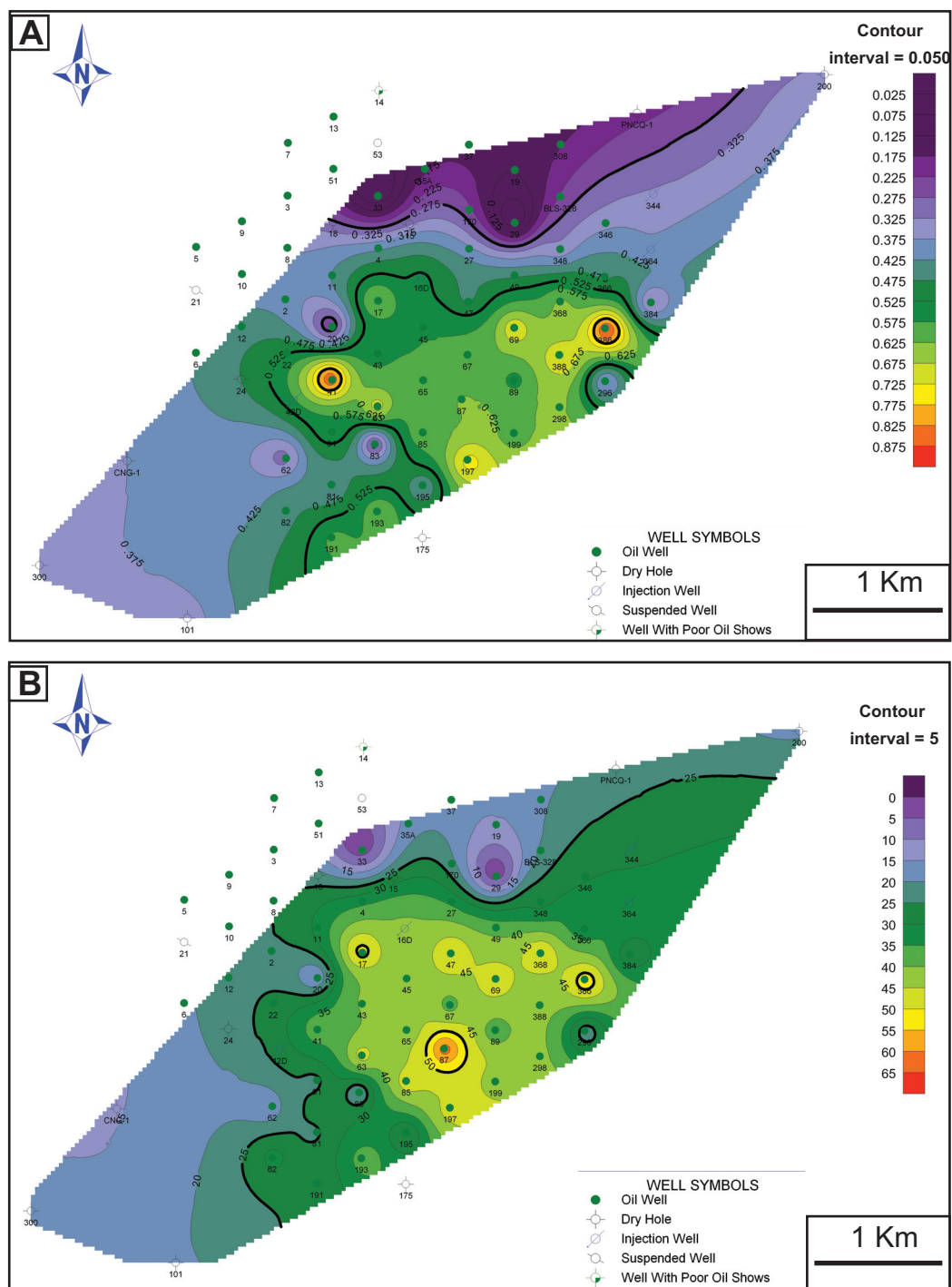


Figure 58. (A) Net-to-gross ratio map from the Sequence 3. Contour interval is 0.05. **(B)** Net-sand map from the Sequence 3. Contour interval is 5 meters.

Interpretation: Channels are interpreted to trend S-N and SW-NE. Facies related with blocky patterns in the map are interpreted as the area with the amalgamated channel fills and they are present in the southeast part of the map. Fining upward trends are interpreted as the margin of the channels systems. Coarsening upward interchannel-channel fill deposits are interpreted as result of the lateral migration of the channel complexes. Serrate pattern is interpreted as isolated channel fills.

Sequence 4 (RS-3_RS-4)

The seismic interpretation of this interval is included in top of RS-2 to top of RS-4 because the top of the Sequence 3 is based in SP wireline logs (**Figure 44**).

Time-structure map: A time-structure contour map of horizon RS-4 shows a similar overall dip to the basin as the underlying sequences (**Figure 59**). The prominent salt body is present in the northern part of the study area (**Figure 59**). A minibasin is located in the south part of the field trends SW -NE becoming shallower in both sides. Three eroded zones are interpreted. One is located to the north, and two in the northeast part of the study area (**Figure 59**). Two sets of faults are present. The first set (F1) is located in the NE of the study area, strikes SE-NW and dips to the northeast (**Figure 59**). The second set of faults is located in the west, which strikes W-E and dips to the north (**Figure 59**).

Isopach map: Fifty four wells penetrated this sequence. The isopach map of this sequence shows thickness variation, from 35 to 130 meters, with the greatest thickness in the central part of the field with thickness (> 110 meters). A zone of lower thickness is located in the west part of the field with thickness (< 40 meters) (**Figure 60**).

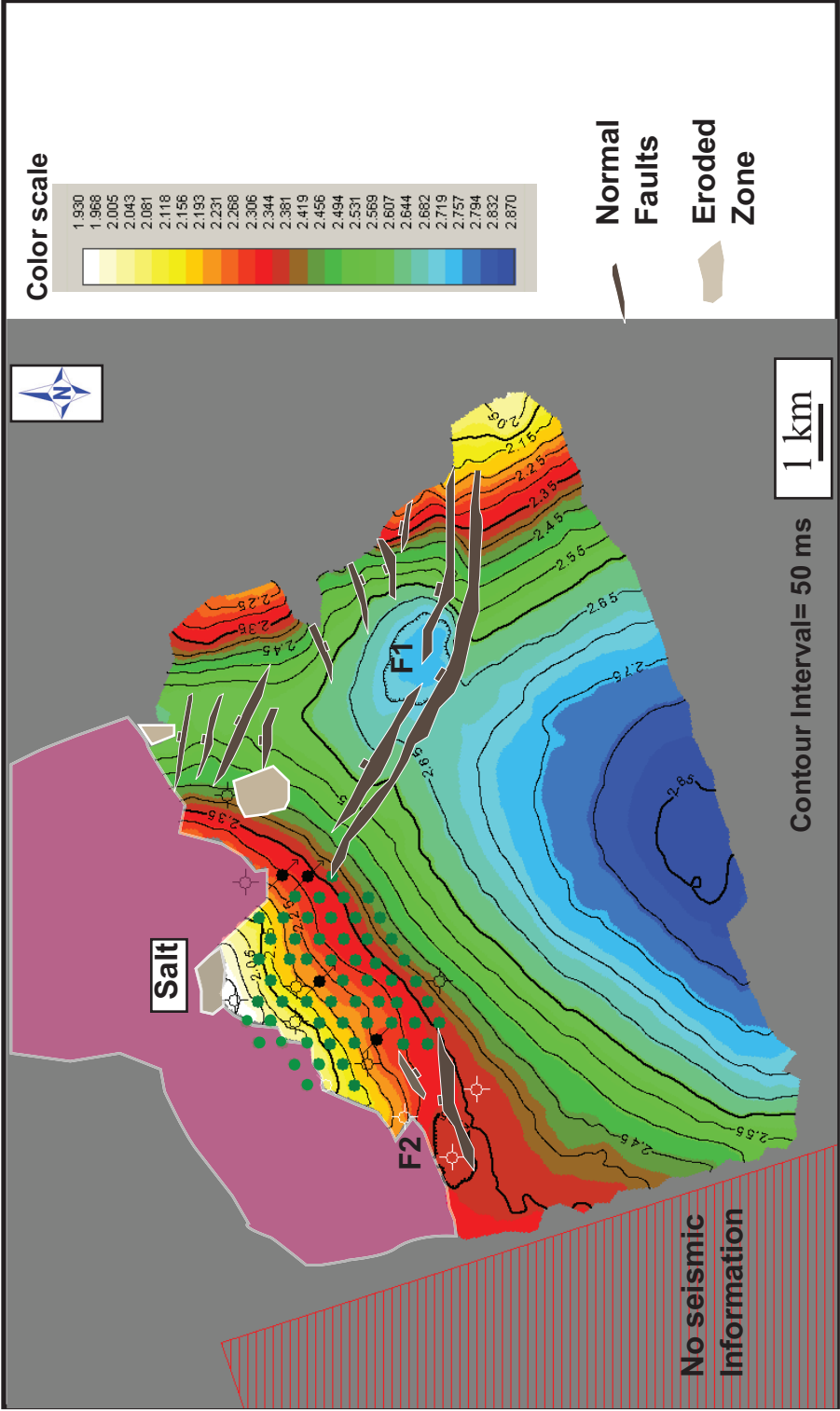


Figure 59. Time-structure contour map (in secs) of the Surface RS-4. A salt body is interpreted in the W-NE part of the study area (pink). This surface presents three different small eroded zones (lower polygons), two of them close to the salt body but the other is not. Two sets of faults are interpreted. The first set (F1) is located in the northeast and southeast side of the study area, strikes SE-NW and dips to the northeast. The second set (F2) strikes SW-NE and dips to the southeast and northeast in both sides.

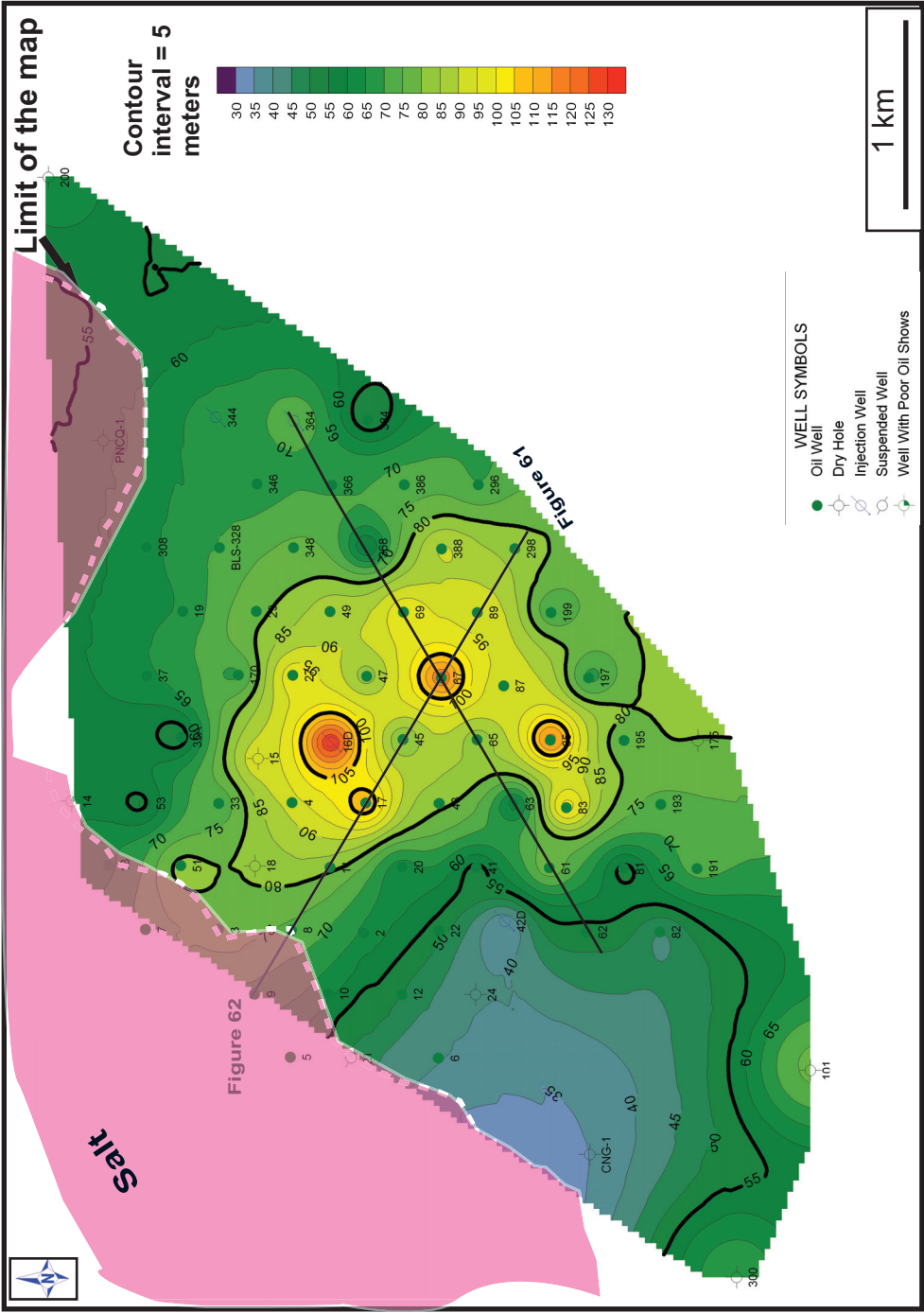


Figure 60 . Isopach map of the Sequence 4. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 61 and 62 are shown.

Lithofacies: Two wireline log cross sections illustrate the sequence in strike (**Figure 61**) and dip views (**Figure 62**). In the strike oriented profile, the thickest sands have a blocky SP pattern and are present in the wells 65, 67 and 69. The thicker sand are correlated between these wells (800 meters apart), the thinner sands are present in the well 368 (fining upward) wells 366 and 364 (fining upward, blocky) present channel fills vertically isolated by shale (**Figure 61**).

The thickest sandstones with blocky SP pattern in the dip oriented profile are present in the wells 67 and 89. They are interpreted as different sand units. The well 45 has a serrate pattern that separates two zones of better development of the channel fills in the NW coarsening upward present in the well 11 and 17, and in the SE the blocky pattern present in the wells 67 and 89 (**Figure 62**).

In map view, the SP log pattern of Sequence 4 shows a complex distribution of the SP shapes, in architecture (**Figure 63**). In general, the zones have southwest-northeast trend. Lateral variations in the log signature are present and no one signature is more common. The blocky character is present in four isolated areas, and the coarsening upward is isolated in five areas. Fining upward and serrate log signatures have the most continuous lateral distribution and are present between the blocky and coarsening upward patterns (**Figure 63**).

Net-to-gross map: The net-to-gross map of this sequence shows values ranging from 0 to 0.65 (**Figure 64 A**). In general, the highest values are to the southern part of the field and decrease to the west and north. One area of isolated higher values (more than 60 %) is present to the northwest (**Figure 64 A**).

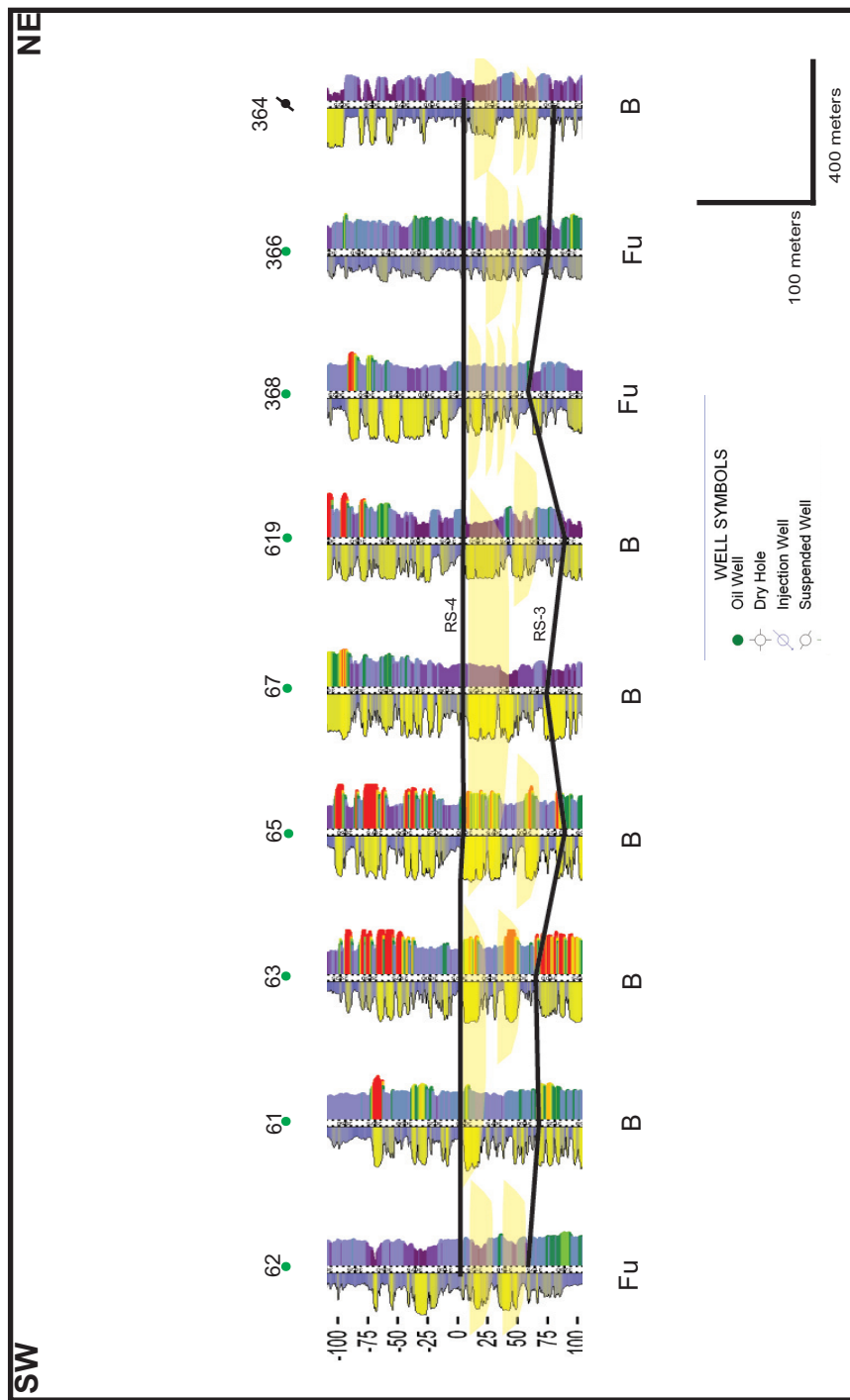


Figure 61. Wireline log cross section showing the Sequence 4 (RS-3 to RS-4). RS-4 is the datum. SP and Resistivity curves are shown. Blocky, coarsening upward and fining upward are the most characteristic log signatures in this sequence. An interpretation of the sandstone distribution is shown in yellow. See Figures 60 and 63 for location of section.

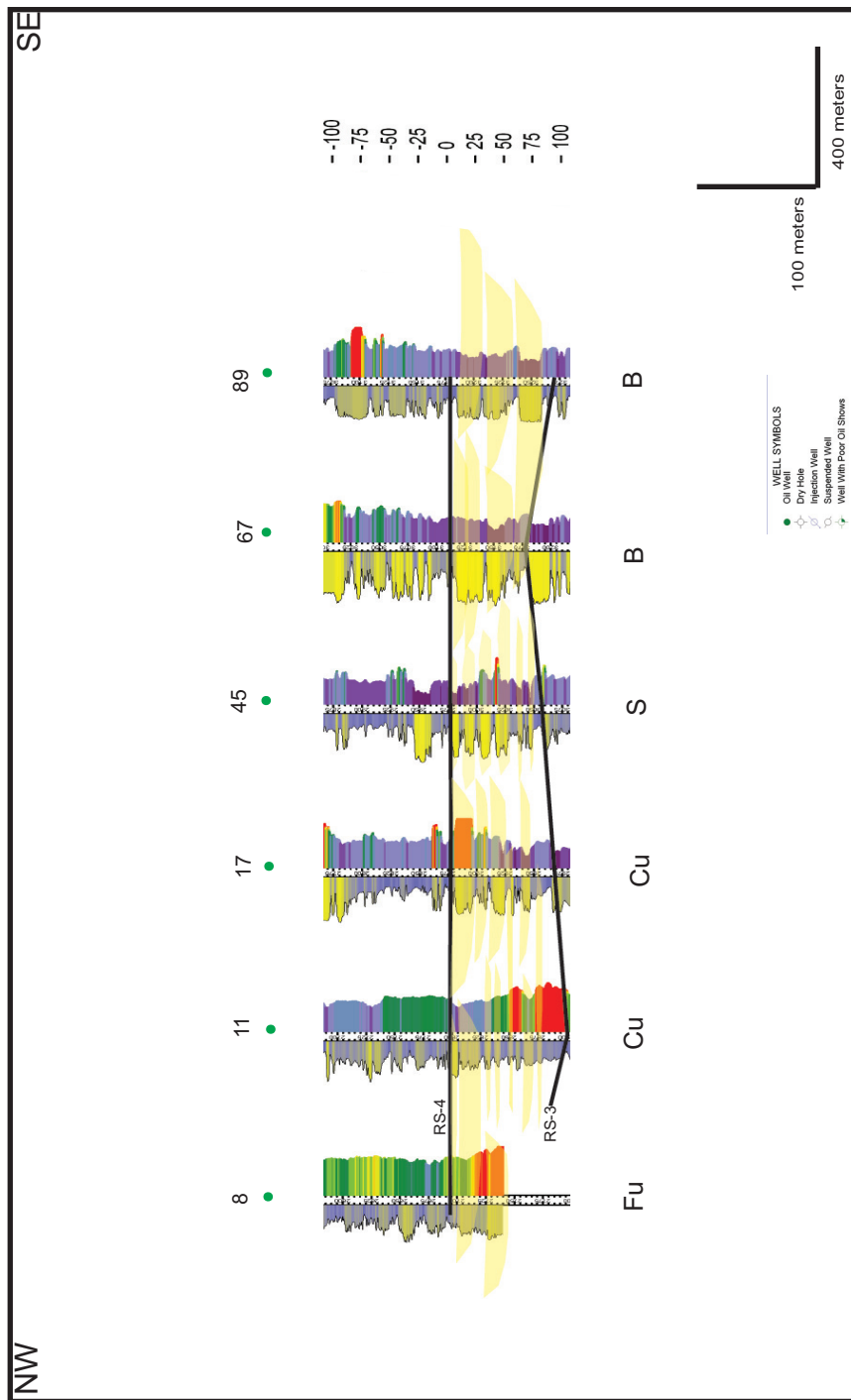


Figure 62. Wireline log cross section showing the Sequence 4 (RS-3 to RS-4). RS-4 is the datum. SP and Resistivity curves are shown. Fining upward, coarsening upward, serrat and blocky signatures are present in this sequence, thicker sandstones bodies are located in the SE. An interpretation of the sandstone distribution is shown in yellow. See Figures 60 and 63 for location of section.

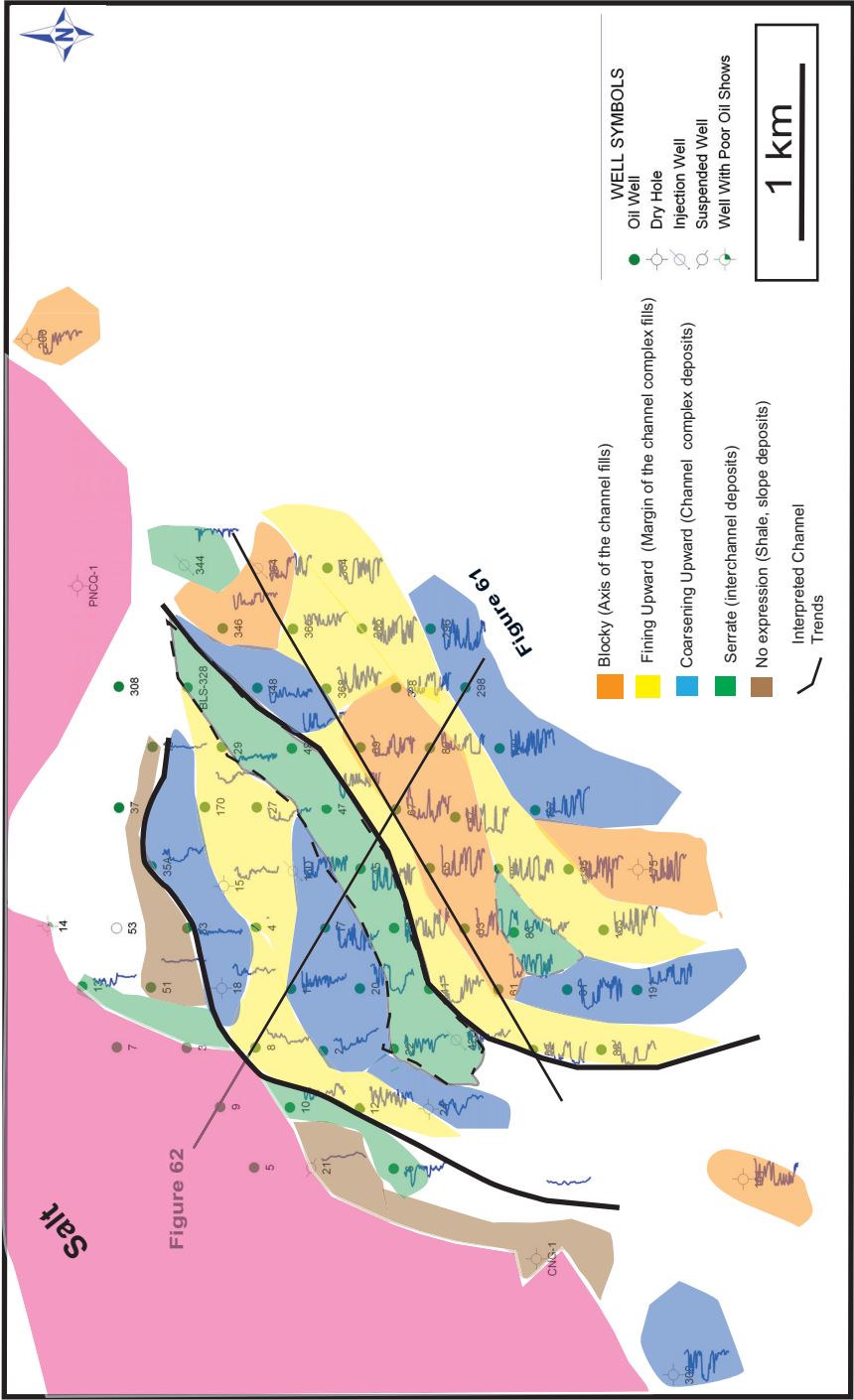


Figure 63. Lithofacies map for the Sequence 4 (RS-3_RS-4) showing the SP logs. Lateral variations of the SP log pattern present in the map are interpreted as result of the lateral migration of channel fill complexes, blocky pattern represent zones where the channel are amalgamated, fining upward represents margin of the systems and coarsening upward pattern is interpreted as channel fills, serrate is interpreted as interchannel zones. Location of Figures 61 and 62 are shown.

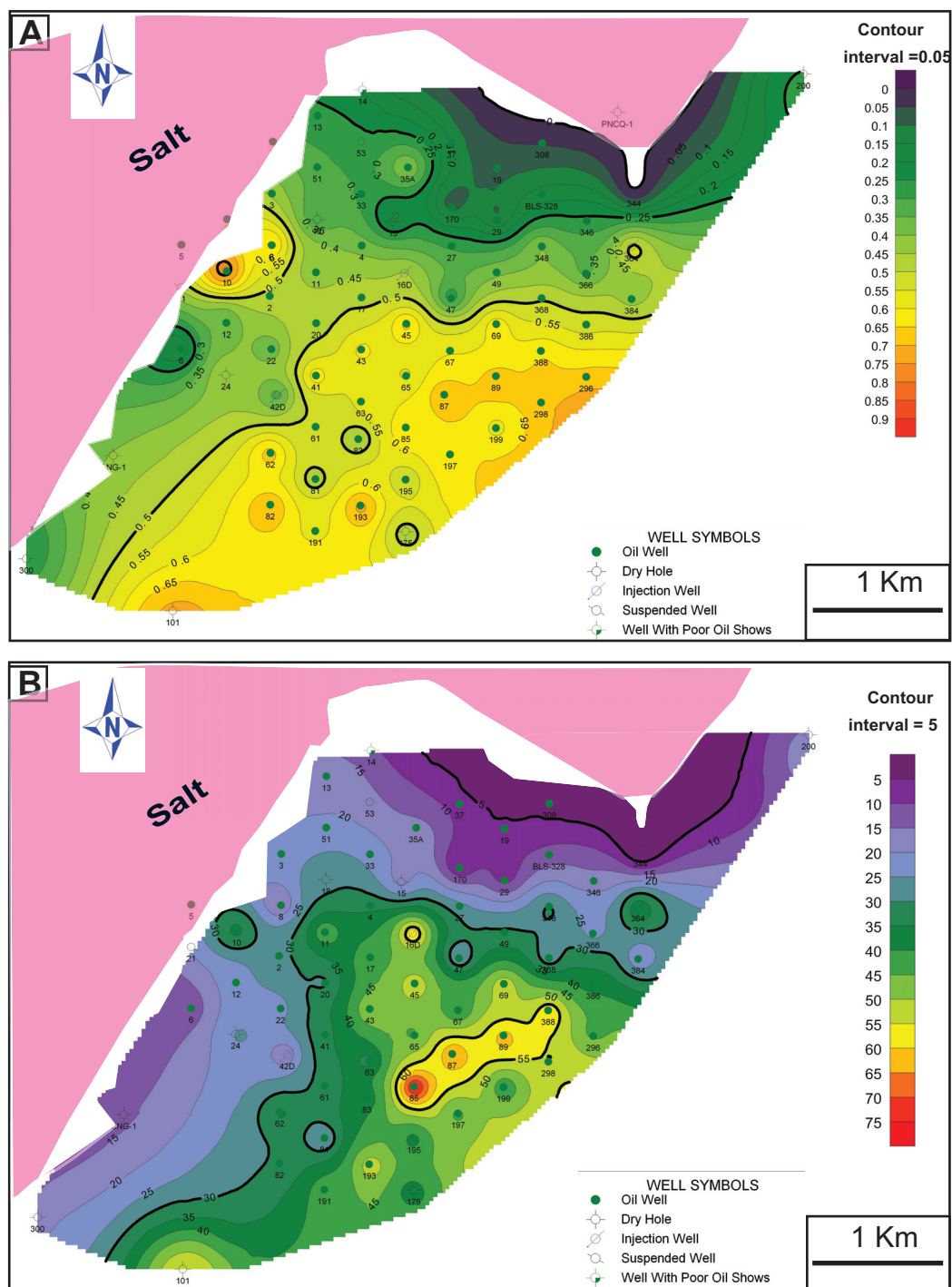


Figure 64. (A). Net-to-gross ratio map from the Sequence 4. Contour interval is 0.05. **(B)** Net-sand map from the Sequence 4. contour interval is 5 meters.

Net-sand map: The net-sand map of this sequence has similar trends as the-net-to-gross map. The area with greatest sand thickness is present in the southeast with a thickness variation of 45 to 65 meters; values decrease to the north and west where they are less than 5 meters of sand (**Figure 64 B**).

Seismic Facies: Description of the seismic facies of this sequence is described above in the section of the Sequence 2 (**Figure 44**).

An RMS amplitude map for this sequence has a gated window from the middle part from the sequence to the Top of the RS-4 shows four general amplitude trends coming from the southeast part of the field and extend to the north/northeast (**Figure 65 A, B**).

Interpretation: The four general amplitude trends interpreted as channel-fill complexes are coming from a south-southeast orientation to the field and they merged inside the field, there is a switch in the orientation of the trends to the northeast. As result of the integration of all maps and SP wireline log profiles, the reservoirs in sequence 4 are interpreted as channel-fill complex sediments that have abrupt changes in lateral continuity and thickness of the sand units.

Sequence 5 (RS-4_RS-5)

In this sequence two small zones of erosion are present in the northeast and southwest part of the field and one bigger in the north part of the field (**Figure 66**).

Time-structure map: The surface has a similar structure as to the underlying horizons, i.e. the horizon dips to the south (**Figure 66**). A prominent syncline is present in the southern part of the map (> 2.80 seconds TWT) that is oriented SW /NE. Two small

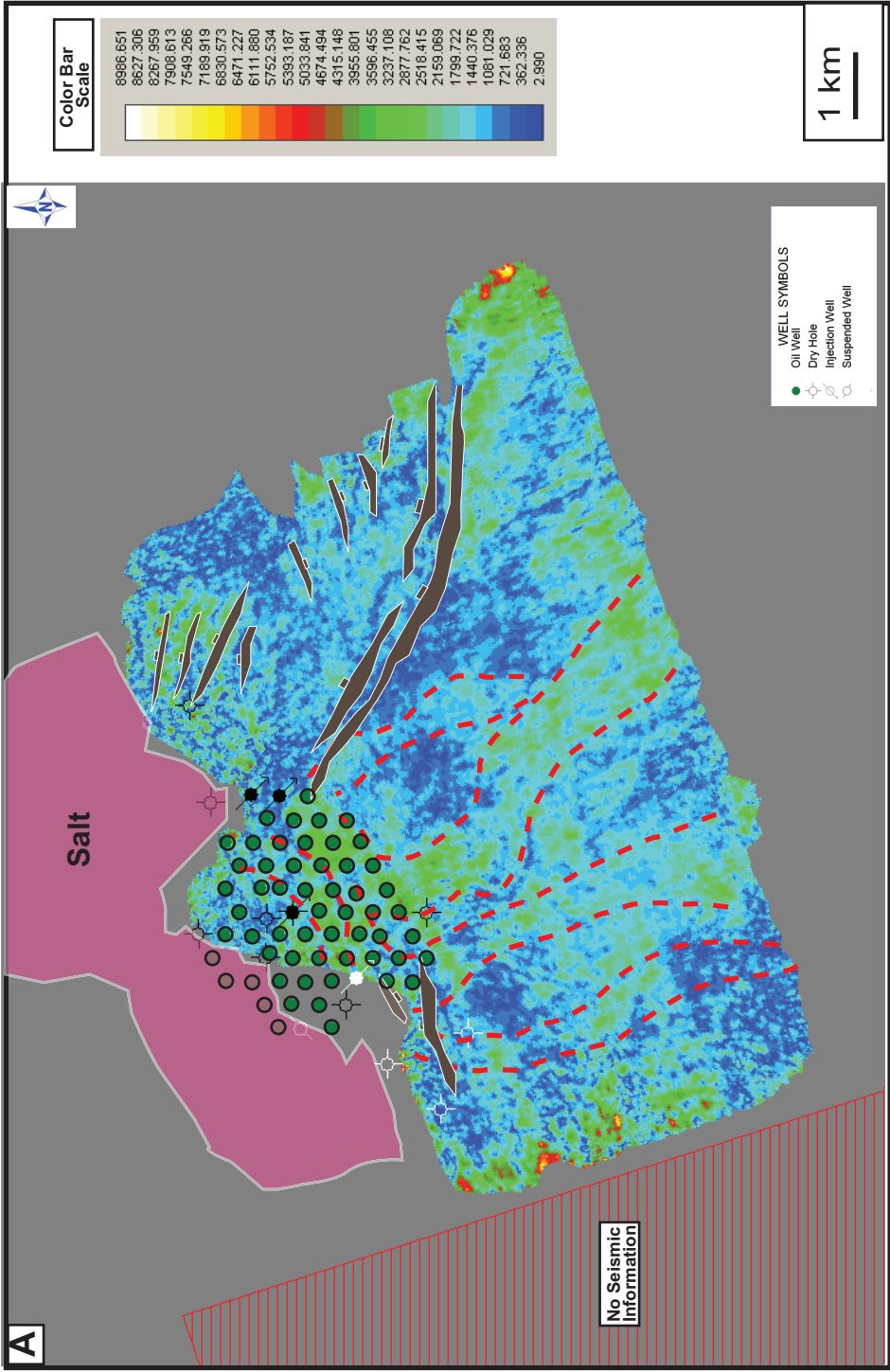


Figure 65. RMS amplitude extraction map from a gated window from the middle part of the sequence to the top of the RS-4 **A)** with well location plotted. **B)** with not wells plotted. Three systems are interpreted coming from the south-southeast to the field, the left system is interpreted cut by the eroded zone, and the central system is cut partially, the right system is interpreted present a bifurcation before to arrive to the field, in general all the system are interpreted in the Field as channel complex fill having a shift in their path as result to face the salt body.

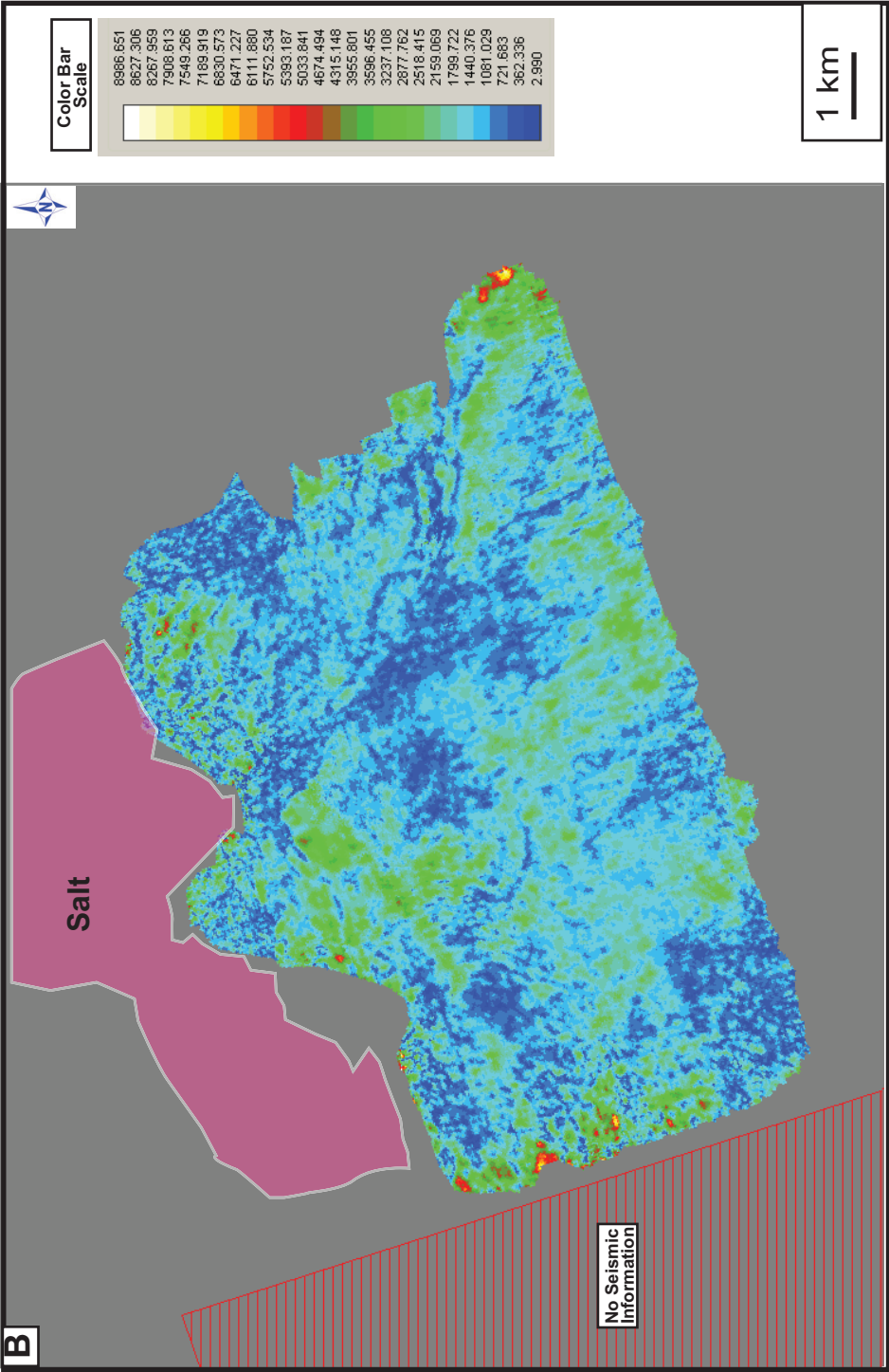


Figure 65 B.

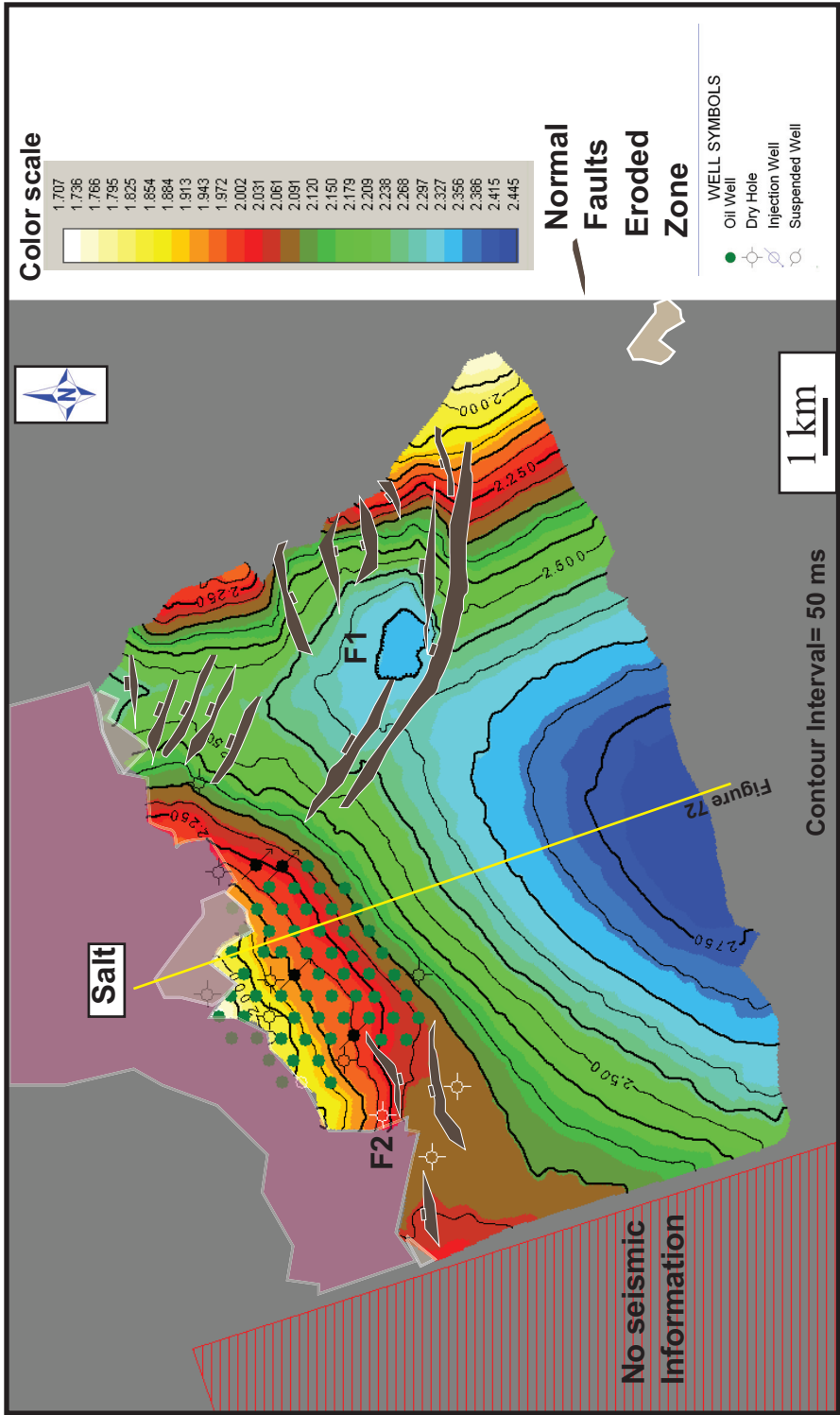


Figure 66. Time-structure contour map (in secs) of the Surface RS-5. A salt body is interpreted in the west-north part of the map (pink), three eroded zones are interpreted in the north, northeast and west part of the map. This surface presents three small erosion zones in the upper part close to the salt body. Two set of faults with a SE-NW (F1) and W-E (F2) orientations with different dips are interpreted, located in the northeast, southeast and west side of the study area. Wells are shown by green dots. Location of Figure 72 is shown in a yellow line.

eroded zones are present near the edge of the top of the salt. Two set of faults are present. The first set (F1) is located to the east, strikes SE-NW, and dips to the northeast (**Figure 66**). The second set (F2) is present to the west strikes west-east, and dips to the north (**Figure 66**).

Isopach map: Sequence 5 was penetrated by 57 wells. The isopach map of the sequence 5 shows a greater range in the thickness values in comparison with the underlying sequences. Thickness values vary from 25 to 120 meters. An isolated zone trends east-west in the central part of the field with values between 60 and 120 meters. Two zones of lower values are present to the southwest and north (values are between 45 and 75 meters) (**Figure 67**).

Lithofacies: Two wireline log cross sections illustrate the sequence in strike oriented (**Figure 68**) and dip oriented views (**Figure 69**). In the strike view, the sand units, have abrupt lateral changes indicating the highly channelized nature of the deposits. Toward the edges of the section, the wells 62, 61, 366, 364 have a serrate pattern (**Figure 68**).

The dip oriented cross section shows deposits of isolated channel fills to the NW, as represented by the lateral changes of different lithofacies (fining upward/coarsening upward, coarsening upward and serrate) in the wells 8, 11 and 17. The development in the architecture toward the SE is more complex where wells 67, 89 and 298 present the thicker sandstones related with fining upward and blocky log patterns. The sand units are interpreted not laterally connected between adjacent wells (**Figure 69**).

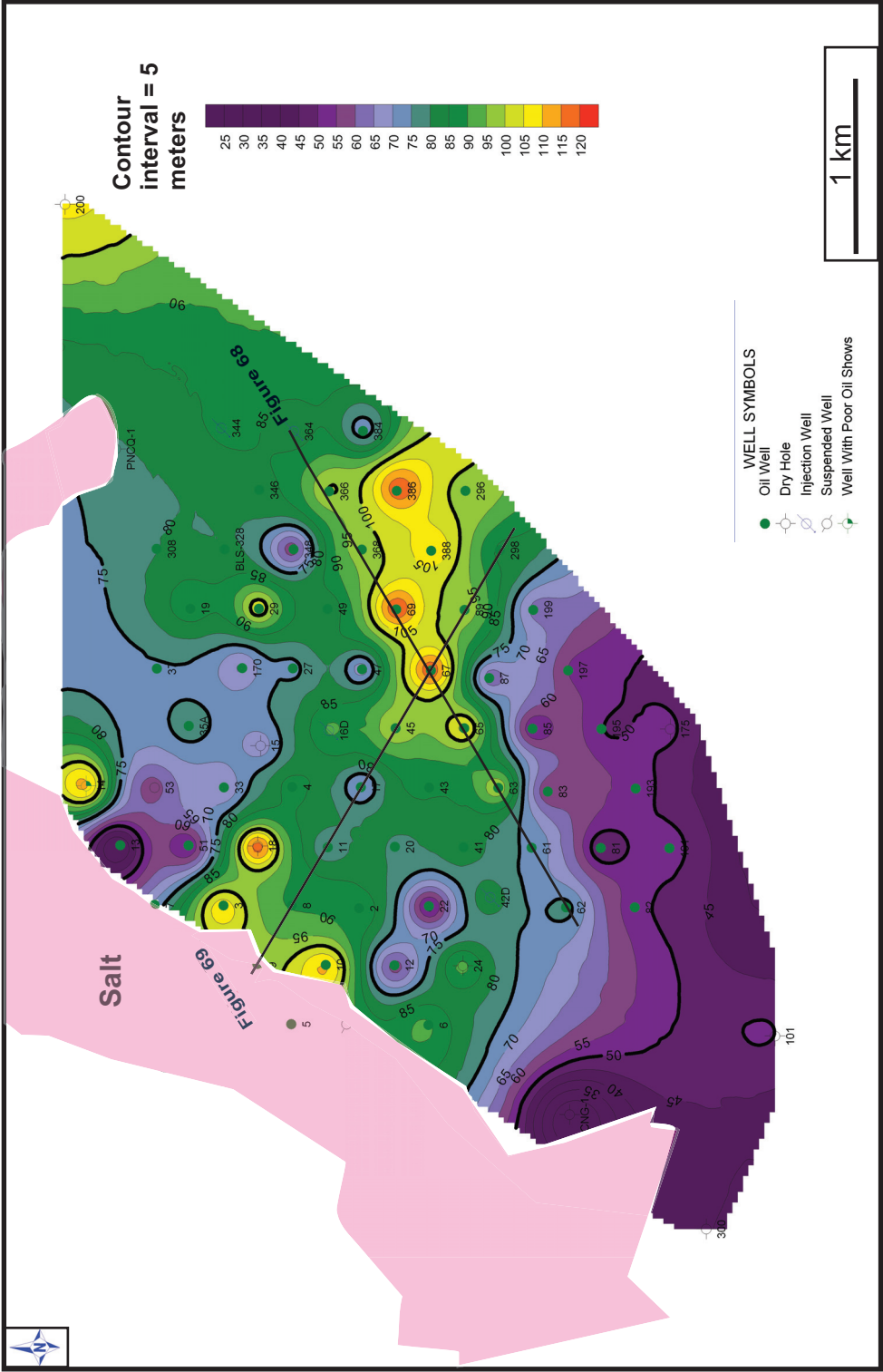


Figure 67. Isopach map of the Sequence 5. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 68 and 69 are shown.

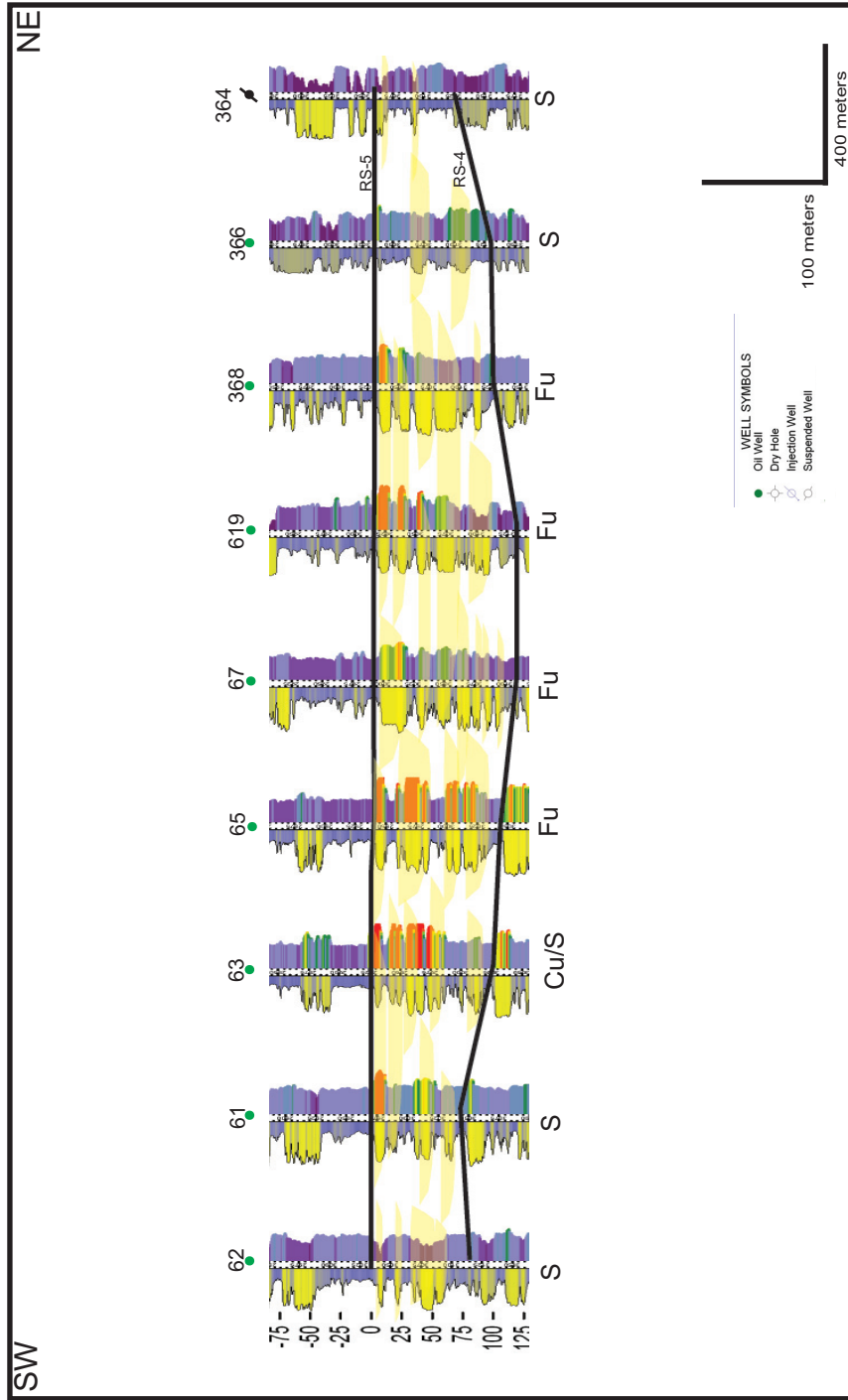


Figure 68. Wireline log cross section showing the Sequence 5 (RS-4 to RS-5). RS-5 is the datum. SP and Resistivity curves are shown. Blocky, fining upward and serrate are the most characteristic log signature in this sequence the sandstones in the central part of the section are better developed. An interpretation of the sandstone distribution is shown in yellow. See Figure 67 and Figure 70 for location of section.

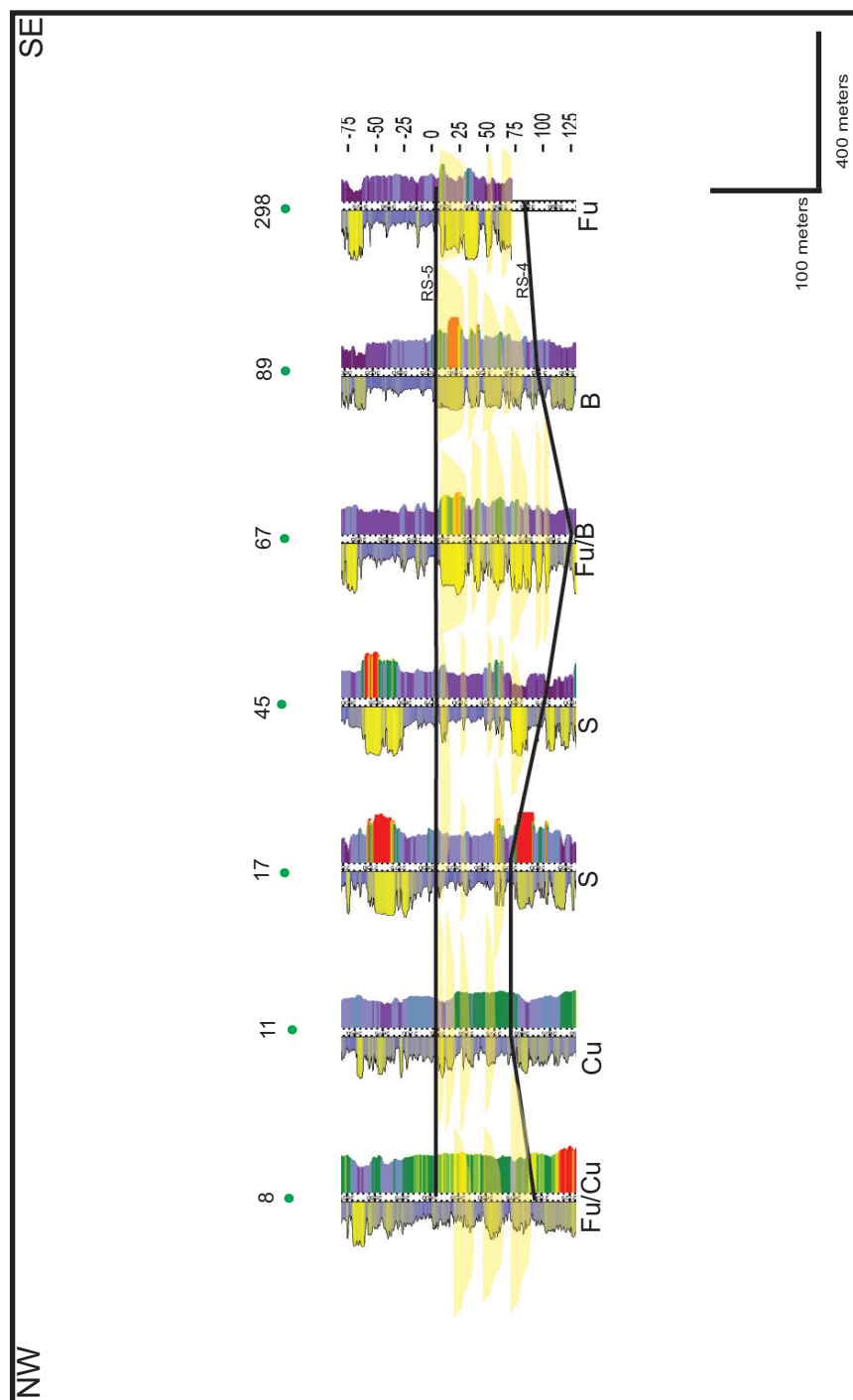


Figure 69. Wireline log cross section showing the Sequence 5 (RS-4 to RS-5). RS-5 is the datum. SP and Resistivity curves are shown. The log signatures serrate, fining upward, coarsening upward and blocky signatures are present in this sequence. There is an increase of the thickness of the sequence and the sandstones to the southeast part of the section. An interpretation of the sandstone distribution is shown in yellow. See Figures 67 and 70 for location of section.

In map view, the SP log patterns for the wells in the field have a similar trend than Sequence 4, i.e. the lithofacies have a northeast trend. The blocky, fining upward, and serrate signatures all have good continuity, whereas the coarsening upward tends to be more isolated each of the zone is about 250 meters wide (**Figure 70**).

Net-to-gross map: The net-to-gross map for this sequence has values ranging from 0.05 to 0.7 (**Figure 71 A**). A zone for the higher values is present in the southeast (0.5 to 0.7). The values decrease laterally to the west and northern. In the north part of the Blasillo field, there is a zone with values less than 0.15 (**Figure 71 A**).

Net-sand map: The net-sand map of sequence 5 shows similar trends to the net-to-gross map. The area of the highest values (75-90 meters) is located to the southeastern part of the field. There is a gradual decrease in values to the north and south. A zone with lowest net-sand is located to the north part of the field (**Figure 71 B**).

Seismic Facies: Two vertical seismic facies are present in this sequence. One presents low amplitude with moderate-high continuity reflections out of the field and the second in the area where wells are present, the reflections have high amplitude and low to moderate continuity and a shingled appearance (**Figure 72**).

An RMS amplitude map from a gated window 40 ms above the surface RS-4 for Sequence 4 shows one or two trend of amplitudes coming from the south and towards the field. The trends corresponding to channel complexes fill change to the northeast (**Figure 73 A, B**).

Interpretation: Amplitude trends coming from the south arrive to the field with a southwest-northeast orientation. Sequence 5 has many similarities to Sequence 4 in

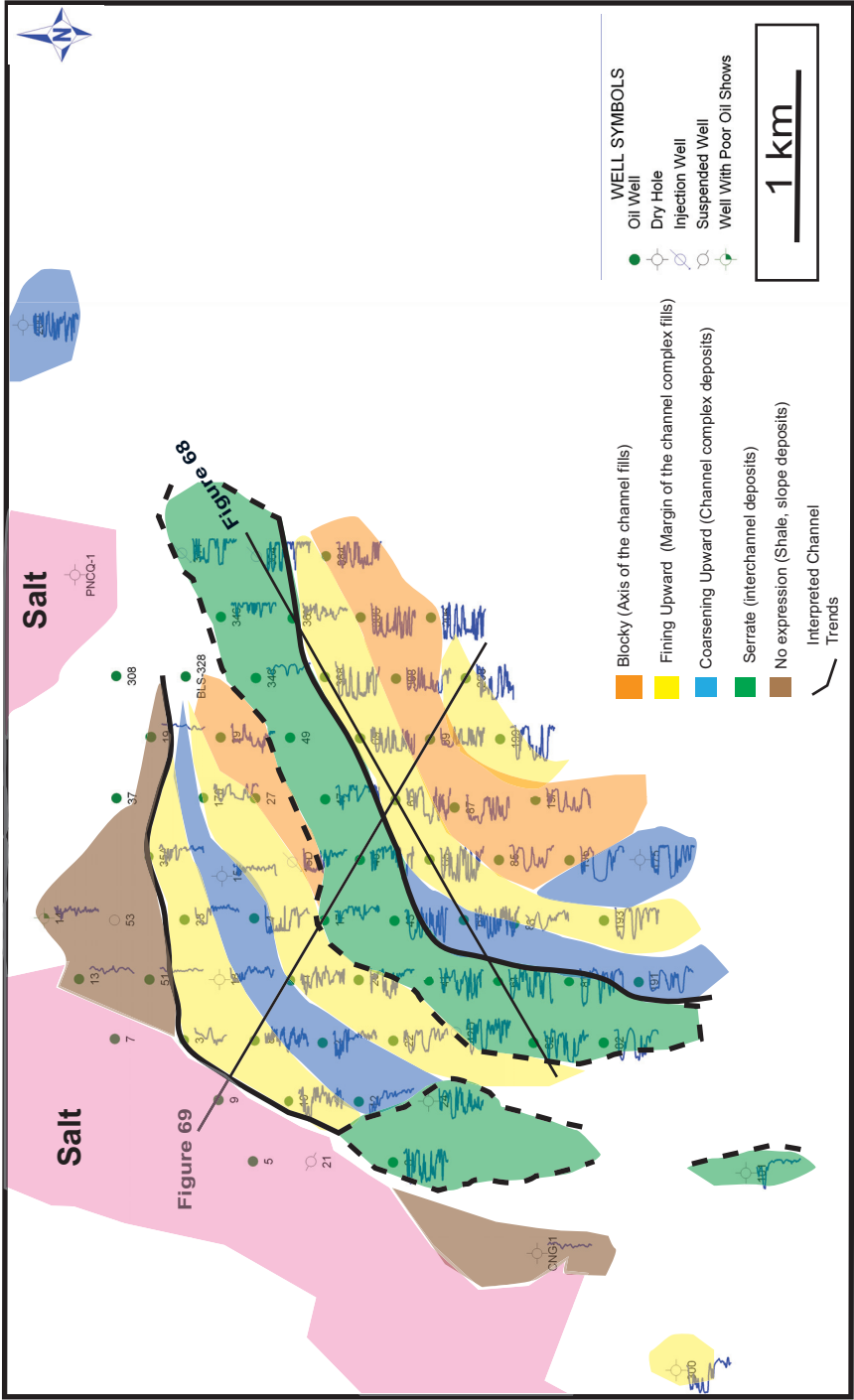


Figure 70. Lithofacies map of the Sequence 5 (RS-4_RS-5) showing the SP logs. Lateral variation of the log signature is interpreted to correspond with lateral migration of semi amalgamated channel fill complexes in a aggradational-erosional phase. Serrate is the more representative log signature in this sequence, Blocky pattern is interpreted with zones where channels present amalgamation,fining upward margin of the system, coarsening upward and serrate interchannel fills/ Laps?. Location of Figures 68 and 69 are shown.

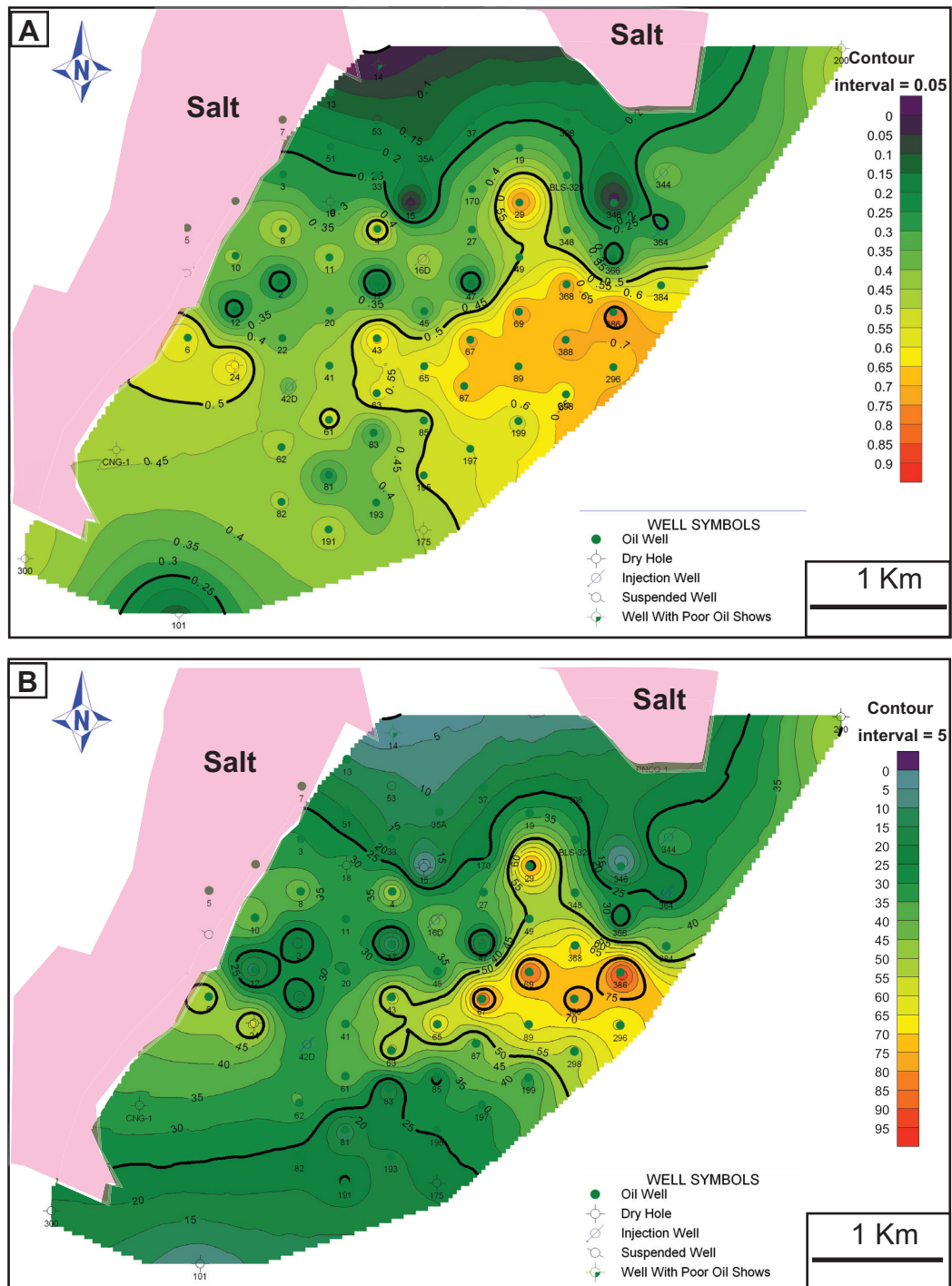


Figure 71. (A) Net-to-gross ratio map from the Sequence 5. Contour interval 0.05
(B) Net-sand map from the Sequence 5. Contour interval 5 meters.

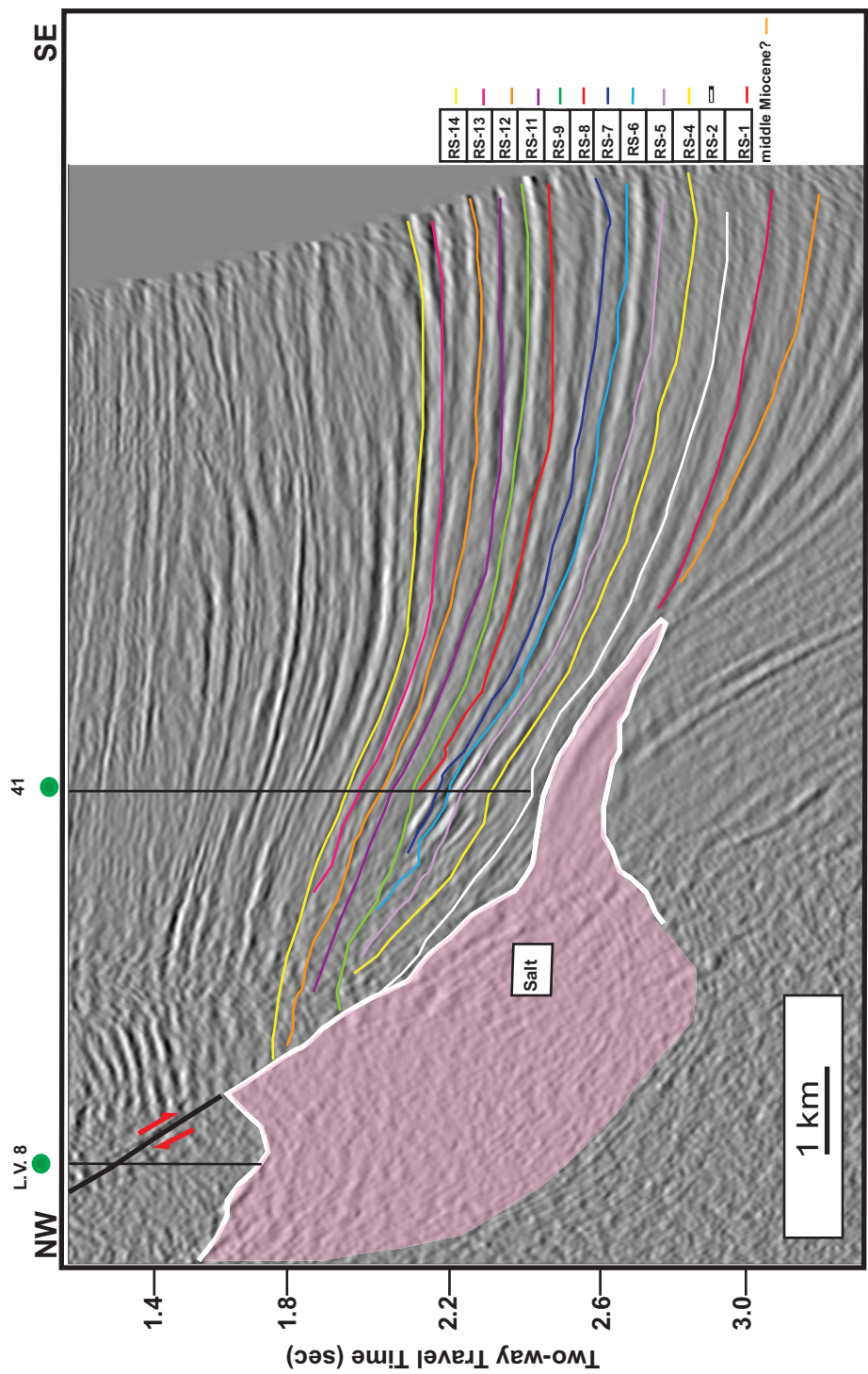


Figure 72. Seismic profile across the interpreted sequences in the main production zone of the Blasillo field from RS-9 to RS-2. Production zone is located in the flank of a salt body (pink). High amplitudes above the salt through RS-9 are interpreted correspond to stacking and lateral migration of channel complexes. See Figure 66 for location of profile.

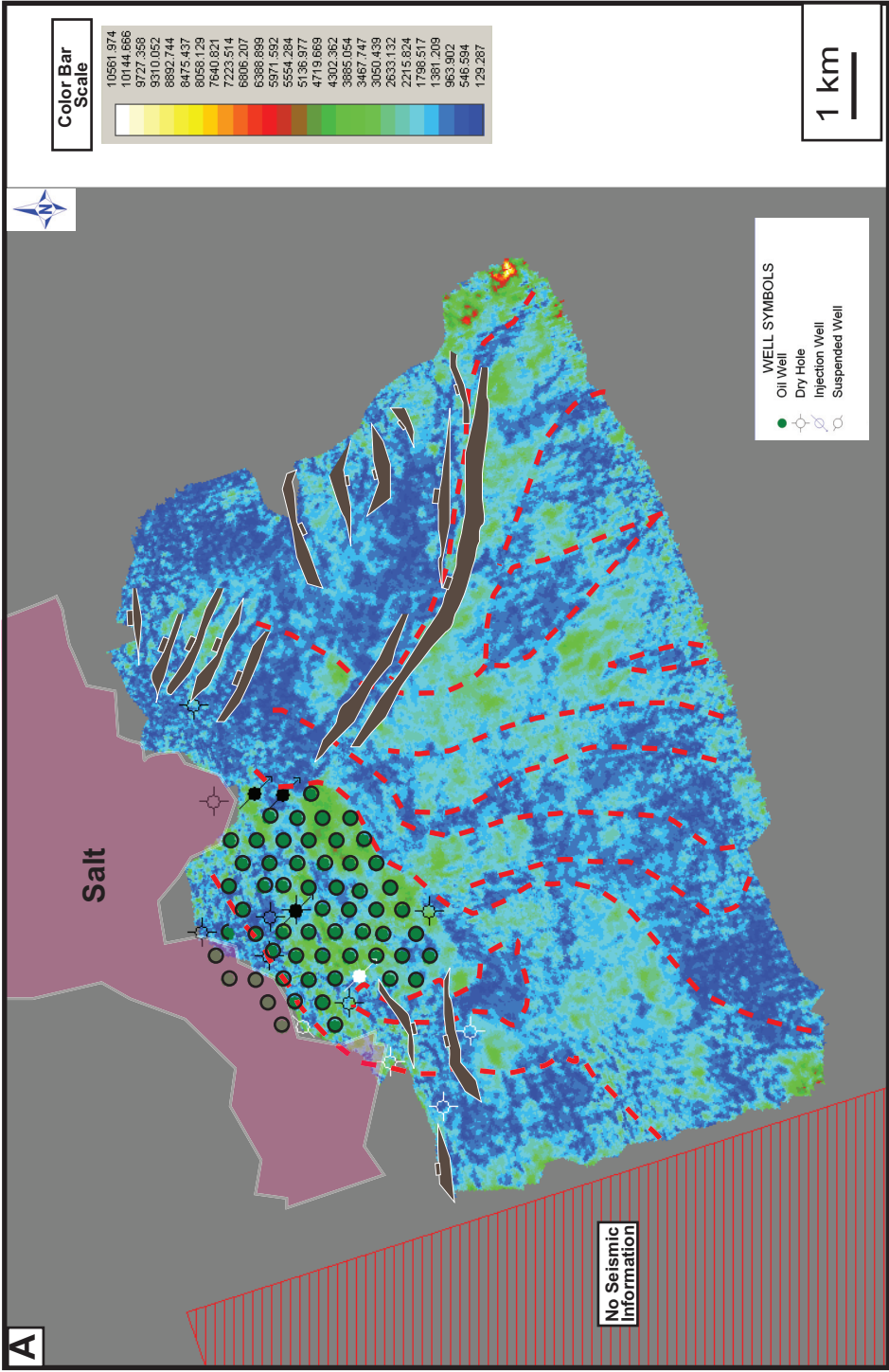


Figure 73. RMS amplitude extraction map from a window 40 ms above the horizon RS-4. **A)** With well location plotted. **B)** with not wells plotted. Three systems, or a lateral migration of a channel complex fill is interpreted in this map they are coming from the south and are showing a shift to the northeast when in their trajectory face the salt body. There is others system coming from the southeast and seems to be changing his trajectory before to arrive to the field.

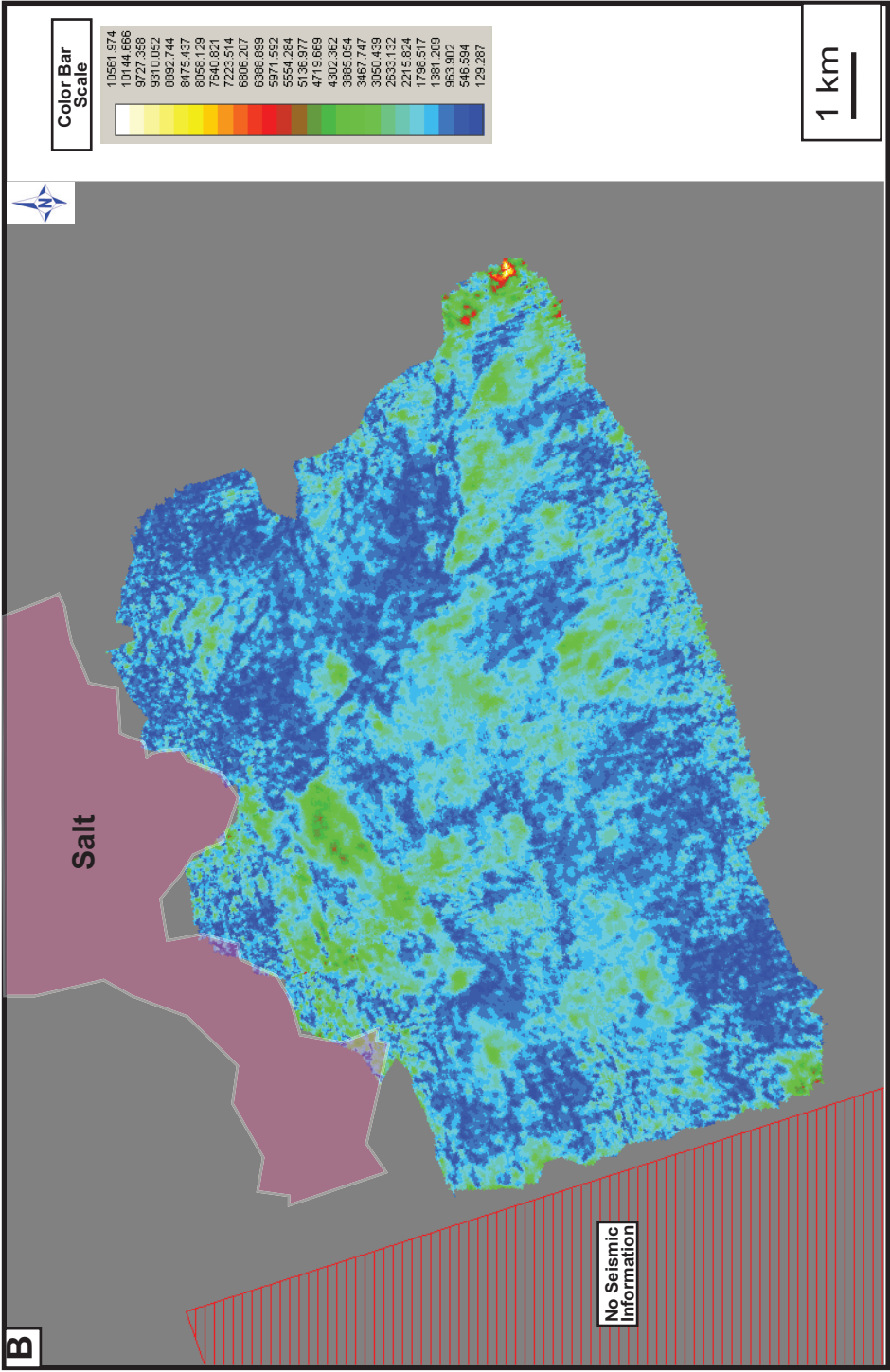


Figure 73 B.

terms of lateral change of the lithofacies in a southeast-northwest orientation but present more lateral continuity of lithofacies in a southwest-northeast orientation.

Sequence 6 (RS-5_RS-6)

This sequence has at least three channel-fill complexes fills based primarily on the log correlation sections. Seismic amplitude map shows a main system coming from the southwest toward the field.

Time-structure map: The time-structure contour map of the horizon RS-6 shows the same overall shape to the study area as the underlying sequences (**Figure 74**). Two set of faults cut the horizon. The first set of faults (F1) is present to the northeast and southeast of the study area, strike on SE-NW and dips to the northeast (Figure 74) The second set (F2) is present in the west side of the study area and strikes SW-NE and dips with different orientation (Figure 74). Time values vary from 1.90 to 2.65 seconds twtt. The Blasillo field is located to the upper part of the minibasin. An eroded zone is observed in the north in the highest position where the field is (**Figure 74**).The deeper part of this horizon (2.69 seconds) is in a syncline that trends SW-NE, the shallower parts are to the northeast and east.

Isopach map: A total of 57 wells penetrate this sequence. The isopach map of sequence 6 varies in thickness from 60 to 125 meters. Two areas of greater thickness (> 130 meters) are present to the west and east side of the field. In the middle of the area, there is a northern trend with values of 65-55 meters that expands to the northwest and northeast (**Figure 75**).

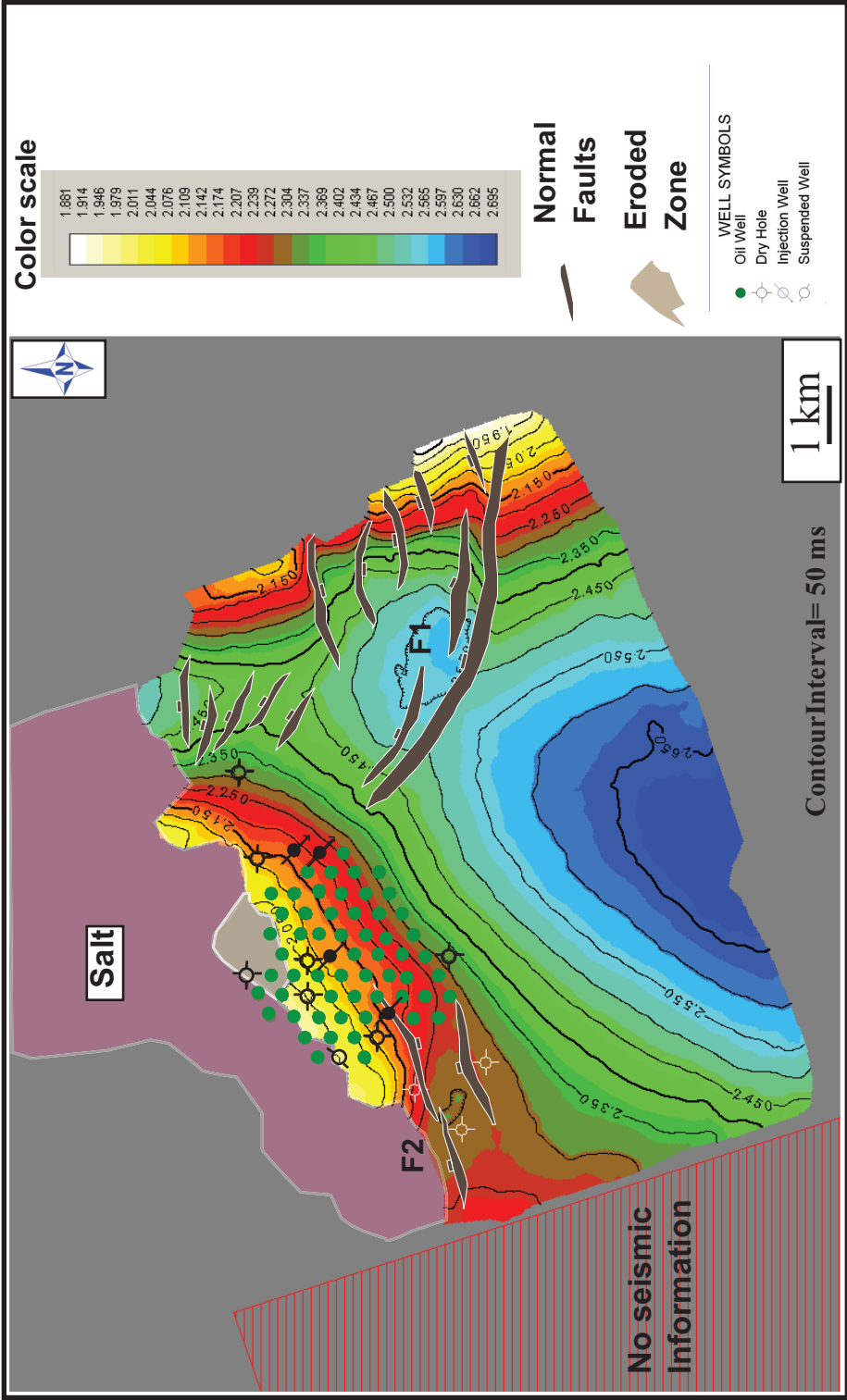


Figure 74 . Time-structure contour map (in secs) of the Surface RS-6 interpreted in the study area. A salt body is interpreted in the north part (pink). This surface presents a small eroded zone between the salt body and the upper part of the field. Two set of faults are present. The first (F1) is present in the southeast and northeast of the study area strikes NW-SE and dips to the northeast, the second (F2) is present in the east and west of the study area, strikes SW-NE and dips with different directions to the northwest and southeast .Wells are shown in green dots.

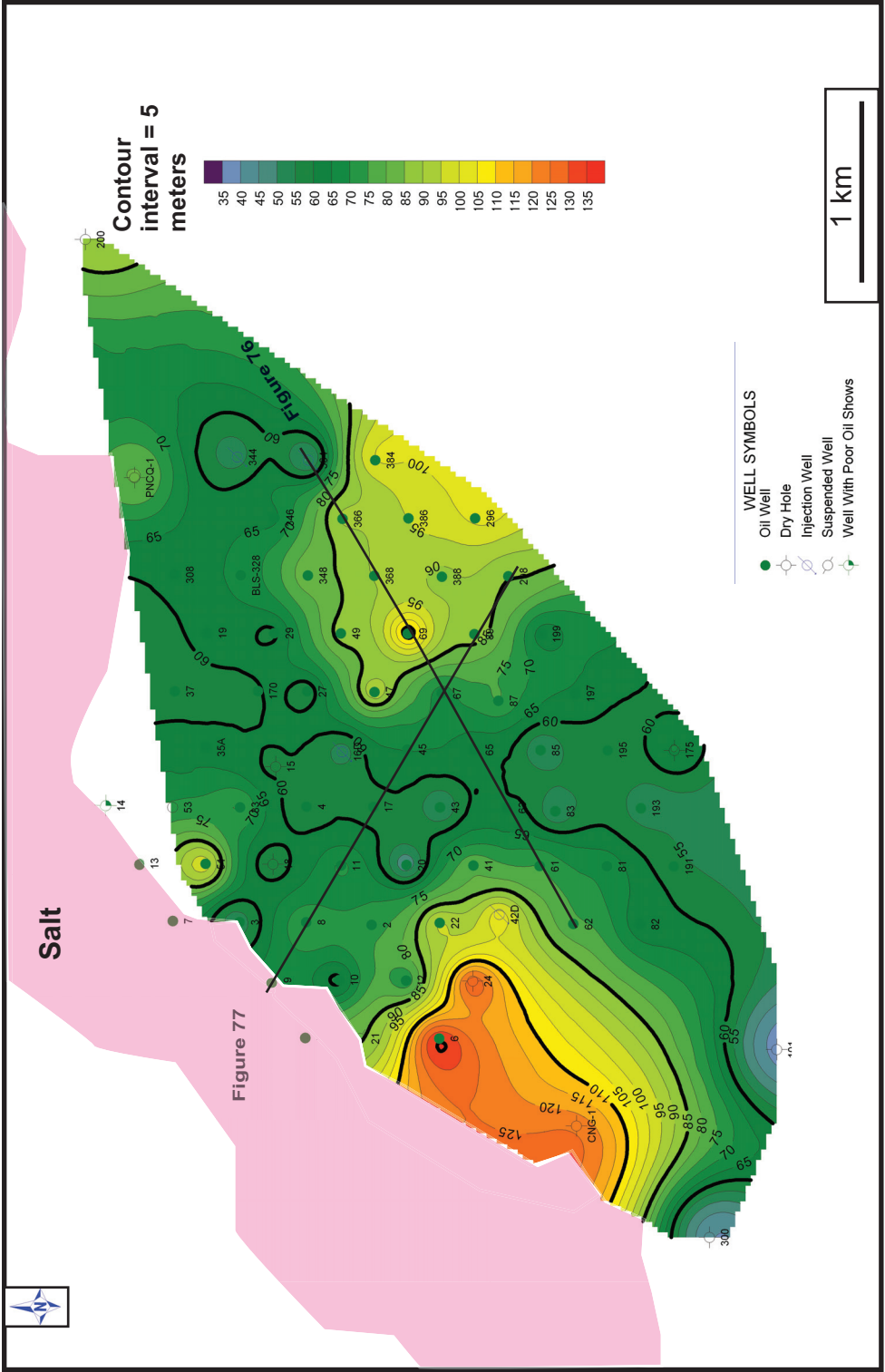


Figure 75. Isopach map of the Sequence 6 in the Blasillo Field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 76 and 77 are shown.

Lithofacies: Two wireline log cross sections illustrate the lithofacies of sequence 6, in strike (**Figure 76**) and dip view (**Figure 77**). In the strike oriented profile, the blocky SP pattern is the most representative signature in this section (**Figure 76**). This pattern is interpreted correlate laterally between adjacent wells in three zones (wells 62 and 61, 67 and 69, 365 and 364). Serrate SP log pattern is present in the well 368 between two of the zones described (**Figure 76**).

The dip oriented profile illustrates the channel-fill sediments are represented by the blocky SP pattern, the most common log signature in this section. Only one well (45) is interpreted to correlate with the adjacent well (17) which presents a fining upward signature (**Figure 77**).

The SP log pattern of sequence 6 in map view has a similar distribution of lithofacies as the underlying sequences in that they all trend to the north-northeast (**Figure 78**). The blocky pattern is the widest zone (up to 0.5 km) and is flanked by zones the coarsening upward and serrate. The fining upward SP log pattern is present in isolated areas (**Figure 78**).

Net-to-gross map: Sequence 6 has ratios varying from 0.05 to 0.7 (**Figure 79 A**). The higher values (>0.5) are present in isolated areas in the middle part of the field. There is a W-E trend in the central area of values between 0.4 and 0.5. The areas with the lowest values are in the north and south (**Figure 79 A**).

Net-sand map: The net-sand map of this sequence has a similar trend as the net-to-gross map (**Figure 79 B**). An isolated area to the west has the thickest net sand (>60

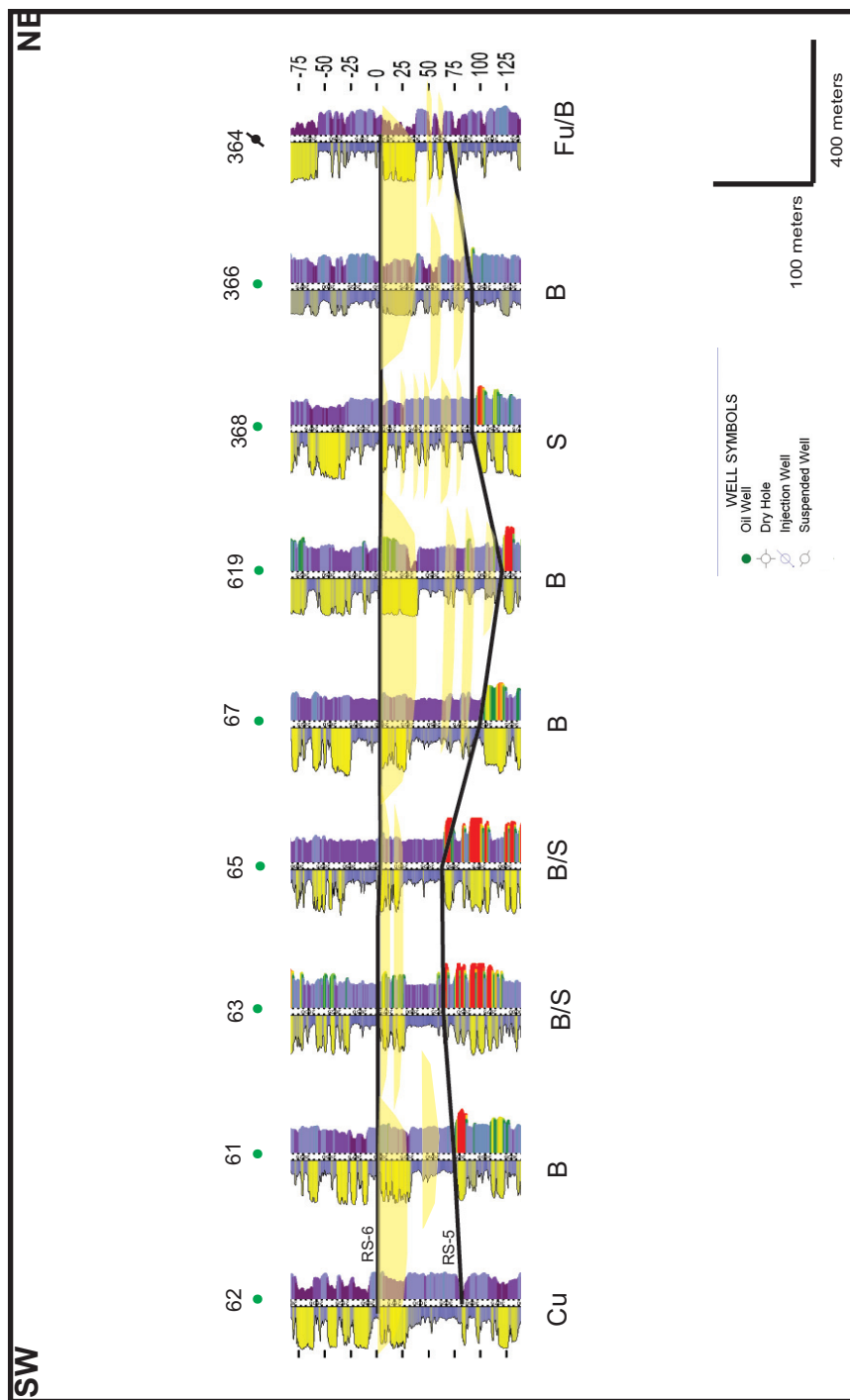


Figure 76. Wireline log cross section showing the Sequence 6 (RS-5 to RS-6). RS-6 is the datum. SP and Resistivity curves are shown. Blocky, upper fining and serrate are the most characteristic log signature in this sequence. An interpretation of the sandstone distribution is shown. See Figures 75 and 78 for location of section.

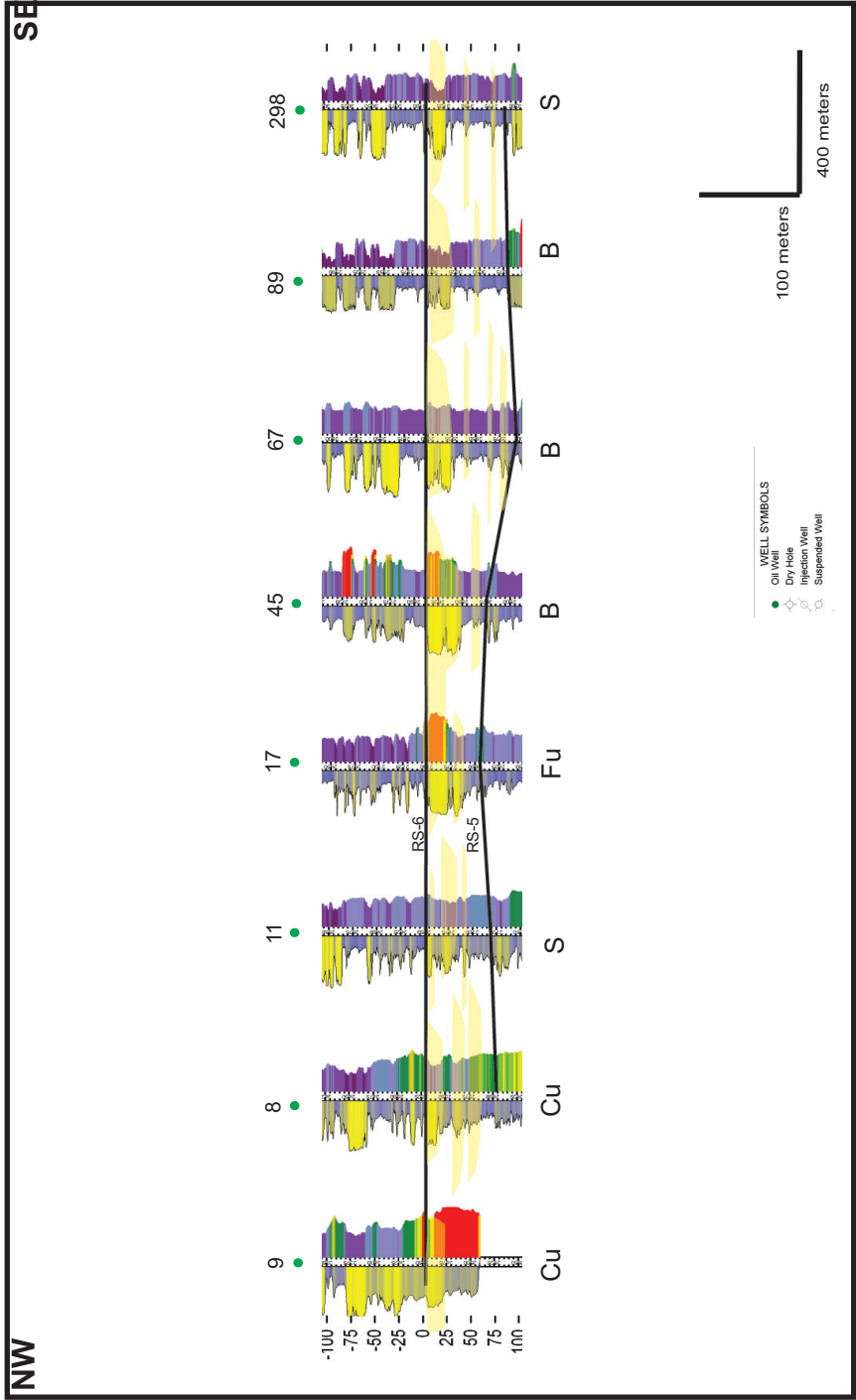


Figure 77. Wireline log cross section showing the sequence 6 (RS to RS-6). Top of RS-6 is the datum. SP and Resistivity curves are shown. Blocky, fining upward, and coarsening upward are the more characteristic log signature in this section. An interpretation of the sandstone distribution is shown in yellow. See Figures 75 and 78 for location of section.

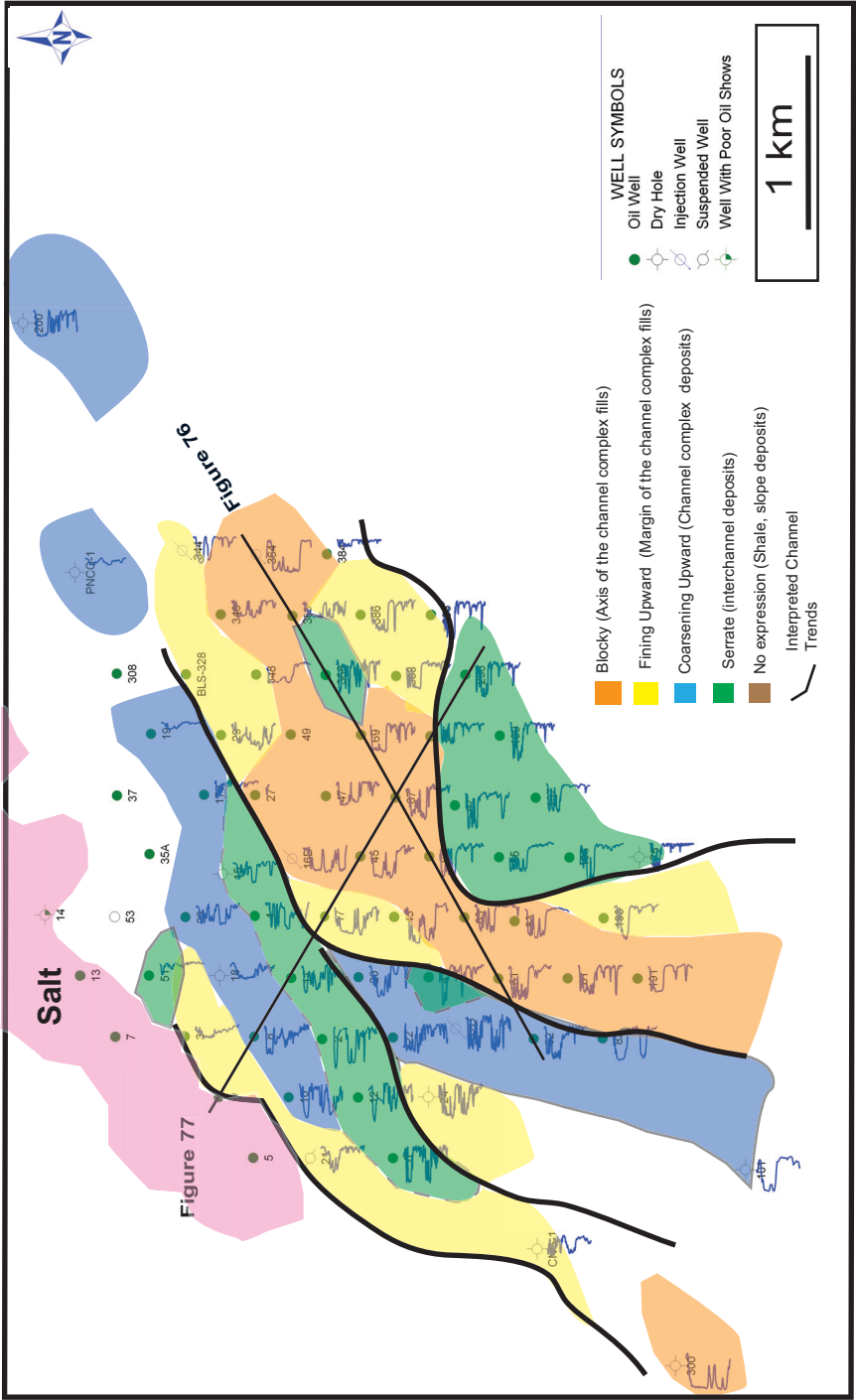


Figure 78. Lithofacies map of the Sequence 6 (RS-5_RS-6) showing the SP logs. A wide area in the central part of the field is related with the blocky signature, coarsening upward is the second more representative log signature here and is bordering with the fining upward and serrate log signatures the blocky signatures. Serrate have a distribution in the north-northwest and southeast. Semi amalgamated channel fill complexes are interpreted in this sequence. Blocky pattern corresponds with the central part of the semi-amalgamated complex fills. Location of Figures 76 and 77 are shown.

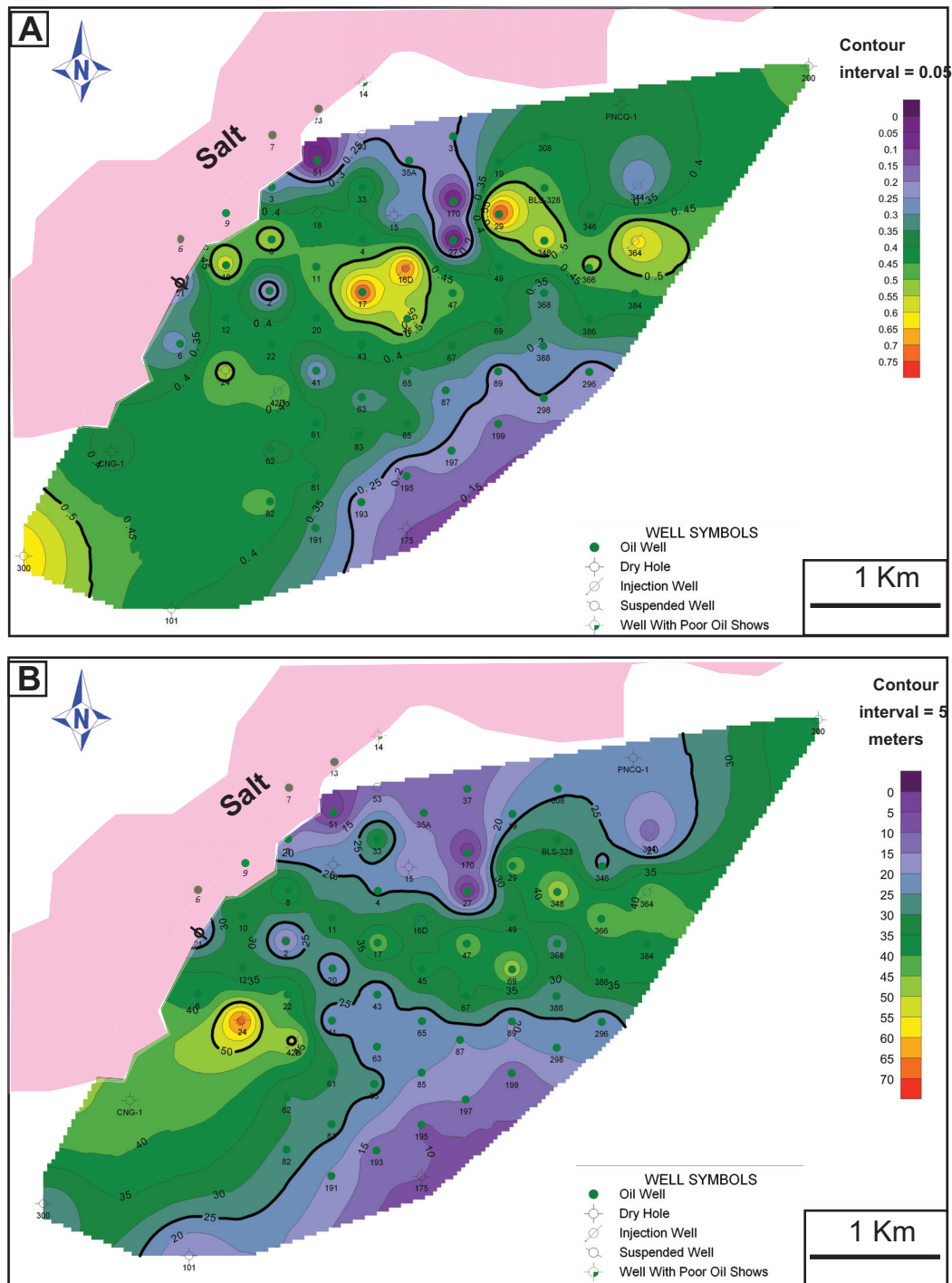


Figure 79. (A) Net-to-gross ratio map from the Sequence 6. Contour interval 0.05.
(B) Net-sand map from the Sequence 6. Contour interval 5 meters.

meters). There is an east-west trending zone in the middle of the area (20-50 meters thickness) flanked to the north and south by thin areas (< 20 meters).

Seismic Facies: Two general seismic facies are present. The first one consists of moderate amplitude high continuity this is far from the wells and the second presents high amplitude and moderate to low continuity and is located in the zone of wells (Figure 72).

An RMS amplitude map for this sequence from a gated window 30 milliseconds above the horizon RS-5, shows a trend of higher amplitude reflections with a SW-NE orientation extending to the field area (Figure 80 A, B).

Interpretation: The amplitude suggests one major channel system delivered sediment to the area of the field; but log correlation shows lateral variation and different vertical distribution from the main sandstones bodies interpreting at least three channel complexes fill involved in this sequence.

Sequence 7 (RS-6_RS-7)

Two main systems are interpreted in this sequence based on the RMS amplitude map. Log scale shows in Figure 84 laterally vertical variation and increment of the thickness to the southeast part.

Time-structure map: A time-structure contour map of the sequence horizon RS-7 indicates a similar shape to the overall basin as the underlying sequences. The major change in the sequence 7, in contrast with the older sequences in the field, is the prominent zone of erosion across the northern part of the area. Two sets of faults cut

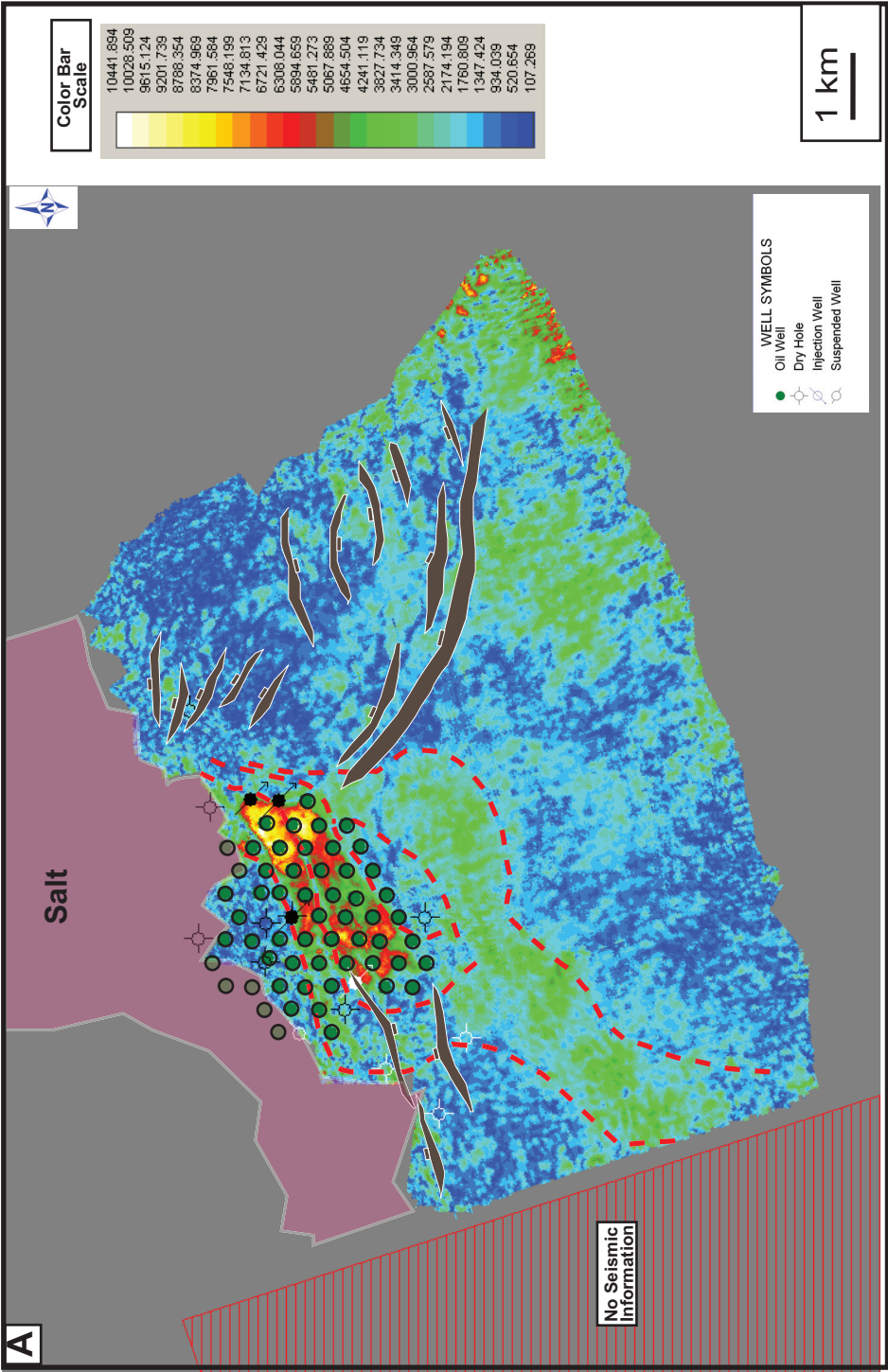


Figure 80. RMS amplitude extraction map from a window 30 ms above surface RS-5. **A)** With well location plotted. **B)** With not wells plotted. A system coming from the south in the west part of the map is interpreted, this systems present a kind of bifurcation, in the field the amplitude anomalies have higher values, interpreting corresponding to the amalgamated channel fill, the system in the field present some straight features in the anomalies.

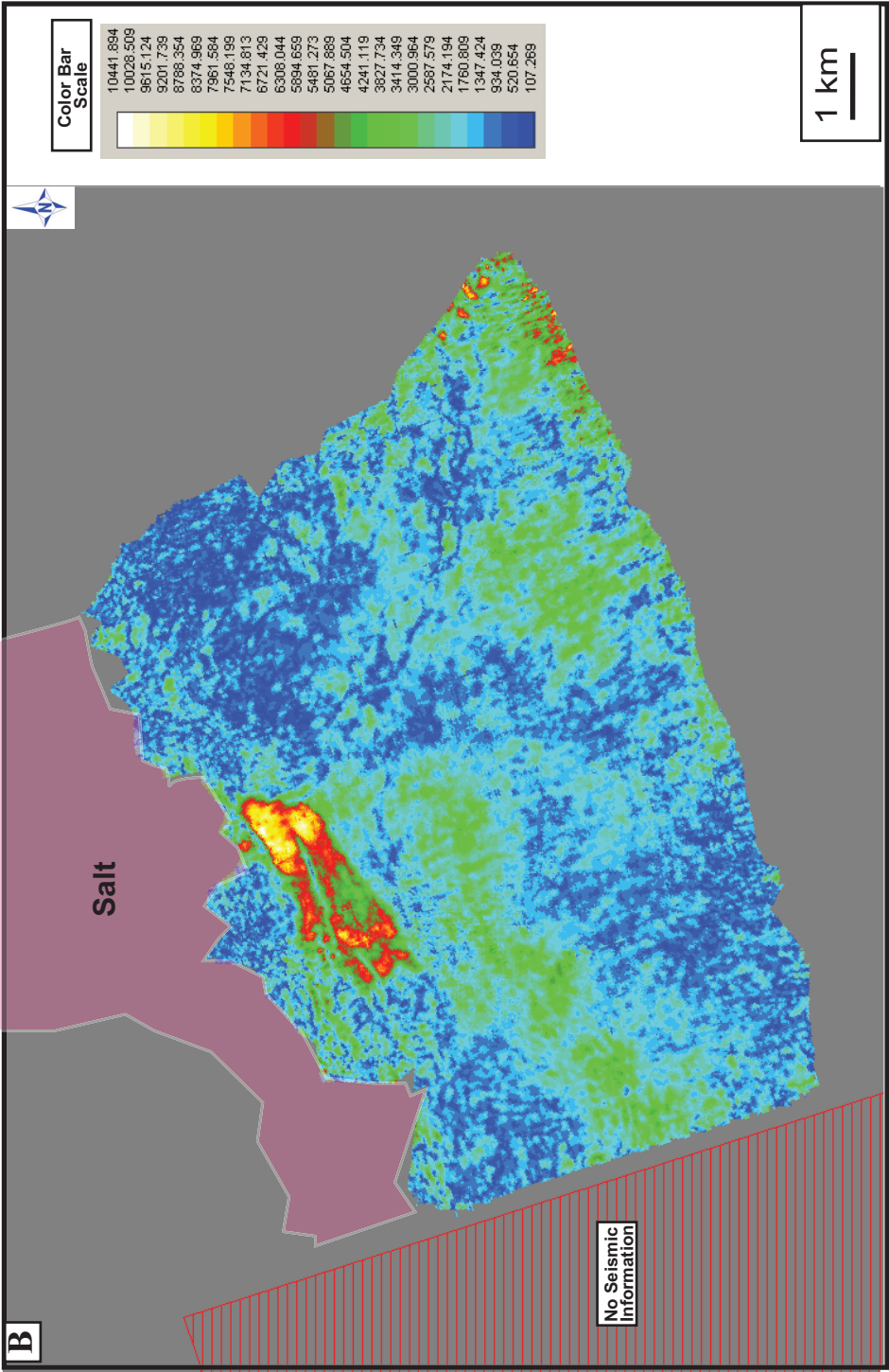


Figure 80 B .

the sequence. The first set (F1) is located in the southeast of the study area, strike SE-NW, and dip to the northeast (**Figure 81**). The second set (F2) strike W-E and have dips with different directions (**Figure 81**). The horizon varies in time-depth from 1.90 to 2.6 seconds TWTT. The deeper part of the sequence (2.6. seconds) is located south of the field in a partial syncline whose axis is oriented SW-NE (**Figure 81**).

Isopach map: This sequence was penetrated by 58 wells. The isopach map shows that in the area of the Blasillo Field the thickness varies between 40-80 meters. The local zone with greater thickness that is located to the northeast is related with the values in one well, these results may be spurious (**Figure 82**).

Lithofacies: Two wireline cross sections illustrate the sequence in strike (**Figure 83**) and dip view (**Figure 84**). In the strike oriented profile, the thickest sand body is present in the well 368 (fining upward) and the thinner sandstones are located in the well 364 with a serrate pattern. At least three distinct vertical levels of channel-fill deposits are present in the section with variation of the thickness and log signatures of the individual channel-fill sandstones (**Figure 83**).

The dip oriented profile shows lateral changes in the SP patterns from the NW to the SE from serrate to blocky denoting the changes of individual thin channel fills being more amalgamated in the SE part of the section. From well 45 to 298 there are at least two distinct vertical level of channel fill deposits interpreted (**Figure 84**).

In map view, the SP log patterns show primarily a northeast trend (**Figure 85**). The serrate pattern has the largest area to the north/northeast and fining upward has

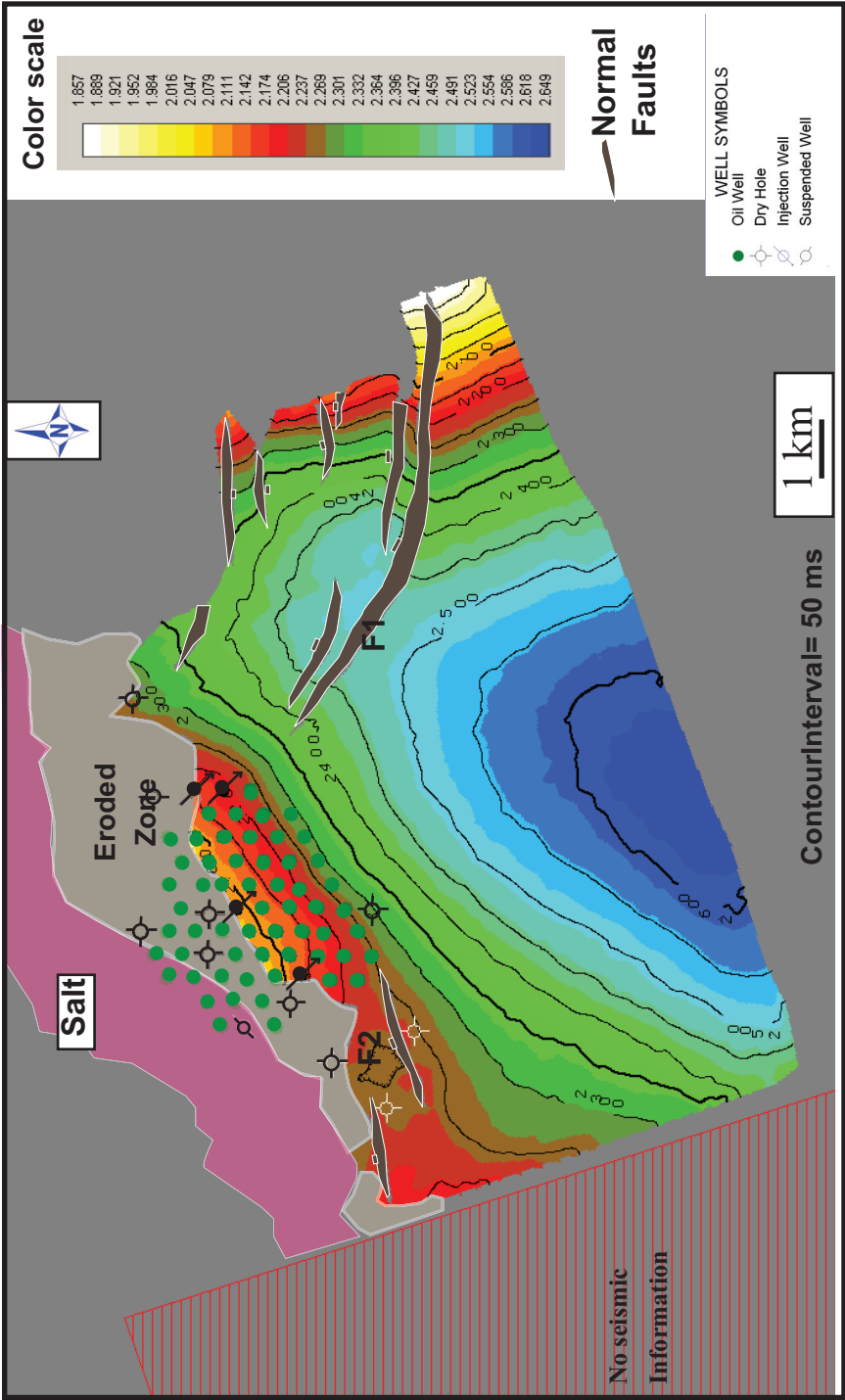


Figure 81. Time-structure contour map (in secs) of the Surface RS-7. A salt body is interpreted in the north part of the field (pink), a big eroded zone is interpreted between the strata that are penetrated by the well and the salt. Two set of faults are interpreted, the first set (F1) is located in the southeast of the study area strikes SE-NW and dips to the northeast. The second set (F2) is located in the east and west of the study area dips with different direction. Wells are shown in green dots.

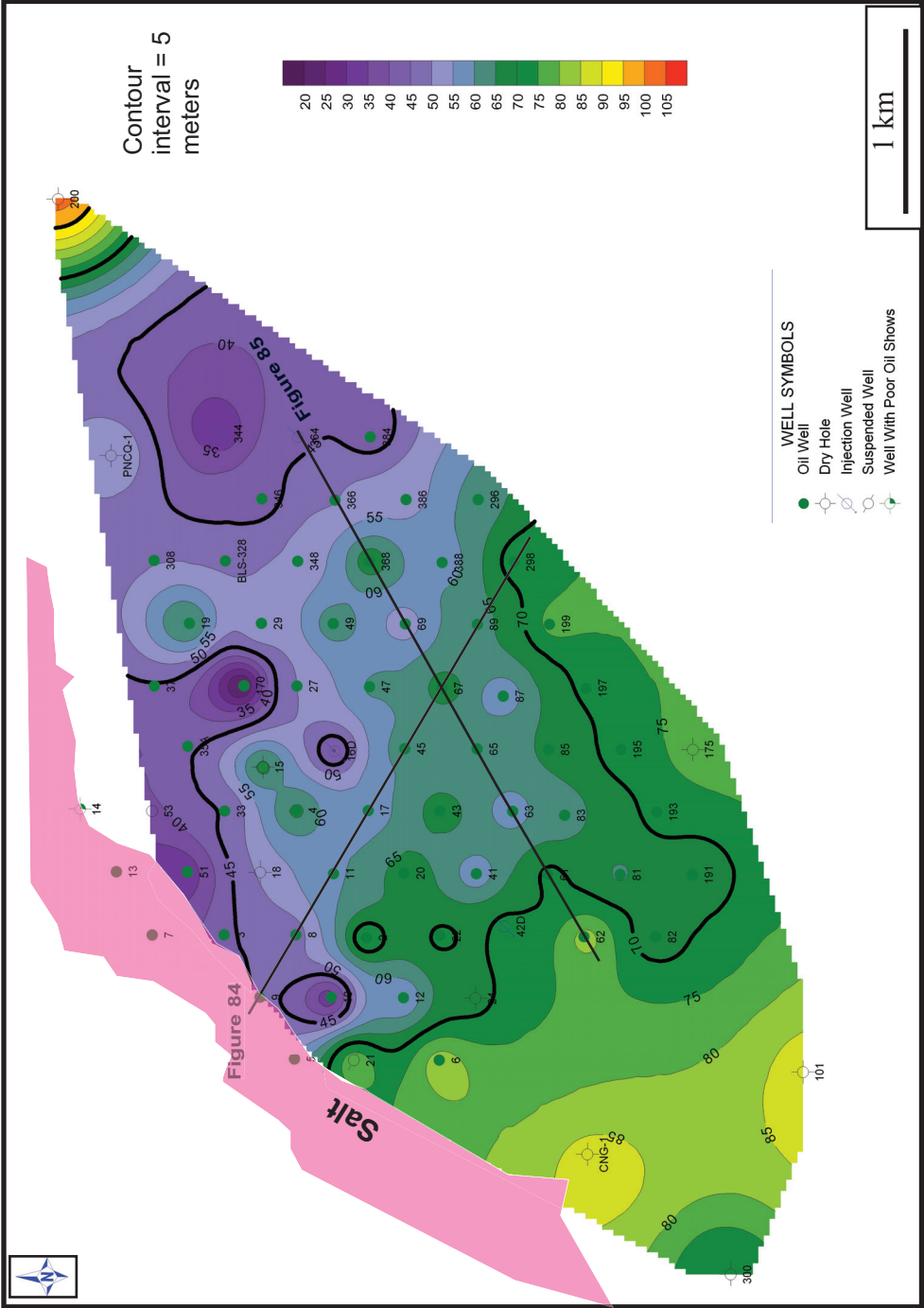


Figure 82. Isopach map of the Sequence 7 in the Blasillo field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 83 and 84 are shown.

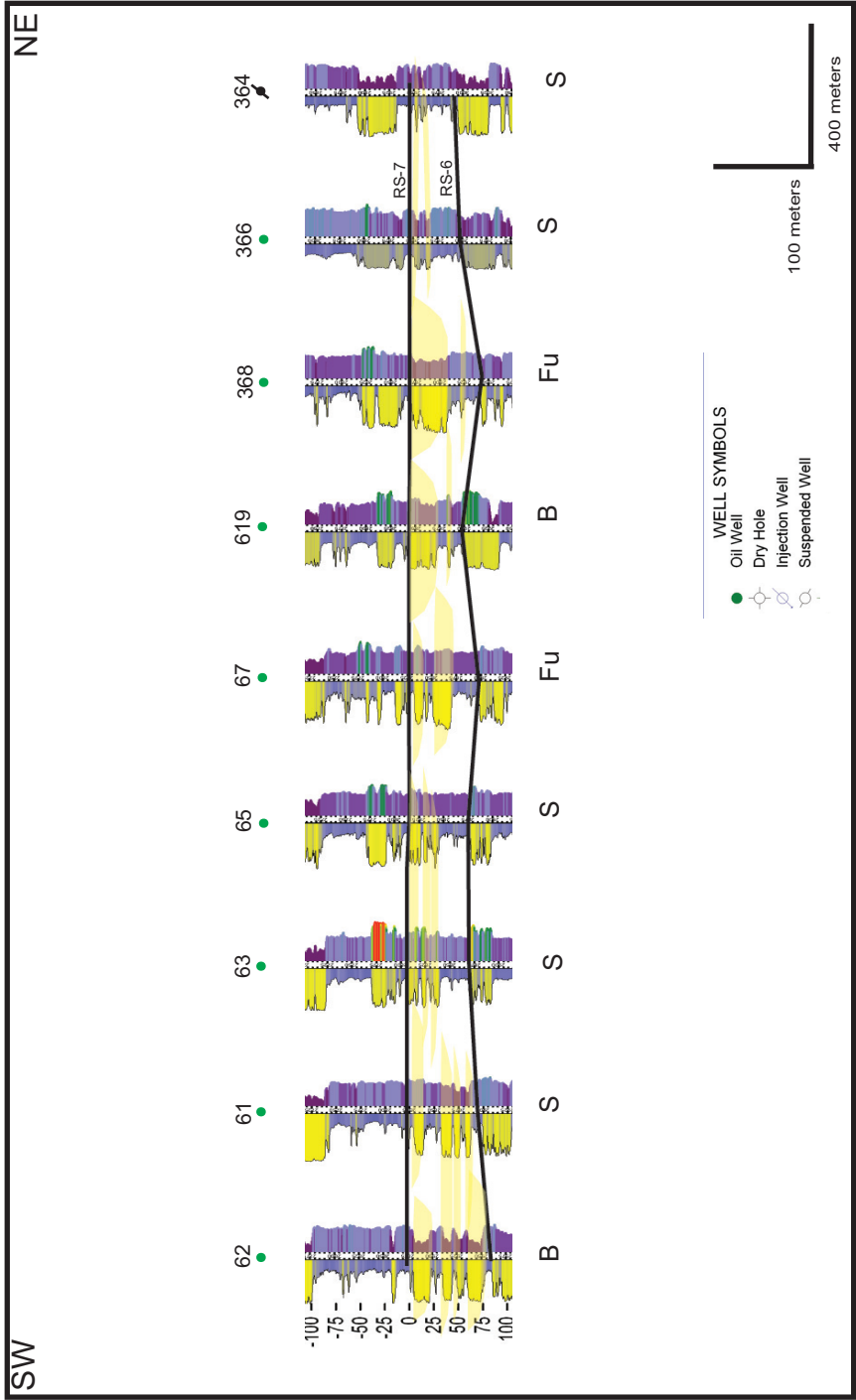


Figure 83. Wireline log cross section showing the Sequence 7 (RS-6 to RS-7). RS-7 is the datum. SP and Resistivity curves are shown. Lateral change of the log signature is evident as well as the change in the thickness of the sandstones blocky, serrate, fining upward and coarsening upwad are present in this sequence. An interpretation of the sandstone distribution is shown in yellow. See Figures 82 and 85 for location of section.

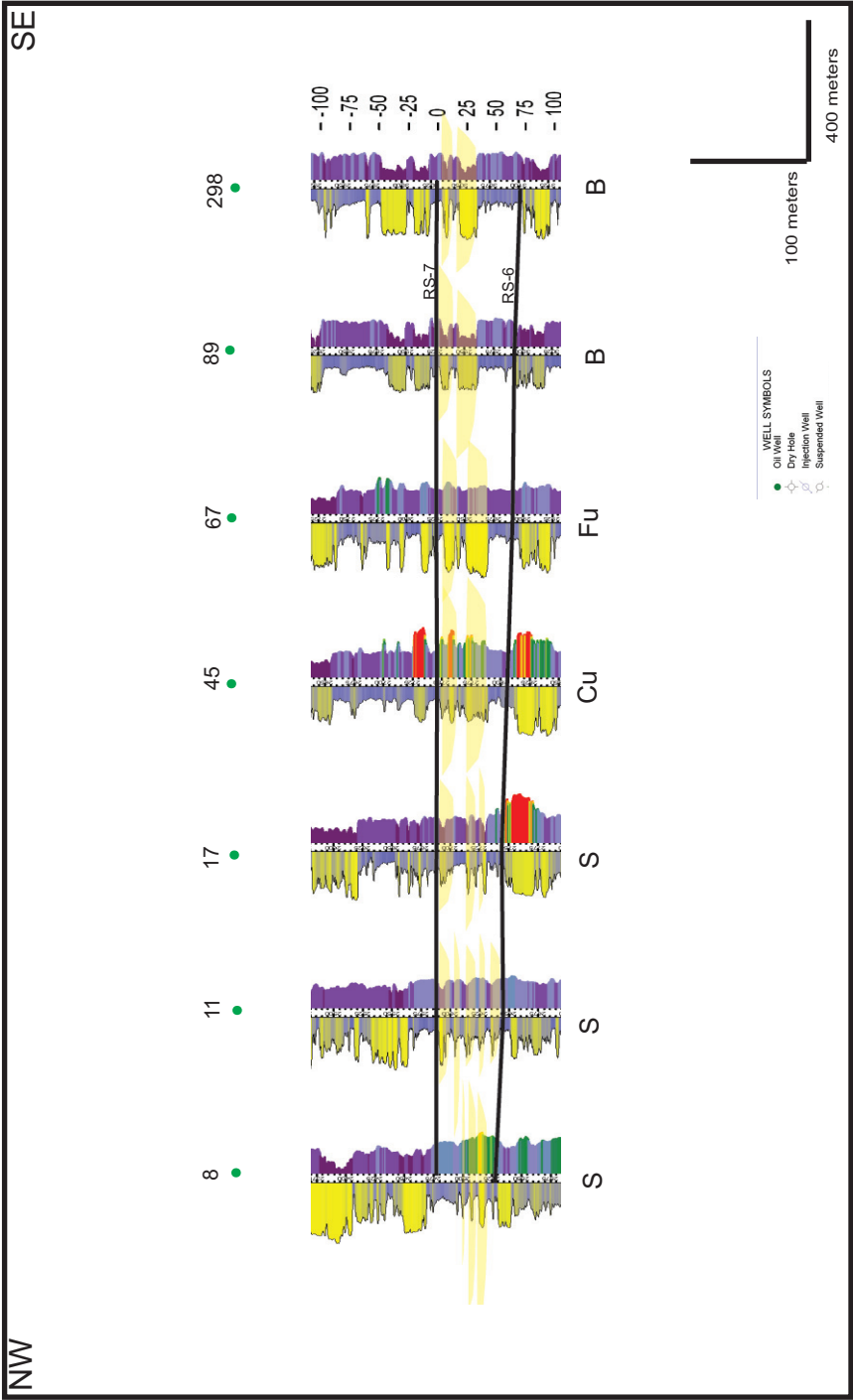


Figure 84. Wireline log cross section showing the Sequence 7 (RS-6 to RS-7). RS-7 is the datum. SP and Resistivity curves are shown. Lateral changes from the log signature are evident as well as change in the sandstones thickness from NW to SE. Serrate log signature and fining upward have more presence in this sequence. An interpretation of the sandstone distribution is shown in yellow. See Figures 82 and 85 for location of section.

similar areal distribution, blocky and coarsening upward have less areal distribution (**Figure 85**).

Net-to-gross map: The net-to-gross sand map of sequence 7 shows ratios varying from 0.0 to 0.5 (**Figure 86 A**). The highest values are present to the south/southwest and they decrease in value to the north (**Figure 86 A**).

Net-sand map: The net-sand map for sequence 7 has values varying from 0 to 50 meters (**Figure 86 B**). It has similar pattern to the net-to-gross map (**Figure 86 A**). Higher thickness values (> 40 meters) are located in the SW and NE part of the field, and the lower values are less than 5 meters and are located in the N-NE part of the field (**Figure 86 B**).

Seismic Facies: Seismic facies in vertical profile in general is characterized by reflections with low amplitude and high continuity (**Figure 72**). High amplitude reflections with low continuity can be observed against the unconformity in the field zone. An RMS amplitude map for this sequence acquired from a gated window 20 ms below the surface RS-7, shows two main amplitude trends coming to the field; one from the south and another from the southeast portion. Some kind of sinuosity is appreciated specially in from the south part, the system deposited in the field in this sequence is interpreted as channel complex fill with lateral migration and development of lateral accretion packages. (**Figure 87 A, B**).

Interpretation: Two systems are present in this sequence. The western system is interpreted to be a system coming from the south and migrating as result of to face the salt body in its trajectory, some sinuosity is evident. The second system appears

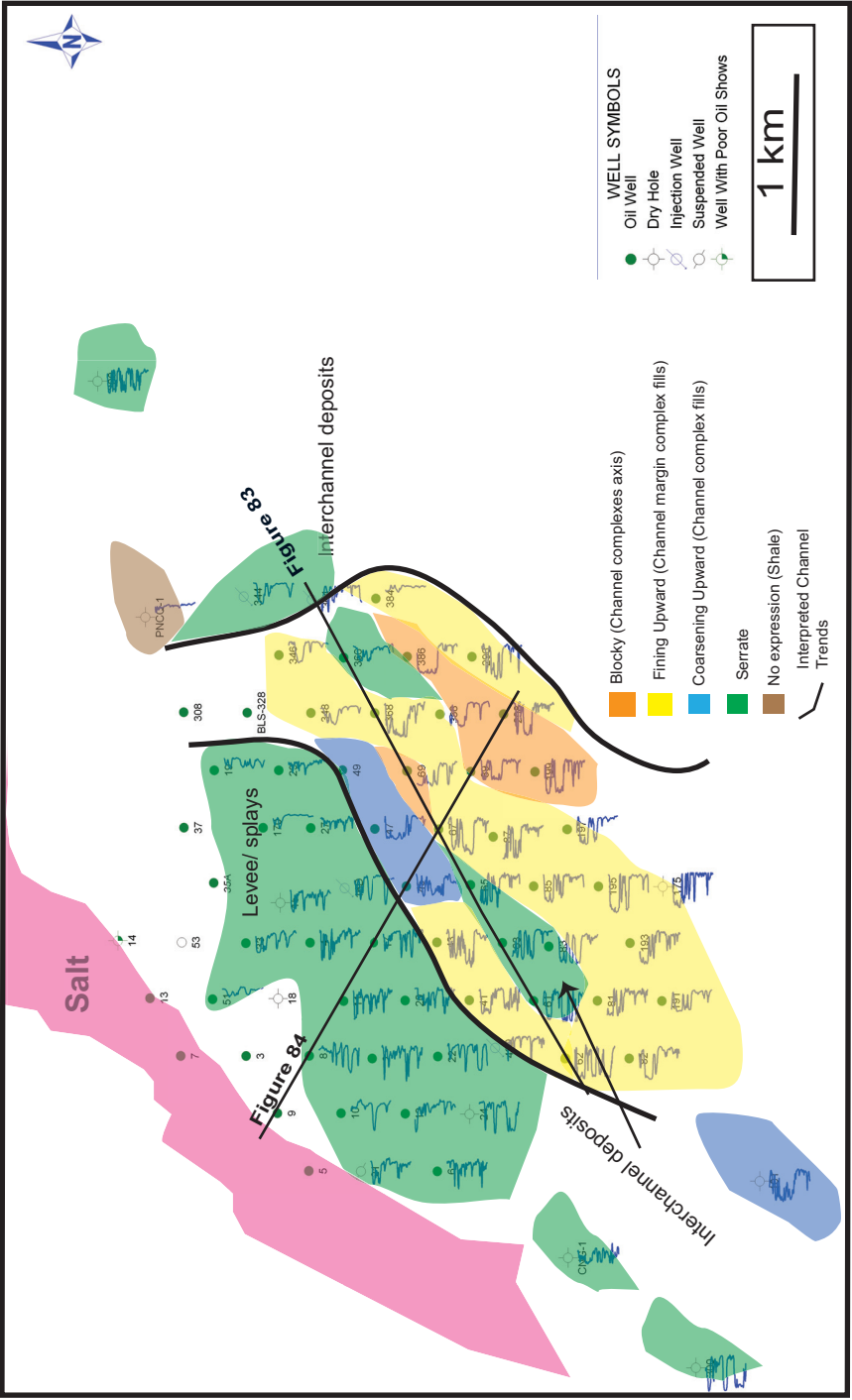


Figure 85. Lithofacies map of the sequence 7 (RS-6_RS-7) showing the SP logs. This facies map present fining upward signature as the more characteristic followed by the Serrate. Supported by the vertical profile the interpretation of these facies association is related with channel complex fills migration with develop of Lateral accretion packages. Location of Figures 83 and 84 are shown.

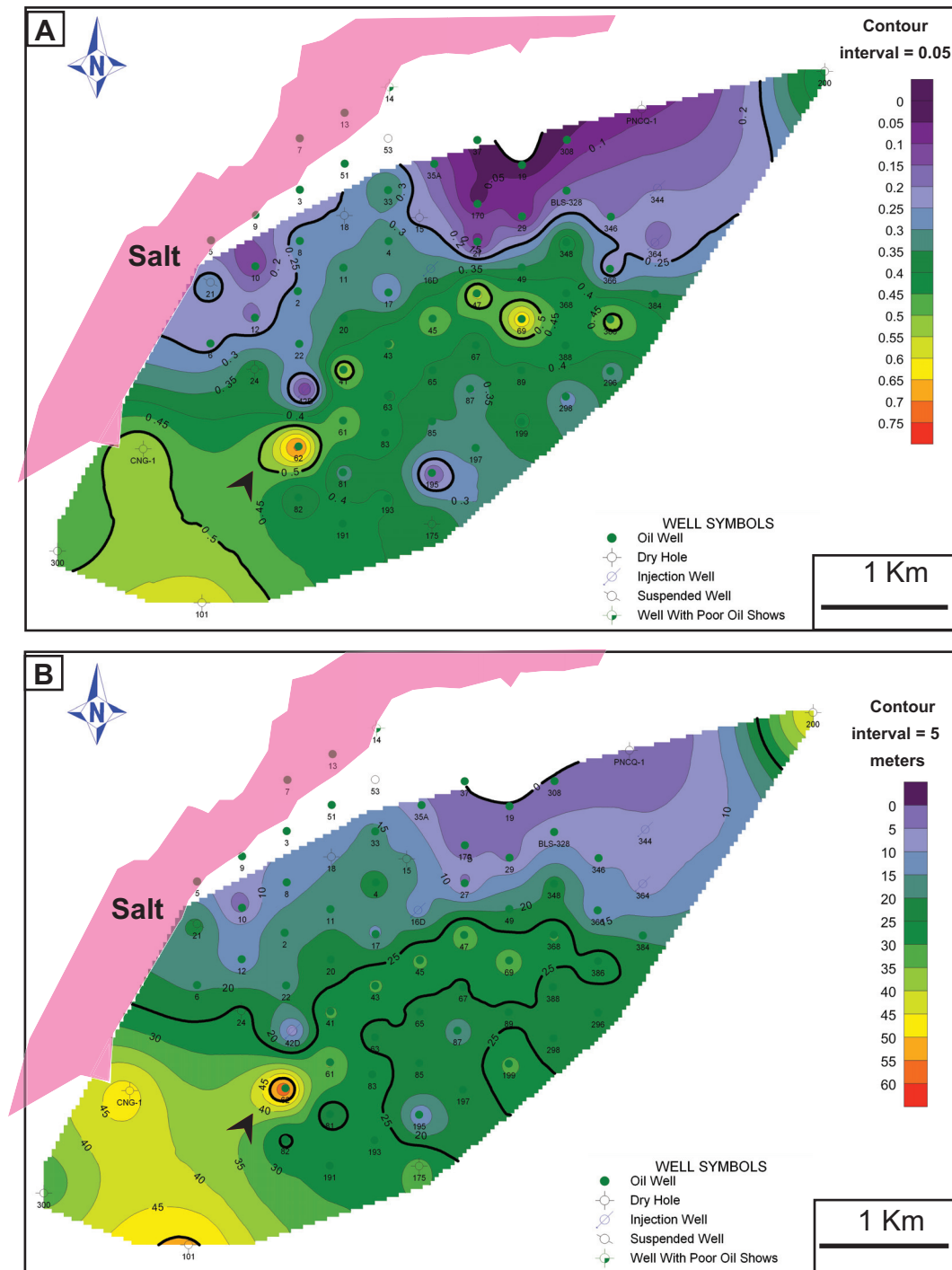


Figure 86. (A) Net-to-gross ratio map from the Sequence 7. Contour interval is 0.05. (B) Net-sand map from the Sequence 7. Contour interval is 5 meters.

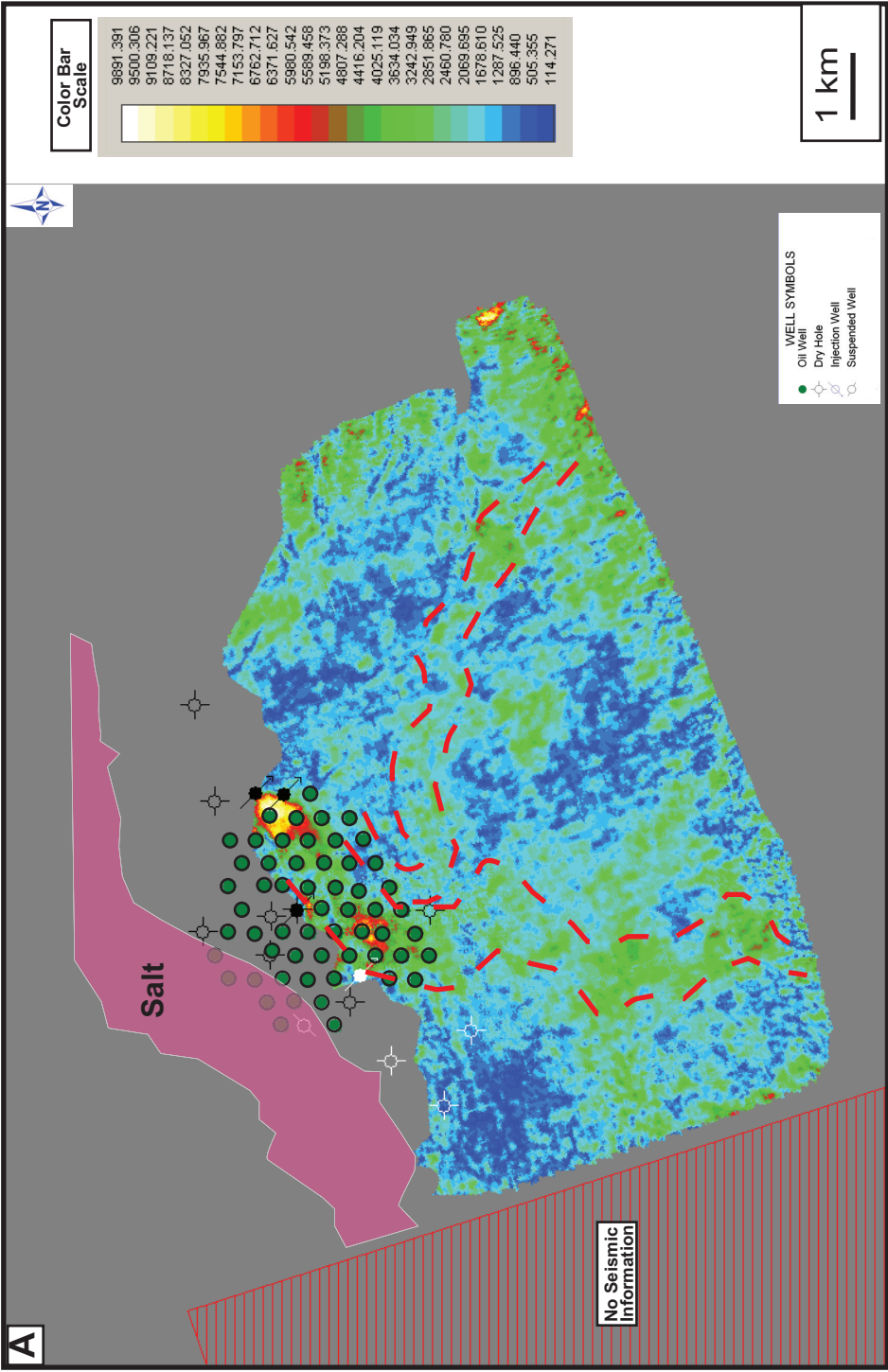


Figure 87. RMS amplitude extraction map from a window 30 ms below the horizon RS-7. **A)** With well location plotted. **B)** With not wells plotted. In this map two system interpreted as channel complex are interpreted coming to the field one with a south_north orientation showing sinuosity and other from a southeast position, the former is interpreted only feed the external wells in the lower part of the field, channel complex fill in the field is interpreted to have a strong relation with the system coming from the south part of the map the systems presents sinuosity.

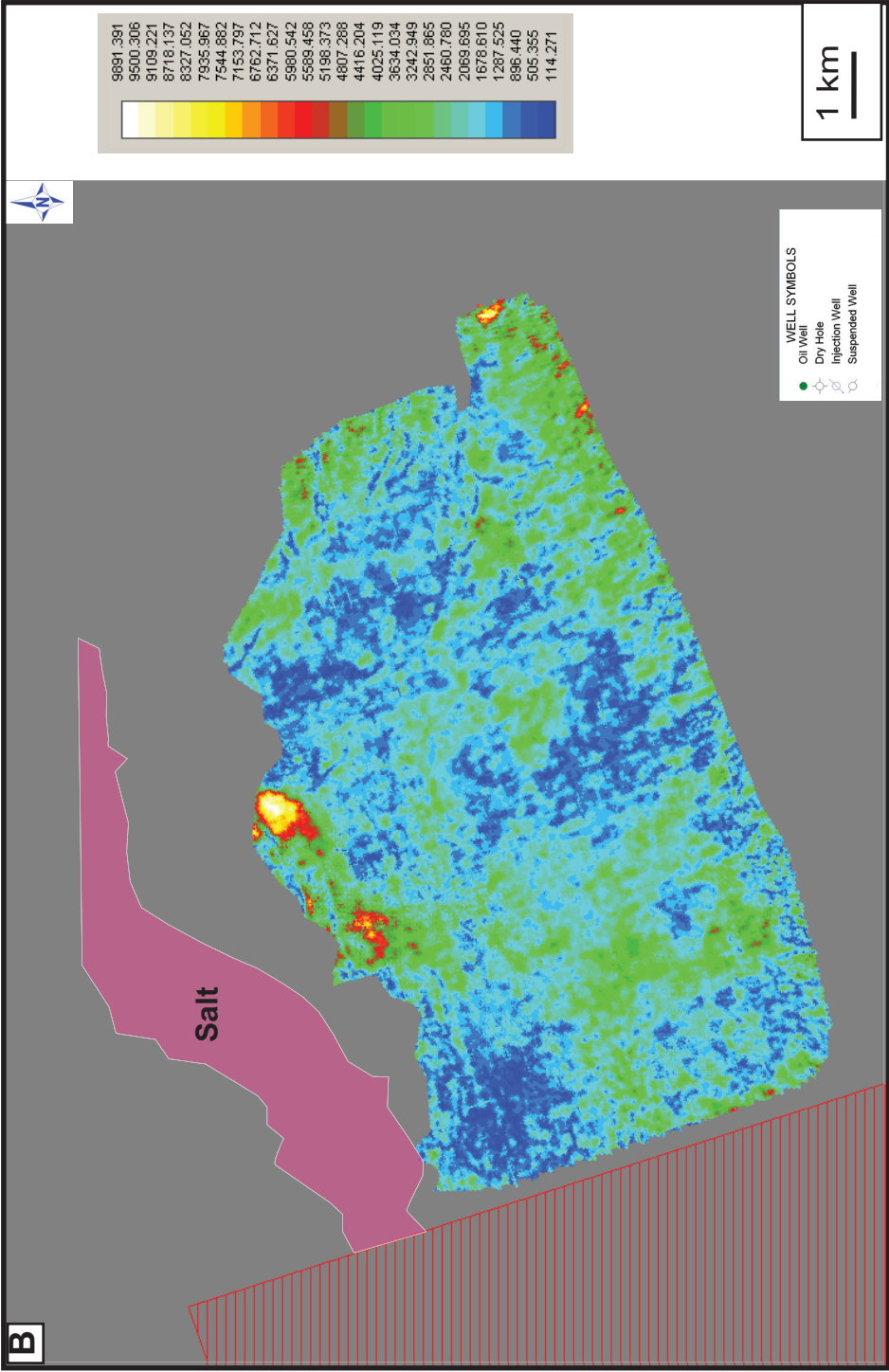


Figure 87 B.

already changing his course when it arrives to the south part of the field. Supported by the vertical profile the interpretation of these facies association is related with channel complex fills migration with develop of lateral accretion packages.

Structural map shows a big eroded zone in the north part, this erosion could be interpreted related with the impact of the salt movement over the sediments.

Sequence 8 (RS-7_ RS-8)

This sequence presents an eroded zone in the north part of the map before reflections pinch out against the salt body. Serrate pattern presents a major distribution in the north-northwest side of the field.

Time-structure map: The time-structure contour map of the horizon RS-8 shows a similar overall shape. The horizon as the underlying sequences, however this map shows a big eroded zone of the field. Two sets of fault are present. The first set (F1) is present in the eastern of the study area; it strikes NW- SE and dips to the northeast (**Figure 88**). The second set (F2) is located in the west side, strikes W-E, and dips to the north (**Figure 88**). South of the field, there is a minibasin with a SW-NE orientation and a deeper part is present at 2.5 seconds and is decreasing in values getting shallower in both flanks (**Figure 88**).

Isopach map: A total of forty four wells penetrated this sequence (as result of the interpreted eroded zone). The isopach map of this sequence shows the thicker zone at the southern side of the field. The thickness varies between 10 to 70 meters. A zone of thickness of lesser than 30 meters is present in the northern part of the field (**Figure 89**).

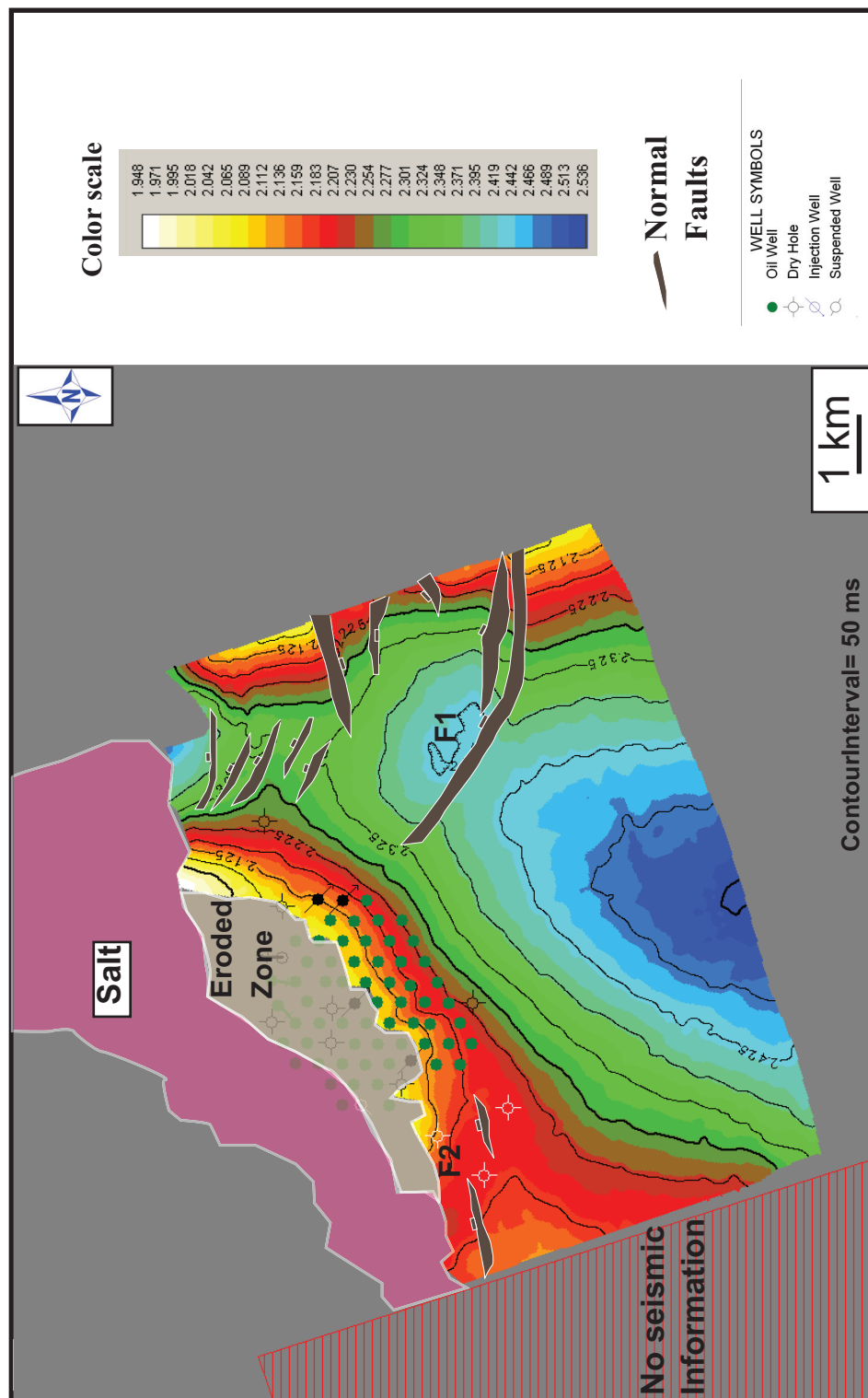


Figure 88. Time-structure contour map (in secs) of the Surface RS-8. A salt body is present in the west-north part of the map (pink). This surface present a big eroded zone close to the salt body. Two set of faults are interpreted in this sequence with SE-NW and W-E orientations, the first set (F1) with a NW-SE orientation is located in the northeast and southeast of the study area dips to the northeast. The second set (F2) with a SW-NE orientation present different dips in the east side to the southeast and in the west side to the northwest. Wells are shown in green dots.

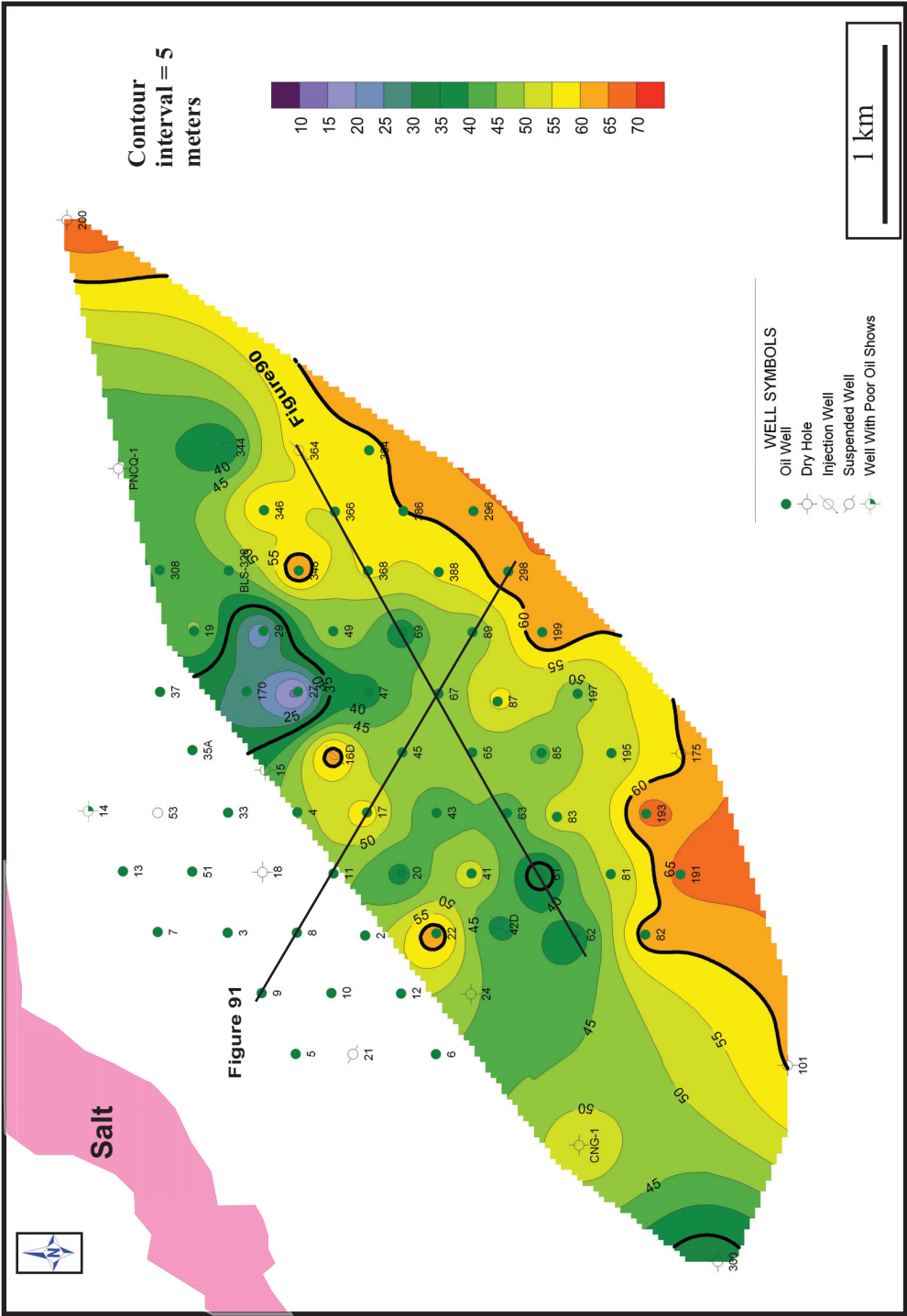


Figure 89. Isopach map of the Sequence 8 in the Blasillo Field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 90 and 91 are shown.

Lithofacies: Two log cross sections illustrate the sequence, strike (**Figure 90**) and dip views (**Figure 91**). On the strike profile, the section is characterized by lateral changes in the thickness and SP log patterns. The Blocky shape is the dominant SP pattern. The thicker sands are located to the NE of the section in the wells 366 and 364, which have a blocky pattern. The thinner sand is located in the well 61 and has a serrate pattern. The lateral continuity of the sands bodies extend up to 500 meters (**Figure 90**).

The dip oriented profile shows the serrate SP patterns as the more distinctive signature (wells 17, 45, 67). The blocky pattern is present in the well 89 and 298 (**Figure 91**).

In map, view the SP log pattern of this sequence shows that the different patterns interpreted have a distinct southwest-northeast orientation. The blocky pattern and serrate are the more common signatures in this sequence. Shale is present on the north side of the field, coarsening upward and fining upward are in the central part of the field changing to serrate pattern to the west side and blocky pattern to the east and are flanked by blocky and serrate patterns (**Figure 92**).

Net-to-gross map: Net-to-gross map of the Sequence 8 shows a clear zone of lower values to the west, into a general increasing of the ratio to the east part. The zone located to the northeast has the highest values, greater than 0.85 (**Figure 93 A**).

Net-sand map: The net-sand map of this sequence shows a zone of lower values than 10 meters in the west side. A discrete area of higher values is present along the north part of the field with values greater than 40 meters. (**Figure 93 B**).

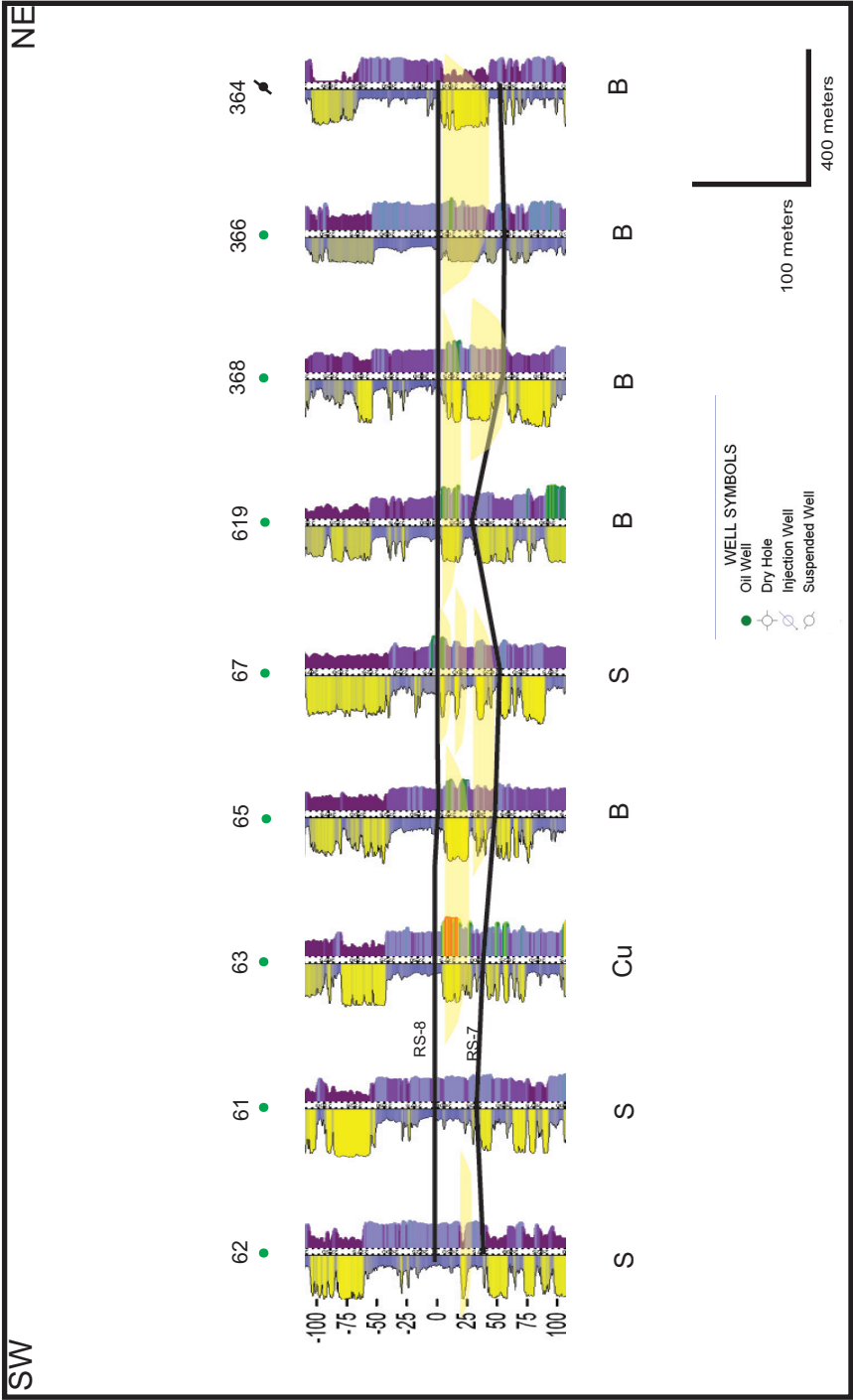


Figure 90. Wireline log cross section showing the sequence 8 (RS-7 to RS-8). RS-8 is the datum. SP and resistivity curves are shown. Blocky, coarsening upward and serratate are the most characteristic log signature in this sequence. An interpretation of the sandstone distribution is shown in yellow. See Figures 89 and 92 for location of section.

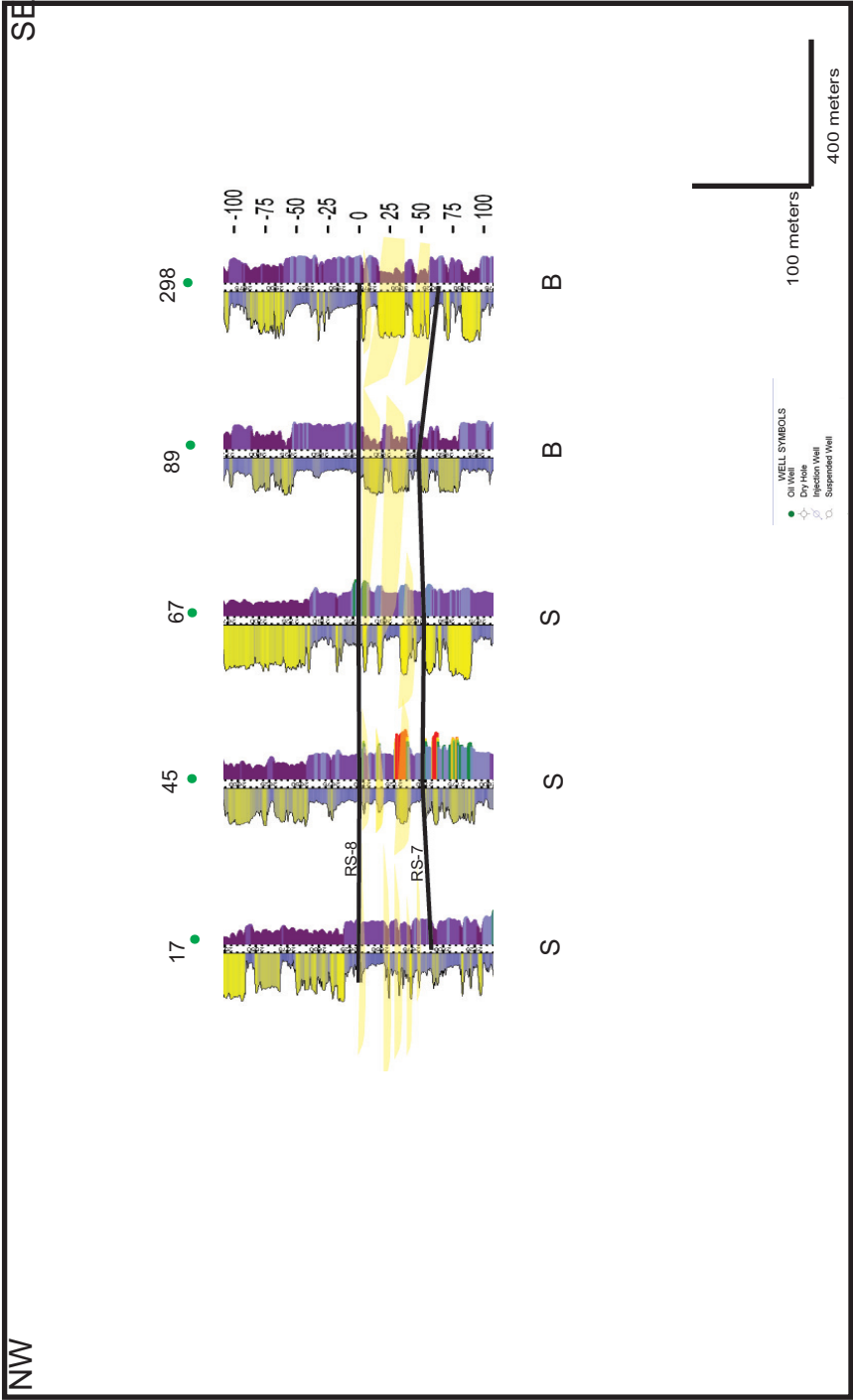


Figure 91. Wireline log cross section showing the sequence 8 (RS-7 to RS-8). RS-8 is the datum. SP and resistivity curves are shown. Lateral changes from the log signature and the sandstones thickness are present from NW to SE. serratite, fining upward, blocky pattern are the more characteristic log signatures in this section. An interpretation of the sandstone distribution is shown in yellow. See Figures 89 and 92 for location of section.

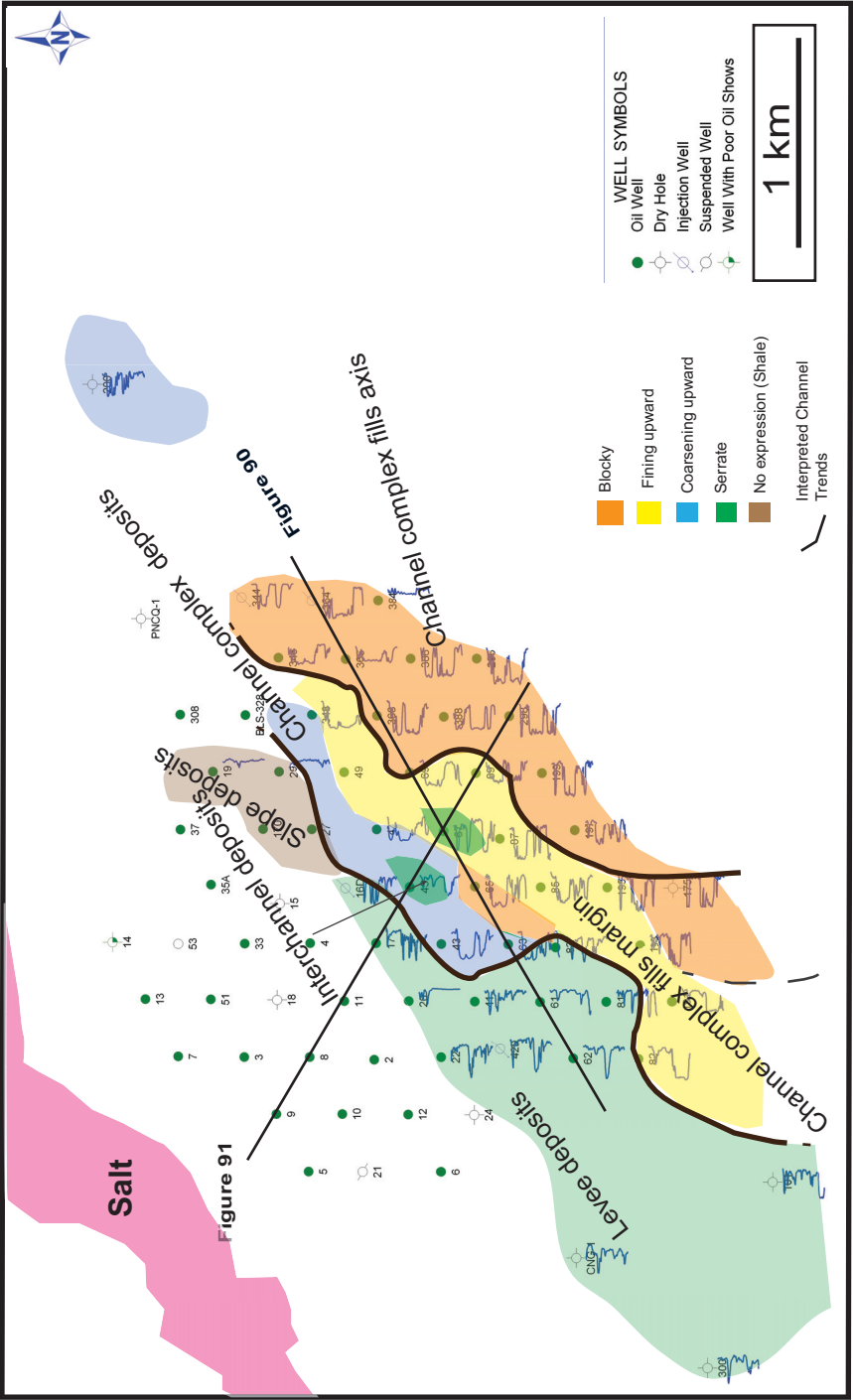


Figure 92. Lithofacies map of the Sequence 8 (RS-7_RS-8) showing the SP logs. The predominant log signature is the blocky pattern in the south-southeast side of the field with orientation southwest-northeast. Serrate pattern is interpreted in the margin of the system (southwest-west). Fining upward signature is associated in lateral change of facies with the blocky pattern. Shale signature is present in the north part of the field. The interpretation is related with a semialgated channel complex fills. Location of Figures 90 and 91 are shown.

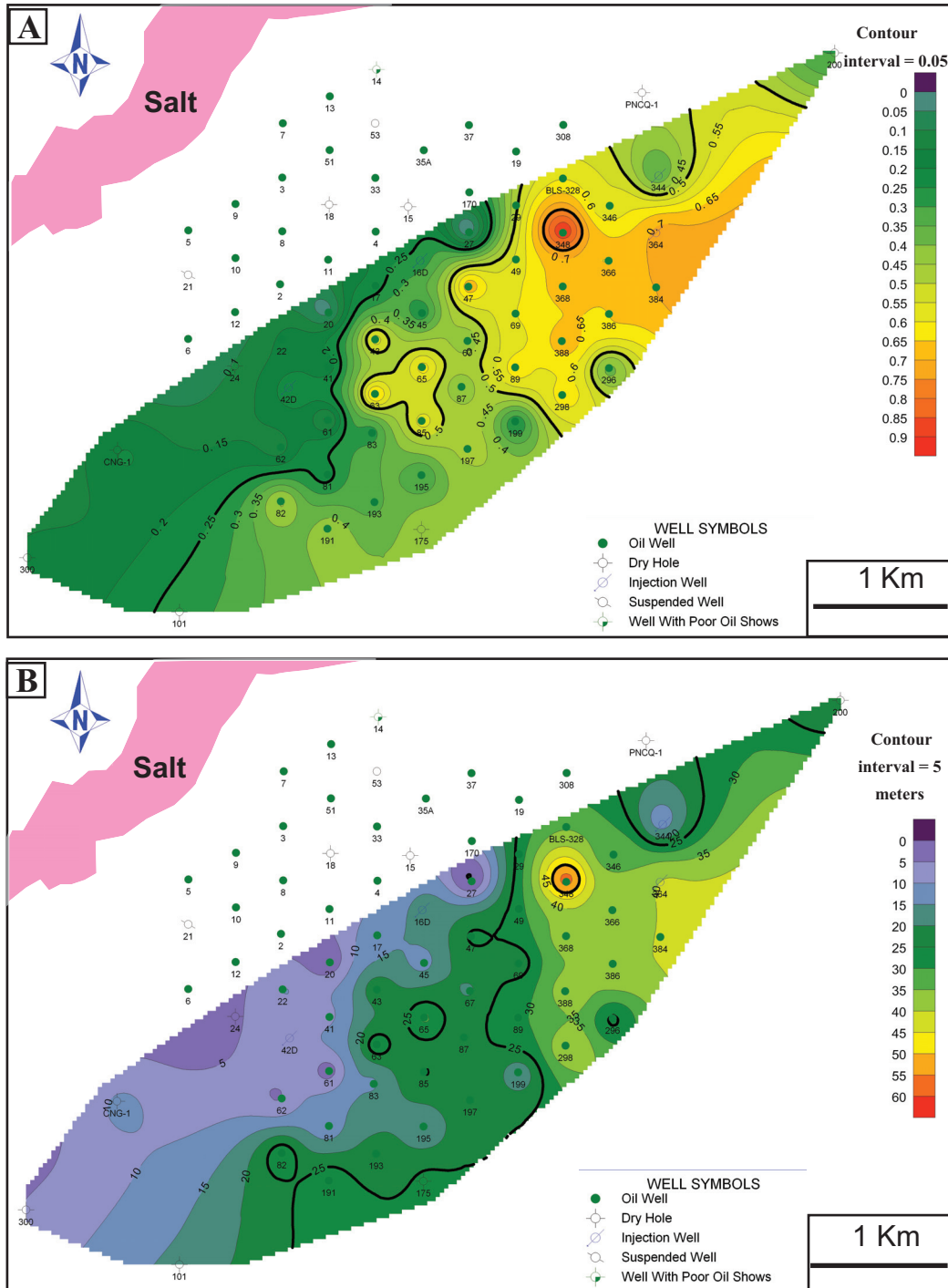


Figure 93. (A) Net-to-gross ratio map from the Sequence 8. Contour interval is 0.05. (B) Net-sand map from the Sequence 8. Contour interval is 5 meters.

Seismic Facies: Two general seismic facies in the vertical profile are present: one is characterized by reflections with low amplitude and with moderate to high continuity located in the deeper part of the sequence. The second facies has high amplitude reflections with and moderate to high continuity in the shallower part of this sequence (**Figure 72**).

An RMS amplitude map for this sequence from a gated window 20 milliseconds above the surface RS-7 shows four anomalies trends. Some of these trends are interpreted to present sinuosity. In the field area high amplitudes present NE-SW orientation (**Figure 94 A, B**).

Interpretation: Three systems interpreted as channels complex fills are coming toward the field, two of these systems present a SE-NW orientation with a change in the orientation when arrive to the field. Straight features are present in the borders of the anomalies. The third trend is arriving toward the field but the relation is not clear.

Sequence 9 (RS-8_RS-9)

The shallower part of the sequence is eroded by the sequence boundary RS-9 in the northern part (**Figure 95**).

Time-structure map: A time-structure contour map of the horizon RS-9 shows the presence of a salt body to the north. The horizon is eroded along the northeast side of the field. Two sets of faults are present in the map. The first set (F1) is located in the east side of the study area, strike NW-SE and dip to the northeast (**Figure 96**). The second set (F2) is present in the west side, strike SW-NE, and dip to the northwest and southeast in the west and east side (**Figure 96**).

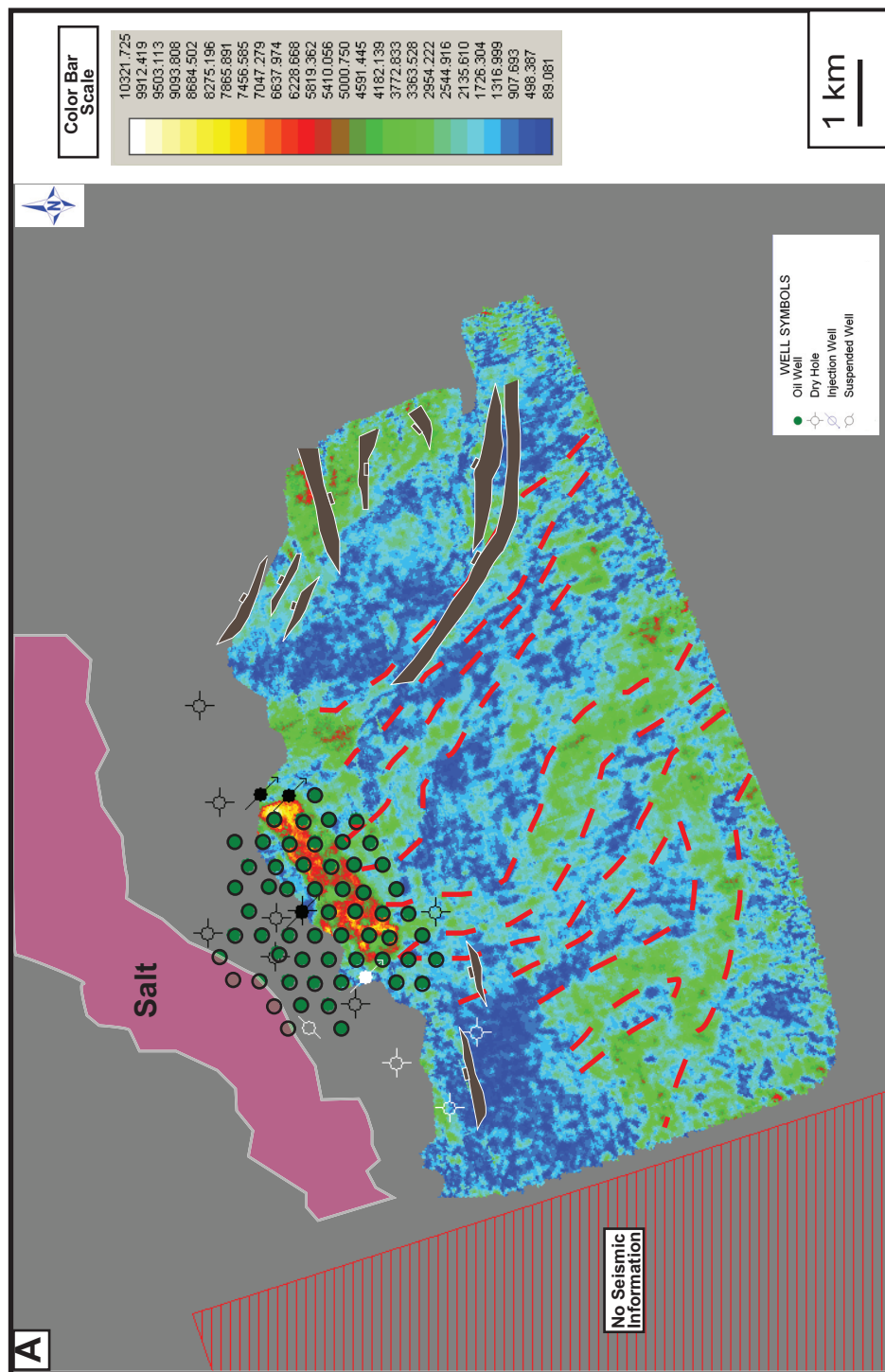


Figure 94. RMS amplitude extraction map from a window 20 ms above the horizon RS-7. **A)** With well location plotted. **B)** With not wells plotted. In this map four systems are interpreted with a SE-NW orientation and present some sinuosity. High amplitude anomalies present a NE-SW orientation in the field area..

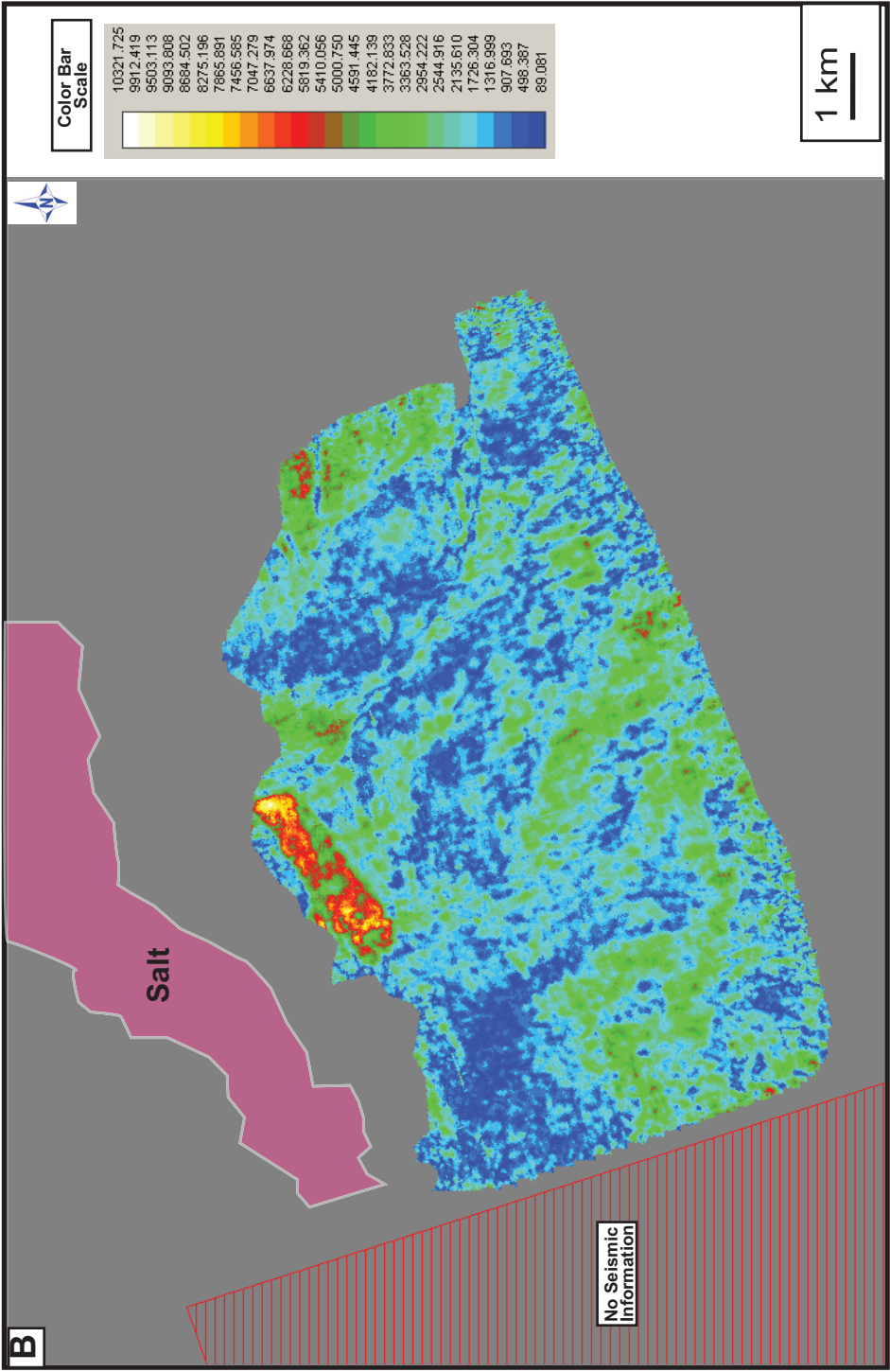


Figure 94 B.

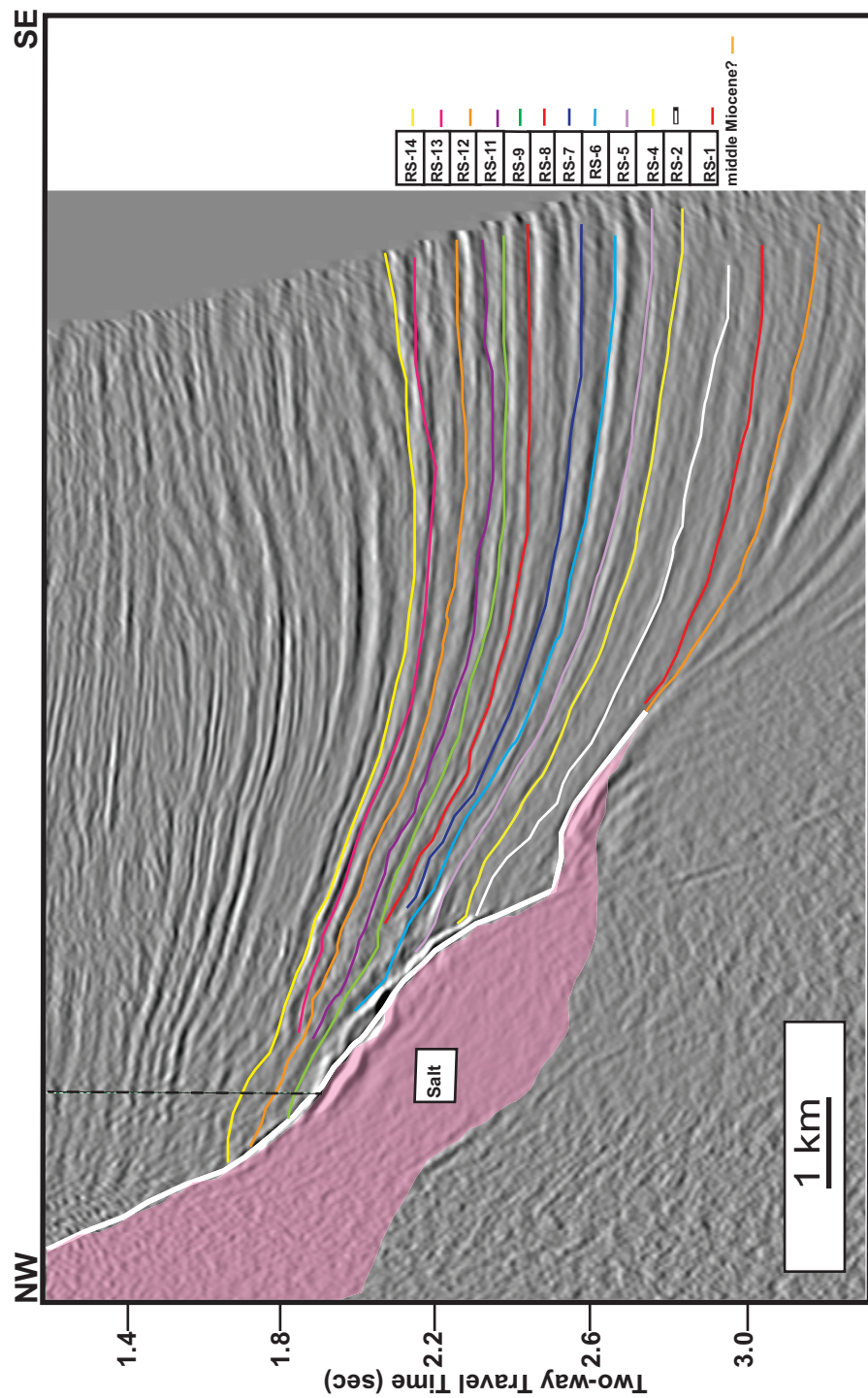


Figure 95. Seismic profile shows the sequences interpreted in the main production zone from the Blasillo field from RS-9 to RS-2. production zone is located in the flank of a salt body (pink). Surface RS-9 is truncating lower surface RS-8. High amplitudes from base of the sequence RS-5 through RS-9 are interpreted correspond to channel complexes. Dashed line represent a projected well from other field not included in this data set. See Figure 96 for location of profile.

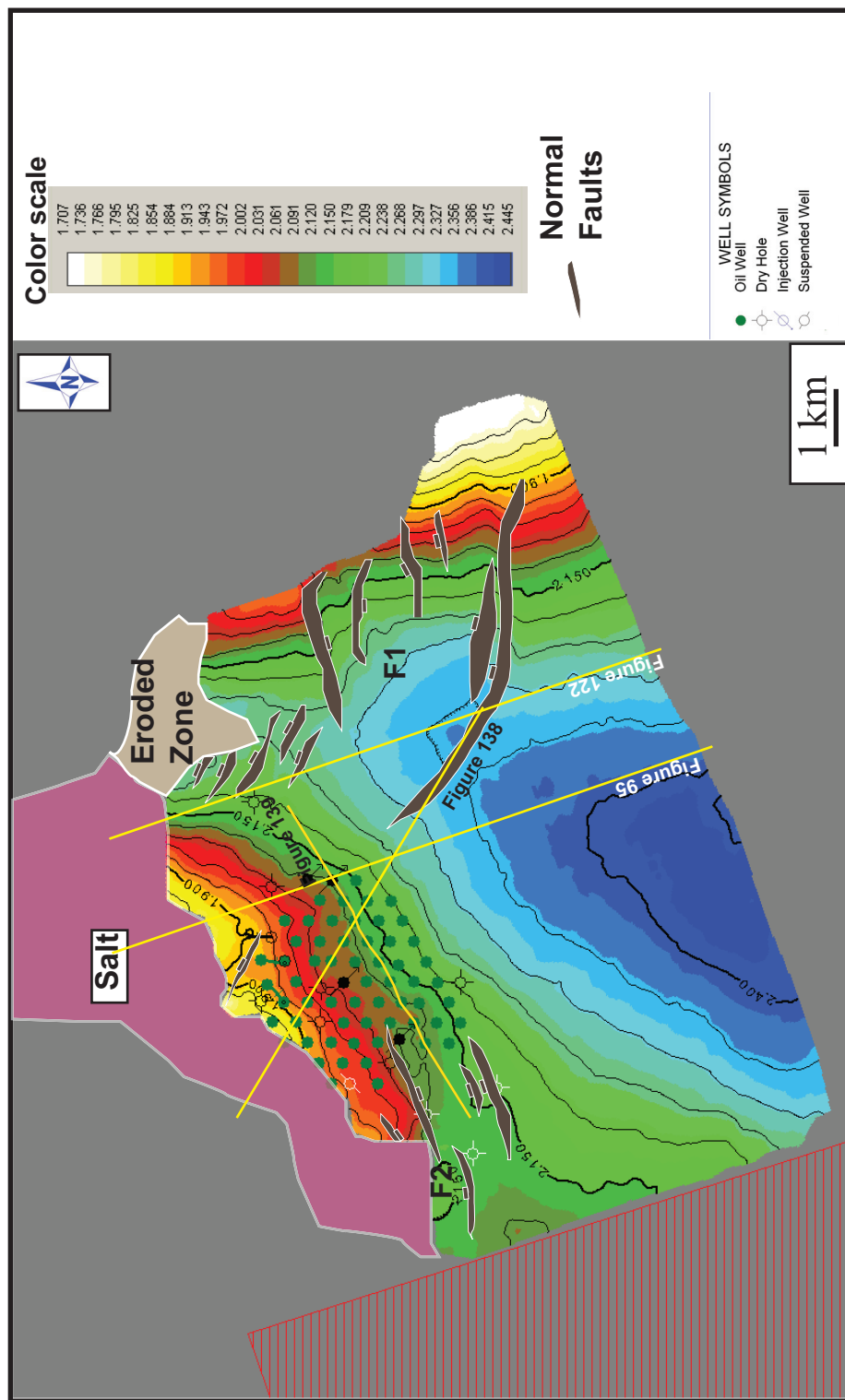


Figure 96. Time structure contour map (in secs) of the Surface RS-9. A salt body is present in the west-north side. An eroded zone is in the north-east. Two sets of faults are present the first is located in the north and northeast and southeast side of the study area strikes NW-SE and dips to the northeast. The second set is present in the east and southeast side strikes SW-NE and dips to the northwest. Wells are shown in green dots. Location of Figures 95, 122, 138 and 139 are shown in yellow lines.

Isopach map: Thirty seven wells penetrated strata of this sequence. The isopach map of this sequence shows that the thicker part of the sequence is developed in the southeast part of the field with values greater than 65 meters. A gradational change to lower values is present toward the northeast (**Figure 97**).

Lithofacies: Two log cross sections illustrate the sequence, in strike (**Figure 98**) and dip view (**Figure 99**). Both sections are showing that serrate-shaped sand bodies and shale are the two most common log signatures in this sequence.

In the strike section, thin sand units with serrate pattern are present. Three wells in this section present log signature related with shale (well 63, 65,366), the rest of them have serrate as the log signature (**Figure 98**). On the dip oriented section, five wells have serrate log signature with very thin development of sandstones (**Figure 99**).

In map view the SP log pattern of this sequence shows that serrate sand bodies and shale are the two type of signature in this sequence (**Figure 100**).

Net-to-gross map: The Net-to-gross map for this sequence shows in the SW part of the field the greater values (> 0.35) to the southwest. A zone of lower values is identified in the northeast part of the field with values lower than 0.01 (**Figure 101 A**).

Net-sand map: The net-sand map of this sequence shows in the northeast part of the field values lower than 5 meters, greater values than 25 meters are located in the southwest part of the map (**Figure 101 B**).

Seismic Facies: Seismic facies in vertical profile is characterized by low amplitude and high continuity reflections (**Figure 95**).

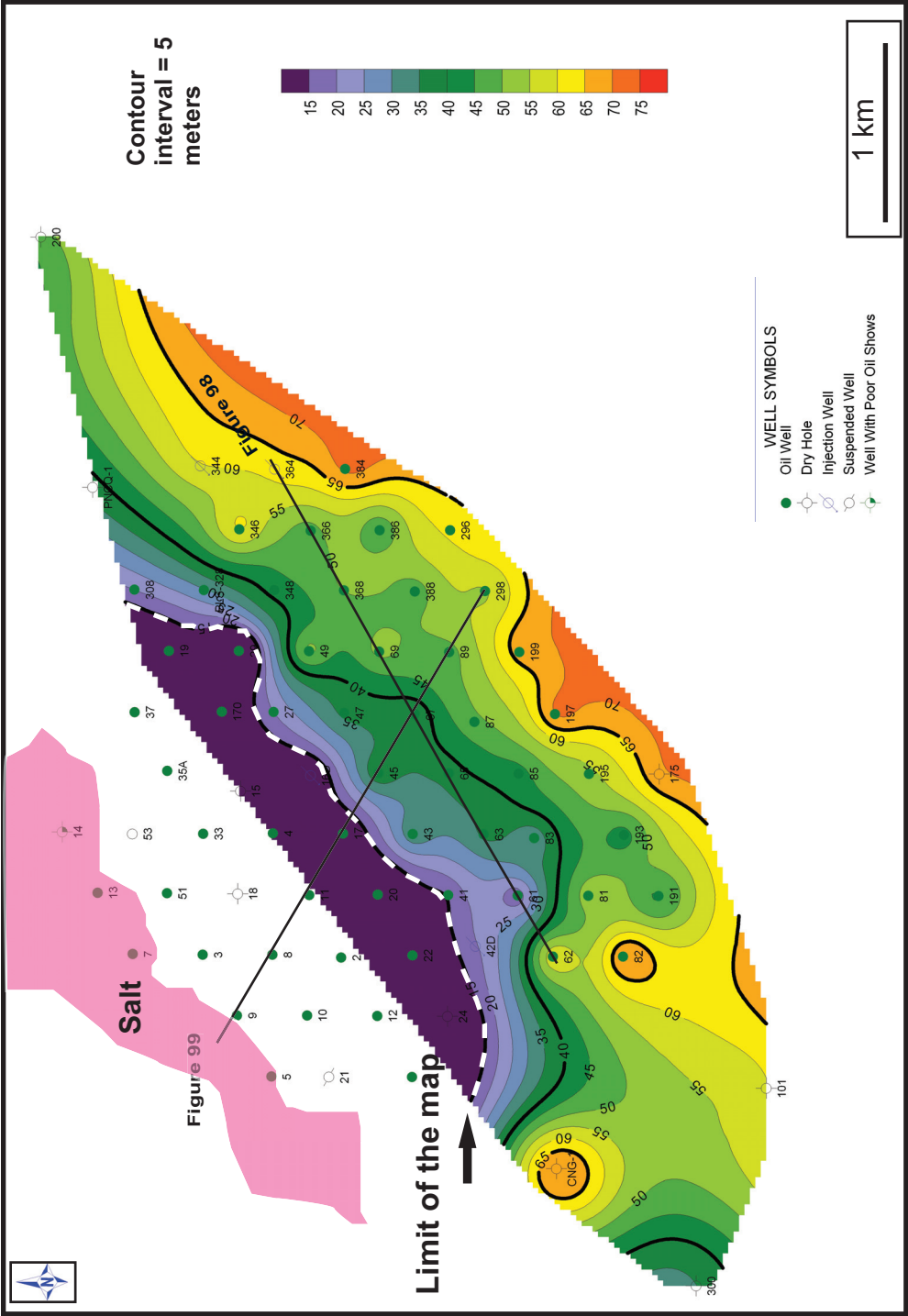


Figure 97. Isopach map of the Sequence 9 in the Blasillo Field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 98 and 99 are shown.

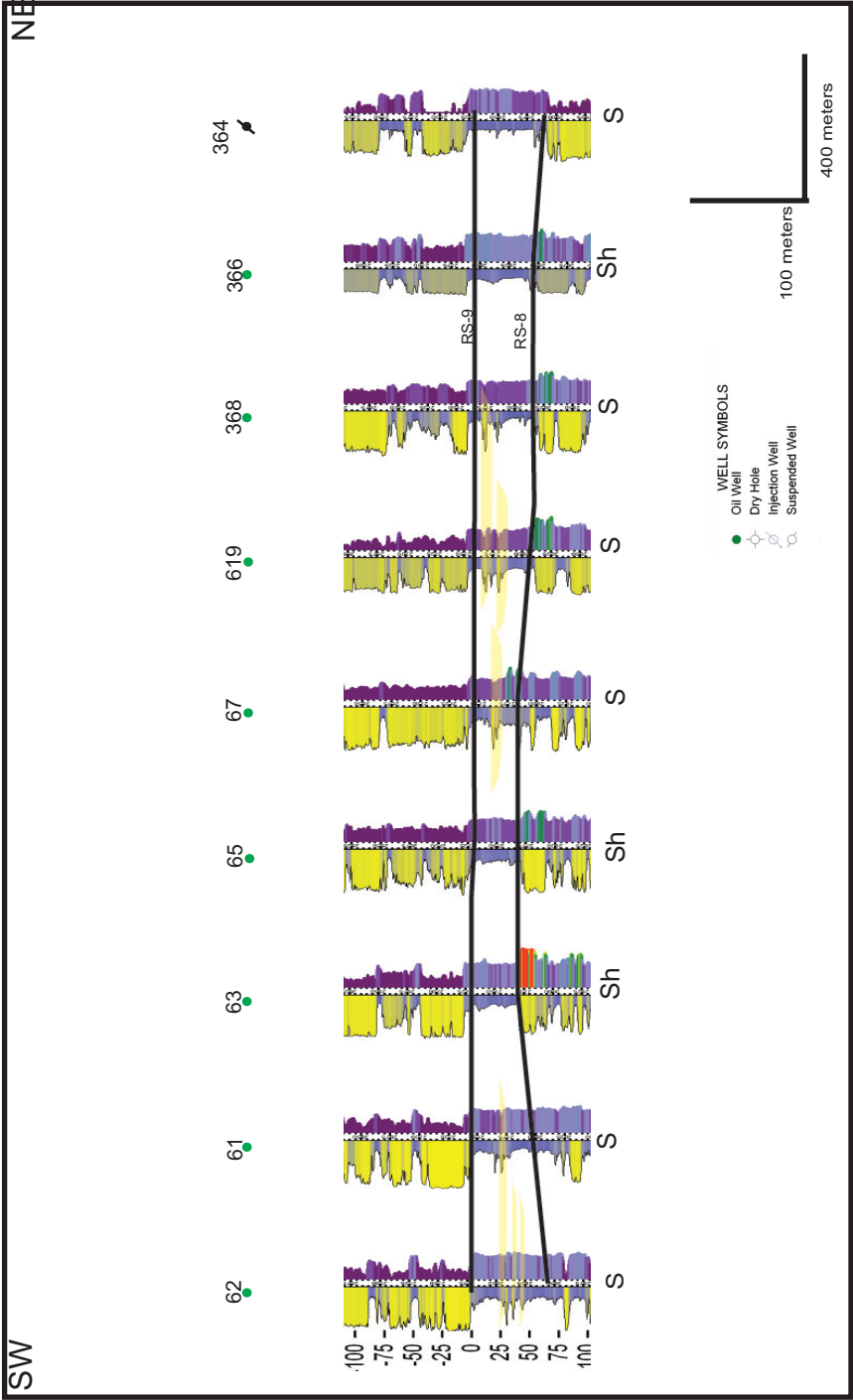


Figure 98. Wireline log cross section showing the Sequence 9 (RS-8 to RS-9). RS-9 is the datum. SP and Resistivity curves are shown. Serrate and shale pattern are the signatures in this section. This sequence is characterized by low presence of sandstones and is considered a condense section, a change of the net to gross ratio is evident above this flatten surface for the upper sequences. An interpretation of the sandstone distribution is shown in yellow. See Figures 97 and 100 for location of section.

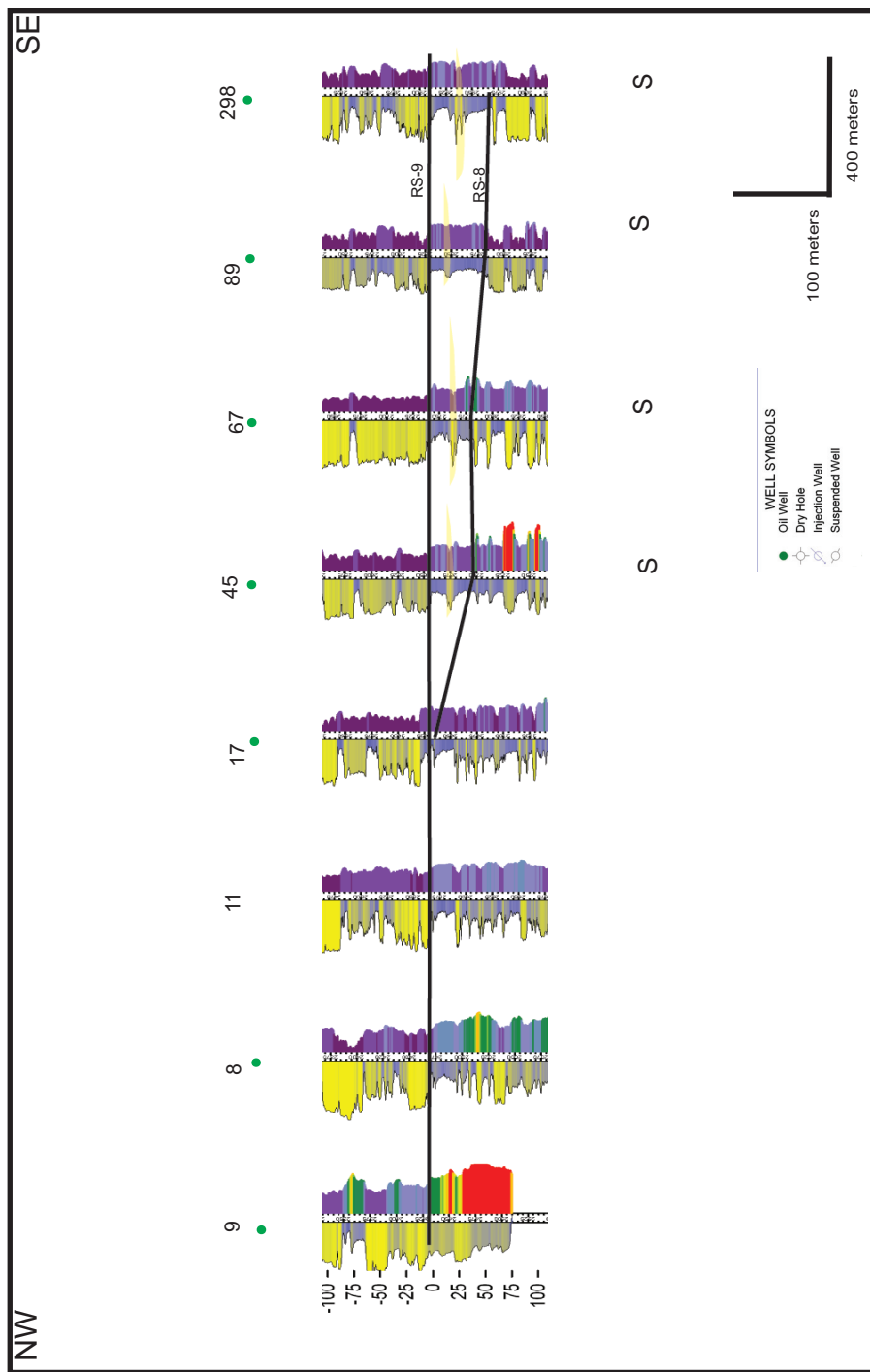


Figure 99. Wireline log cross section showing the sequence 9 (RS-8 to RS-9). RS-9 is the datum. SP and Resistivity curves are shown. Wells in the right side of the section did not reach these sediments the RS_9 surface is eroding the lower sequences, this sequence has low sandstones content, serrate and shale log signature is the more characteristic. An interpretation of the sandstone distribution is shown in yellow. See Figures 97 and 100 for location of section.

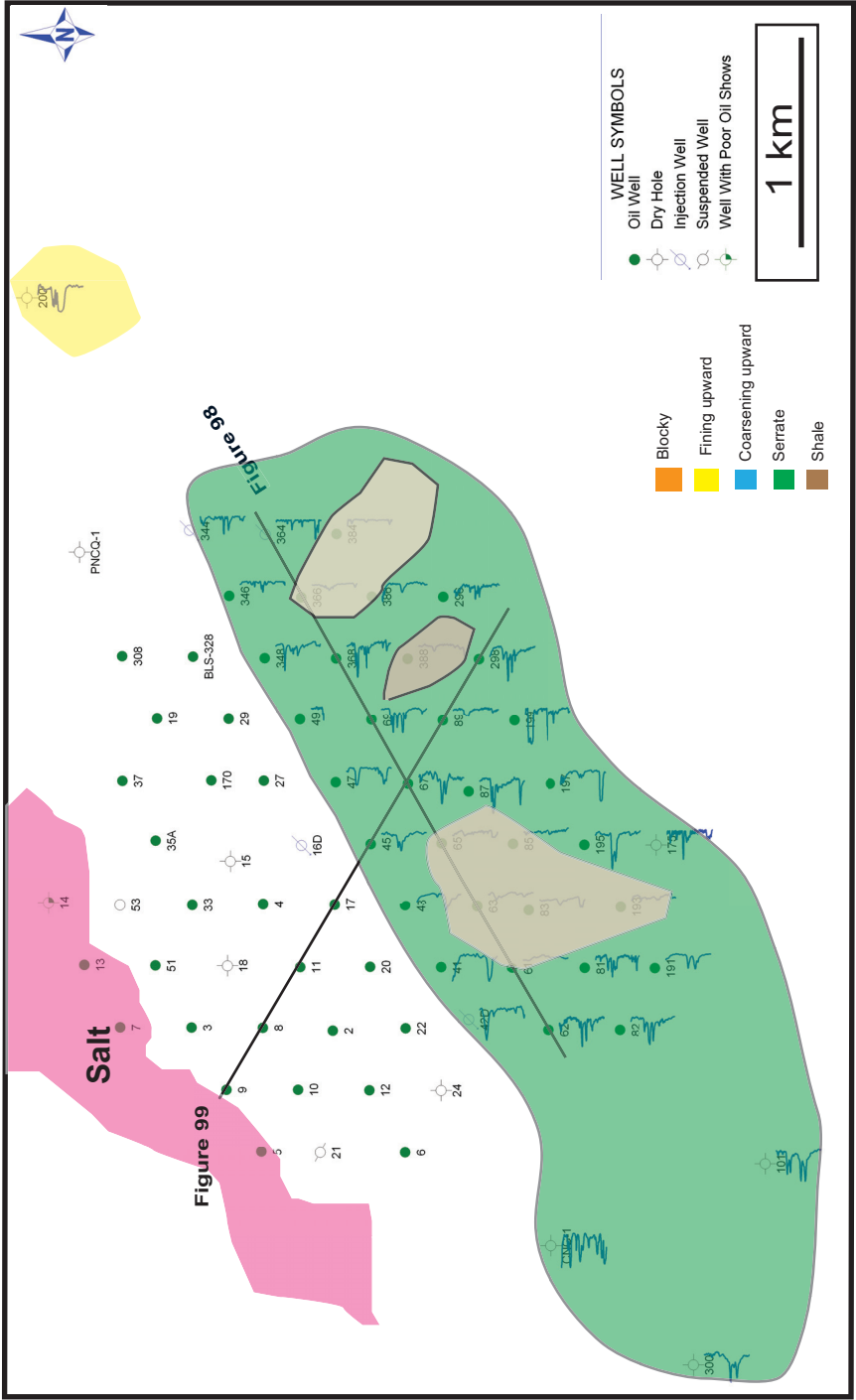


Figure 100. Lithofacies map for Sequence 9 (RS-8-RS-9) showing the SP logs. Serrate is the main log signature identified in this sequence, in the right part of the map a fining upward signature is present. The interpretation of this pattern is related with small develop of channels. Location of Figures 98 and 99 are shown.

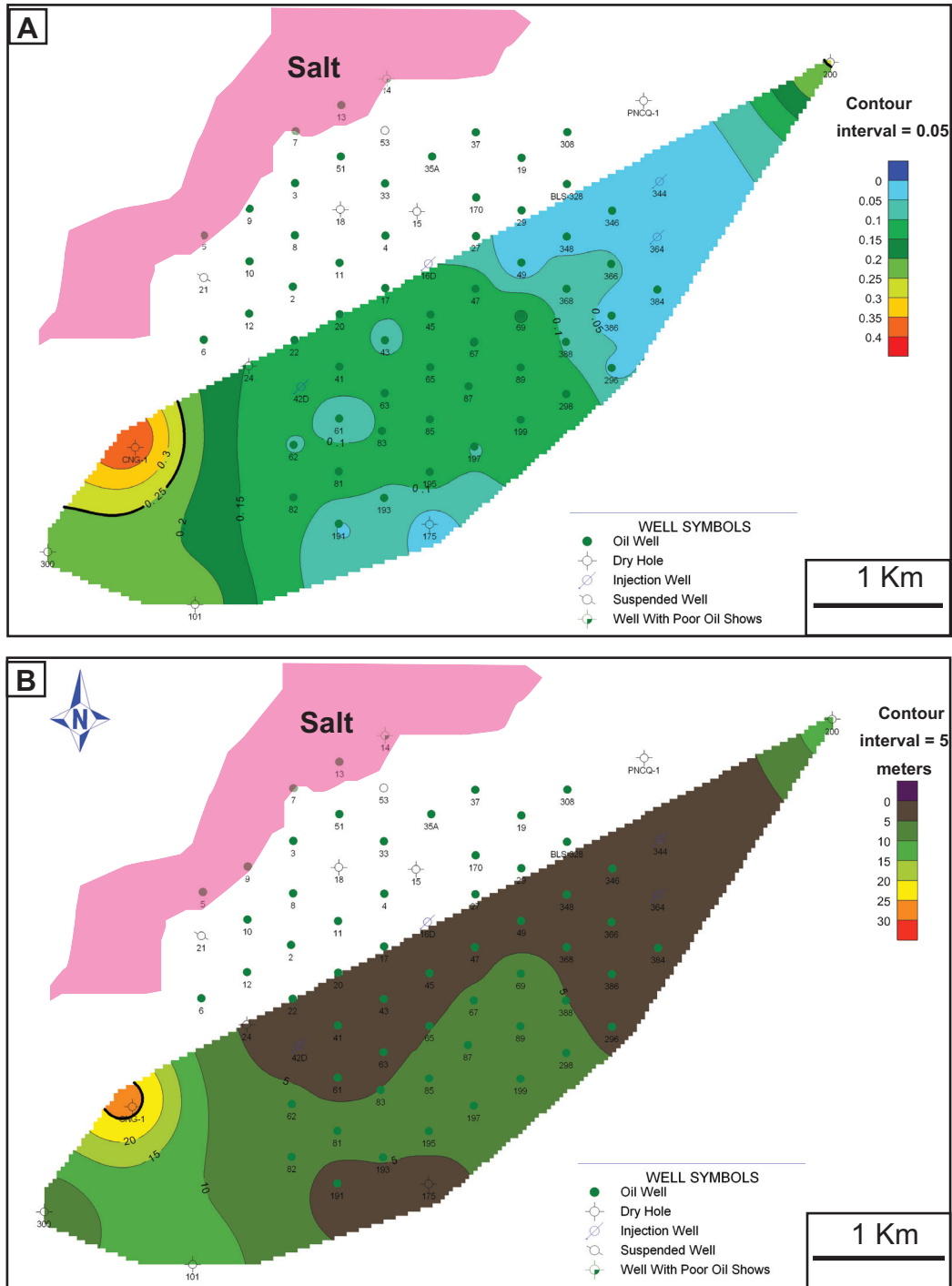


Figure 101. (A) Net-to-gross ratio map from the Sequence 9. Contour interval is 0.05.
 (B) Net-sand map from the Sequence 9. Contour interval is 5 meters.

An RMS amplitude map for this sequence from a gated window 10 ms below the surface RS-9 shows narrow trends of amplitude coming toward the field from the southeast (**Figure 102 A, B**).

Interpretation: These three channel-fill systems are interpreted as small channel fills that flow to the north into the area of the field.

Sequence 10 (RS-9_RS-10)

Time-structure map: A time-structure map is not included for this sequence due to lack of seismic resolution in the study area. Data for this sequence are based on downhole logs, in the area of the field.

The structure map of the top of this sequence (RS-10) shows the shallower position in the north part of the field (2310 m), and the deeper part in the south (2850 m) (**Figure 103**).

Isopach map: sixty five wells penetrated this sequence. Isopach map from this sequence shows a maximum value of 90 meters of thickness in the southeastern part of the field and the thinnest part to the northwest, where the thickness decreases to 10 meters. The map shows the decrease in thickness trending from the southeastern part of the field to the northwest. In general, the greatest thickness is to the southwest. Within this area in the southwest part of the field, a zone is recognized with thicknesses between 60 and 75 meters in a W-E direction (**Figure 104**).

Lithofacies: Two wireline cross sections illustrate the sequence in strike (**Figure 105**) and dip views (**Figure 106**). The strike section(X1) (**Figure 105**) has an SW-NE

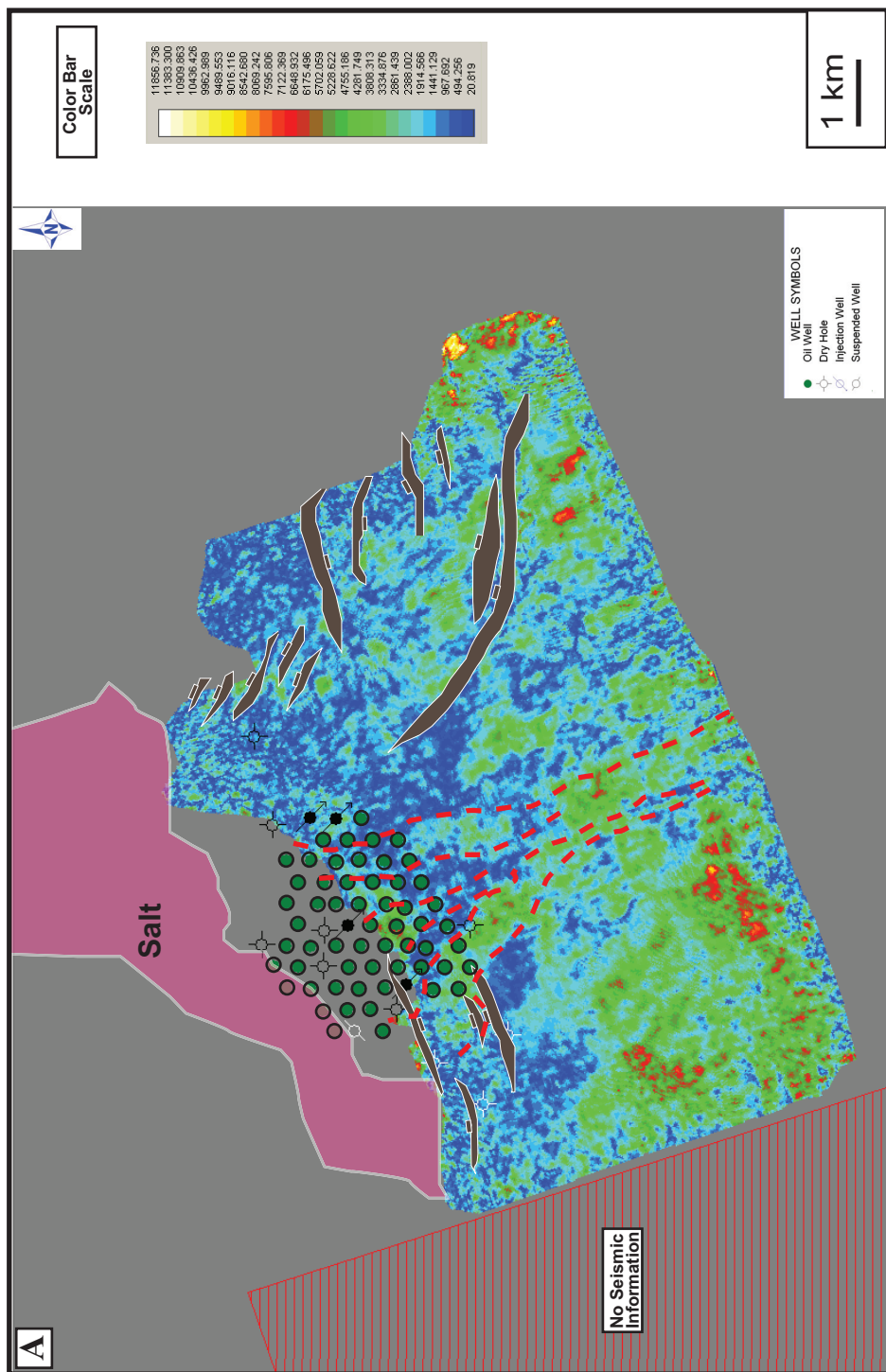


Figure 102. RMS amplitude extraction map from a window 10 ms below the horizon RS-9. **A)** With well location plotted. **B)** With not wells plotted. Three channel complexes are interpreted be related with the field coming from the South East part of the map one of them is having a little bifurcation and feeding the left and central part of the field, the other two have some sinuosity and are feeding the right part of the field.

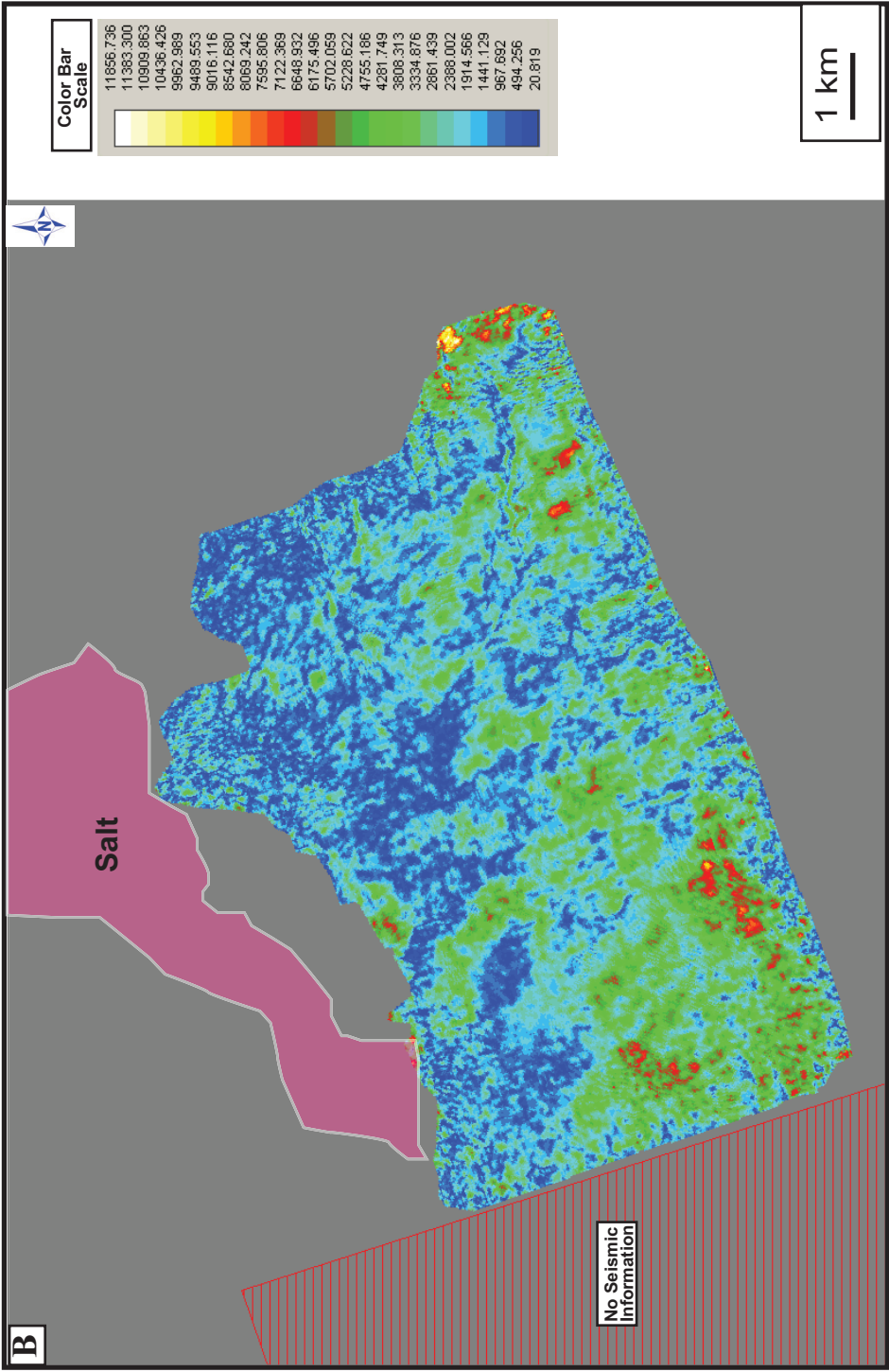


Figure 102 B.

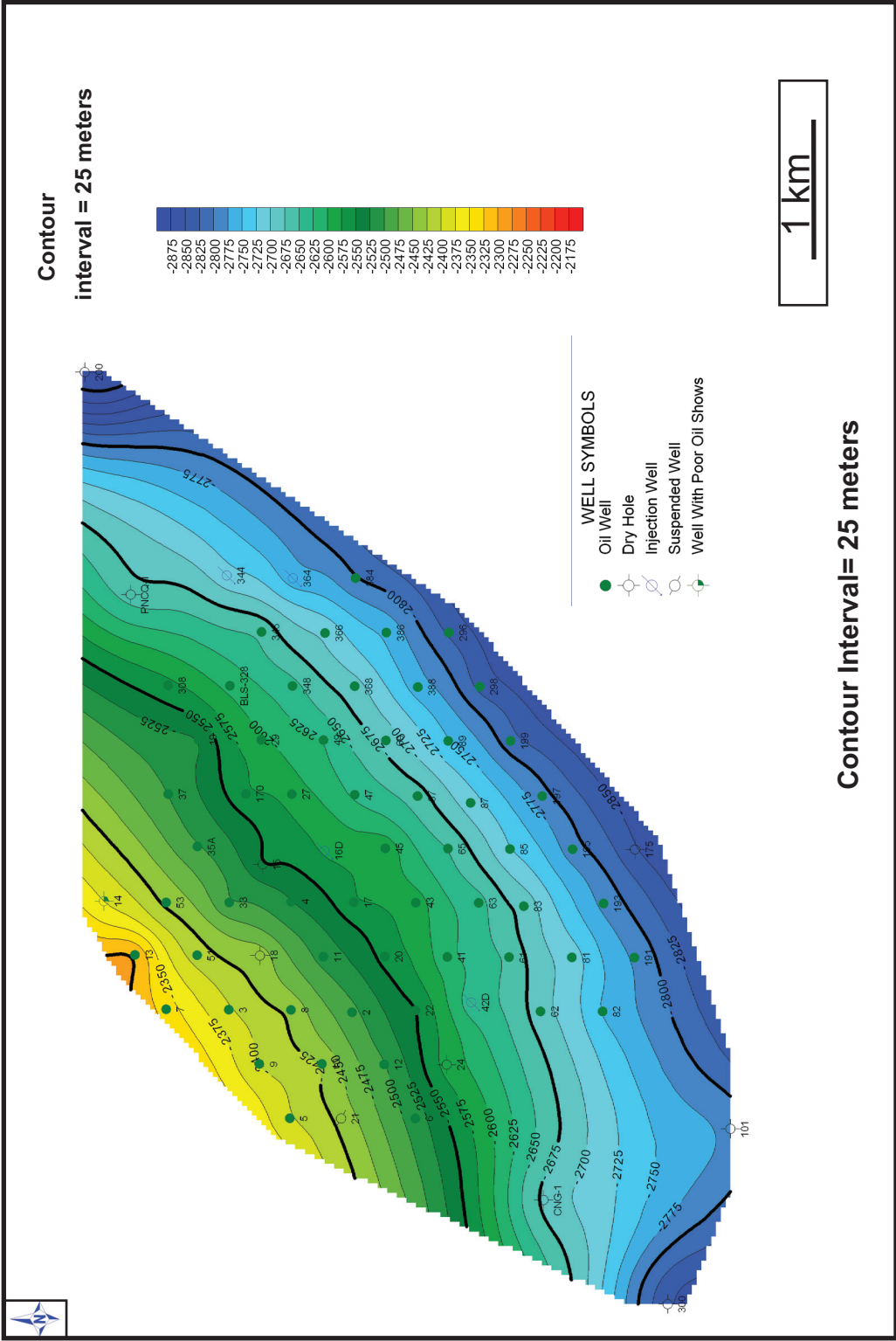


Figure 103 . Structure contour map (in meters) of the Surface RS-10. The shallower position of this sequence is 2300 meters and the deeper is 2825 meters. the surface dips to the southeast.

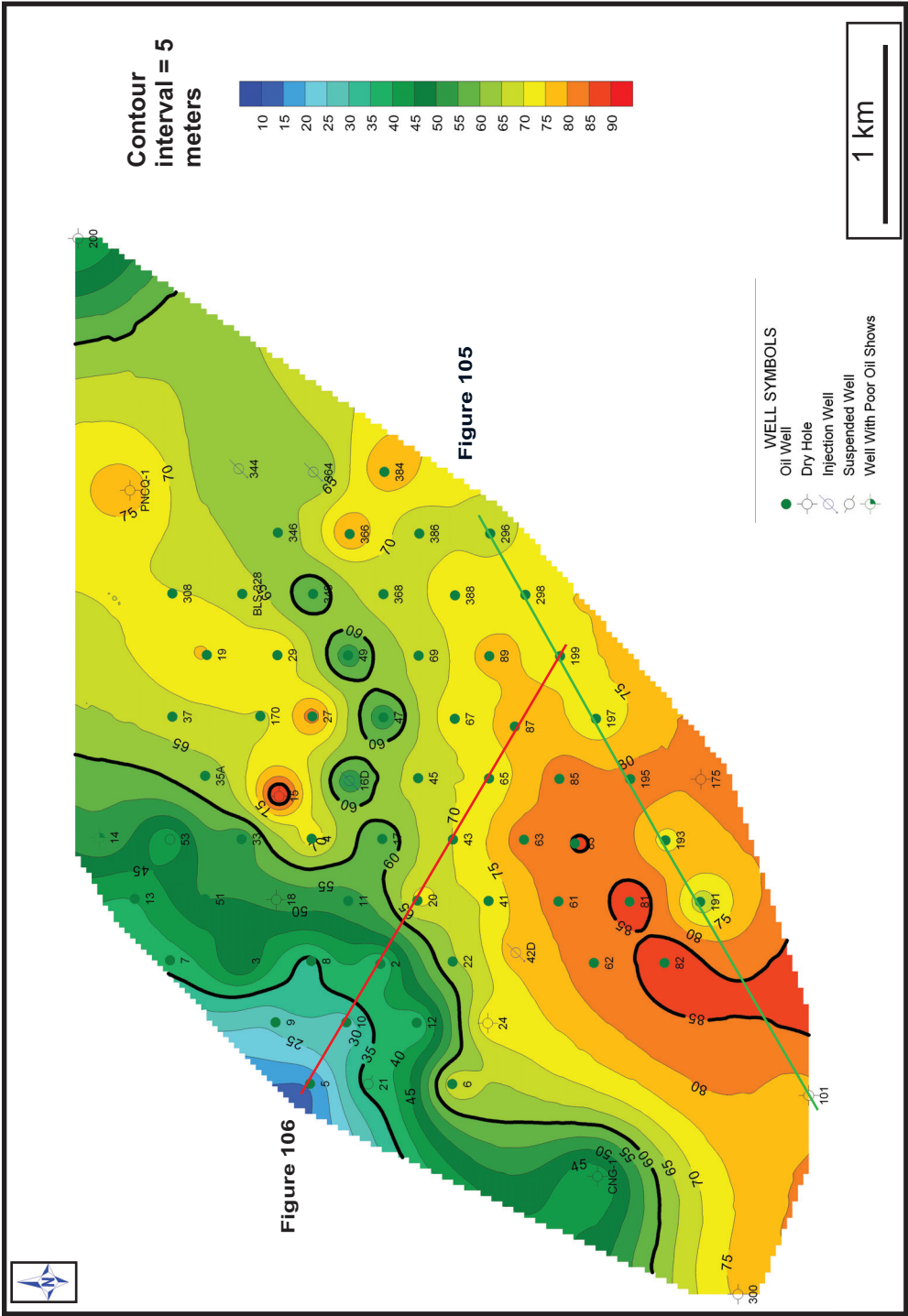


Figure 104. Isopach map of the Sequence 10 in the Blasillo field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 105 and 106 are shown.

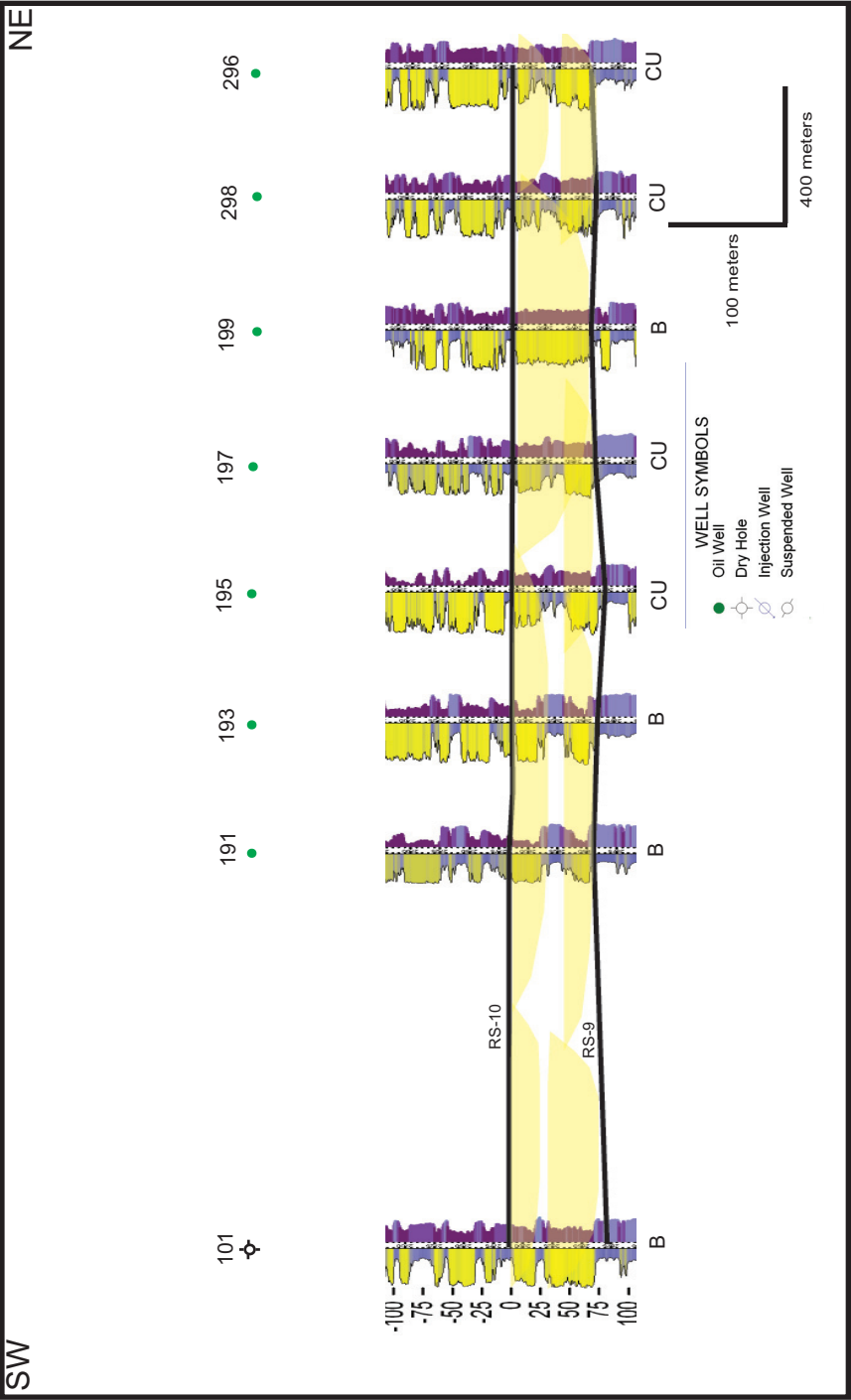


Figure 105. Wireline log cross section showing the sequence 10 (RS-9_RS-10). RS-10 is the datum. SP and resistivity curves are shown. Lateral changes in the log signature are evident. Well 199 presents a thicker sand with a blocky signature. An interpretation of the sandstone distribution is shown in yellow. See Figures 104 and 107 for the location of section.

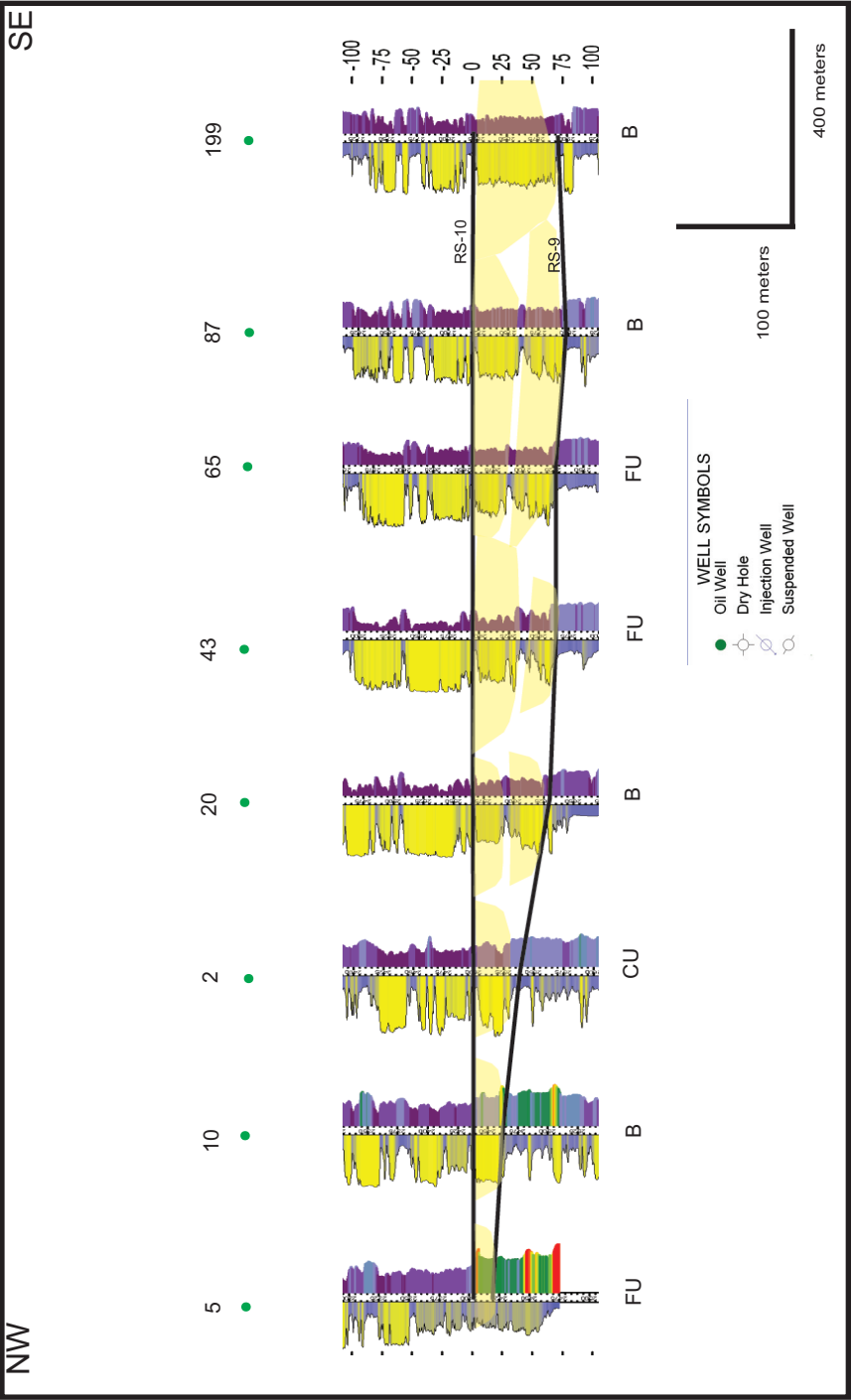


Figure 106. Wireline log cross section showing the sequence 10 (RS-9_RS-10). RS-10 is the datum. SP and resistivity curves are shown. This sequence is the first one above the horizon considered as the big unconformity in the section. A change in the net to gross ratio to higher sand content is characteristic for this and the upper sequences of this study. Blocky pattern signature is the more characteristic in this sequence but some upper fining is evident. An interpretation of the sandstone distribution is shown in yellow. See Figures 104 and 107 for the location of the section.

orientation and shows eight wells with two distinctive sand bodies. First some sands have blocky and upward coarsening signature with a thickness between 25 and 50 meters, with the exception of the well 199 which have sand with a maximum thickness of 70 meters.

Second, the sandstones in the lower part of the sequence show a fining upward pattern for all the wells except for well 199 that shows a blocky pattern. The sandstones located in the upper part of the sequence shown a blocky pattern in well 101, 191, 193, and 199, coarsening upward in wells 195 and 197, and fining upward pattern in wells 296 and 298 (**Figure 105**).

The northwest-southeast dip section (Z6) has a total of eight wells (**Figure 106**): three of the wells to the northwest have only one sand body, whereas the rest of the wells, except for well 199, have two sand bodies. The Well 5 in the northwest has more shale content with a fining upward signature. Blocky pattern is the more characteristic log signature in this cross section (well 10, 20, 87, 199), and only one well has upward coarsening signature (well 2) (**Figure 106**).

A map view of the well log patterns shows that the blocky signature dominates in the study area. Coarsening upward sands are surrounded by blocky and fining upward pattern. The serrate pattern is not common in this sequence and is confined to the north side of the field (**Figure 107**).

Net-to-gross map: Net-to-gross map shows a zone of low ratio of net sand in the north that creates a bifurcation of higher net to gross (65 percent). Adjacent to the southeast,

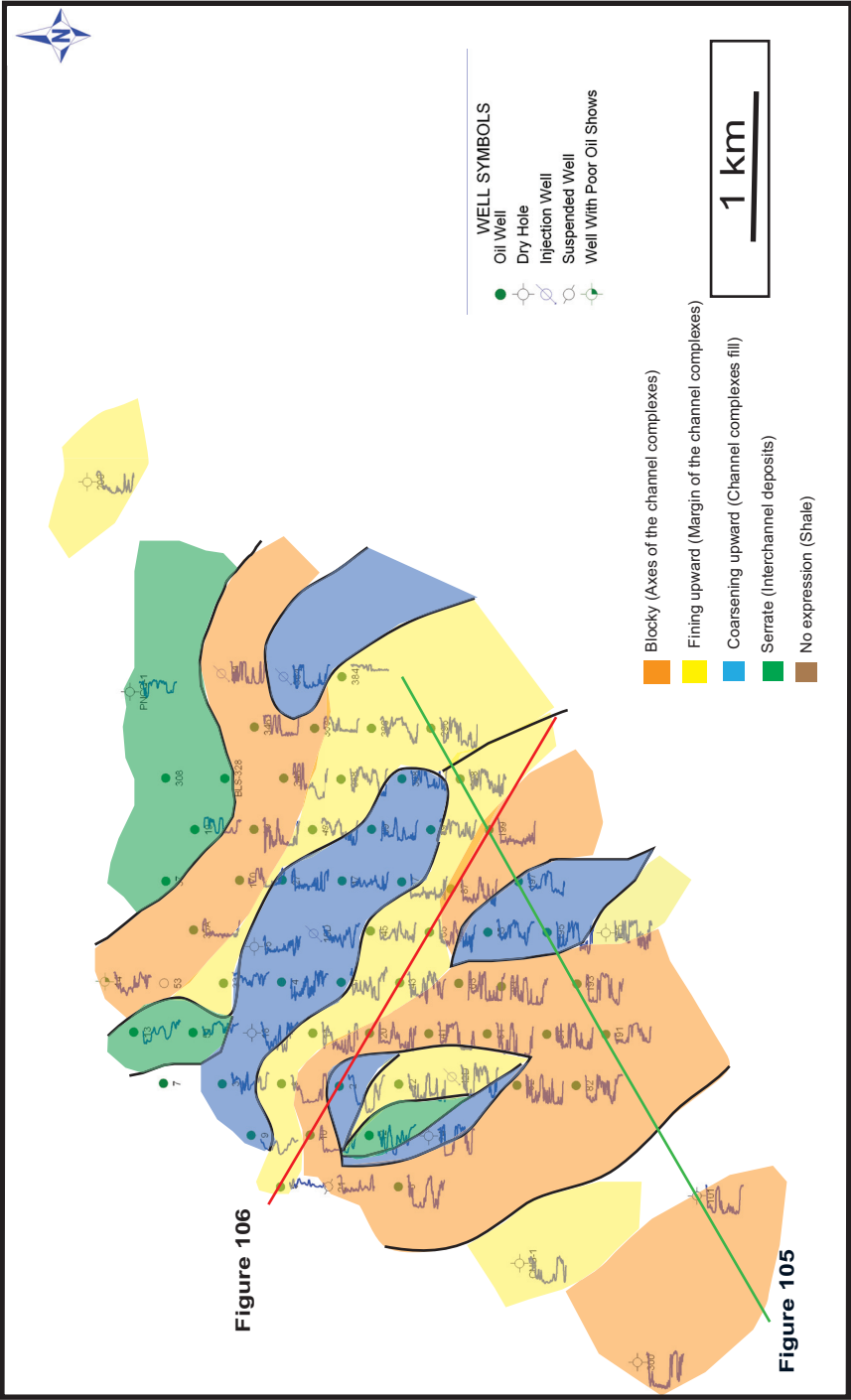


Figure 107. Lithofacies map for sequence 10 (RS-9-RS-10) showing the SP logs. RS-10 is the datum. The more characteristic log signature in this sequence is the blocky pattern, fining upward and coarsening upward present a similar distribution, serrate is less evident in this map. The interpretation is related with amalgamated channel complex fills in a confined area. Blocky represents the zones with more amalgamation (axes of the channel complexes), fining upward is interpreted as margin of the systems, coarsening upward is interpreted as channel deposits and serrate as interchannel deposits. Location of Figures 105 and 106 are shown.

sands with a net-to-gross of less than 1:3 are mostly located in the north, southwest and northeast. Higher values are located in the central zone of the trend (**Figure 108 A**).

Net-sand map: The map shows the major increase in net sand to the central part of the field with values greater than 65 meters with a southwest-northeast trend. Lower values of net sand have a similar orientation to those that shown on the net-to-gross map (**Figure 108 B**).

Seismic Facies: Seismic facies description for this sequence is included with the overlying sequence. This sequence is characterized by two types of seismic facies: one of moderate to high amplitude with high continuity located in the deeper part of the sequence and another of low to moderate continuity with low amplitude located in the shallower part close to the salt body. The sequence was penetrated by nearly all the wells present in the map (**Figure 95**).

Interpretation: This sequence is related to the channels and interchannel deposits. Three main channels are interpreted for the field; the width of this systems is between 400 and 500 meters each. These systems present few shale breaks and therefore the connectivity between the sand is interpreted to be high.

Sequence 11 (RS-10_RS-11)

This sequence is defined at its top by the RS-11 marker. The seismic facies analysis has the same description as the underlying sequence, being below the seismic resolution on the field area. Small eroded zones are interpreted on the upper portion of the sequence in the north and west side.

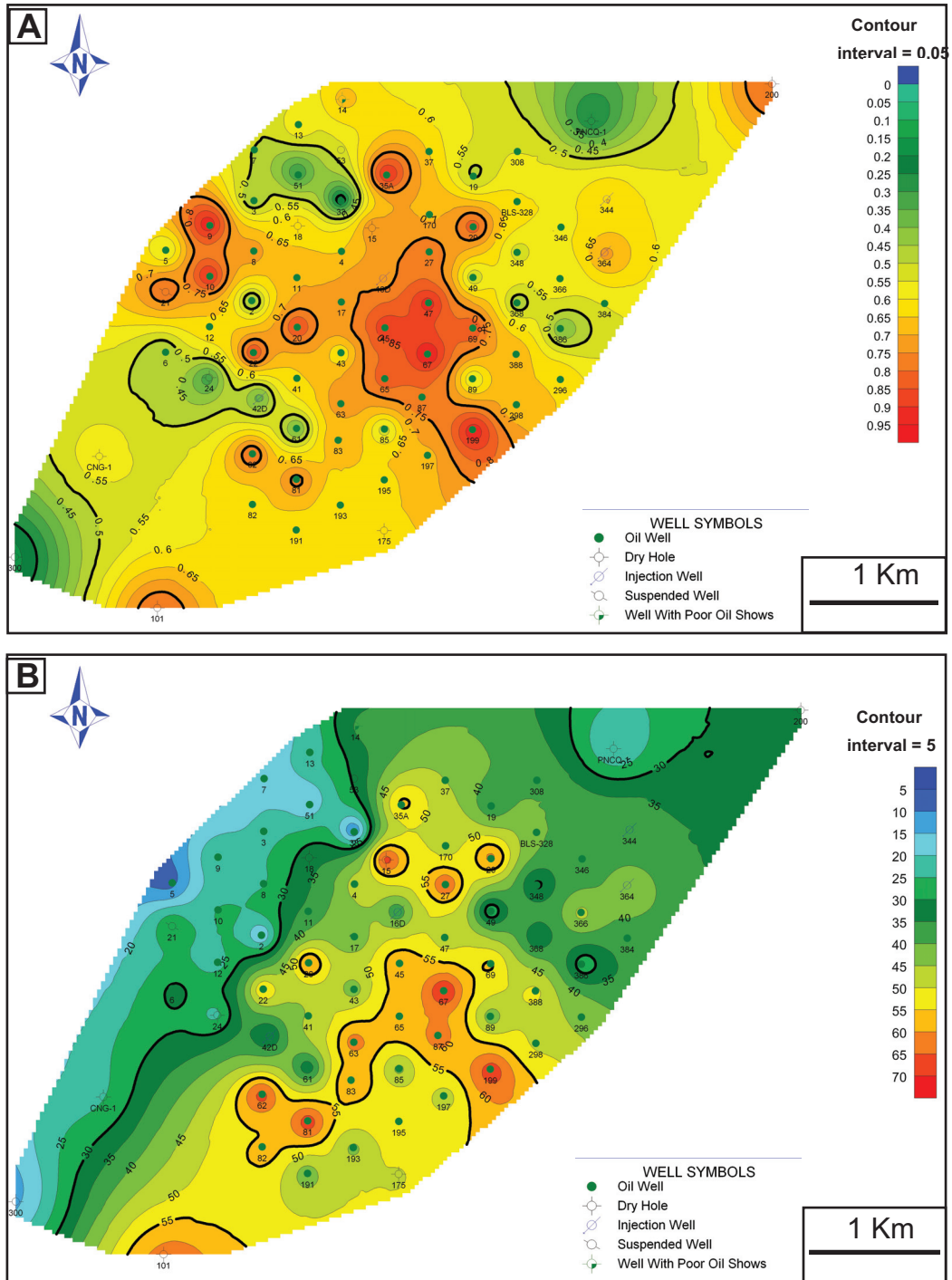


Figure 108. (A) Net-to-gross ratio map from Sequence 10. Contour interval is 0.05
 (B) Net-sand map from Sequence 10. Contour interval is 5 meters.

Time-structure map: The time-structure contour map of the top of the Sequence 11 shows two different fault sets are present. The first set (F1) is located to the east of the study area strikes SE-NW, and dips primarily to the northeast. The second set (F2) strikes with a SW-NE orientation and is located in the eastern part of the field. The deeper part of the sequence is located in the south and is present at 2.3 seconds. The shallower parts are located on both sides of the minibasin with 1.82 seconds in the northwest and 1.6 seconds in the southeast part of the map (**Figure 109**).

Isopach map: Sixty six wells penetrate this sequence. Isopach map shows the thicker sand sections are in the central part of the field and to the south-southeastern part of the field. Maximum thickness is greater than 60 meters and a minimum is less than 35 meters located in the western part of the field (**Figure 110**).

Lithofacies: Two wireline log cross sections illustrate the sequence in strike (**Figure 111**) and dip view (**Figure 112**). The strike section (X1) has eight wells, consisting primarily of a blocky gamma ray pattern only one well is interpreted as fining upward (**Figure 111**). In the dip oriented section (Z6), seven of the eight wells have a blocky pattern, and only the well 2 has a fining upward signature (**Figure 112**).

A map view of the well log patterns shows that the blocky pattern predominates and the fining upward and the coarsening upward are present also with lesser degree (**Figure 113**).

Net-to-gross map: This map shows ratios greater than 0.80 in the central part of the field and a decreasing trend until values less than 0.5 occur in both sides of the field (**Figure 114 A**).

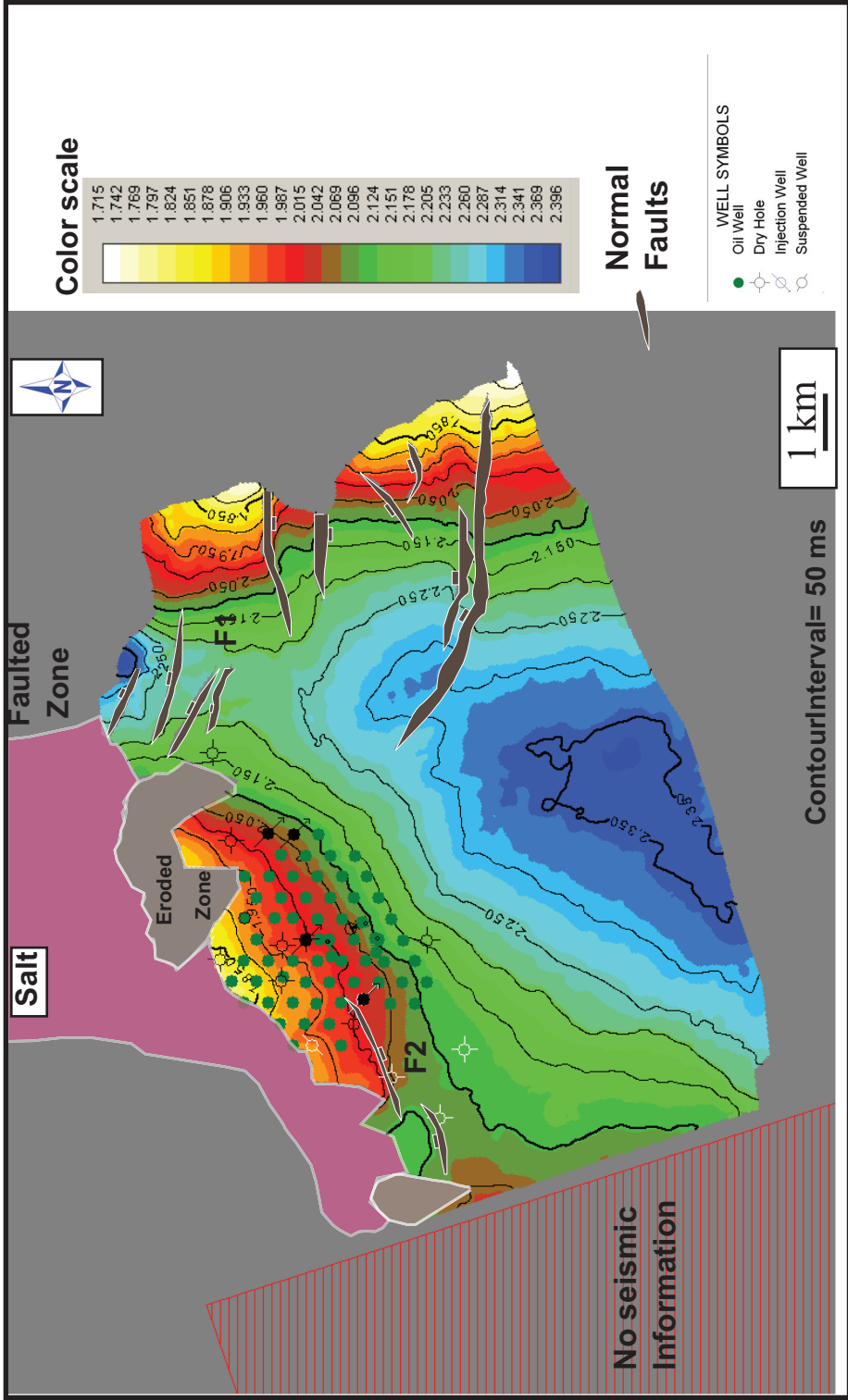


Figure 109. Time-structure contour map (in secs) of the Surface RS-11. Salt body interpreted is located in the north-west part of the field. Eroded zones are present in the north and west side of the field. Two set of fault are present the first is located in the northeast part strike NW-SE and dips to the northeast. The second set is present in the west side strikes SW-NE and dips to the north and south. Wells are shown in green dots.

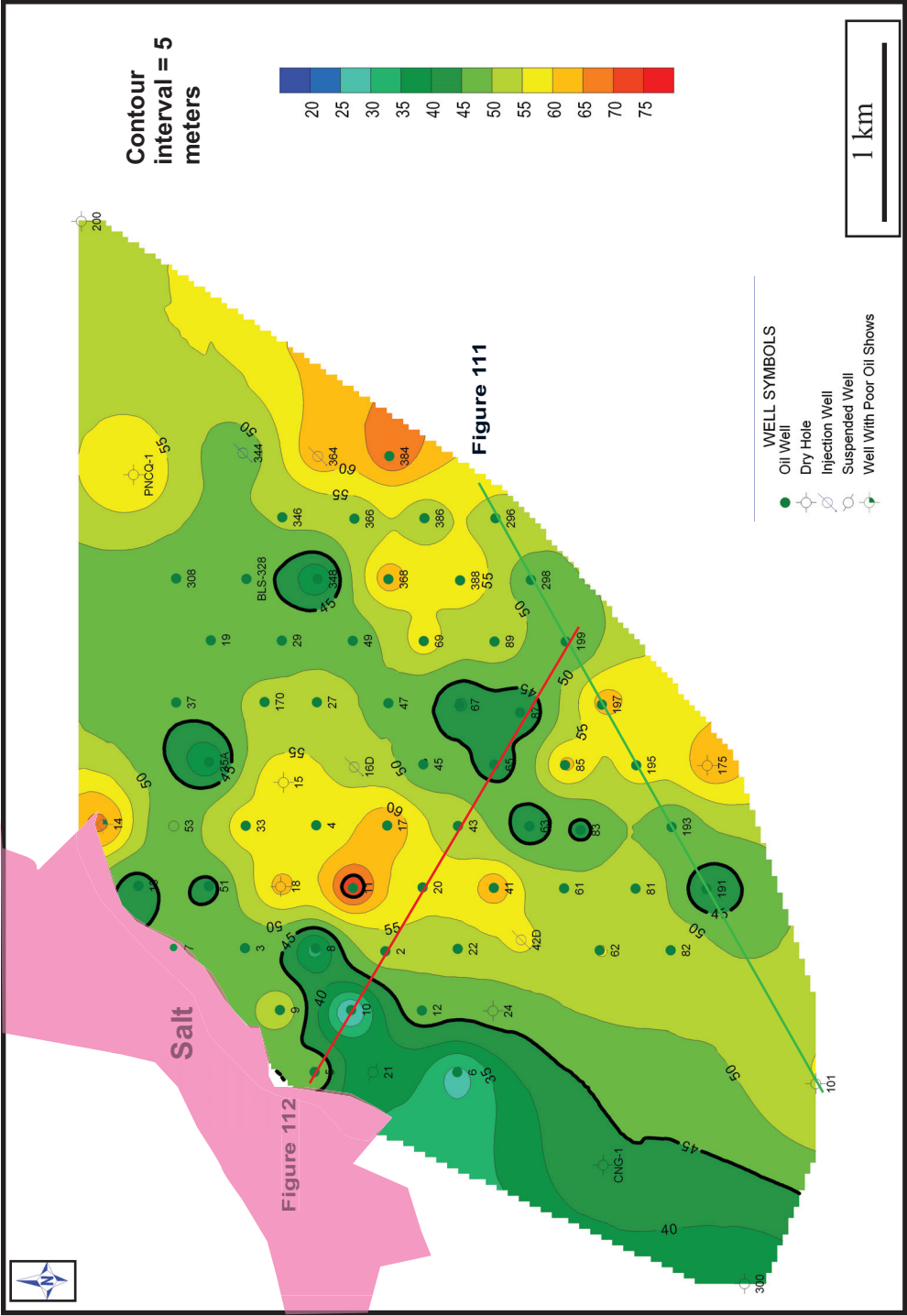


Figure 110. Isopach map of the Sequence 11 in the Blasillo field. Contour interval 5 meters. Wells are shown by green dots. Location of Figures 111 and 112 are shown.

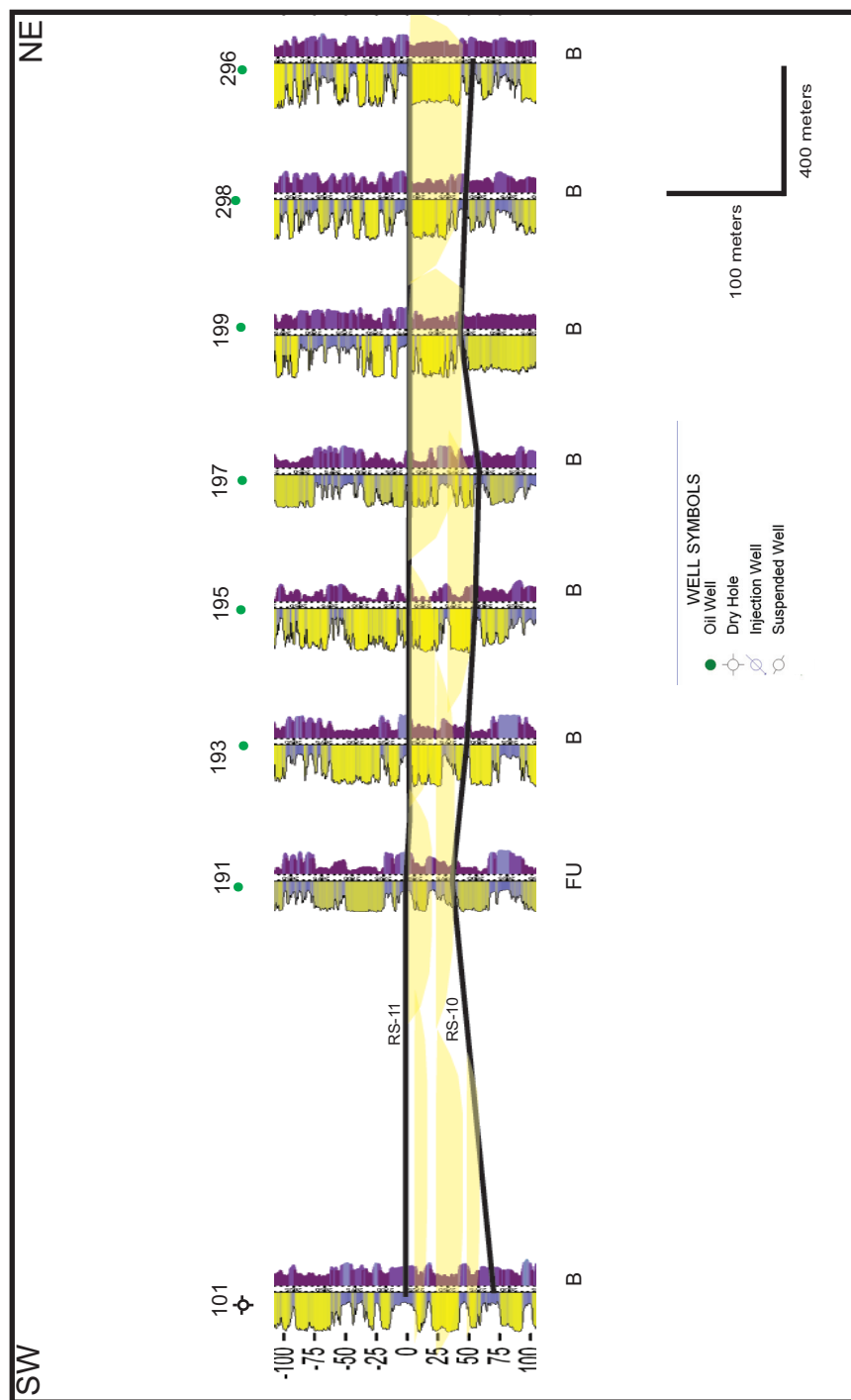


Figure 111. Wireline log cross section showing the Sequence 11 (RS-10_RS-11). RS-11 is the datum. SP and resistivity curves are shown. Lateral changes in the log signature are evident, blocky pattern is the log signature more representative in this sequence. An interpretation of the sandstone distribution is shown in yellow. See Figures 110 and 113 for location of section.

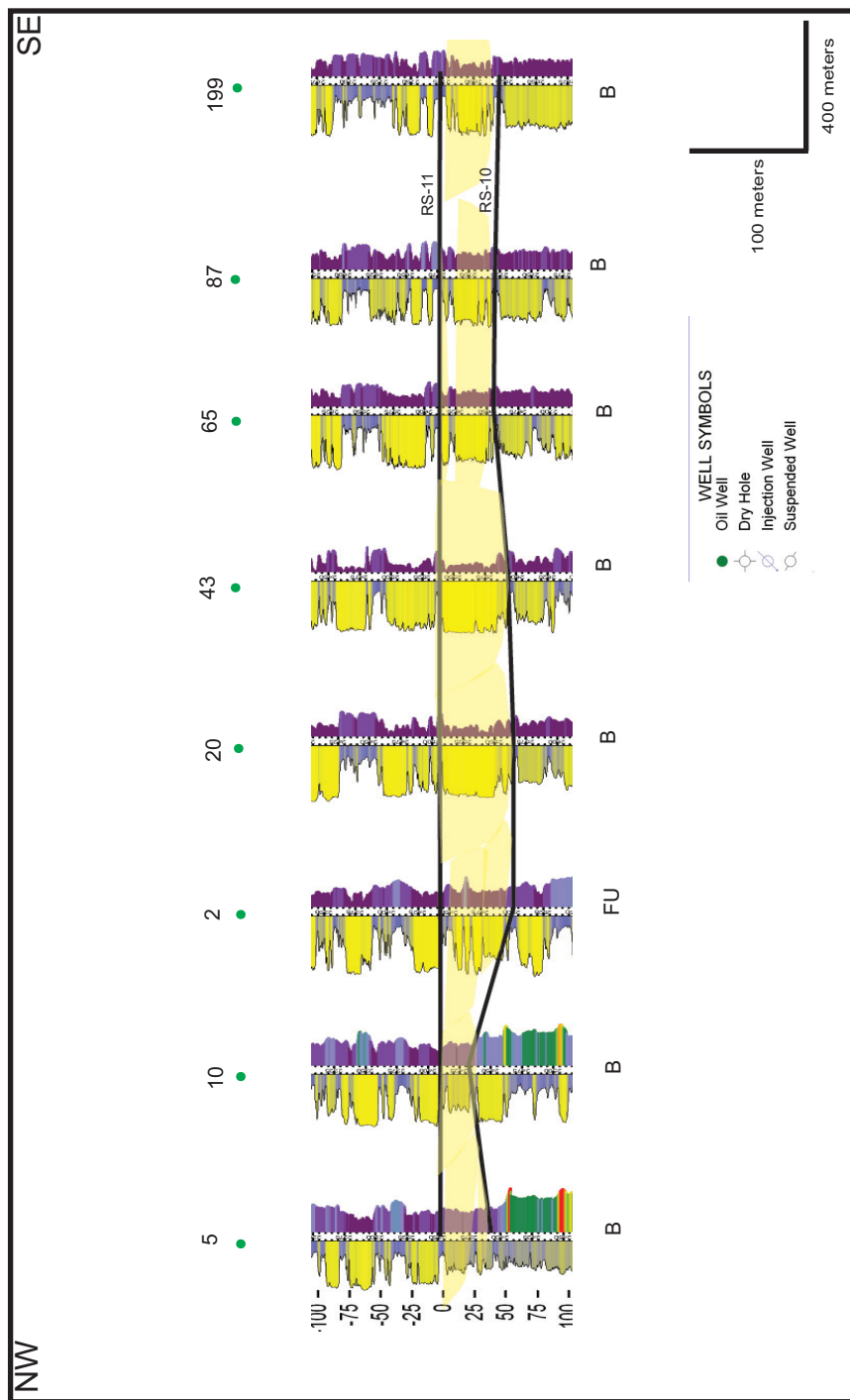


Figure 112. Wireline log cross section showing the Sequence 11 (RS-10_RS-11). RS-11 is the datum. SP and resistivity curves are shown. This sequence has a high net to gross ratio, blocky pattern is the more common some sand packages have values close to 50 meters sequence is thinner in both side of the section. An interpretation of the sandstone distribution is shown in yellow. See Figures 110 and 113 for location of section.

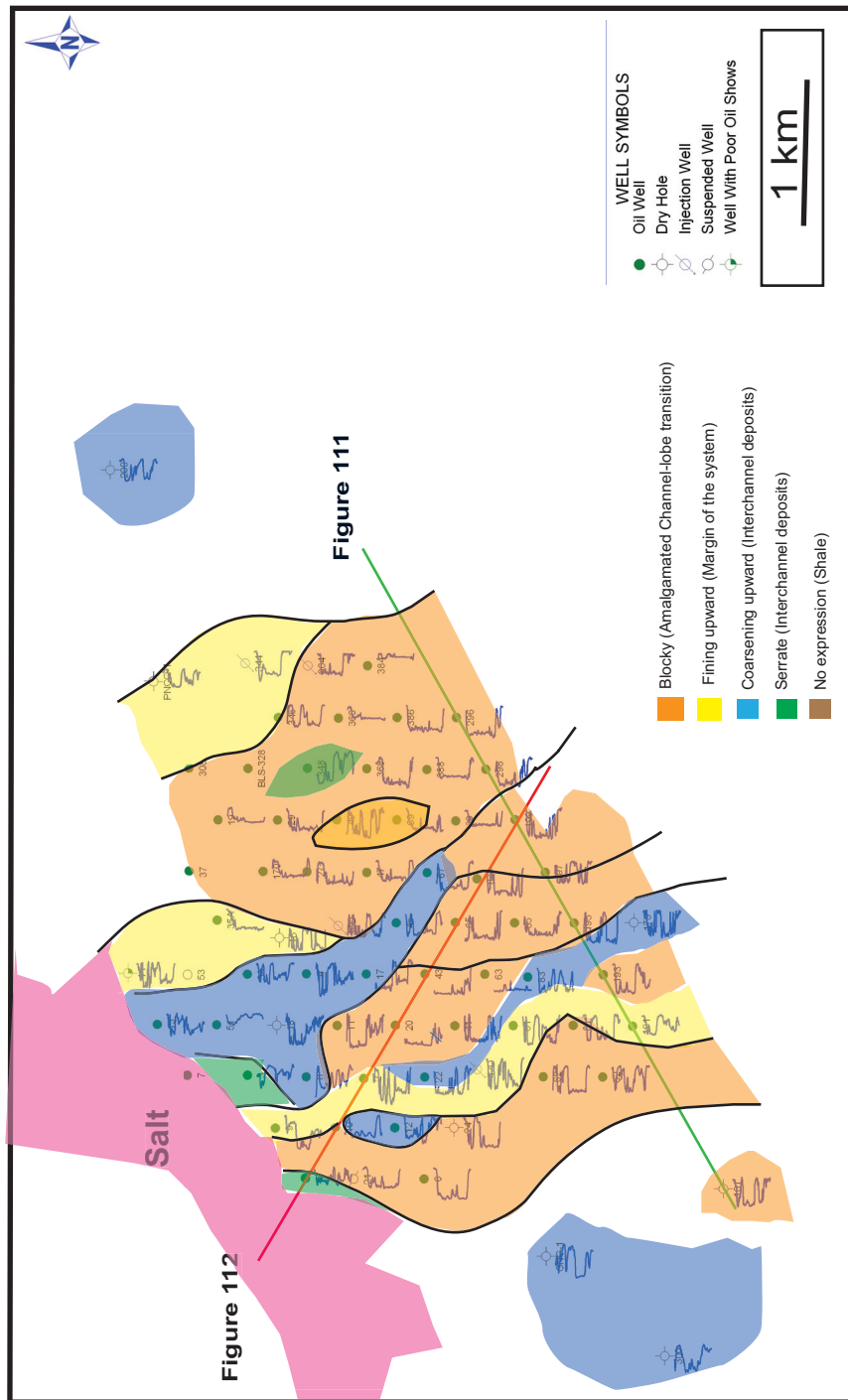


Figure 113. Lithofacies map of the Sequence 11 showing the SP logs. Blocky pattern is the log signature more characteristic in this sequence, inside the field, fining upward and coarsening upward pattern are present between blocky patterns. The interpretation is related with amalgamated channel complex fills that start to change to a channel lobe transition zone in a weakly confined system, blocky pattern is interpreted as the main zone of amalgamation (axis), fining upward is interpreted as margin of the systems and coarsening upward and serrate are interpreted as inter-channel fills. Location of Figures 111 and 112 are shown.

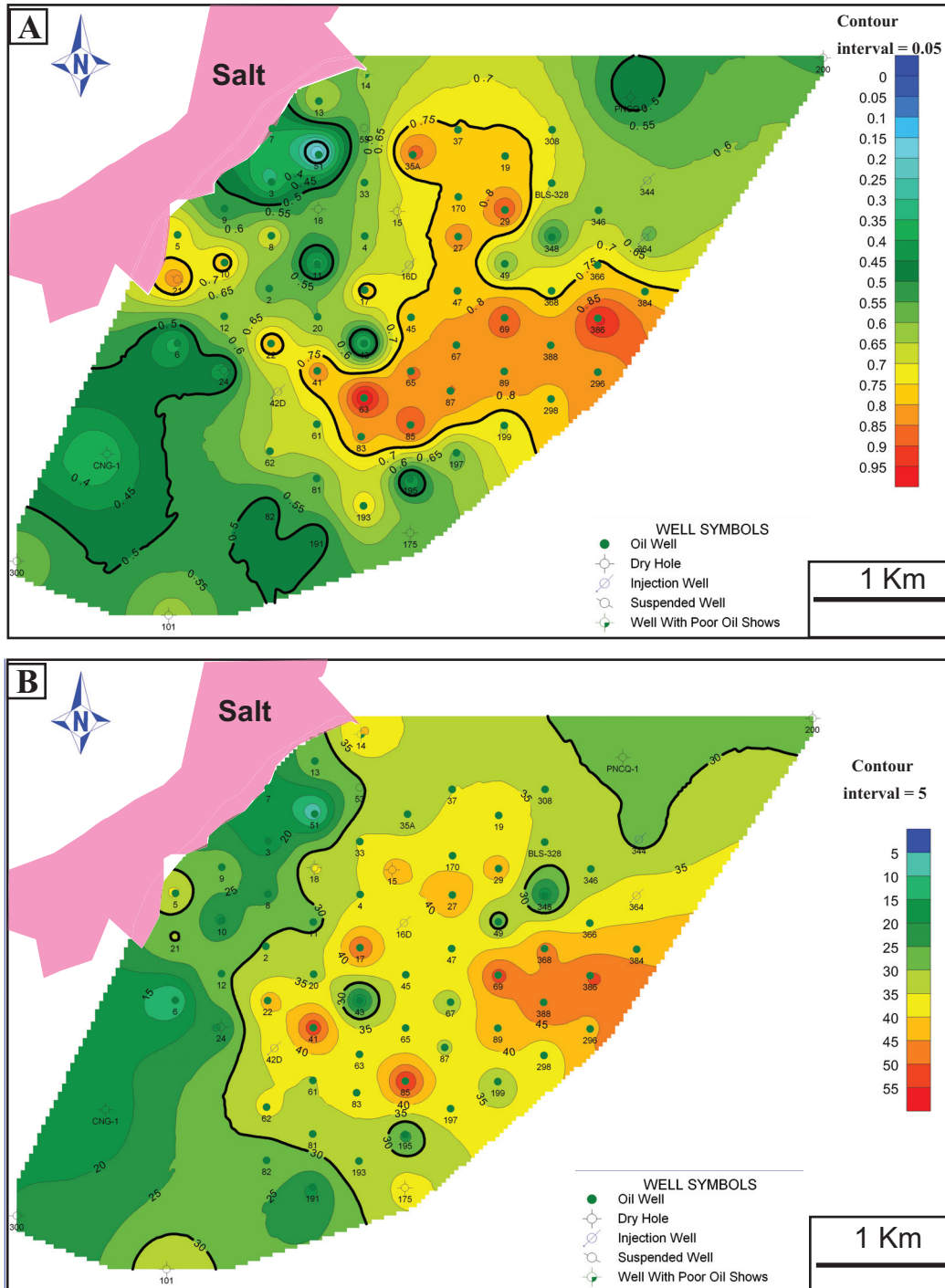


Figure 114. (A) Net-to-gross ratio map from Sequence 11. Cotour interval is 0.05. (B) Net-sand map from Sequence 11. Contour interval is 5 meters.

Net-sand map: This map indicates that the higher values of net sand (greater than 40 meters), are located in the central southeast part of the field. These values decrease laterally with sand less than 20 meters in the NW part of the field (**Figure 114 B**).

Seismic Facies: The field is characterized by two types of seismic facies: one of moderate to high amplitude with good continuity located in the lower part of the sequence and another of low-to moderate continuity, low amplitude located in the shallower part close to the salt body. This sequence was penetrated by nearly all the wells present in the map (**Figure 95**).

The amplitude map that is most representative of this sequence is from an extraction window of 30 milliseconds below the RS-11 horizon. This amplitude extraction map shows two main amplitude trends near the field one from the south-south east and the other from the southeast. One of the features interpreted in this map is that the amplitude trends increase in width by three times at the field. In the northern part of the field, the amplitude is less pronounced in comparison to the surrounding sediments (**Figure 115 A, B**).

Interpretation: Two major channel systems are identified that extend from the southeast part of the map towards the field. Down dip (SW-NE), these systems begin wider and the system farther north seems to have a bifurcation within the field. The seismic amplitude is less continuous possibly caused by the high sand content of facies within the field due to less impedance contrast. Thus, these systems are lately related with channels in the dip up position that start to spread to more depositional lobe at the field.

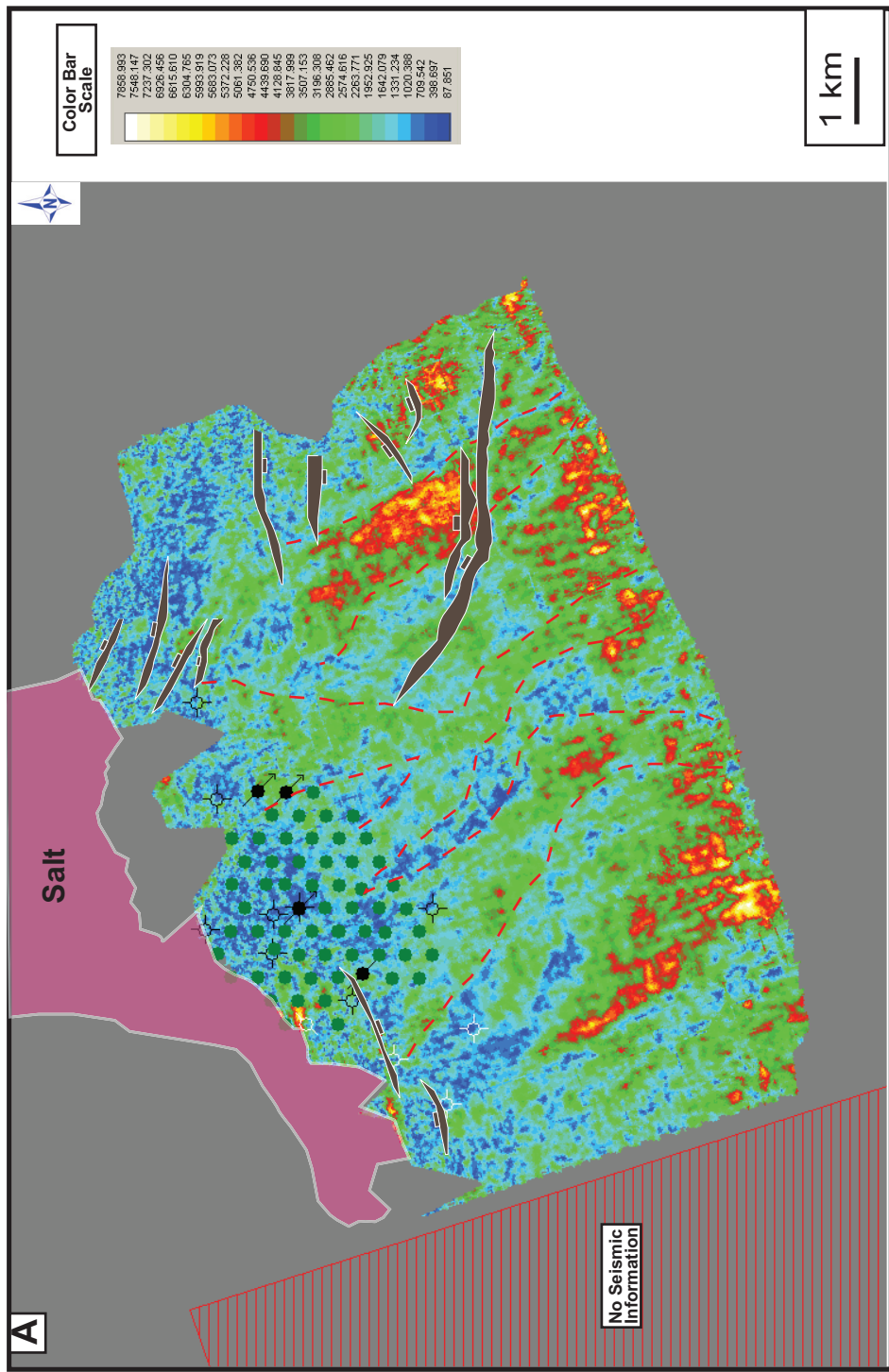


Figure 115. RMS amplitude extraction map from a gated window 20 ms below the Horizon RS-11. **A)** With well location plotted. **B)** With no wells plotted. Two systems are identified coming to the field from the southwest and is evident the change of the width when they are arriving to the field, one of them (Right) seems to present a bifurcation before arrives to the field. These systems are interpreted as channel complexes starting to have lobe shape or systems in a channel lobe-transition.

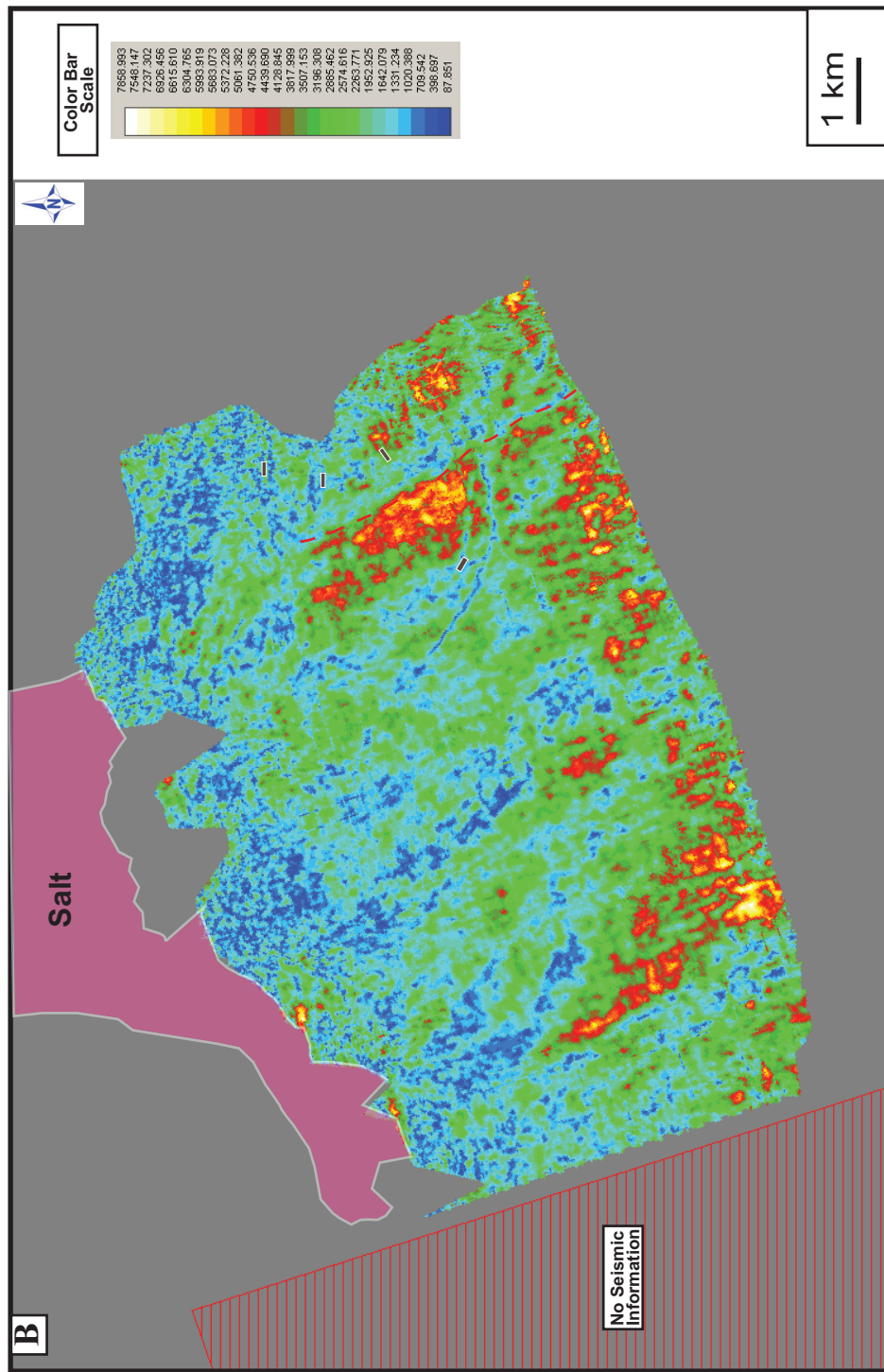


Figure 115 B.

Sequence 12 (RS-11_RS-12)

This sequence is not partially eroded as the two underlying sequences and, therefore can be shown in the time-structure map.

Time-structure map: A time-structure contour map of the top of the horizon -RS-12 shows the presence of the salt body in the north. Two set of faults are present. The first set (F1) is present to the east, strike southeast-northwest, and dip primarily to the northeast. The second set of faults (F2) has a southwest-northeast orientation. The deepest part of this horizon is located in the northeastern. A deeper zone is located below the field (2.29 seconds); this zone gradually changes to shallower position in both sides of the depression reaching values of 1.78 seconds in the field area and less than 1.60 seconds on the opposite side (**Figure 116**).

Isopach map: Sixty six wells penetrate this sequence. The isopach map of this sequence shows thicknesses less than 40 meters in the north. The thickness in the rest of the field is about 65-70 meters with the exception of well 200 in the northeast which gas greater thickness (**Figure 117**).

Lithofacies: Two wireline log cross sections illustrate the sequence in strike (**Figure 118**) and dip views (**Figure 119**). The strike section (X1) shows eight wells with different log signatures; most show blocky and serrate patterns (**Figure 118**). In the dip section (Z5), the eight wells have blocky and fining upward patterns as the more characteristic log signature. A serrate pattern is present in only one well (199) (**Figure 119**).

A map view from this sequence shows the blocky patterns as the more dominant log signature, with some fining upward signatures. Serrate patterns are only present in a

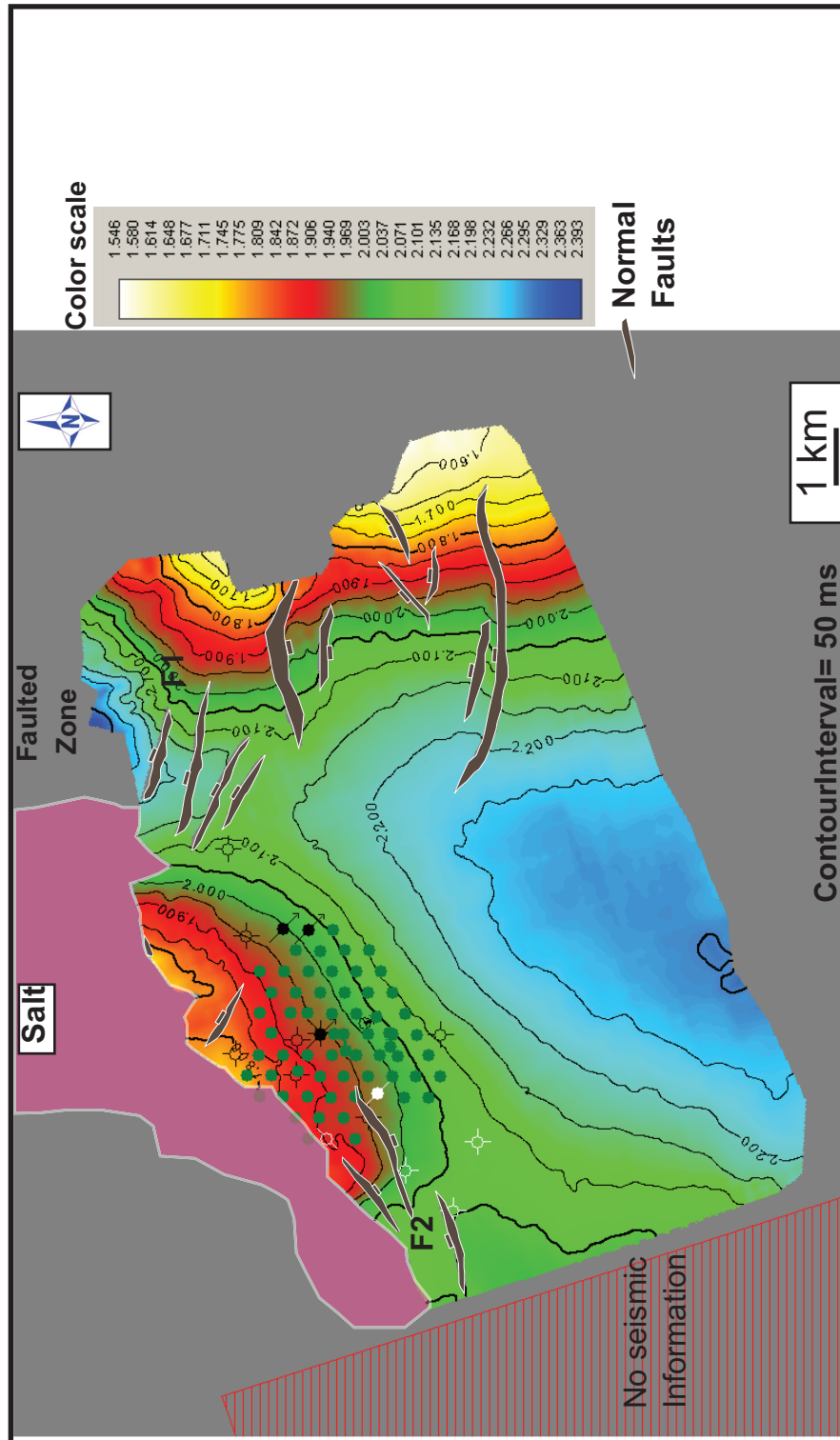


Figure 116. Time-structure contour map (in secs) of the Surface RS-12. Salt body interpreted is located in the north-west part of the field (pink). Two set of faults are interpreted. The first set strikes NW-SE and dips to the northeast and is located in the northeast and southeast. The second set is present in the west side strikes SW-NE and dips to the north and south. Wells are shown in green dots.

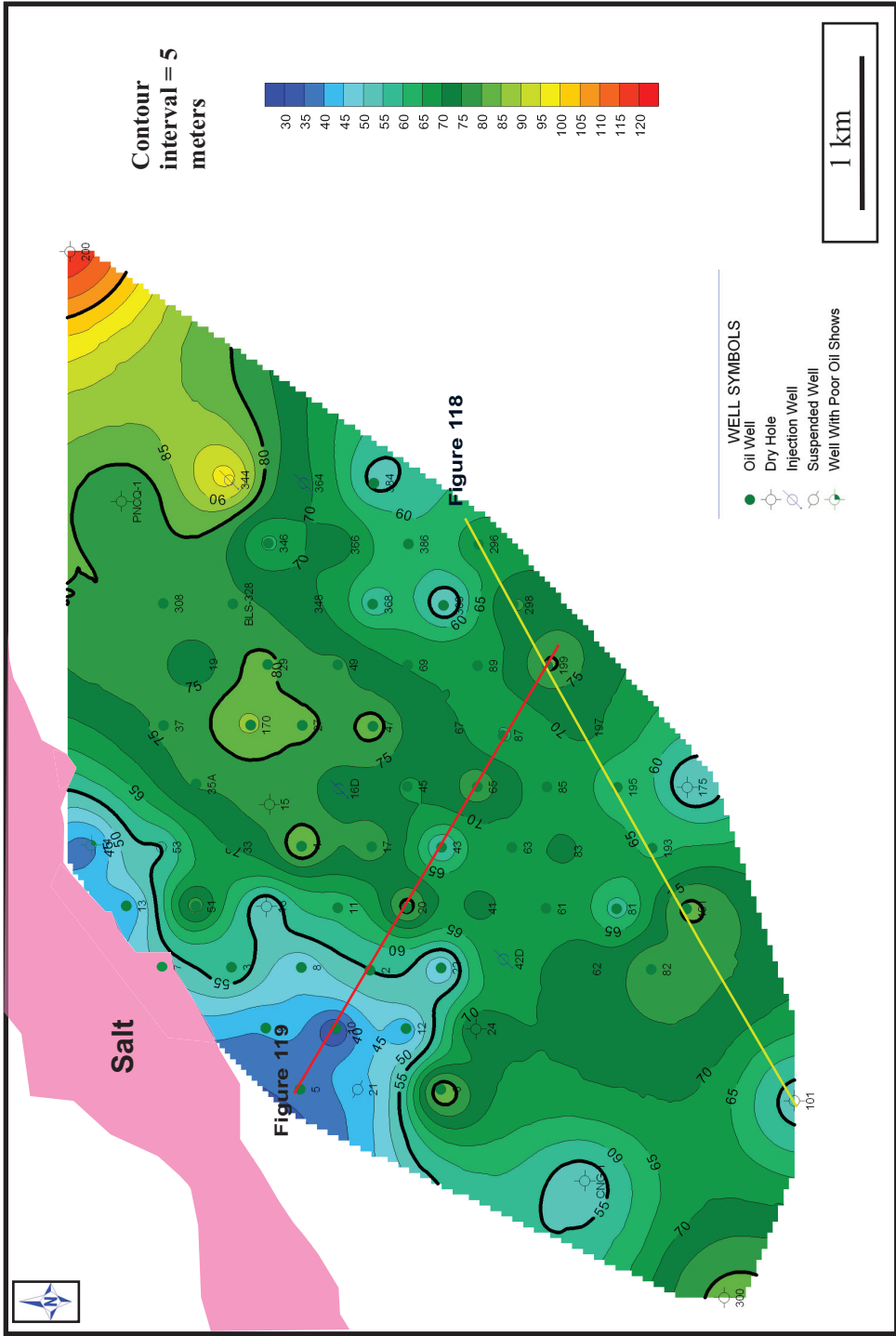


Figure 117. Isopach map of the Sequence 12 in the Blasillo field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 118 and 119 are shown.

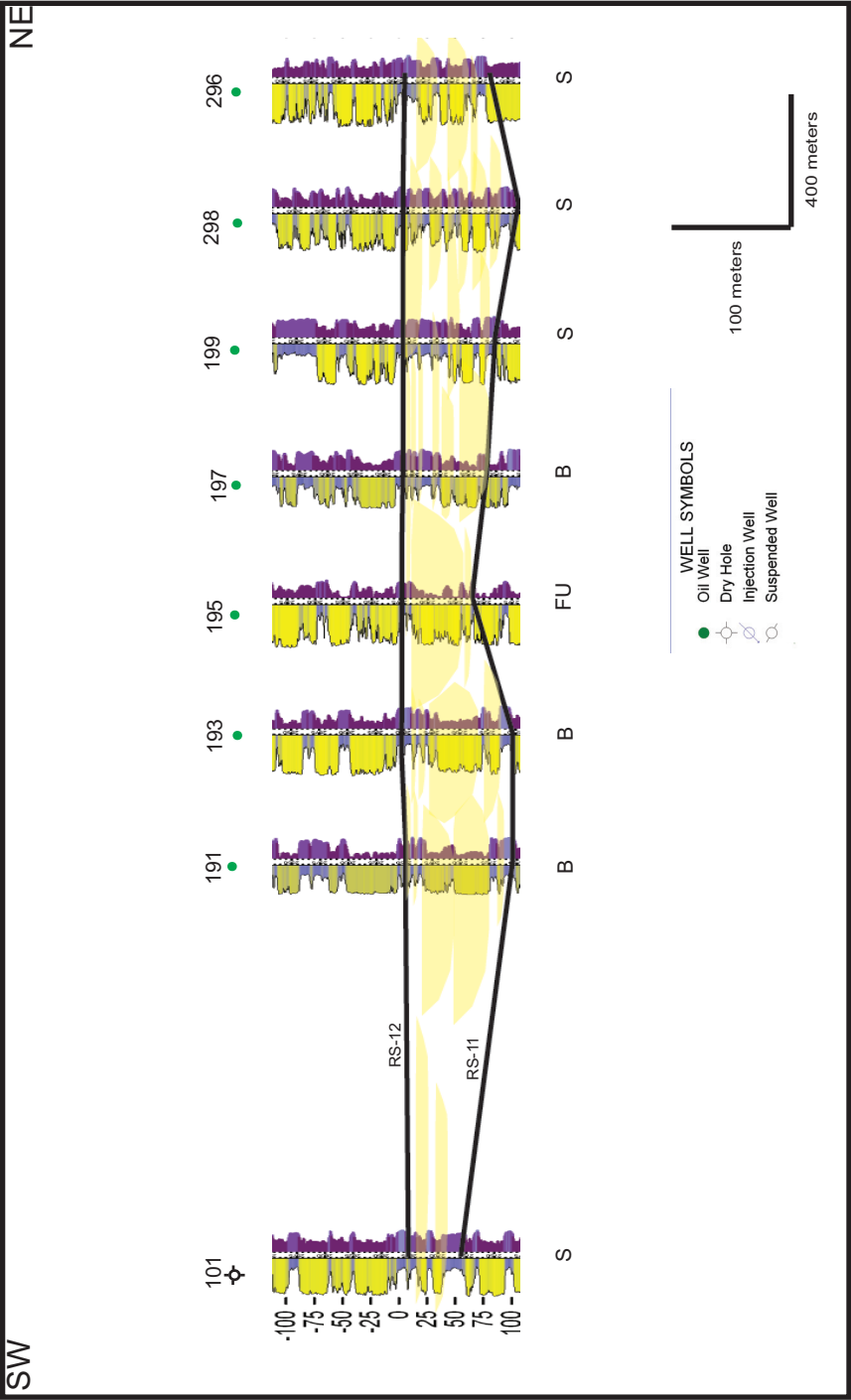


Figure 118. Wireline log cross section showing the sequence 12 (RS-11_RS-12). RS-12 is the datum. SP and resistivity curves are shown. Lateral changes in the log signature are evident. An interpretation of the sandstone distribution is shown in yellow. See Figures 117 and 120 for location of section.

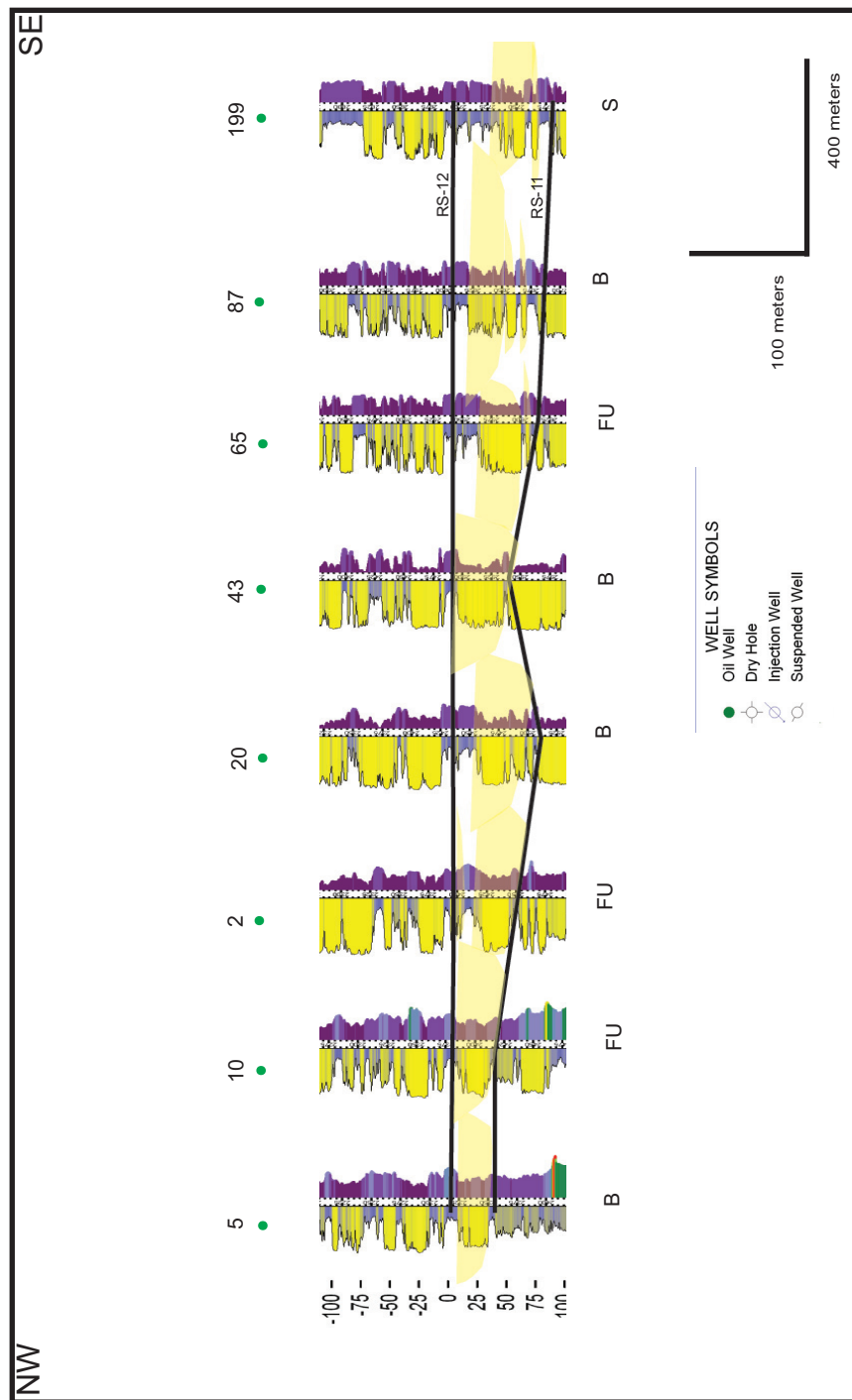


Figure 119. Wireline log cross section showing the sequence 12. (RS-11_RS-12). RS-12 is the datum. SP and resistivity curves are shown. This sequence has a high net to gross ratio blocky pattern is the more common. An interpretation of the sandstone distribution is shown in yellow. See Figures 117 and 120 for location of section.

few zones and the coarsening upward signature is the less developed than the other two (**Figure 120**).

Net-to-gross map: The net-to-gross map shows ratios lower than 0.45 flanking values greater than 0.55 in the central part of the field (**Figure 121A**). Higher values are located in the northern and southern parts of the field. The Well 200 presents a ratio greater than 75 percent (**Figure 121 A**).

Net-sand map: The net-sand map shows similar trends to the net-to-gross map. In the middle of the field, values higher than 40 meters are being flanked by thicknesses less than 35 m. In this map, higher values occur in both edges of the field (to the southwest and northeast), net sand values increase toward well number 200 (**Figure 121B**).

Seismic Facies: The vertical profile illustrates only one seismic facies: low amplitude with moderate to high continuity. The shallower part of the section near to the salt body sometimes has less continuity within the reflections. The sequence was penetrated by nearly all the wells present in the map (**Figure 122**).

Amplitude extraction map of this interval shows trends of anomalies from the southeast toward the field. These trends are straight and are very close each other appearing to be merging in the eastern part of the field. Anomaly trends of identified in the western part look more parallel but some trends start to have a wider expression (**Figure 123 A, B**).

Interpretation: Interpretation for this sequence is related with channel fill complexes in a weakly confined area. Two main channel systems are present up slope that appears to be shifting from west to east through this. The eastern channel system is interpreted

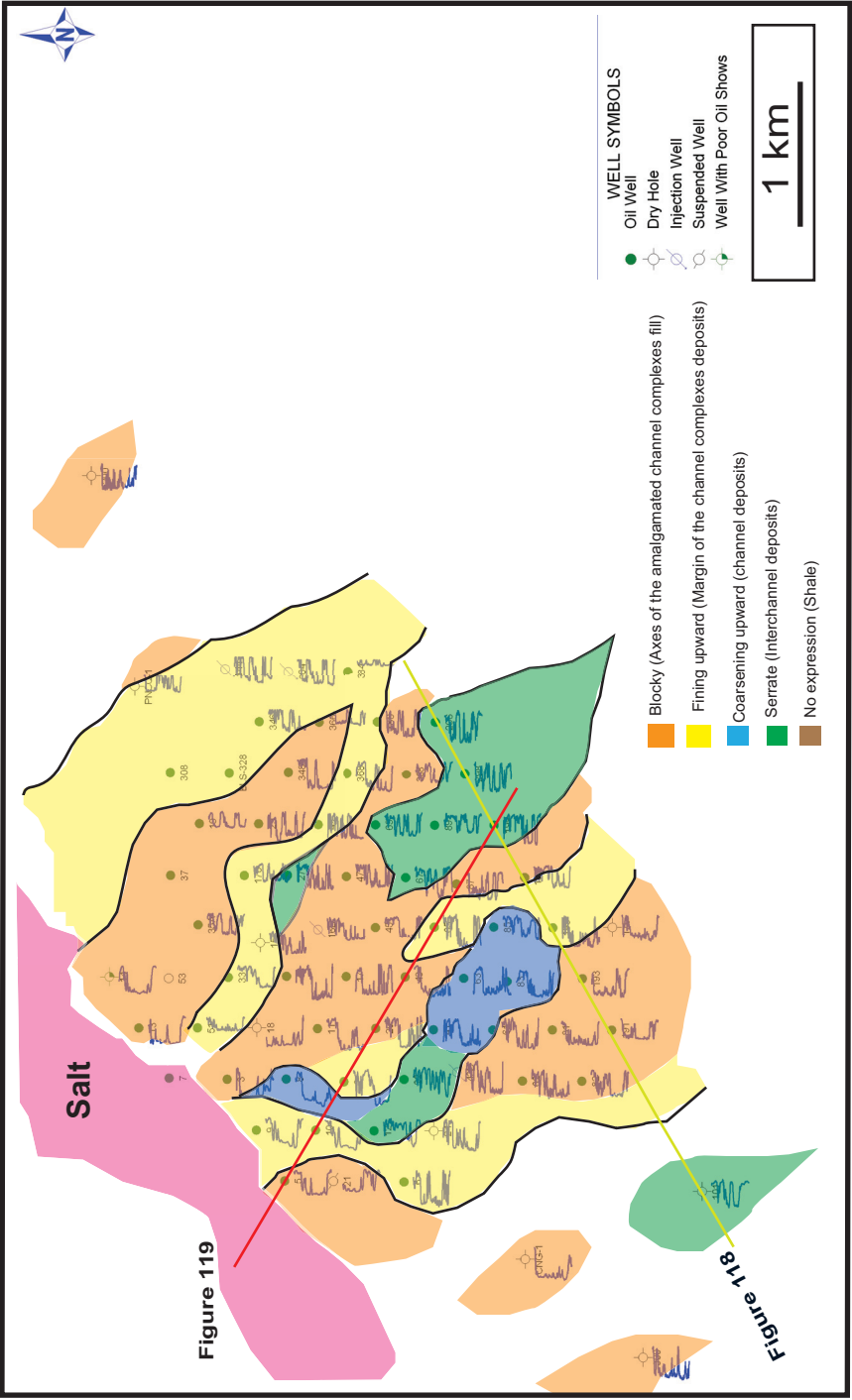


Figure 120. Lithofacies map of the sequence 12 showing the SP logs. Blocky singature is the main characteristic in this sequence, the fining upward is the second signature present in the well logs, coarsening upward and serrate are present in a lower relation. Amalgamated channel complex fills in a weakly confined area. Fining upward is interpreted as channel margin, coarsening upward is interpreted as channel complexes deposits and serrate is interpreted as interchannel deposits and blocky signature as the zone with more amalgamation. Location of Figures 118 and 119 are shown.

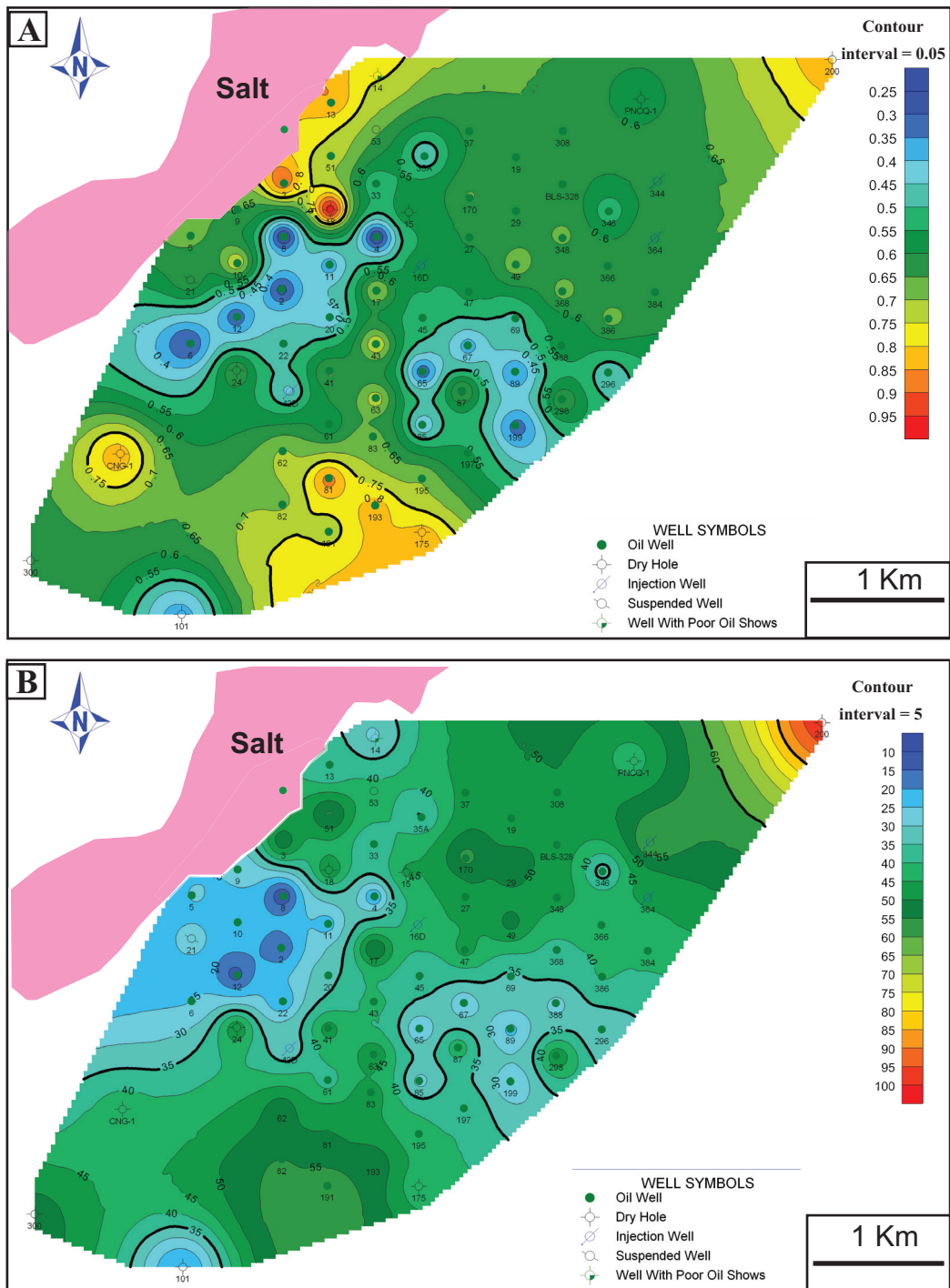


Figure 121. (A) Net-to-gross ratio map from Sequence 12. Contour interval is 0.05.
(B) Net-sand map Sequence 12. Contour interval is 5 meters

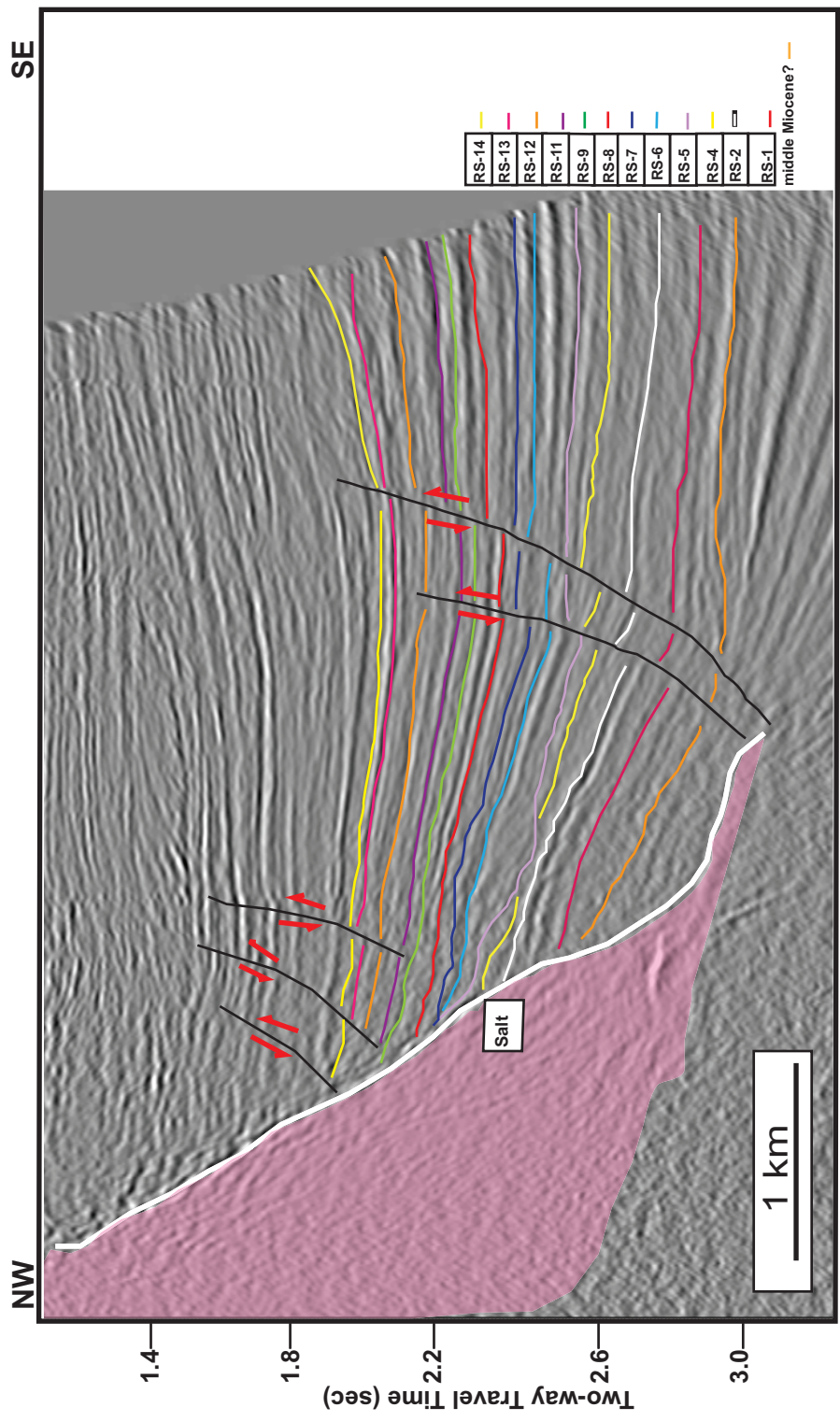


Figure 122. Seismic profile showing the interpreted sequences in the main production zone from the Blasillo field from RS-14 to middle Miocene. Production zone is located in the flank of a salt body (pink). Hrzs RS-5 eroded partially the lower sequence and show a stacking pattern of lateral migration. See Figure 96 for location of profile.

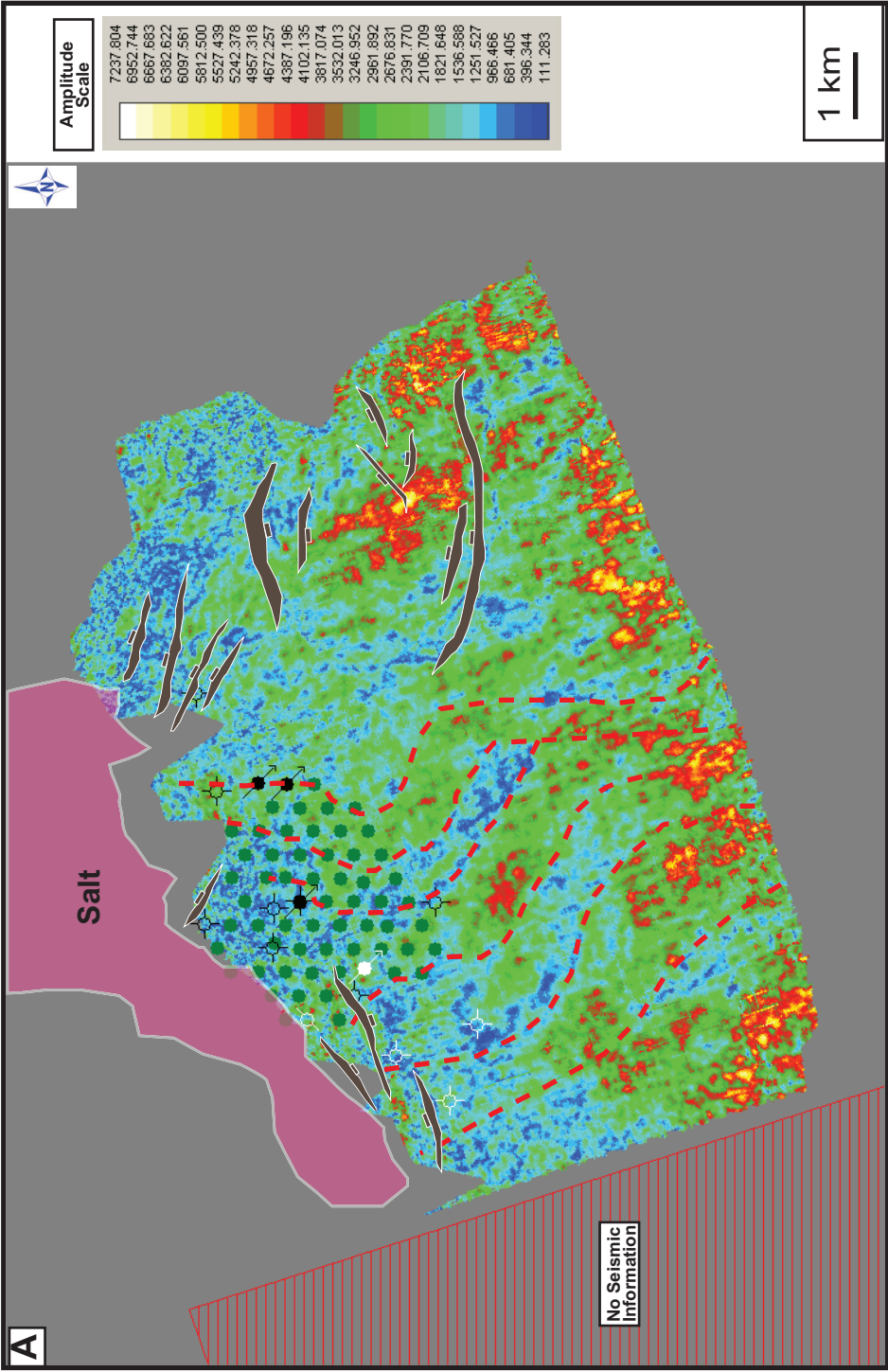


Figure 123. RMS amplitude extraction map from a gated window 30 ms above the Horizon RS-11. A) With well location plotted. B) With no wells plotted. Three different systems are outlined interpreting channels complex fill the origin of the sedimentary supply for these channel complexes are very close and the trend present a SE_NW orientation.

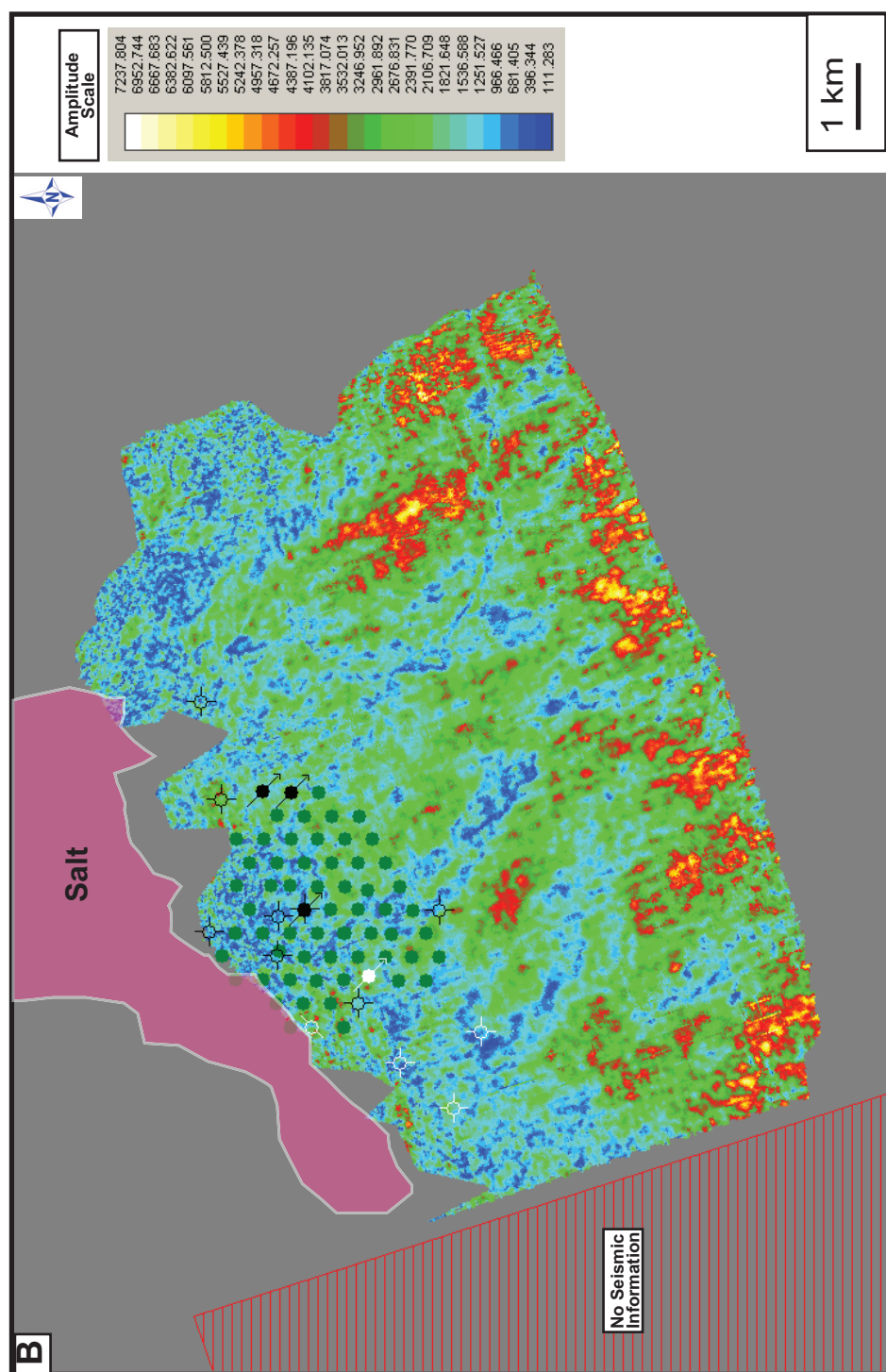


Figure 123 B.

as a sinuous shape. The main channel is interpreted about 800 meters wide in the central part.

Sequence 13 (Rs-12_RS-13)

For this sequence, the northern side of the field are bounded by a thin salt body, a large eroded zone, and a fault zone (**Figure 124**).

Time-structure map: A time-structure contour map of the top of the horizon -RS-13 shows the presence of a thin salt body to the north. The field is located in the northern part bounded by the flank of the salt body and an eroded zone. There are two set of faults. The first set (F1) with a northwest-southeast orientation and the other set (F2) with almost west-east orientation. The first group of faults is located in the south east and east from the field. The second set of faults is located in the east part of the field and close to the field in its western extension. At the deepest part of this map to the southern part of the field (2.22 seconds TWTT) the faults strike southwest-northeast. This zone has a gradual change until shallower positions in both sides of the depression reaching values lower than 1.75 seconds on both sides of the map (**Figure 124**).

Isopach map: Sixty six wells penetrate this sequence. Isopach map from this sequence shows the higher thickness in the SW portion of the field with a value greater than 85 meters and the lower values are towards the north reaching a low of 26 meters (**Figure 125**).

Lithofacies: Two wireline log cross sections illustrate the sequence in strike (**Figure 126**) and dip views (**Figure 127**). The strike section (X1) shows 8 wells. The blocky and coarsening upward patterns are the dominant log signature on this section. The lack of

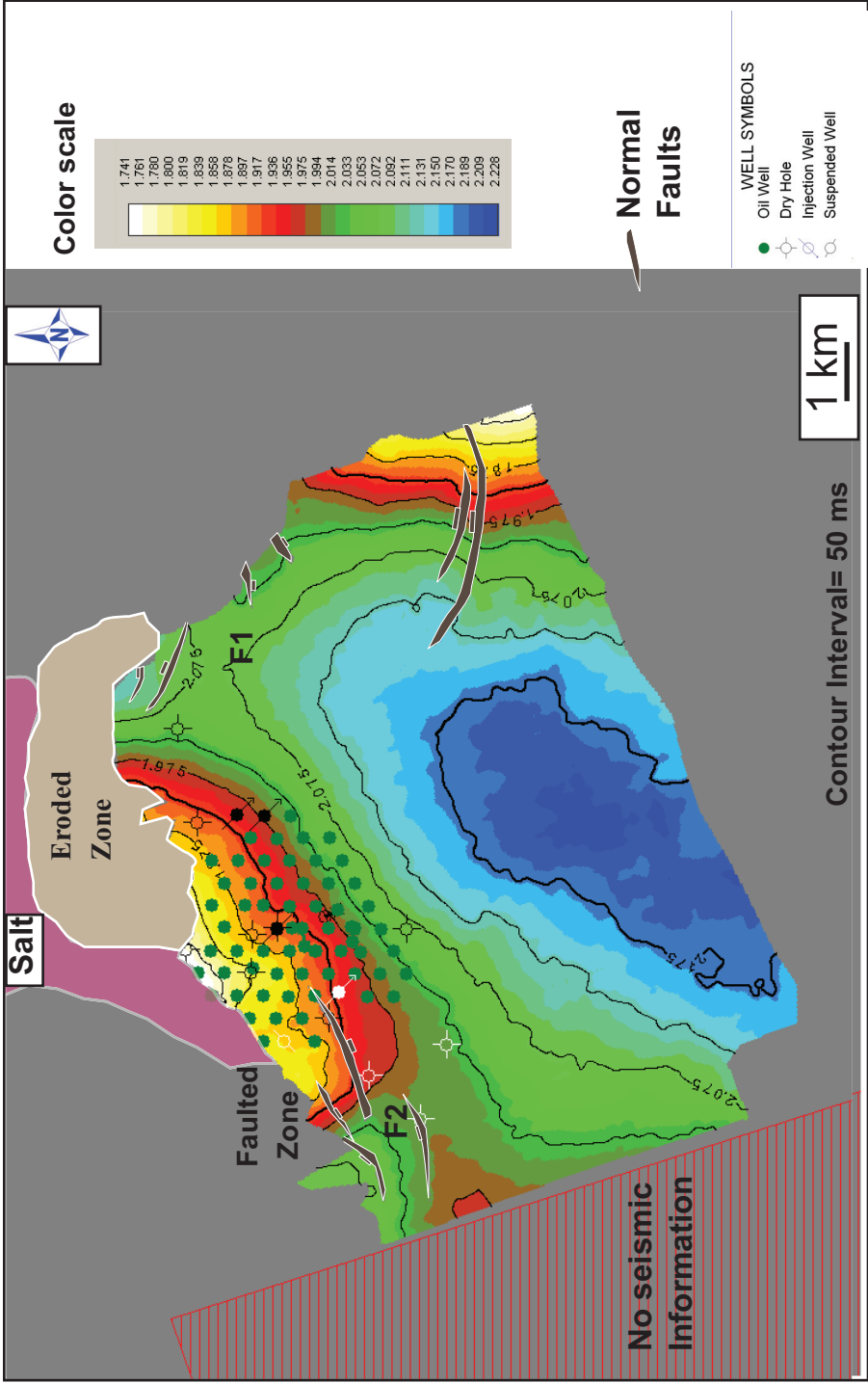


Figure 124. Time structure contour map (in secs) of the Surface RS-13. A salt body interpreted is located in the north-northwest part of the field. An eroded zone interpreted is located in the north-northeast side of the field. Two set of faults are interpreted. The first set strikes NW-SE and dips to the northeast is located in the northeast and southeast. The second set is present in the west side strikes SW-NE and dips to the south. Wells are shown in green dots.

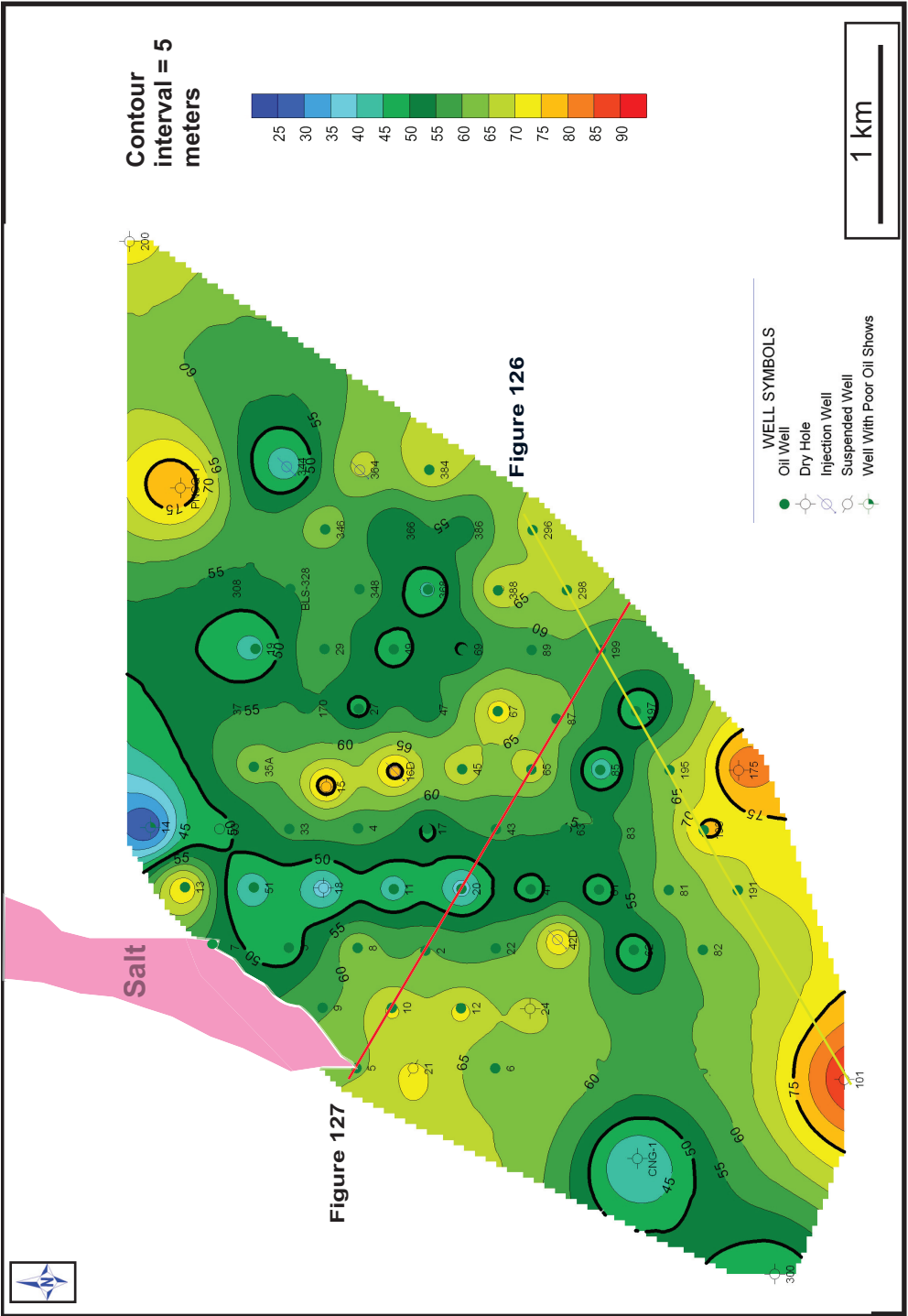


Figure 125. Isopach map of the Sequence13 in the Blasillo Field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 126 and 127 are shown.

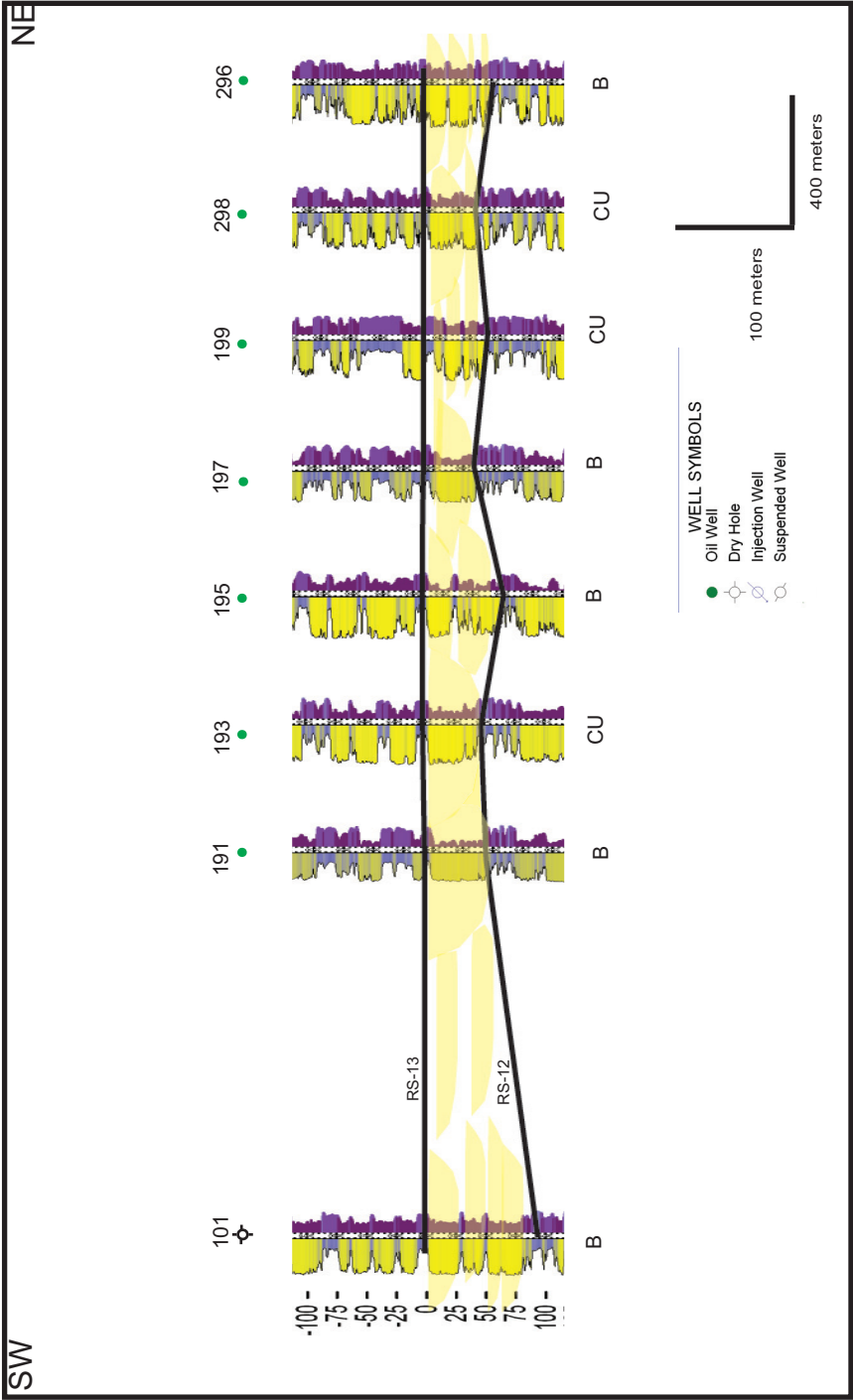


Figure 126. Wireline log cross section showing the sequence RS-12 to RS-13. RS-13 is the datum. SP and resistivity curves are shown. Lateral changes in the log signature are evident. Blocky pattern and coarsening upward signature are representative in this section. An interpretation of the sandstone distribution is shown in yellow. See Figures 125 and 128 for location of section.

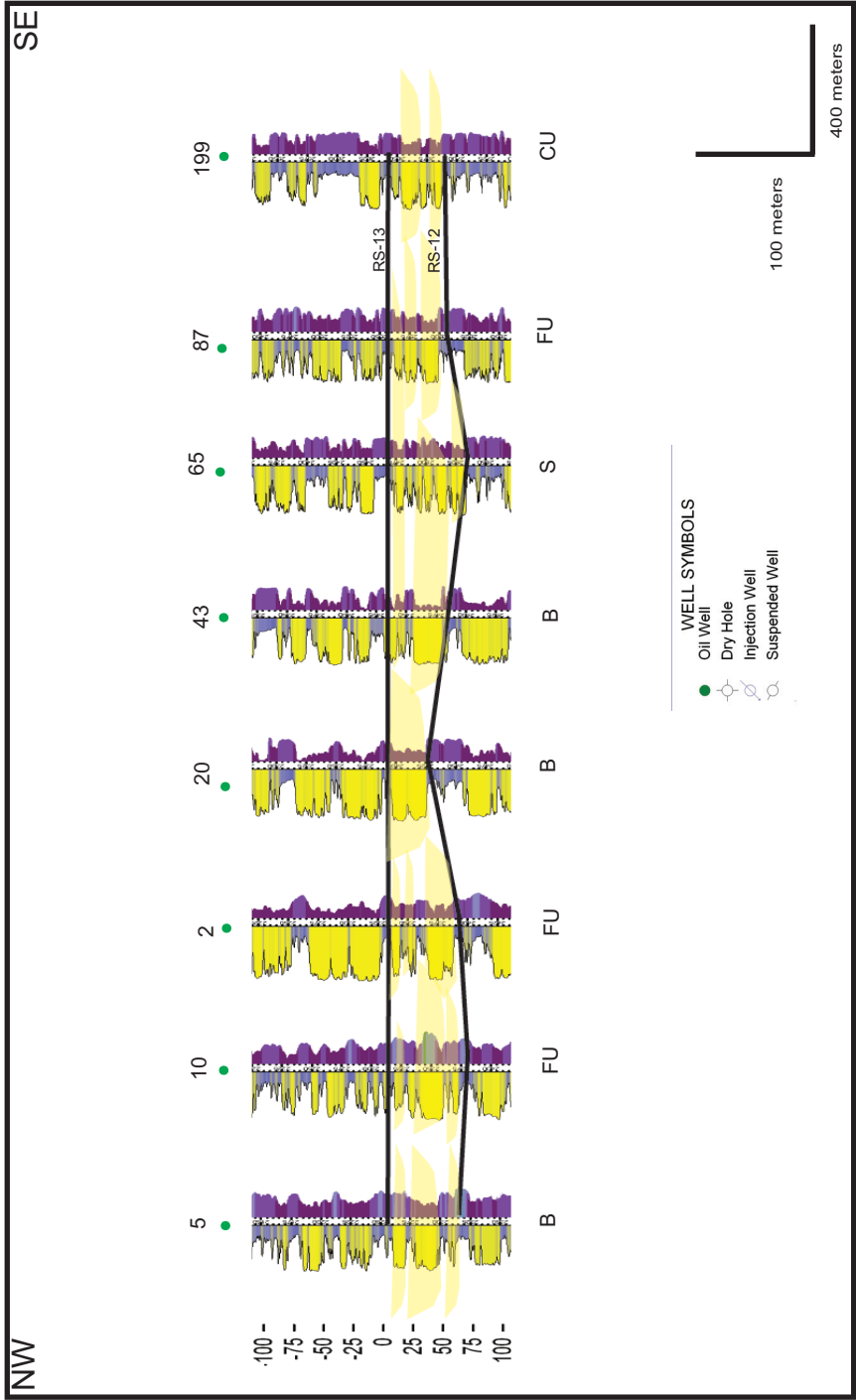


Figure 127. Wireline log cross section showing the sequence 13 (RS-12_RS-13). RS-13 is the datum. SP and resistivity curves are shown. This sequence has less net to gross ratio than the previous one serrate and blocky pattern are the more common. An interpretation of the sandstone distribution is shown in yellow. See Figures 125 and 128 for location of section.

continuity of the shale layers between wells is interpreted as the result of the erosional and the stacking channels complex fills. Sand bodies approximately 75 meters in thickness can be correlated between two wells (191,193) (**Figure 126**). Eight wells on the dip oriented profile (Z6) have blocky and fining upward patterns that are their characteristic log signature, the coarsening upward and serrate patterns are only present in one well each (65 and 199, respectively) (**Figure 127**).

The facies map shows primarily a blocky log signature that changes laterally to fining upward or coarsening upward log signature. Coarsening upward is surrounded by the blocky and fining upward log signatures. Serrate pattern is the lesser common log signature in the sequence, it is present in only two wells with the high sand ratio (**Figure 128**).

Net-to-gross map: Net-to-gross map shows a distribution of high values (>0.75) along the northern part of the field to the southwest and east portion, values decrease to 0.55 with an orientation from the southeast to northwest. A zone is present with values lower than 0.5 in the north side of the field (**Figure 129 A**).

Net-sand map: Net-sand map shows similar patterns to the main net sand trending north to south with values > 40 and shows a distribution of high values (> 60) to the southwest part of the study area. A trend of lower net sands is parallel to the first more centrally located zone within the study area (**Figure 129 B**).

Seismic Facies: This sequence is characterized by low amplitude with moderate continuity seismic facies (**Figure 122**). The amplitude extraction map from a gated window 60 milliseconds below the horizon RS_11 shows a distinct trend extending to

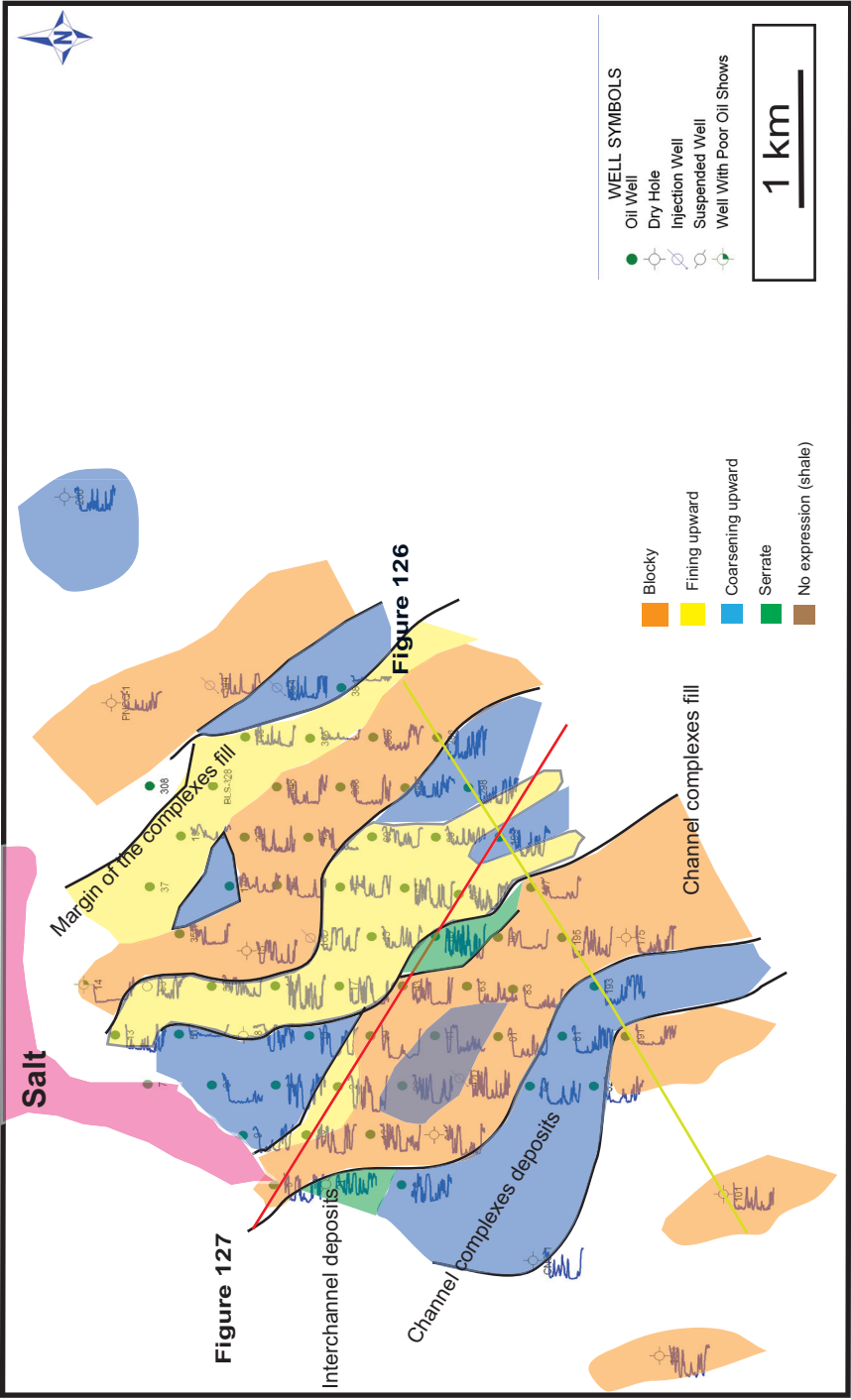


Figure 128. Lithofacies map of the sequence 13 showing the blocky signature flanked by fining upward and coarsening upward serrate is present in only two wells. Interpretation is related with channel complex fills having interchannel deposits. Blocky pattern represent areas where the channel fills are more amalgamated, coarsening upward and serrate are interpreted as interchannel fills and fining upward is interpreted as margin of the channel complexes. Location of Figures 126 and 127 are shown.

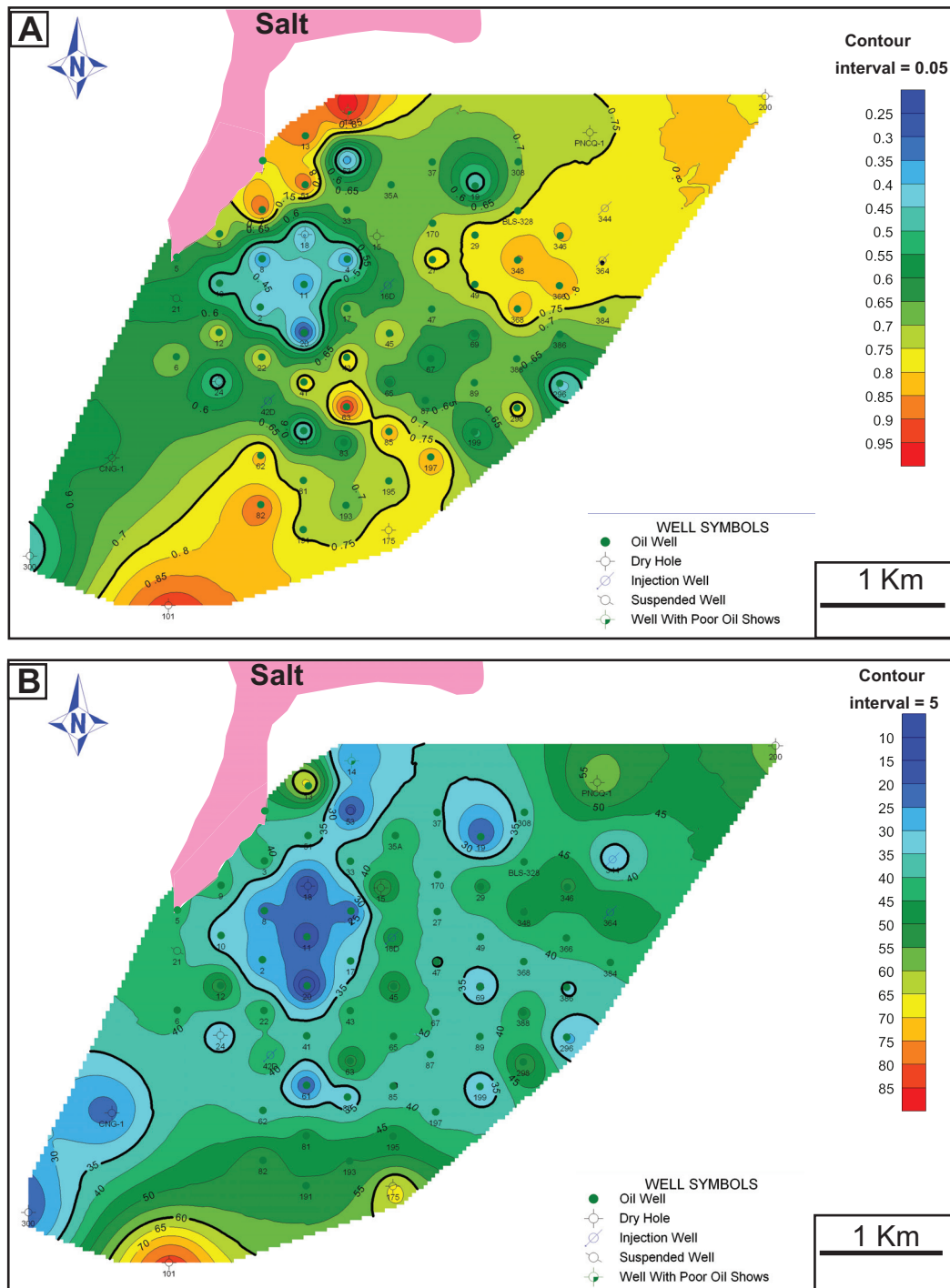


Figure 129. (A) Net-to-gross ratio map from Sequence 13. Contour interval is 0.05. (B) Net-sand map from Sequence 13. Contour interval is 5 meters.

the field from the south-east. These trends have varying amplitudes values with a linear to sinuous pattern (**Figure 130 A, B**).

Interpretation: Several channel systems extend from the southeast of the map to the field. In the area near well number 101, single-story channel fill sediments are interpreted with poorly continuous amplitude feature. Sinuous patterns are also present in this area. The high amplitude reflections are associated with the presence of more amalgamated channels. In the central part of the area, sinuous channels are present.

Sequence 14 (Rs_13_RS_14)

This sequence is defined at its top by the RS-14 marker. The sequence is bounded by the salt body to the north part of the field. The eroded zone is present like the previous sequence but with reduced area.

Time-structure map: A time-structure contour map of the top of the horizon RS-14 shows the presence of a salt body toward the northern part of the field that overlies and rests against the sands. Two set of faults are present. The first set (F1) strikes southeast-northwest, and dips primarily to the northeast, whereas the other set (F2) have a SW-NE orientation. The first set of faults is located to the southeast and east. The second set of faults is located in the west strikes SW-NE and dips to the north and south. The deepest part of this horizon is located in the south from the field, at 2.15 seconds TWTT and oriented SW-NE. This zone gradually changes to a shallower position on both sides of the depression having values lower than 1.64 seconds on both sides of the map (**Figure 131**).

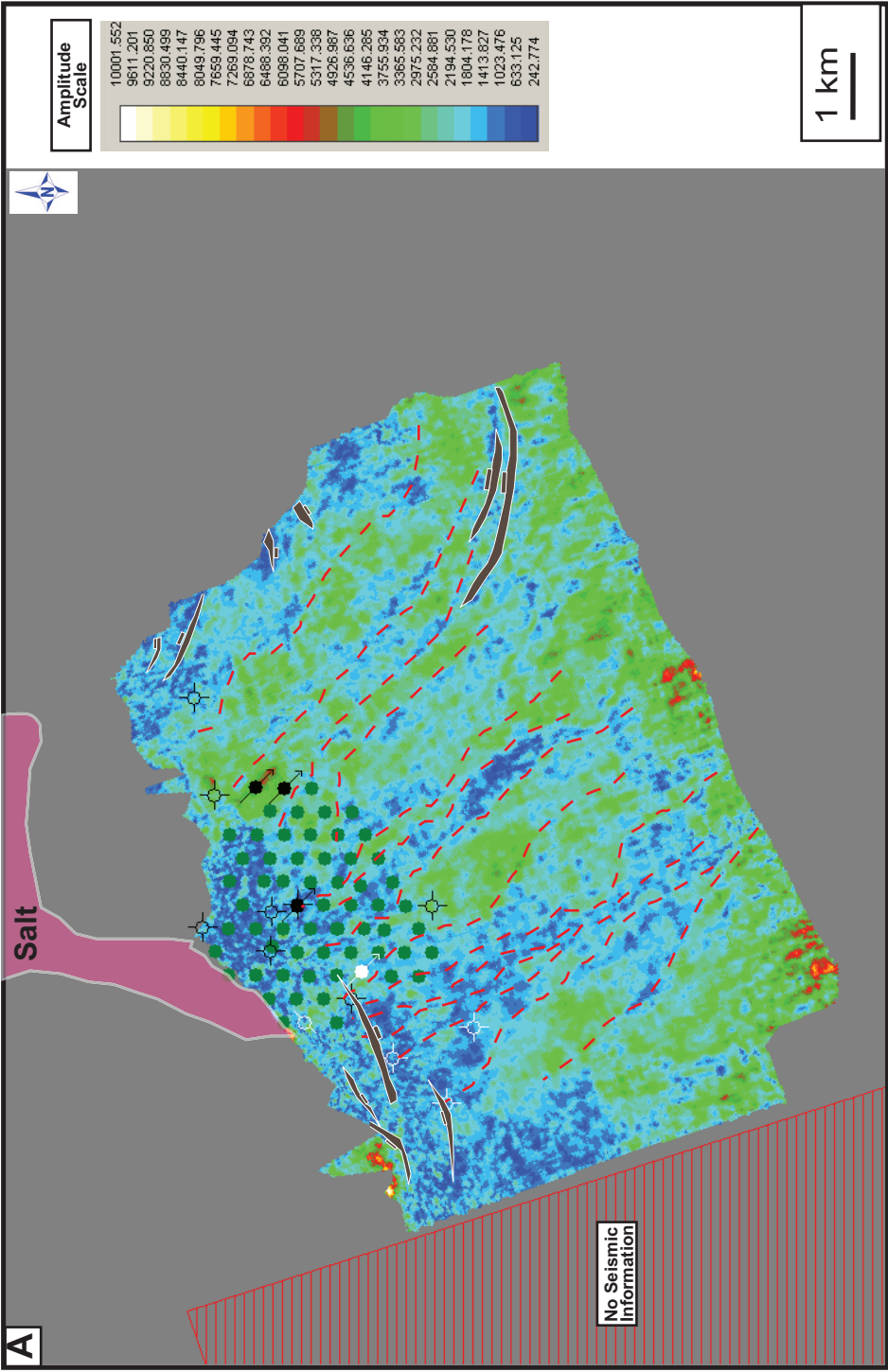


Figure 130. RMS amplitude extraction map from a gated window 60 ms below Horizon RS-13. A). With wel plotted. B) With no wells plotted. Several trends are observed coming from the south east part with a north west orientation to the field at least three of these systems are feeding the field having close but different origins.

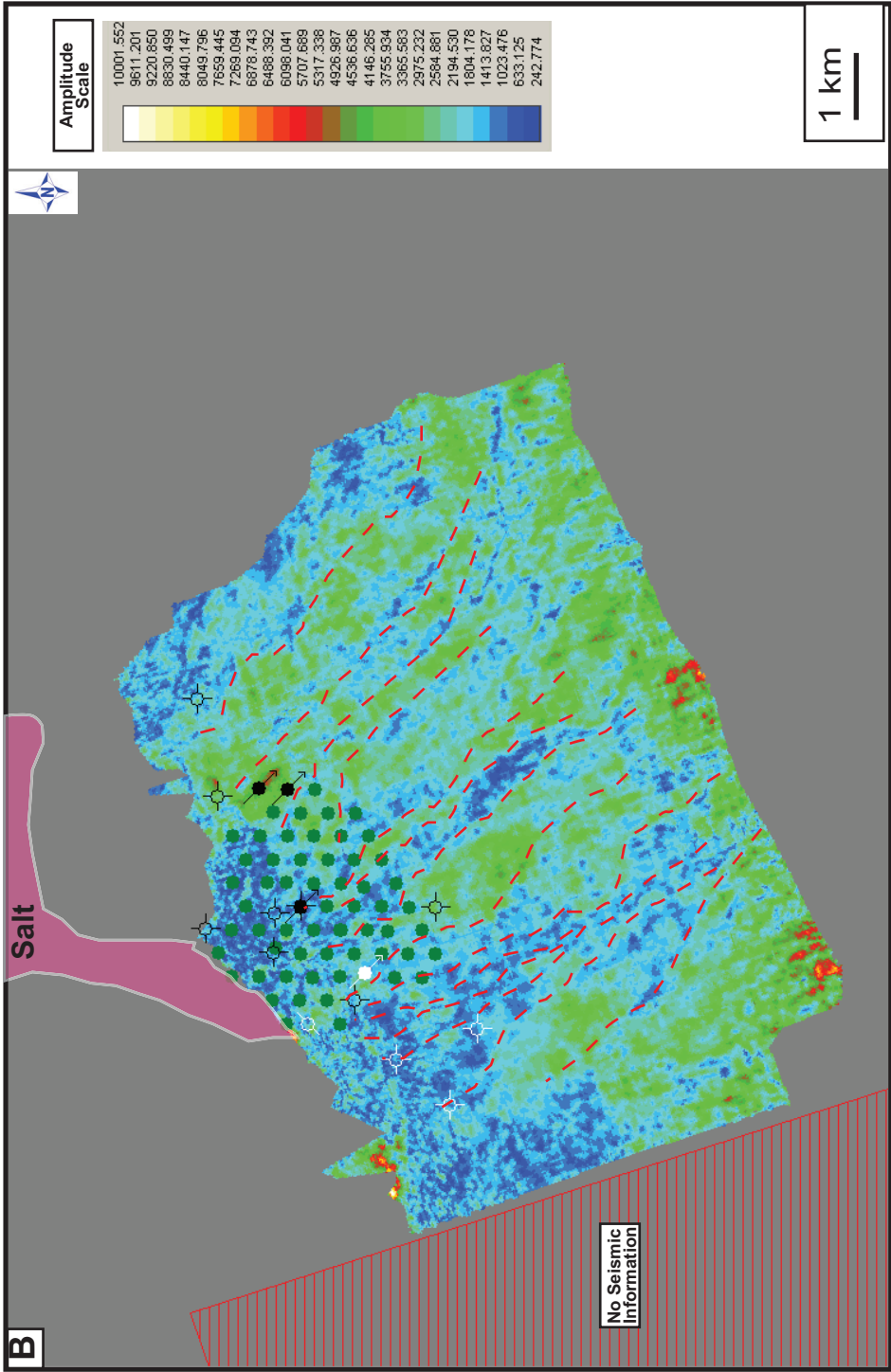


Figure 130 B.

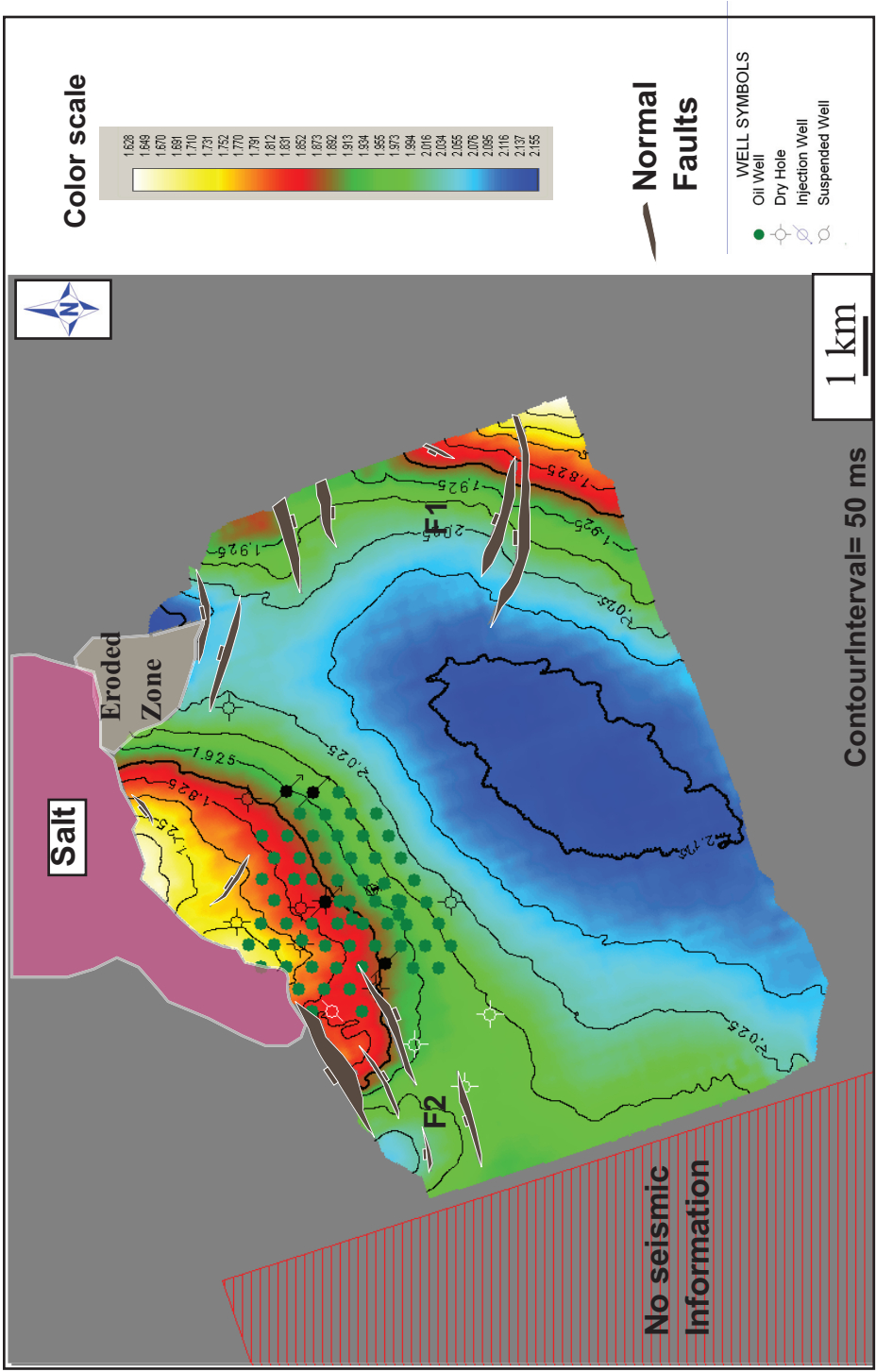


Figure 131. Time-structure contour map (in secs) of the Surface RS-14. A salt body interpreted is located in the north-northwest part of the study area. An eroded zone interpreted is located in the northeast. Two set of faults are interpreted. The first set strikes NW-SE and dips to the northeast is located in the northeast and southeast. The second set is present in the west side strikes SW-NE and dips to the north and south. Wells are shown in green dots.

Isopach map: A total of sixty eight wells penetrate this sequence. The isopach map shows the central part of the field with moderate values with a range between 50 to 70 meters. Lower values reaching a low of 30 meters are present in the northern part of the field, and the higher values greater than 100 meters are in the south, southwest and north part of the field (**Figure 132**).

Lithofacies: Two wireline log cross sections illustrate the sequence in strike (**Figure 133**) and dip views (**Figure 134**). The strike section (X1) has 8 wells; the blocky patterns are the most common (101, 191, 193, 195). Four wells have serrate pattern and associated sandstones are thick reaching values of 12 meters or more (wells 197, 199, 298); Well 296 has a fining upward signature (**Figure 133**). The dip oriented section has the eight wells with a dominantly blocky pattern a serrate pattern is also in several wells (**Figure 134**).

The facies map shows blocky pattern, is the more common signature in this sequence and is located in the central part of the field. The serrate pattern is located adjacent to the blocky pattern. Fining upward and coarsening upward patterns are the least represented facies in this sequence and are located around the edges of the field (**Figure 135**).

Net-to-gross map: This map indicates a trend of higher values than 0.80 to the north and southwest side of the field. A zone with lower values than 0.60 is present in the middle part of the field separated the zone with higher values. Lower values than 0.20 are located in the eastern part of the map (**Figure 136A**).

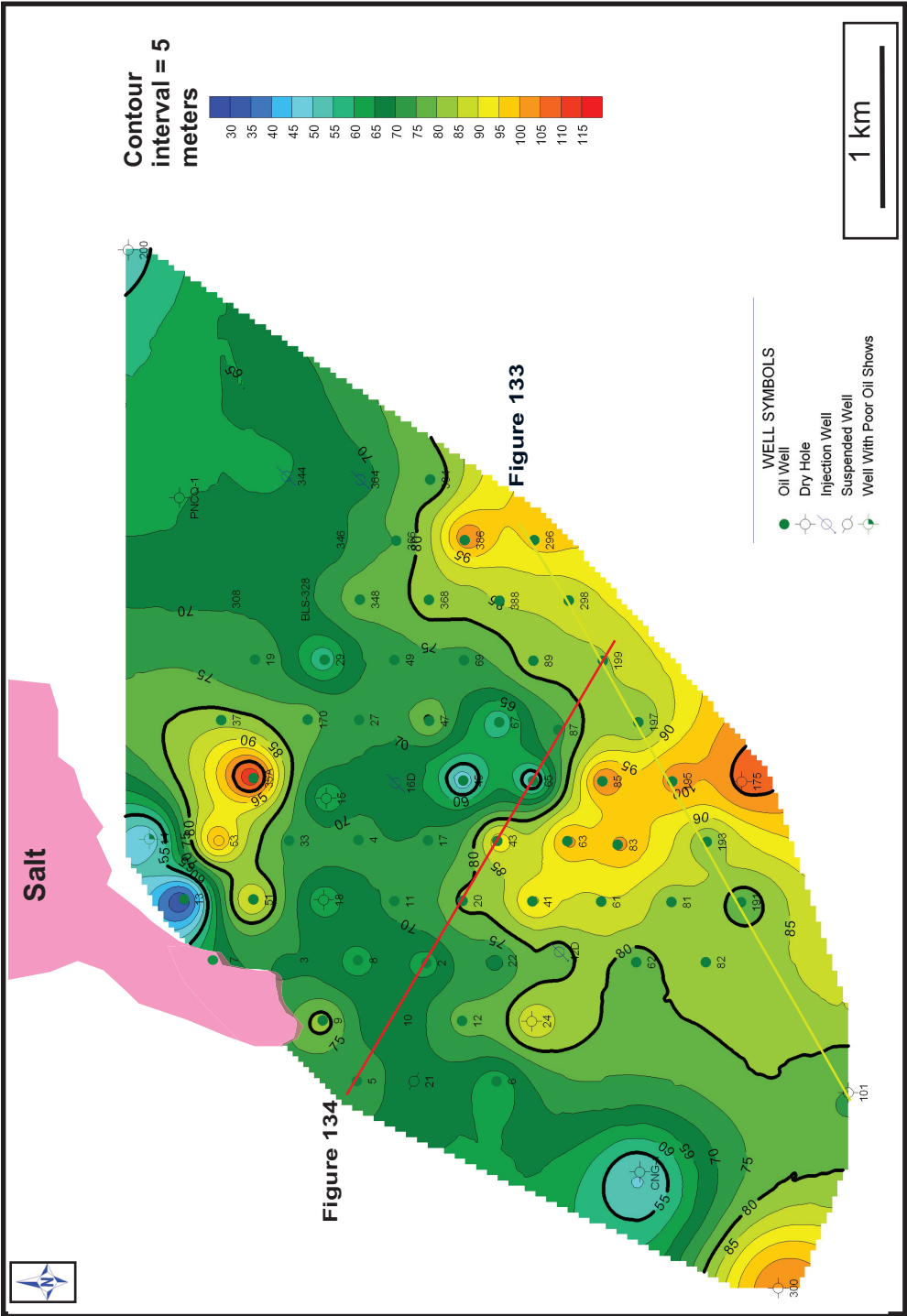


Figure 132. Isopach map of the Sequence 14 in the Blasillo field. Contour interval is 5 meters. Wells are shown by green dots. Location of Figures 133 and 134 are shown.



Figure 133. Wireline log cross section showing the sequence 14 (RS-13_RS-14). RS-14 is the datum. Lateral changes in the log signature are evident, blocky, fining upward and serrate are more representative for this section. In yellow is presented an interpretation of the sandstone distribution on a vertical profile. See figures 132 and 134 for location of section.



Figure 134. Wireline log cross section showing the sequence 14 (RS-13_RS-14). RS-14 is the datum. SP and resistivity curves are shown. Blocky pattern is the more characteristic some serrate signatures can be identified. An interpretation of the sandstones distribution is shown in yellow. See Figures 132 and 135 for location of section.

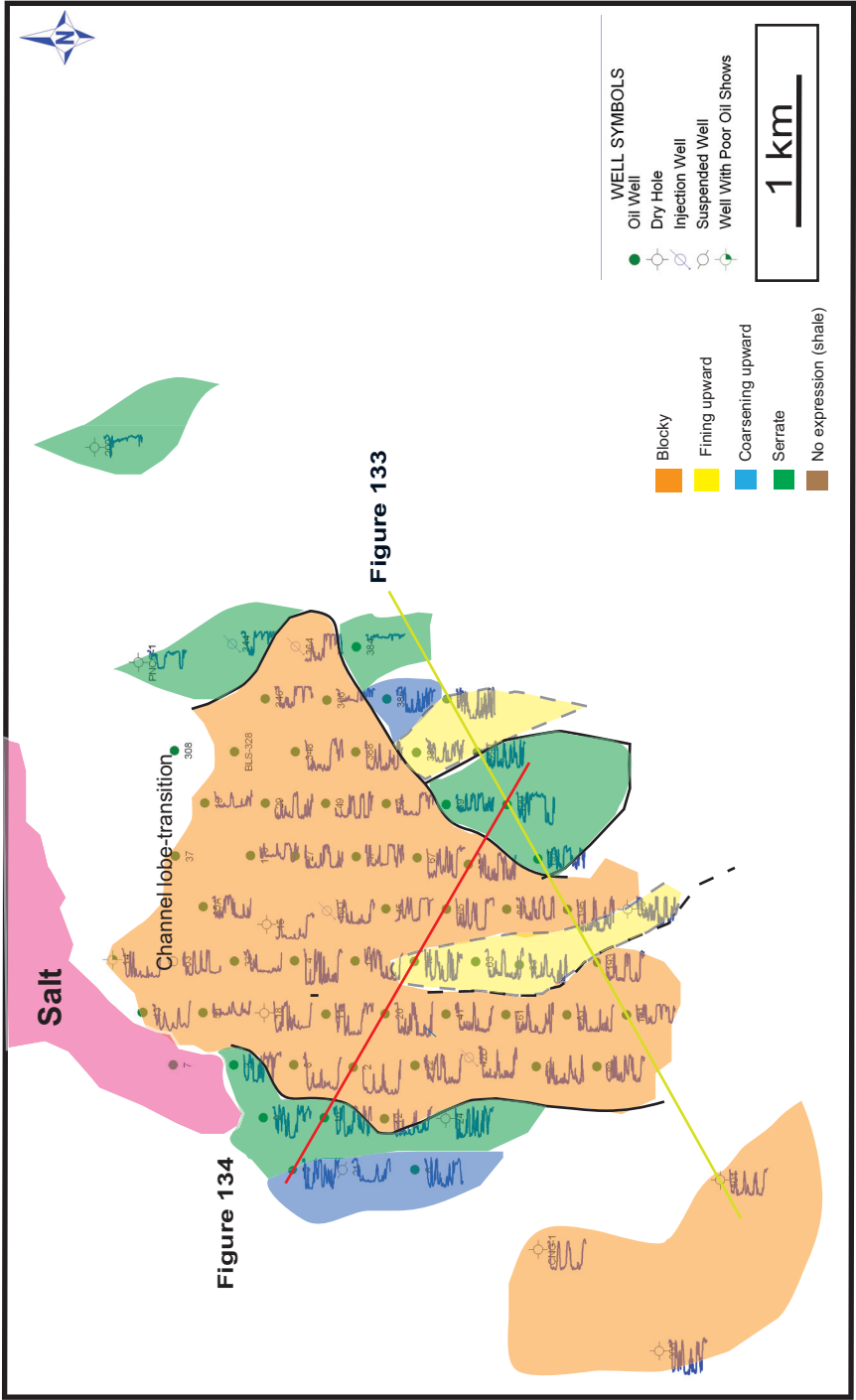


Figure 135. Lithofacies map of the sequence 14 showing the SP logs. Blocky signature is the main signature in this map, serrate pattern is located around the blocky pattern, fining upward is located in a trend one of them interpreted inside the blocky pattern, coarsening upward is less represented. The interpretation is related with semi amalgamated channel -lobe transition complex. Location of Figures 133 and 134 are shown.

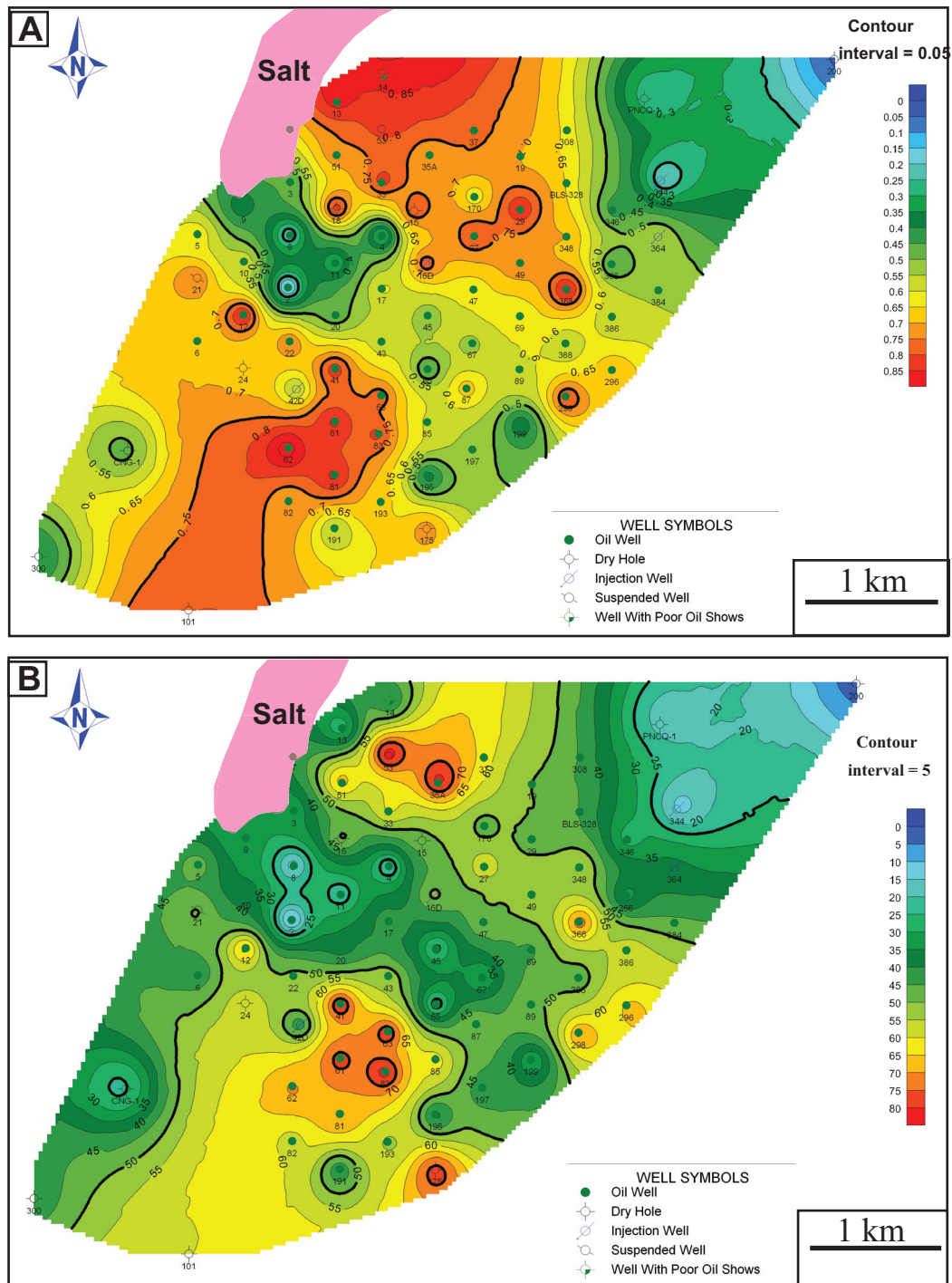


Figure 136. (A) Net-to-gross ratio map from Sequence 14. Contour interval is 0.05. (B) Net-sand Map from Sequence 14. Contour interval is 5 meters.

Net-sand map: The net-sand map has similar trends as the net-to-gross map, however the relative width of these trends are slightly reduced (**Figure 136 B**).

Seismic Facies: In this sequence, the seismic data in a vertical profile is characterized by moderate amplitude with moderate-good continuity. The continuity decreases in the shallower part closer to the edge of the salt body in the field area, due to poor resolution. The sequence was penetrated almost by all the wells present in the map (**Figure 122**).

The amplitude map for this sequence shows a trend of amplitude coming from the southeast part toward the field that appears change into the entire field its sediments. The feature has the same point source and is increasing in width when in arriving to the field. Faint bifurcations the amplitude trends are present. (**Figure 137 A, B**).

Interpretation: Three major channels systems are interpreted in this map. Near to the field, the central channel system that feeds the field widens and bifurcates. The interpretation is that the field is located in a channel-lobe transition zone within the field blocky log signature is the more common facies.

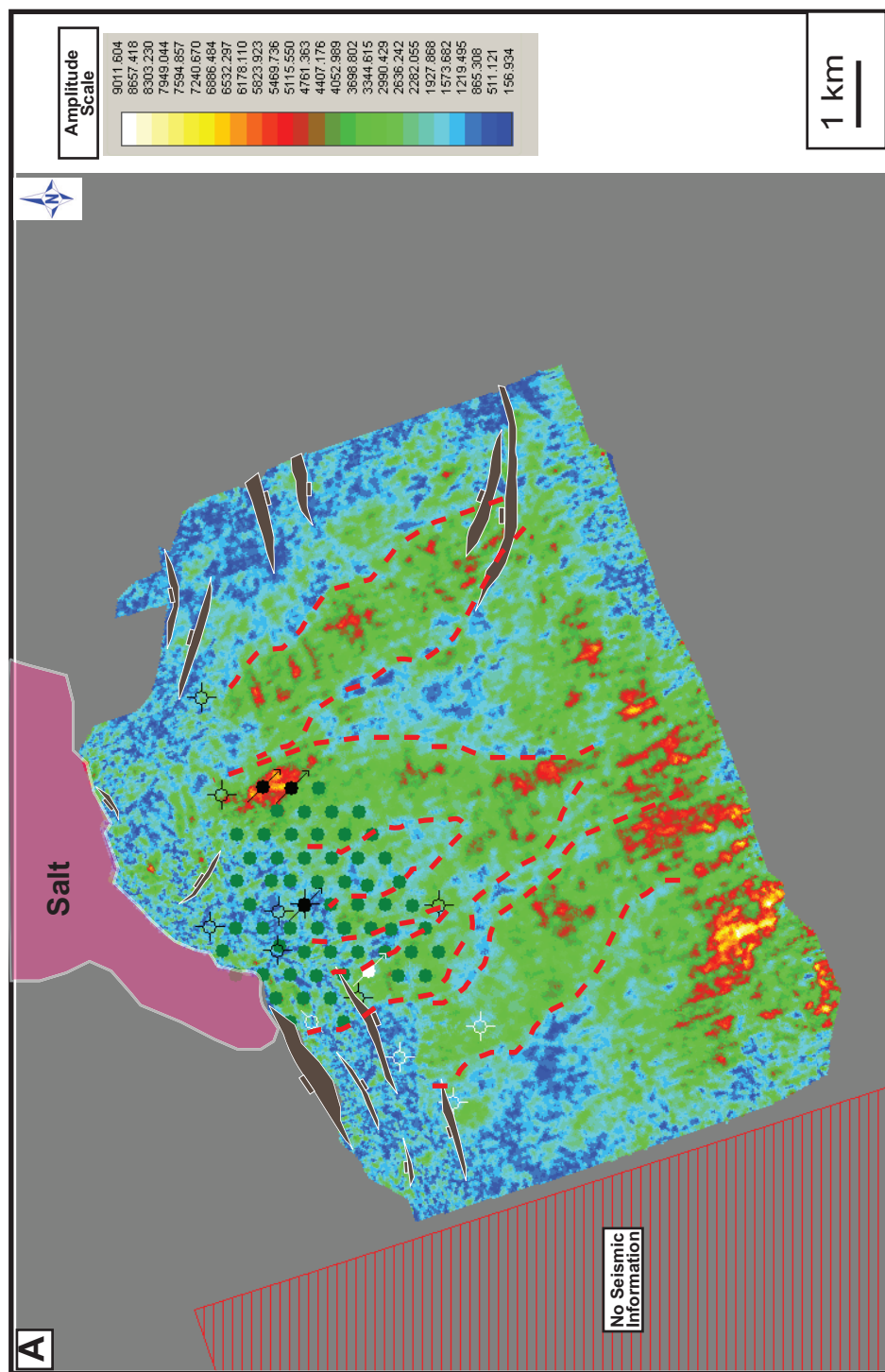


Figure 137. RMS amplitude extraction map from a gated window 40 ms below Horizon RS-14. **A)** With well location plotted. **B)** With no wells plotted. Red outline shows three main systems identified and related with this sequence. Central system is feeding the field a channel complex that start to change its width having a lobe shape. The interpretation is related with a Channel-lobe transition zone.

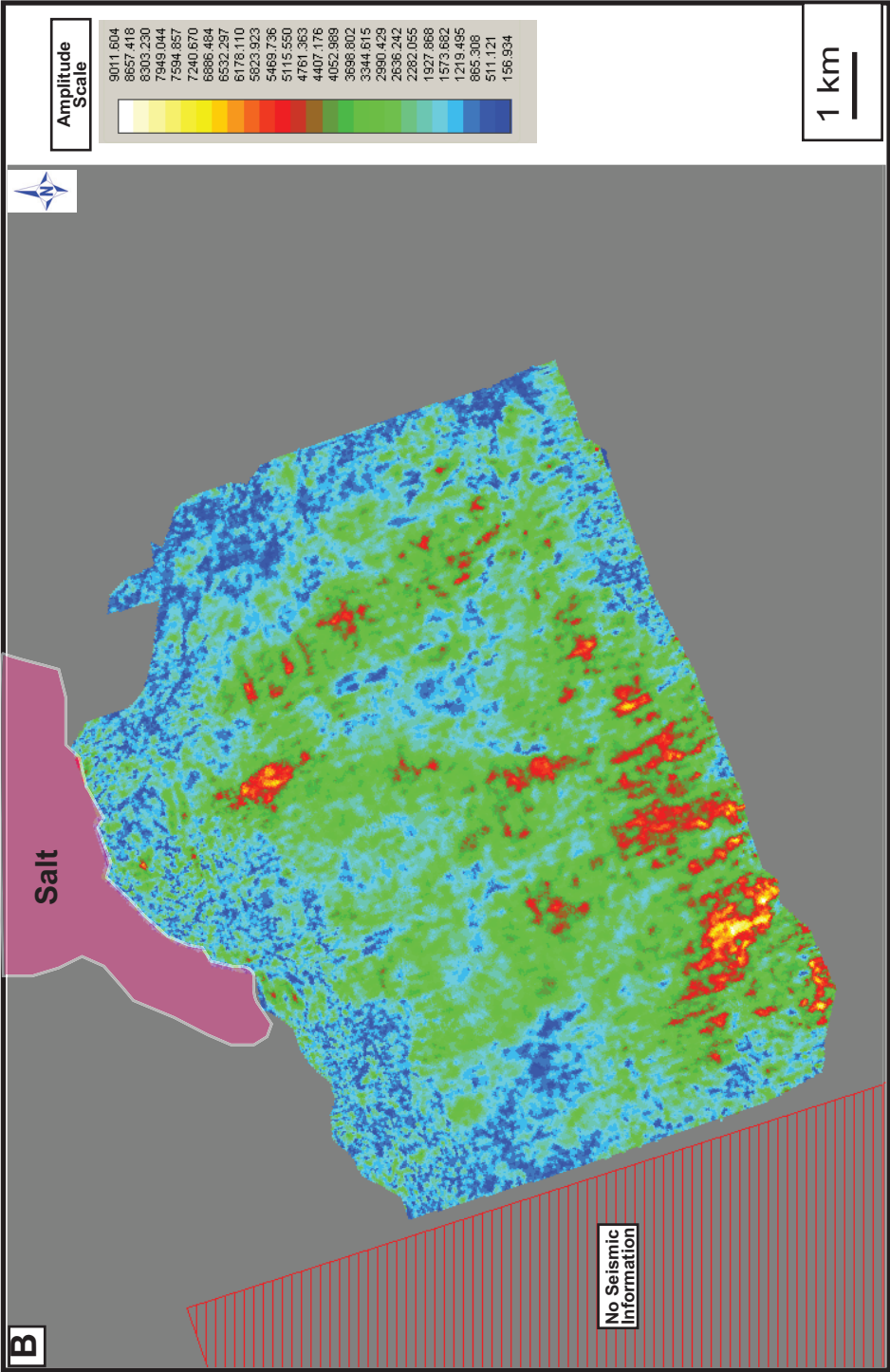


Figure 137 B.

DISCUSSION

The production zone in the Blasillo field is related with seismic amplitude anomalies located along the flank of the salt body (Figures 138,139). The edges and shape of the salt body is interpreted based of the seismic character (discordant relation of the body shape with the strata), high amplitude and select well data which penetrated salt and anhydrite. In a dip view, the field rests along the flank of this salt body (**Figure 138**). One of the most significant features of these anomalies is an overall lens-like pattern, which is easy to see in a strike view (**Figure 139**), another distinctive feature is the presence of an imbricate pattern of reflections within the field. These imbrications are interpreted as result of channel system migrations shifting away from the salt body (**Figure 15**). To illustrate this pattern, an arbitrary line is considered a key element for the understanding and interpretation of the geological model and the stratigraphic framework of the field in this work.

Stacking patterns within a sequence stratigraphic framework

After well log correlations and seismic interpretation, fifteen surfaces were used to define the stratigraphic framework, and fourteen sequences were identified based at log scale. These sequences are all upper Miocene and are considered to be of third-order or higher in their frequency; some of these sequences are below the seismic resolution and they were identified only in the well log scale. The third-order sequences are proposed based on correlation to the chart of the Gulf of Mexico (**Figure 17**).

One of the key results in this study is the recognition of the changes in the architecture of the reservoir intervals, both laterally within sequences, and between sequences vertically.

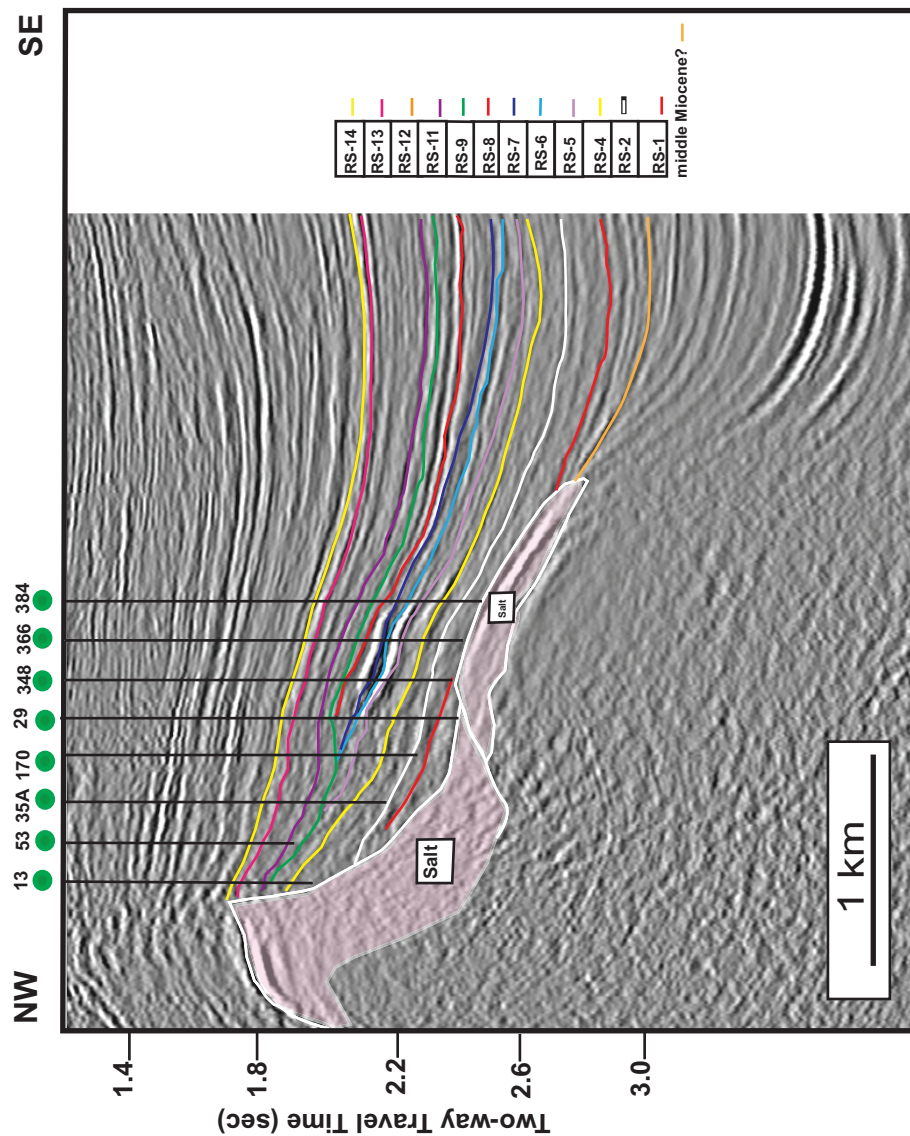


Figure 138. Seismic profile showing the interpreted sequences in the main production zone from the Blasillo field from RS-9 to RS-2. production zone is located in the flank of a salt body (pink). High amplitudes from RS-4 through RS-9 are interpreted correspond to channel complexes fills. See Figure 96 for location of profile.

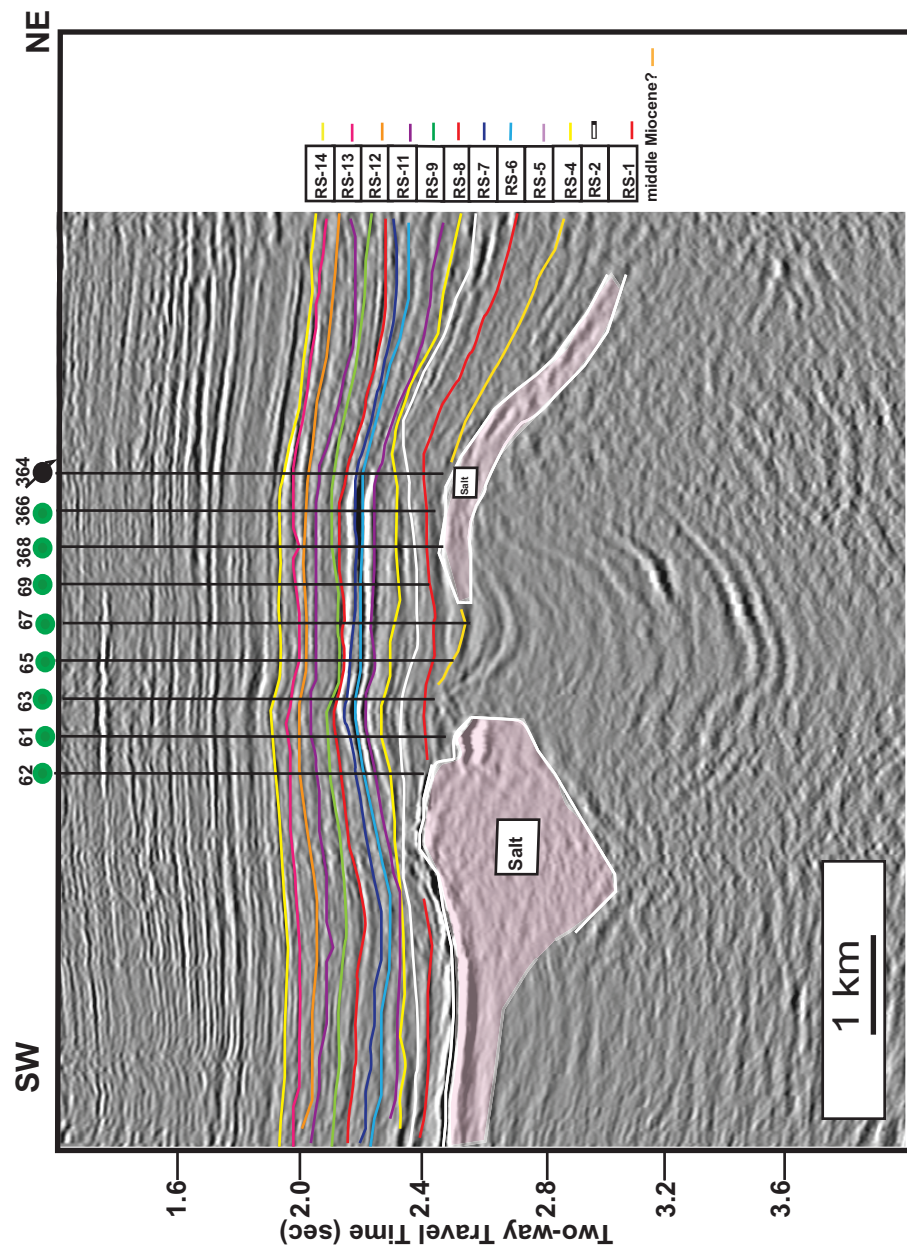


Figure 139. Seismic profile (section of correlation X3) showing the interpreted sequences in this work. Main production zone from the Blasillo field is located from RS-8 to RS-2; production zone is located in this profile above a salt body (pink). High amplitudes from RS-2 through RS-8 are interpreted correspond to stacking and lateral migration of channel fill complexes. See Figure 96 for location of profile.

Using log correlations, these abrupt lateral facies changes are interpreted to be caused primarily due to presence of channel complex fills instead of sheet sands in the field. The second observation is that there is a distinct change in lithofacies, thickness, and net:gross between sequences 1 to 9 and sequences 10-14.

Several authors have noted that differences in thickness as an important criteria to distinguish between channel-fill (less than 15 meters) from channel-fill complexes (25 meters or more). **Table 1** summarizes the different thickness of net sand and net-to-gross ratio identified in this thesis for the different sequences. Channel-fill complexes are interpreted to be the main architectural elements within the sequences 1-14.

The stacking patterns for sequences 1 to 9 are shown in a strike view in **Figure 140**. This vertical stacking presents vertical and horizontal variations of the thickness and internal architecture for each sequence illustrating an extremely complex dynamic deepwater system. The dip orientated wireline log profile for sequences 1 to 9 shows similar pattern in the internal architecture of channel fills (**Figure 141**).

In general, a strike view shows that sequences 1-5 are thinner and increase in thickness upward through sequence five (**Figure 140**). Sequence five is the thickest and fewer shale breaks within the channel-fill complexes. There is a distinct change as the thickness decreases in the upper sequences and the channel-fill complexes become more amalgamated. The channel complexes are interpreted to be more amalgamated in sequences 6 and 8, in contrast to those in sequences seven and nine (**Figure 140**).

Distinct changes in the net:gross and overall thickness are present in

Sequences	Maximum thickness	Minimum Thickness	Maximum net sand	Minimum net sand	Maximum net-gross	Minimum net-gross
RS-14	105	30	75	5	0.85	0.1
RS-13	90	30	80	20	0.9	0.35
RS-12	120	30	100	10	0.9	0.35
RS-11	75	20	55	5	0.9	0.2
RS-10	90	10	70	5	0.9	0.2
RS-9	75	15	25	0	0.35	0
RS-8	70	10	60	0	0.85	0.1
RS-7	105	20	60	0	0.65	0
RS-6	135	35	70	0	0.7	0
RS-5	120	25	90	5	0.75	0
RS-4	130	30	75	5	0.75	0
RS-3	115	35	65	0	0.82	0.025
RS-2	130	35	60	5	0.8	0.25
RS-1	160	10	85	0	0.5	0.005

Table 1. Shows maximum and minimum values from different parameters measured in the different sequences.

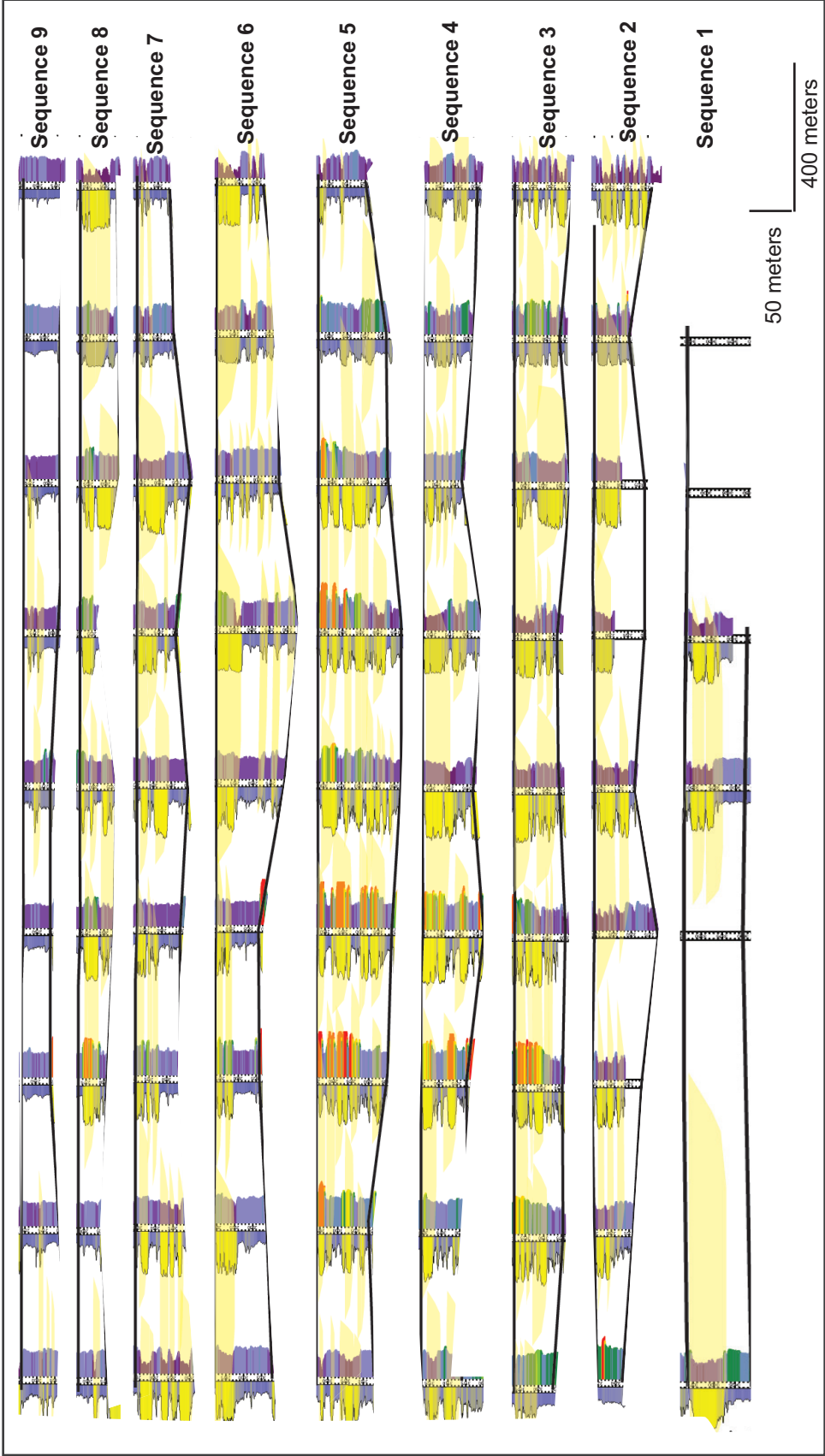


Figure 140. Strike view of the different log correlation sections using the upper boundary of the sequence as datum. Thickness of the seq. increase from the lower Sequence to the sequence 5 and decreasing from this to the Sequence 9. Different shale brakes are observed inside the sequences and they have different levels and distribution which are interpreted as baffles and vertical barriers between the sandstones bodies.

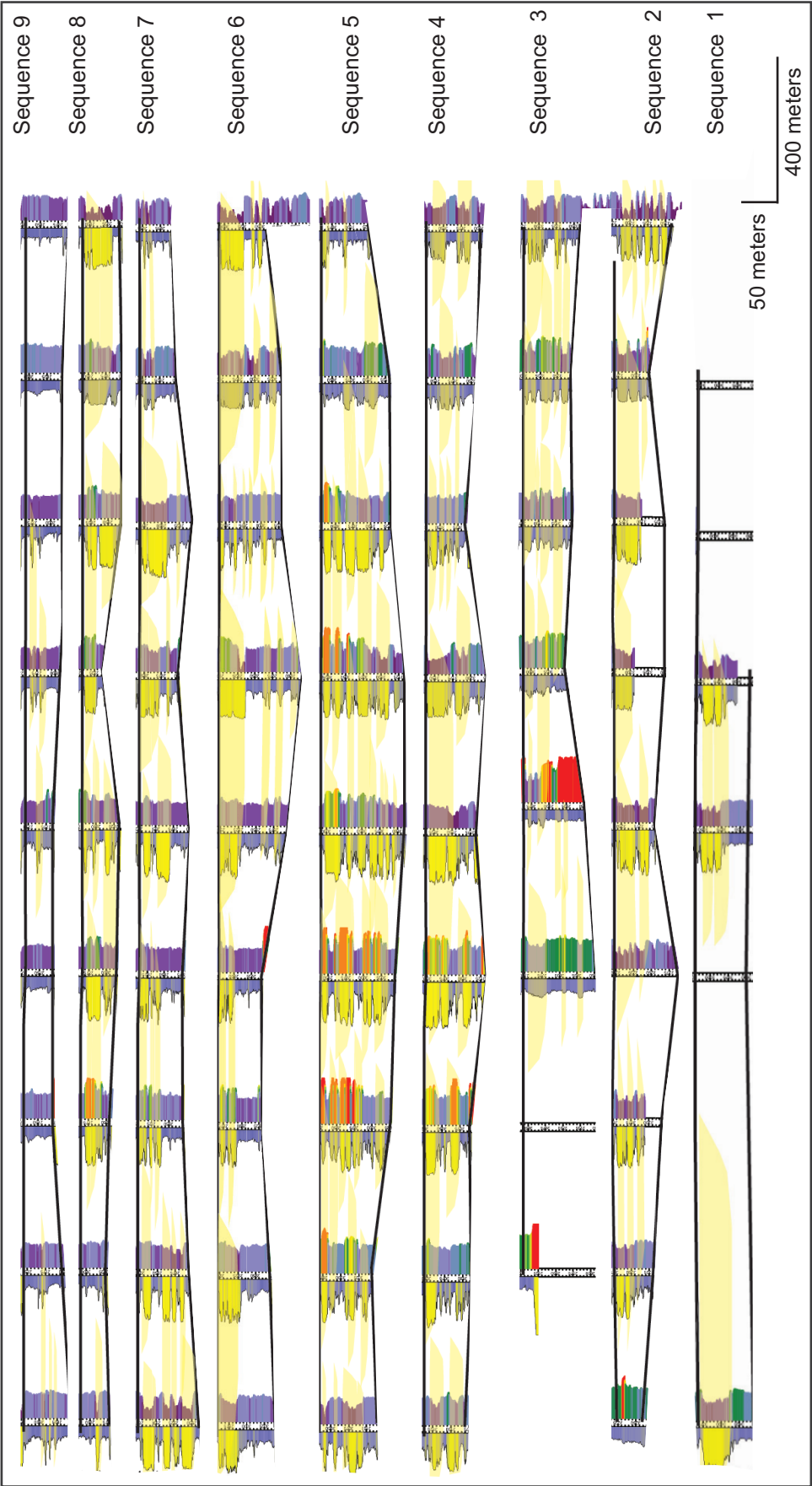


Figure 141. Dip view of the different log correlation sections using the upper boundary of the sequence as datum. Thickness of the sequences increase from the lower sequence to the Sequence 5 and decreasing from this to the sequence 9. Different staking pattern are evidents showing the complexity of the systems and the variations of the thicker sandstone position through the sequences.

sequences 10-14. Sandstones bodies are thicker than in the underlying sequences (one to nine). The vertical stacking patterns are shown in strike and dip view in **Figures 142 and 143**, respectively. The blocky wireline pattern is the dominant log signature; shale layers are present but in general these sequences are highlighted by thick sandstones bodies.

Evolution of channel-fill architecture through time

As shown in **Figure 37B**, channel patterns can change both spatially and temporally from erosional to erosional/aggradation to aggradational. Sequences 1 to 14 likely consist of alternating cycles of one erosional and one erosional/aggradational channel-fill pattern (**Figure 37B**); Together, these cycles form one third-order cycle. This relationship can be seen in the wireline log patterns (Figures 140-143) and on the seismic data for sequences 1-9. This relationship is less evident on the seismic data for the younger sequences (10 to 14), but is interpreted to exist based on the wireline log patterns (**Figures 142-143**).

Interpreted erosional /aggradational channel-fill consist of the following in sequences one to nine: (a) upward fining SP signature with the largest areal distribution, and (b) blocky pattern with less areal distribution. The serrated SP pattern is present in these sequences but with not clear areal distribution. The presence of better developed, fining upward facies in the erosional/aggradational sequences is interpreted to be the result of the lateral migration of the channels complexes. Facies with blocky pattern are considered as the zones where more amalgamation of channel fills exist (central part of channels).

Only three sequences with channel fills that are considered to be entirely

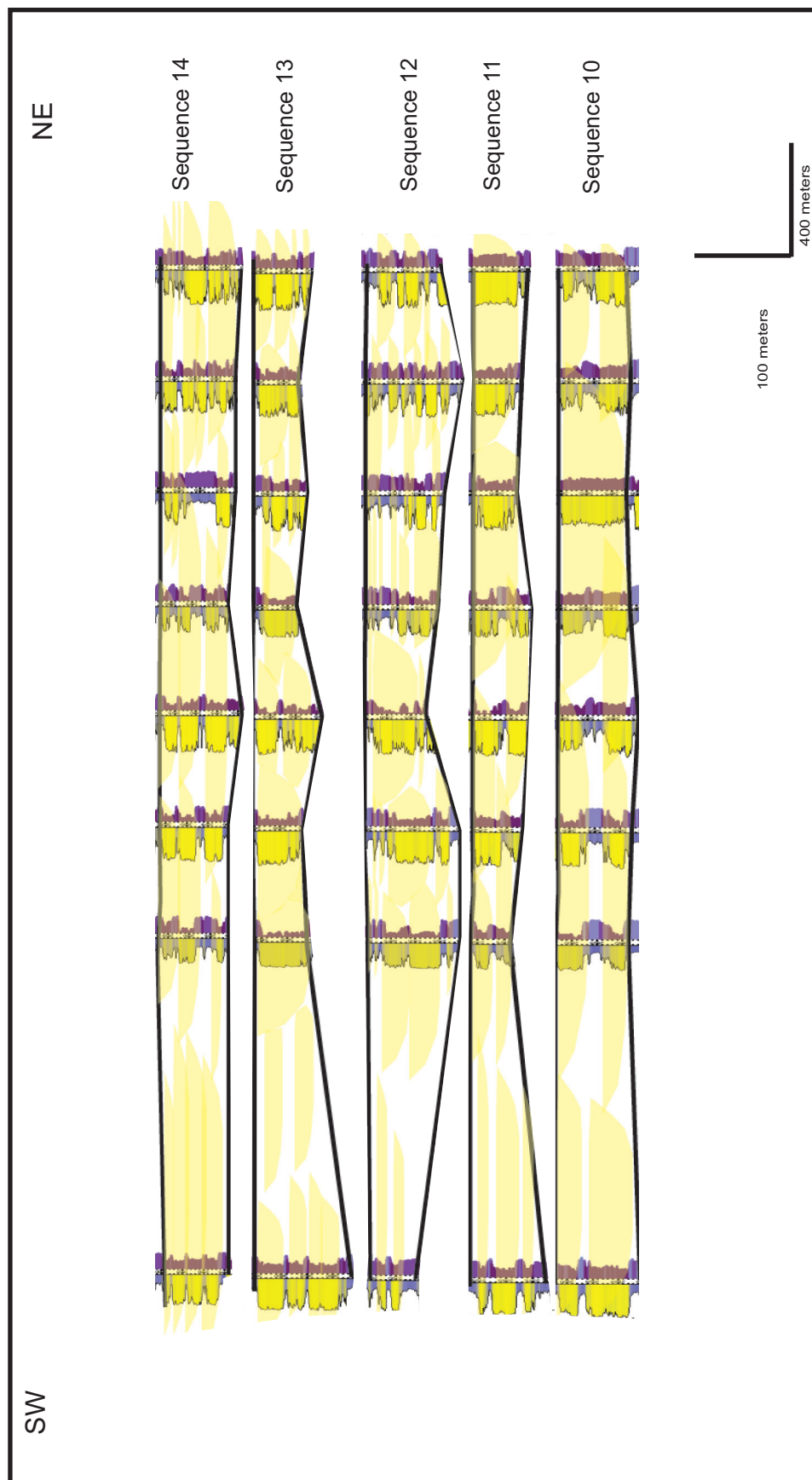


Figure 142. Figure shows a strike view of the vertical stacking of the sequences RS-10 to RS-14 using the top of each sequence as datum. High net to gross sequences are shown with amalgamated and semiamalgamated sandstones bodies with thin shale breaks showing lateral changes in the log pattern interpreted as channel complexes.

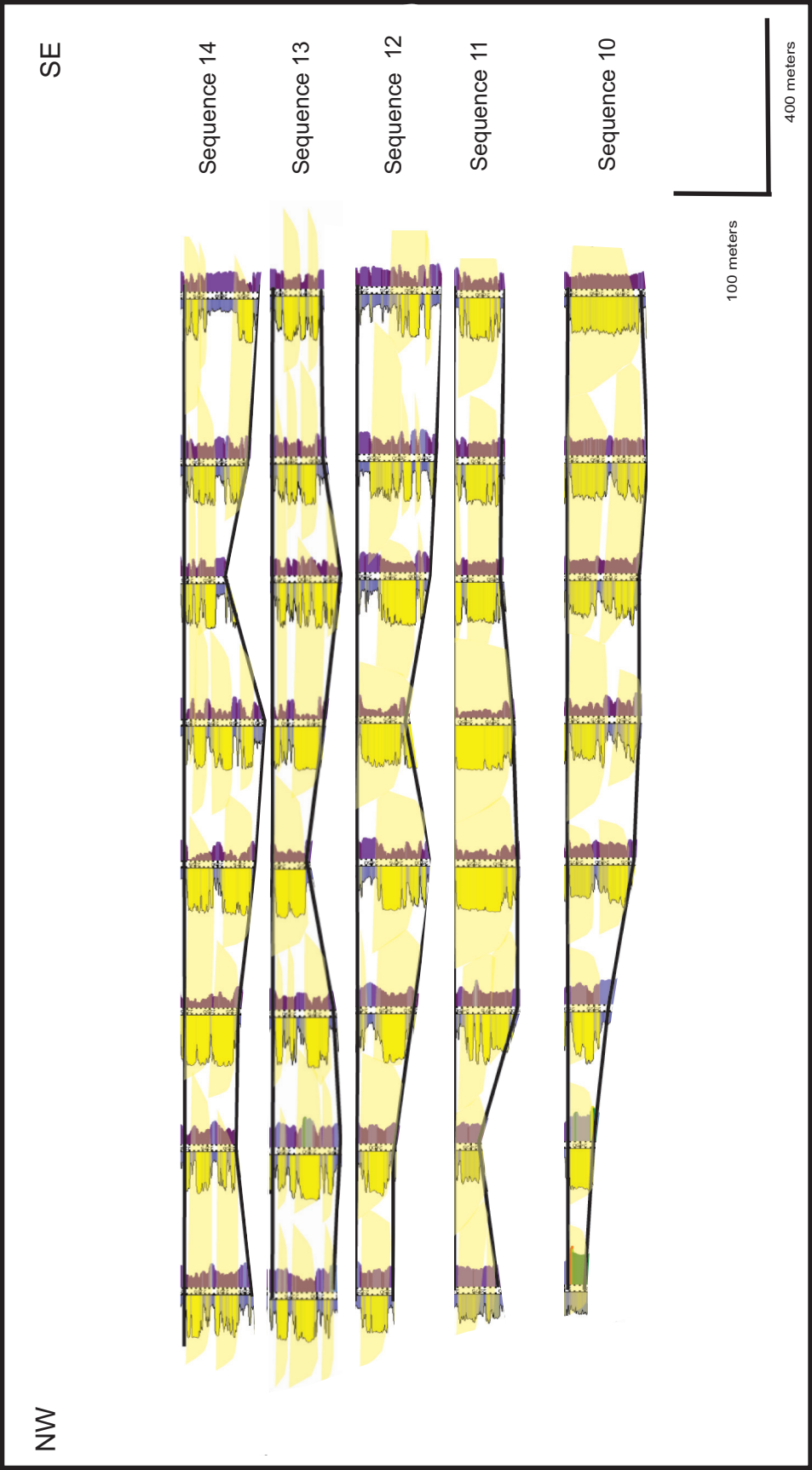


Figure 143. Dip oriented view of the vertical stacking from the sections of correlation of the sequences RS-10 to RS-14 using the top of each sequence as datum. High net to gross sequences are shown with amalgamated and semi-amalgamated sandstones bodies with thin shale breaks showing lateral changes in the log pattern interpreted as channel complexes.

erosional have good lateral continuity of blocky facies in the production zone (Sequences 3, 6, and 8). The implication for developing of the field and is related with more connectivity of sandstones within these sequences.

Relation of production to lithofacies

The producing zone in sequences 2, 5, 7 consists of channel-fill sediments deposited in on erosional/aggradational stages. Reservoirs are compartmentalized and lateral accretion packages are present associated with lateral migration of channel complexes. The result of this study suggests that the future infill wells could be drilled in closer space between wells. This interpretation need to be corroborated with detailed analysis of production data.

Production data from the field show that although there is production in the highest structural position in the northeast part of the field, the wells with better production are located in the central to south part of the field, and the production is not uniform. Production data show different rates even for wells that have closer space.

Production data from recent wells indicate heterogeneity in the reservoirs in the producing zone of the field; this is interpreted to be related with shale barriers and the compartmentalization of the reservoirs in the field (Pemex Exploracion y Producción 2009).

Sequences 10 to 14 have few producer wells inside them. In general blocky pattern is the dominant log signature (**Figures 107, 113, 120, 128, 135**). However, channel-lobe transition is interpreted to be present in sequences 11 and 14. For the rest of the sequences 10-14, the interpretation is related with channel fill complexes. Only sequences one to nine have more evidences to interpreted cyclicity and changes from erosional to erosional/aggradational

channels complexes fills. Reviewing of different lithofacies maps, shown, that the lateral relation of this system is complex and that production data need to be integrated in order to understand well this relation in the field. The seismic profiles help recognize a pattern (**Figure 15**) and the combination of this with the vertical stacking of the channel complexes (**Figures 142 and 143**) and lithofacies maps help to interpret the geological model and the cycles that were described before.

Even the seismic information used in this work does not have high frequency; main trends and some features in the different sequences are shown or are delineated. Interpretation of amplitude extraction maps show that sequences interpreted with erosive channels (**Figures 42, 57, 70, 85, 100,113, and 128**) have less evidence of lateral migration and have channels with more straight features.

In the other hand, sequences with aggradational/erosional channel fills (**Figures 50,63,78,92, 107, 113, 120,135**) shown or at least is interpreted that present more sinuosity. Better seismic image with major frequency or the use of seismic attributes is needed to be done to improve the resolution of the amplitude maps.

Salt-sediment interaction

There was clear syndepositional movement of salt during the deposition of the reservoir sands in the Blasillo field. The movement of the salt was result of sedimentary loading. Some evidence of the salt-sediment interaction is the different eroded zones near to the salt body where changes of slope gradient caused erosional zones to develop within the field area.

Net:gross and net sand maps of the different sequences illustrate different trends than those in the isopach maps. A comparison of these maps for all of the

sequences shows the zones of areas of lower sand values in the sequences change in their location (**Figures 43, 51, 58, 64, 71, 79, 86, 93, 108, 114, 121, 129, 136**). An increase in the local seafloor gradient created by salt movement and/or subsidence allowed only the finer portion of sediments be deposited close to the salt body reflecting the lower net:gross values close to the salt. At other times, with decreases in sea-floor gradient associated with decreasing accommodation, sand bodies were deposited close to the salt body.

Table 2 summarizes the distance from the salt boundary to the first thick sand and the thickness from each sequence within the time-structural map is calculated showing the well number and the orientation that it keeps regarded with the interpreted salt boundary.

Lateral accretion packages

Abreu et al., (2003) identified the presence of shingled seismic reflections (similar to those present in Blasillo) along the channel margins in the upper portion of a confined channel system' these reflections formed by the lateral migration and local avulsion of a single channel that was approximately 300 meters wide and 40 m deep. These seismic reflections were interpreted to be associated with lateral migration during the channel evolution, resulting in the deposition of sediments that they named "Lateral accretion packages" (**Figure 144 A**).

If the presence of lateral accretion packages in the Blasillo field is well understood and related with production data, the implications for production are: (a) the seismic stratigraphic evidence that some lateral-accretion packages have not penetrated yet by wells (Figure 15), and (b) they constitute a potential areas even in some packages lower part could present connectivity. According to the log signature, shale breaks between the sand bodies are considered to be possible barriers due to

Sequence	Distance to the First thick sand	Sequence thickness in the well	Well	Location from the salt body
Sequence 1	350 meters	97	16 D	Southeast
Sequence 2	375 meters	40	41	East
Sequence 3				
Sequence 4	50 meters	60	10	South
Sequence 5	100 meters	110	10	Southeast
Sequence 6	200 meters	65	10	South
Sequence 7	~50 meters	75	21	East
Sequence 8	1700 meters	60	22	Southeast
Sequence 9	2500 meters	55	200	East
Sequence 10				
Sequence 11	~75 meters	50	9	Southeast
Sequence 12	~75 meters	41	9	South
Sequence 13	~20 meters	59	9	South
Sequence 14	75 meters	35	13	Southeast

Table 2. Relationship between the salt body and the closer well with the first thick sand body. The position from the first thick sand body is changing during the development of different sequences but for some sequences the sand body is close to the same well.

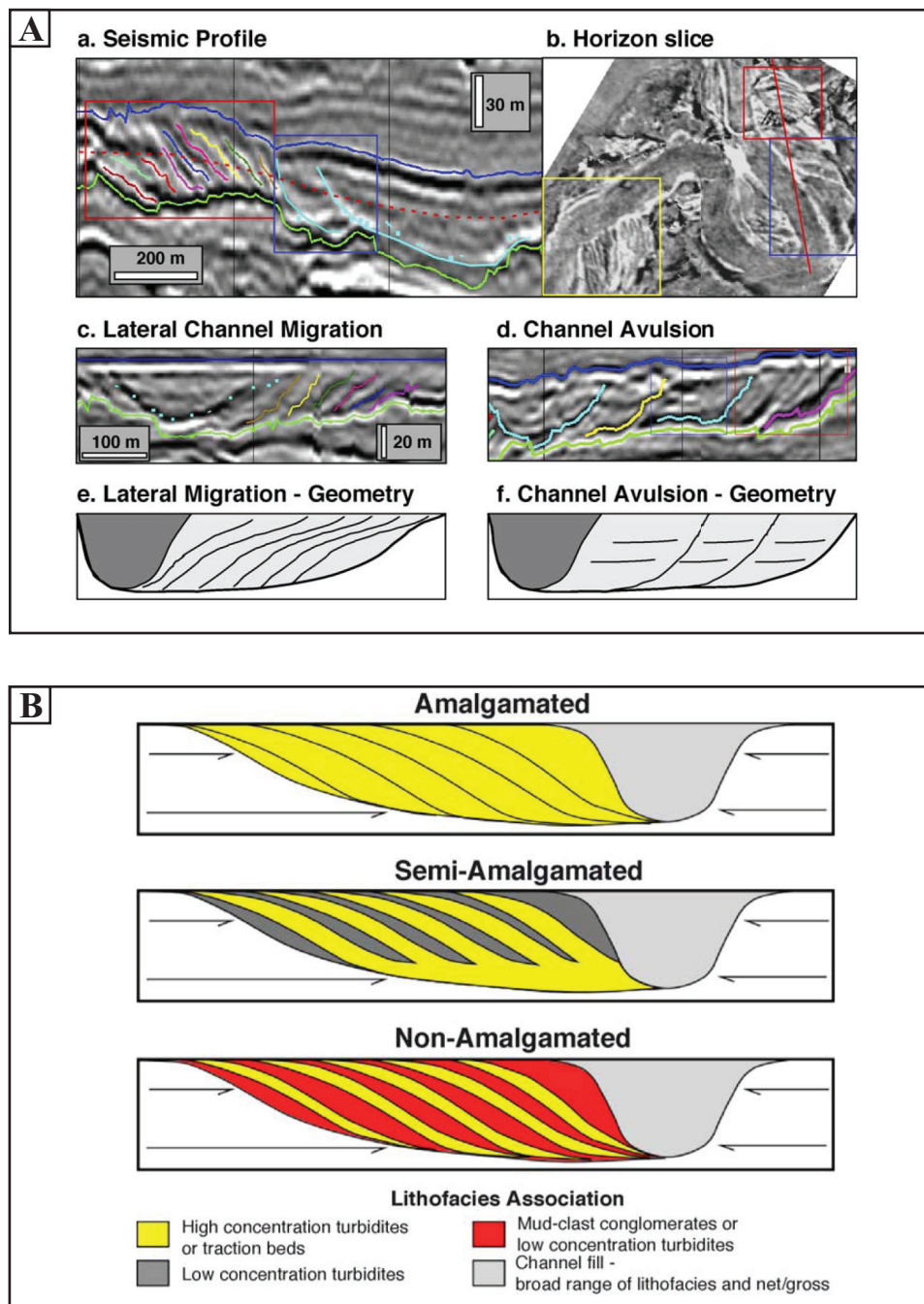


Figure 144 (A). Two different geometries identified by Abreu et al., 2003, figures a) red square, c) and e) related with lateral channel migration(shingled pattern). a) Blue square d) and f) related with lateral avulsion. Taken from Abreu et al., 2003

(B). Variation in the amalgamation of channels complex . Semi-amalgamated channels fills a re interpreted to be present in the study area and present potential barriers. Figures A and B taken from Abreu et al., 2003

the lateral migration; sand bodies could be isolated between the existing spacing of the wells.

Abreu et al (2003) associated these LAPs with laterally migrating sinuous channels, These authors noted grain-size present in these deposits vary laterally and vertically and these trends affect reservoir development: from amalgamated, to semi amalgamated, and non-amalgamated (**Figure 144 B**). In the Blasillo field, the lateral accretion packages are interpreted primarily as semi-amalgamated.

Future development and exploration

The sedimentary model in the Blasillo field developed for this thesis can be used as a guide to define and propose areas where infill wells could be drilled based on a geological model instead of the previously designed geometry of the uniform well spacing every 400 meters. The models proposed for these sequences allow us to define those areas where channel sediments are more connected and those where they have lateral migration with development of lateral accretion packages and sandstones bodies could be more isolated.

Five main recommendations for future development work in the Blasillo field and for exploration in the nearby area. First, the presence of the lateral accretion packages in some sequences provides for a new way to plan well development to access and connect different channel-fill bodies that are present between the wells. Mapping individual packages is necessary and where they stack vertically helps to define enhanced areas to drill.

A second recommendation is the develop of petrophysical models to help develop the relationship between the sand bodies using the lithofacies map as a guide combined with additional information of pressure data from the field.

Third, the model needs to evaluate the connectivity of the vertical relation of sandstones bodies; this is an important step to establish a dynamic model in the field and developing a good strategy for secondary recovery.

Fourth, an extended coring program in the field in new wells is necessary to understand vertical and lateral variability of the petrophysical properties before the implementation of the secondary recovery program. Specifically, additional cores will help define the nature of the sediment gravity flows, which in terms can be used in building the reservoir model.

Finally, a significant finding of this thesis is the large exploration potential that is present in the area below the allochthonous salt. Seismic reflections below the salt body are interpreted as strata with the potential to have traps below the salt body against the feeder, (**Figure 145**). A complete strategy for to explore this new play could include: (a) reprocessing of the seismic data for pre-stack depth migration and or (b) additional acquisition of new data to improve the image and resolution of the seismic reflection below this salt body. This improved imaging should help increase play and prospects analysis. The potential to extend the success of production below the salt bodies opens a new opportunity to have discoveries into new plays in the onshore part of Salina del Istmo basin.

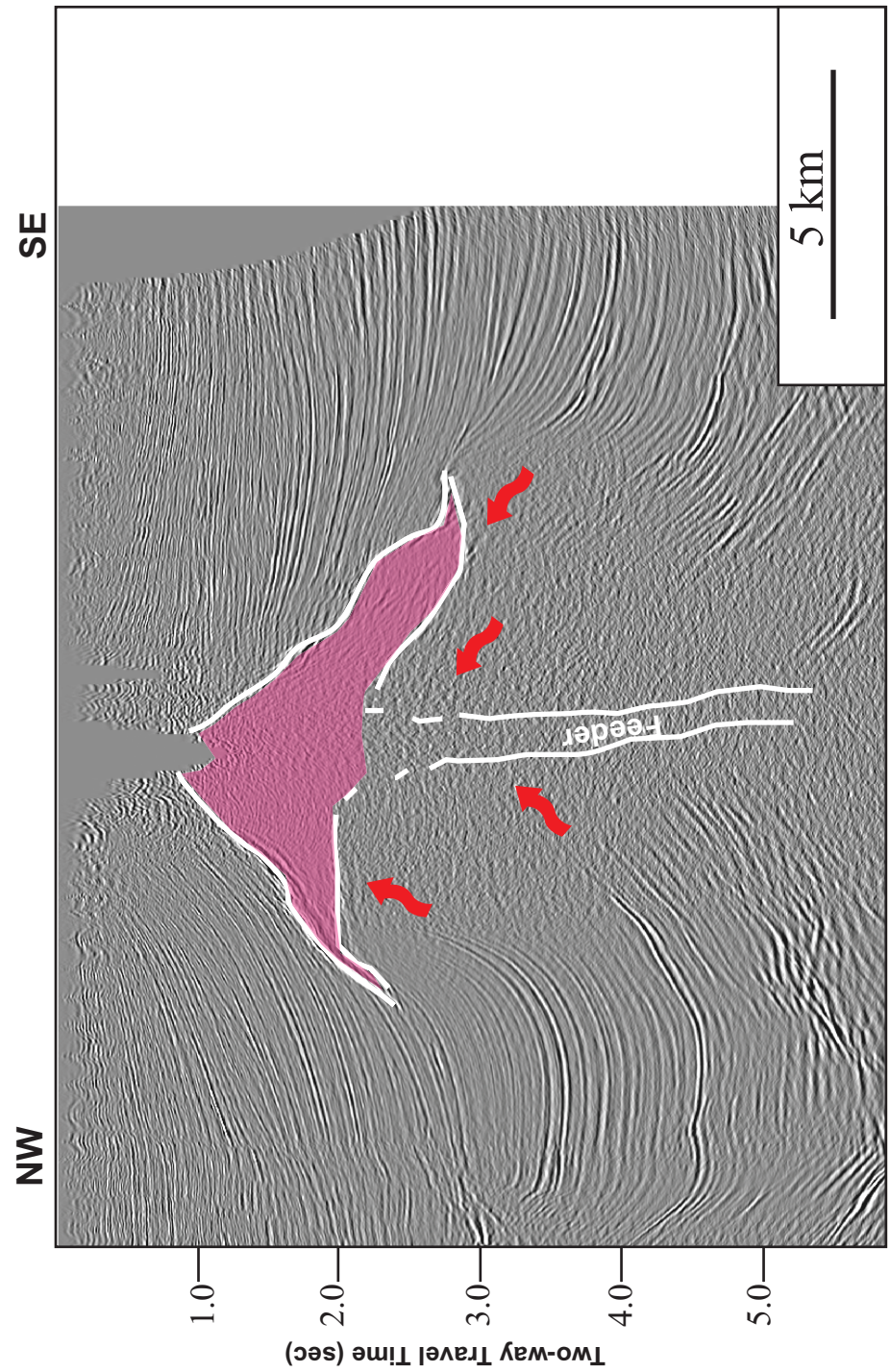


Figure 145. Seismic profile shows a complete view of the seismic section with the Blasillo field, Seismic information is not clear below the salt body, lateral reflection in both side of the salt let interpreted that sediment below the salt could be present below this body with the presence of potential traps against the feeder. Red arrows point out the potential trap areas below this salt body. See Figure 4 for location of profile.

CONCLUSIONS

1. The Blasillo field in the Salina del Istmo Basin is a mature field with good potential for in-fill drilling for secondary recovery. The field dips south on the flank of a shallow allochthonous salt feature. Reservoirs are upper Miocene turbidites that were deposited in upper bathyal water depths. Sediments were transported primarily from the south and southwest to the north and northeast.
2. Fourteen depositional sequences were identified using wireline logs separated by regional shales. They were associated in the seismic scale to third-order sequences. Detailed wireline log correlations indicated that each sequence consists of channel fills and channel complex fills. Within the sequences, cycles of alternating between erosional and erosional/aggradational channels are present. Net:gross and total net sand maps of each sequence show variation between the sequences.
3. Interpretation of the 3D seismic data shows the presence of LAP's (lateral accretion packages) as result of the migration of the channel complexes. These correspond to upward fining/thinning on wireline log.
4. Near the edge of updip salt, in eroded zones are present in several sequences and are interpreted correspond to period of salt movement. Changing seafloor gradients associated with salt movement created areas where sand were deposited in some sequences, or where shales developed in other sequences.
5. Based on a detailed understanding the geologic model of this field, a development strategy for infill drilling was developed. Understanding the distribution of the channel-fill architecture, and the LAPs are critical to developing the best spacing for well placement.

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