Gulf of Mexico Hydrate Mapping and Interpretation Analysis

Project Area 4 Report
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This report satisfies Mapping and Prospect Identification within Project Area 4 for BOEM award Gulf of Mexico Gas Hydrate Mapping and Interpretation Analysis, which is Deliverable/Milestone #5 (Table 1).

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Table 1. List of required deliverables and figures.

	Deliverable	Figure #
1	A map showing the distribution of shallow trubidite channel levee systems and shallow salt bodies.	7
2	A map showing the depth to the BSR and the spatial distribution of BSR's.	7, 8, 12, 16, 17
3	Regional seismic cross sections showing the base of gas hydrate stability and the relationship of perspective reservoir intervals to channel levee systems, faults, salt, and other geologic features.	9, 10, 12, 13, 16, 17, 18, 20
4	Subsurface geologic/geophysical maps at the base of gas hydrate stability as determined through mapping, modeling, and the integration of well log data	2, 3, 4, 5, 6
5	Subsurface geologic maps of one or more seismic reflectors within the gas hydrate stability zone (or that cross the gas hydrate stability zone) that have a high probability of containing coarse-grained sand based on well log analysis and the nature of the seismic reflector. Maps will include both strucural and amplitide renderings.	11, 12
6	Interpreted seismic lines that illustrate geologic fearures related to the prospective reservoirs including BSR's, faults, base of gas hydrate stability, and zones of interest.	9, 10, 12, 13, 16, 17
7	If wells occur in the vicinity of the prospect, annotated well-logs at each gas hydrate prospect showing the thickness of hydrates within the stability zone, interpreted base of gas hydrate stability, and the presence of feree gas beneath the gas hydrate stability zone.	13, 14, 18, 19, 20, 21

1. Study area and data

Project Area 4 occupies the northern and northeastern sectors of the Green Canyon protraction area in the northern Gulf of Mexico, water depths 400-1600 m. Project Area 4 includes several sedimentary minibasins separated by allochthonous salt ridges including the Thibodaux, Stewart and Ship minibasins (Figure 1). The area is characterized by persistent sediment mass transport deposits evidenced from multiple escarpments in the modern bathymetry data as well as from paleo mass transport complexes observed in the seismic data. There is no evidence for modern channelizing in the seafloor bathymetry. We do observe several buried channel systems in the seismic data, however, they are less developed and less organized compared to Project Areas 1, 2 and 3. This is likely due to enclosed character of minibasins in the central part of the continental slope restricting channel development and progradation within Project Area 4. In the southwestern part of Project Area 4, seismic data show multiple gas chimneys that have not been previously identified by BOEM in public documents. Gas chimneys terminate at the seafloor where they appear as doming features, possibly mud volcanoes or pingo-like features. Spacious bottom simulating reflectors (BSRs) have been previously interpreted across the Project Area; some of the BSRs are confirmed and described in the current report.

Importantly, a major part of this report is devoted to a large high-confidence (i.e. showing prominent BSR and phase reversals within a low gamma ray unit) but previously unknown gas hydrate prospect in the southwestern sector of Project Area 4 in Zone 1. We named this prospect Moby-Dick. Moby-Dick features a clear BSR with a phase reversal persistent over ~9,000 m and a prominent high-amplitude peak-leading reflector within up to 180 m thick coarse-grained channel system. To our knowledge, there is only one geologically similar gas hydrate reservoir known so far in the Gulf of Mexico – Terrebonne in Walker Ridge Block 313 (Frye et al., 2012). This report shows that Moby-Dick is another promising gas hydrate system that can be an excellent candidate for potential production tests in the Gulf of Mexico.

Elsewhere in Project Area 4, Zone 2 shows low-confidence gas hydrate accumulations that were previously outlined in Shedd et al. (2012) and are confirmed and described in this report. Zone 3 shows a low-confidence BSR that is likely related to a coarse-grained unit including channel deposits. This report also includes analyses of well log data within several additional locations that don't show high-confidence extensive BSRs but do show clear fluid flow features that may act as conduits to transport gas into the gas hydrate stability zone (GHSZ).

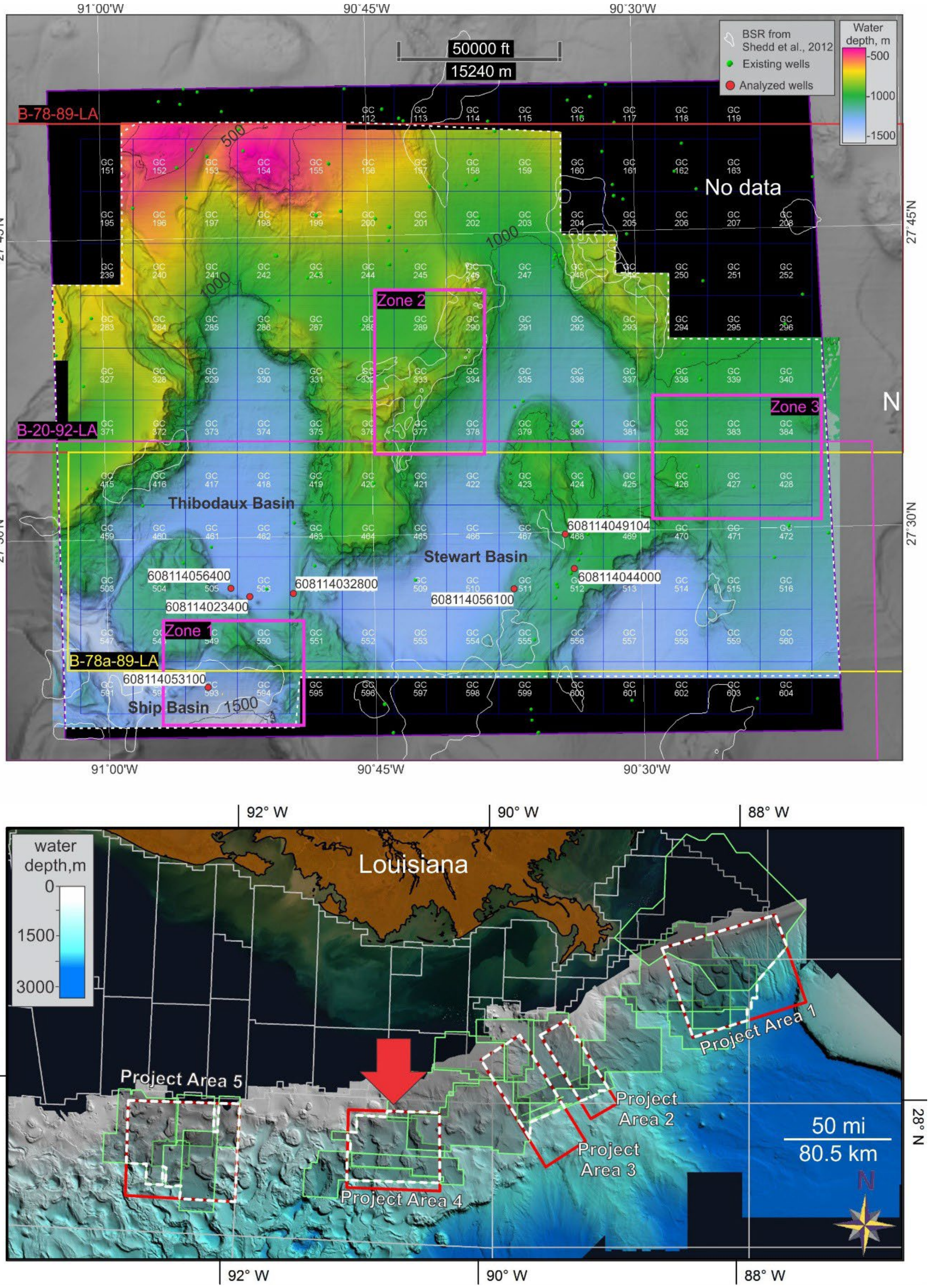

Figure 1. a) The bathymetry map and location of three 3D seismic surveys selected for interpretation based on the data quality assessment. See Table 2 for details. Analyzed wells are marked with red circles and labeled. Zones of interest are marked with magenta boxes and labeled. No seismic data are available outside the dashed white area. Known BSRs (Shedd et al., 2012) are indicated by white polygons. b) A bathymetry map of the northern Gulf of Mexico and five Project Areas. The location of Project Area 4 is defined with the red arrow.

Within Project Area 4, three seismic surveys were exported from the NAMSS database for data quality assessment (Figure 1a, Table 2). The total area of Project Area 4 is 4255.8 km^2 of which ~3250.6 km^2 (76 %) had 3D seismic data coverage. Based on spatial coverage and overall good data quality, we selected all three surveys to perform further data analyses and interpretation.

Table 2. Details on the 3D seismic surveys uploaded for initial data quality analyses within Project Area 4. Yellow color marks surveys selected for further data interpretation.

Survey number	Survey name/BOEM identifier	Project Area #	Year	Number of 3D volumes	Area of seismic survey (km^2)	Frequency range (Hz)	Bin size (m)	Projection
1	B-78-89-LA/ L89-078	4	1989	4	2254	5-70	25x25	15N NAD27, feet
2	B-78a-89-LA/ L89-078	4	1989	3	1531	5-70	25x25	15N NAD27, feet
3	B-20-92-LA/ L92-020	4	1992	6	2118	5-90	25x25	15N NAD27, feet

2. Using RMS for mapping bottom simulating reflections and paleo-channels

To identify the BSRs in Project Area 4, regional root-mean square (RMS) amplitude calculations were performed independently within all 3D seismic surveys (Figure 1a). Within Project Area 4 we did not follow the standard water depth-based workflow used in Project Areas 1, 2 and 3 and explained in Project Area 1 report. The reason for that are widespread shallow bedded salt features, which significantly disturb geothermal gradient and form hummocky base of GHSZ regardless of the water depth (i.e. hydrostatic pressure). To cover all depth intervals and manually inspect all amplitude anomalies, in each seismic volume we calculated RMS amplitudes within the following depth intervals: 10-50, 50-250, 250-500, 500-700 and 700-850 msec (Figures 2-6). These maps showed prevalence of salt-roof amplitude anomalies in the shallower intervals, where gas and possibly gas hydrate accumulate over salt (Figures 2, 3, 4), and increased number of amplitude anomalies in minibasins better displayed on deeper interval maps (Figures 5, 6).

BSRs in Project Area 4 are observed in depth interval between 1000 and 1800 msec TWT (~800-1500 mbsl, 100-600 mbsf) and they cluster spatially in three major zones: Zone 1, Zone 2 and Zone 3. We identified these zones of interest based on BSRs and other indications of gas hydrate accumulations. These BSR areas are extensive, however, they are smaller than the previously mapped BSRs by Shedd et al., (2012) (Figure 7, 8). Zone 1 includes the high confidence Moby-Dick gas hydrate prospect.

RMS analyses also helped to map paleo channels and identify locations with potentially higher content of coarse-grained sediments. Generally, channels in Project Area 4 are low-sinuosity and have north-south extent within the central parts of minibasins (Figure 7).

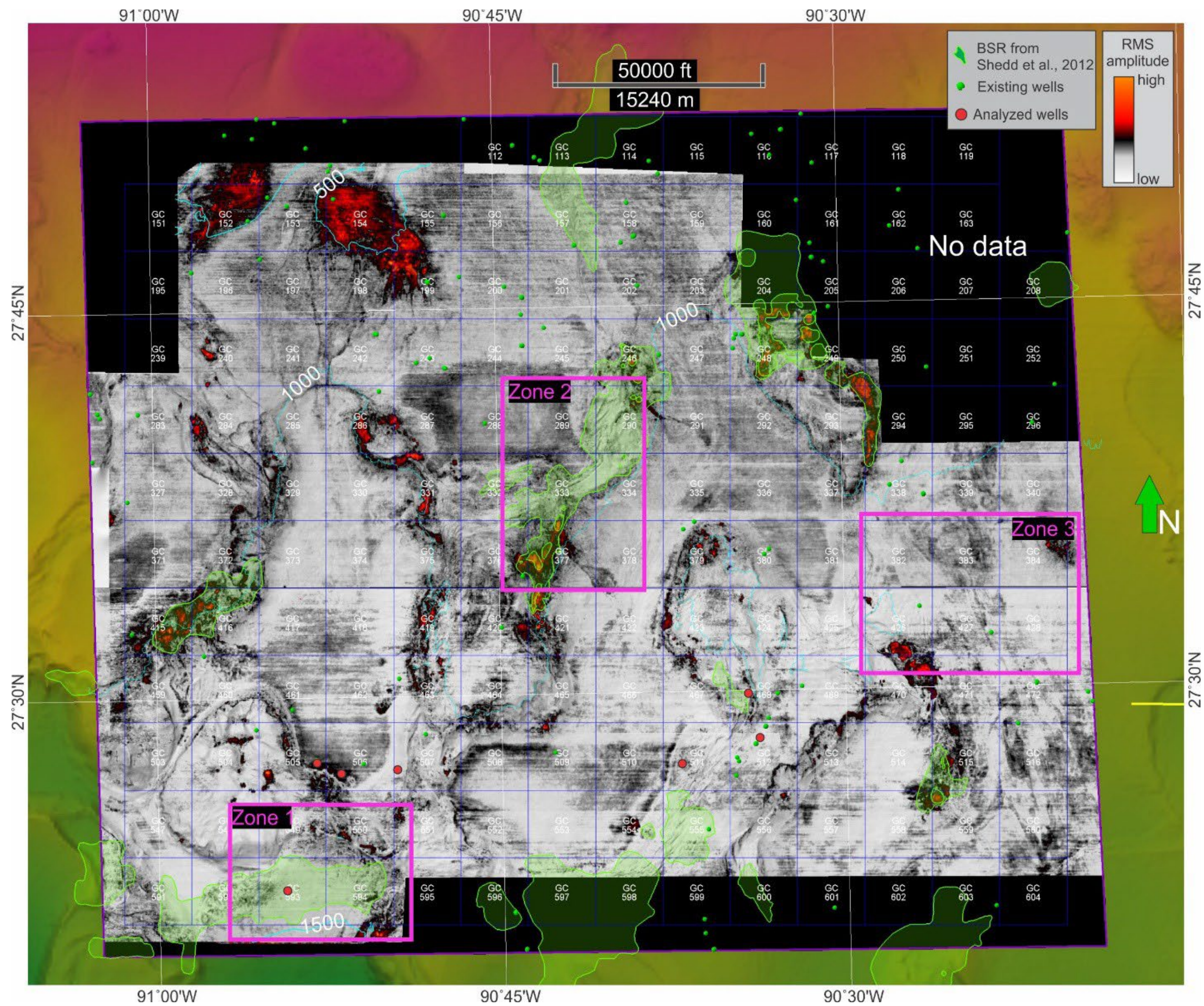

Figure 2. RMS amplitude map calculated for a subseafloor interval of 10-50 msec. Zones of Interest (purple), lease blocks (blue), existing wells (green dots) and known BSRs (green-shaded polygons; Shedd et al., 2012) are indicated.

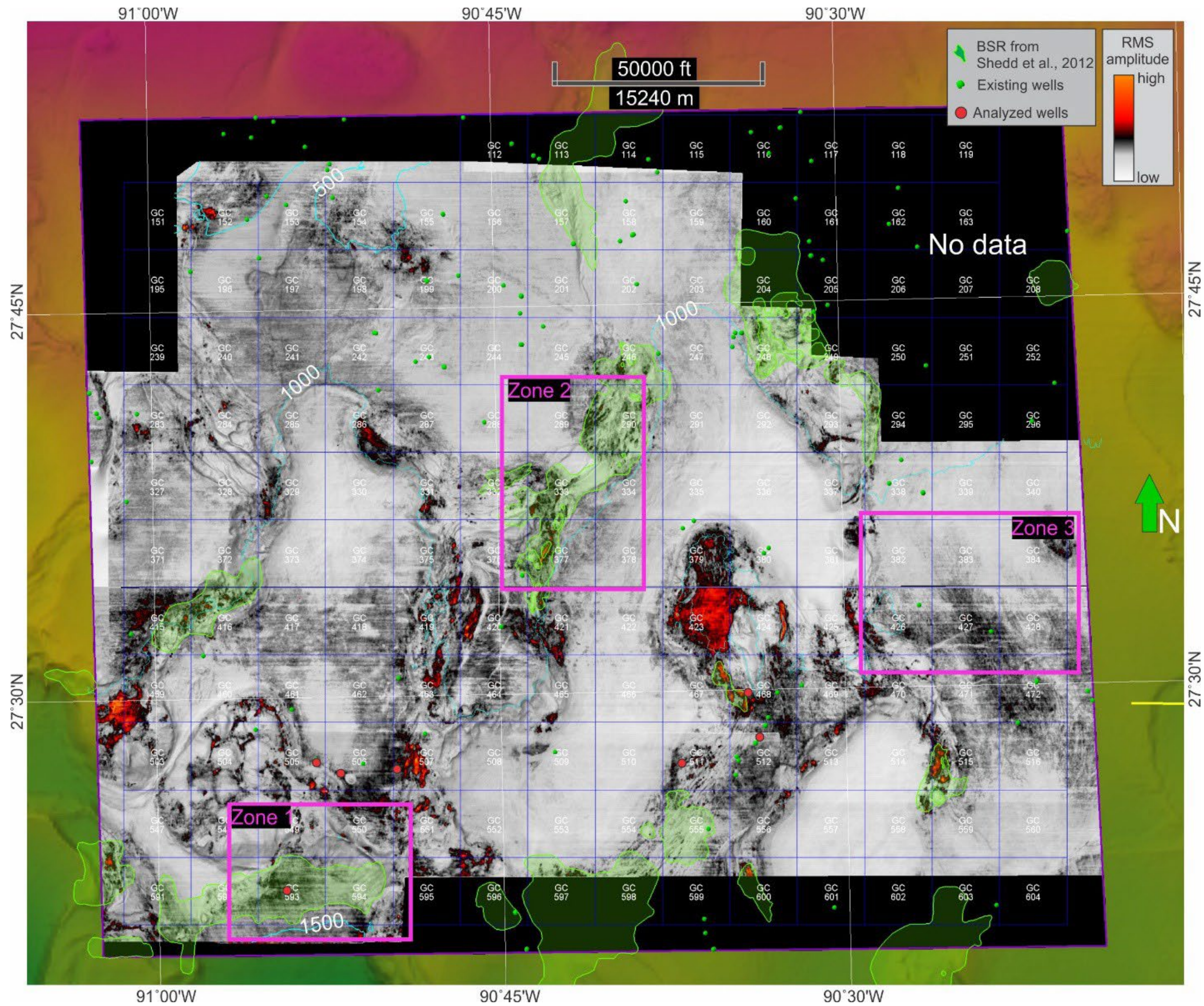

Figure 3. RMS amplitude map calculated for a subseafloor interval of 50-250 msec. Zones of interest, lease blocks, existing wells and known BSRs outlined in green (Shedd et al., 2012) are indicated.

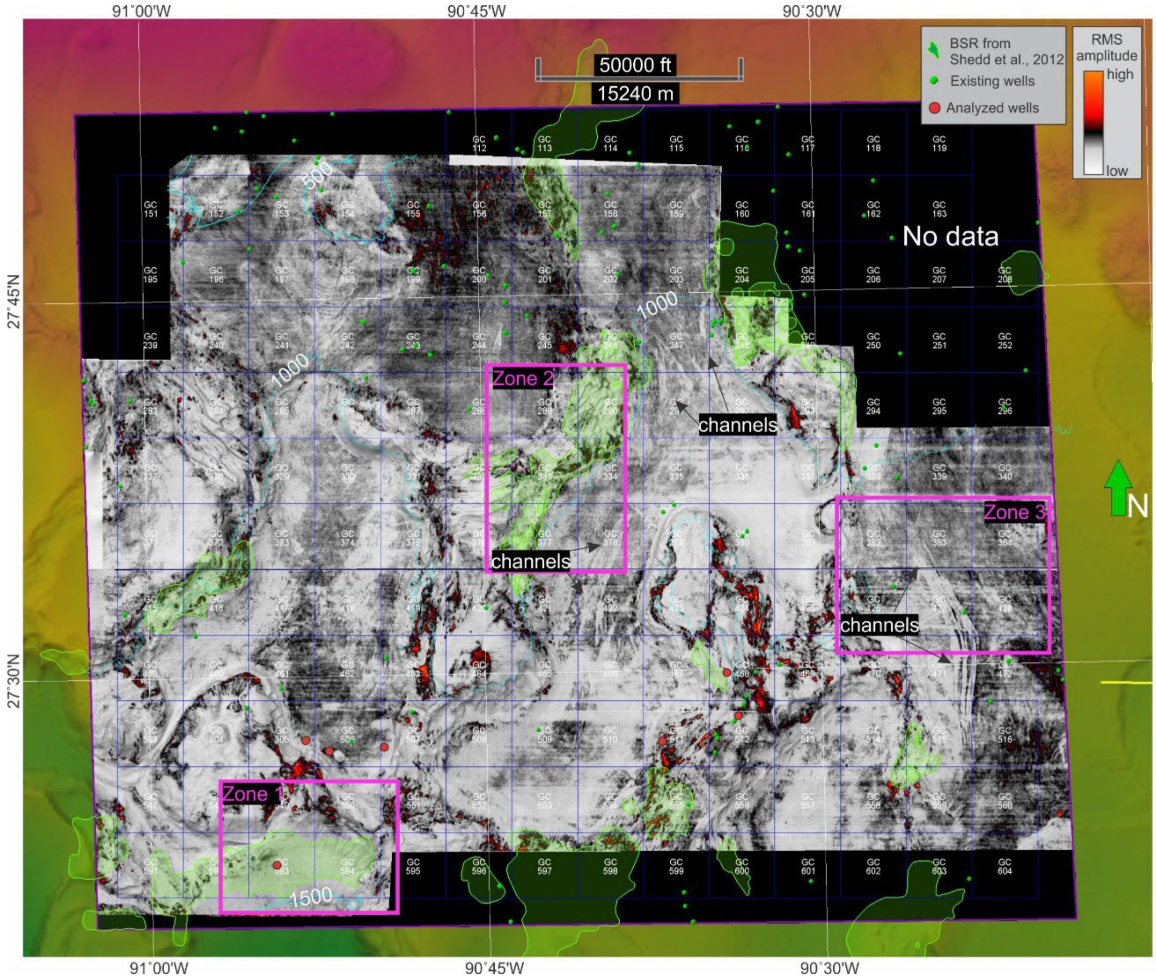

Figure 4. RMS amplitude map calculated for a subseafloor interval of 250-500 msec. Zones of interest, lease blocks, existing wells and known BSRs (Shedd et al., 2012) are indicated.

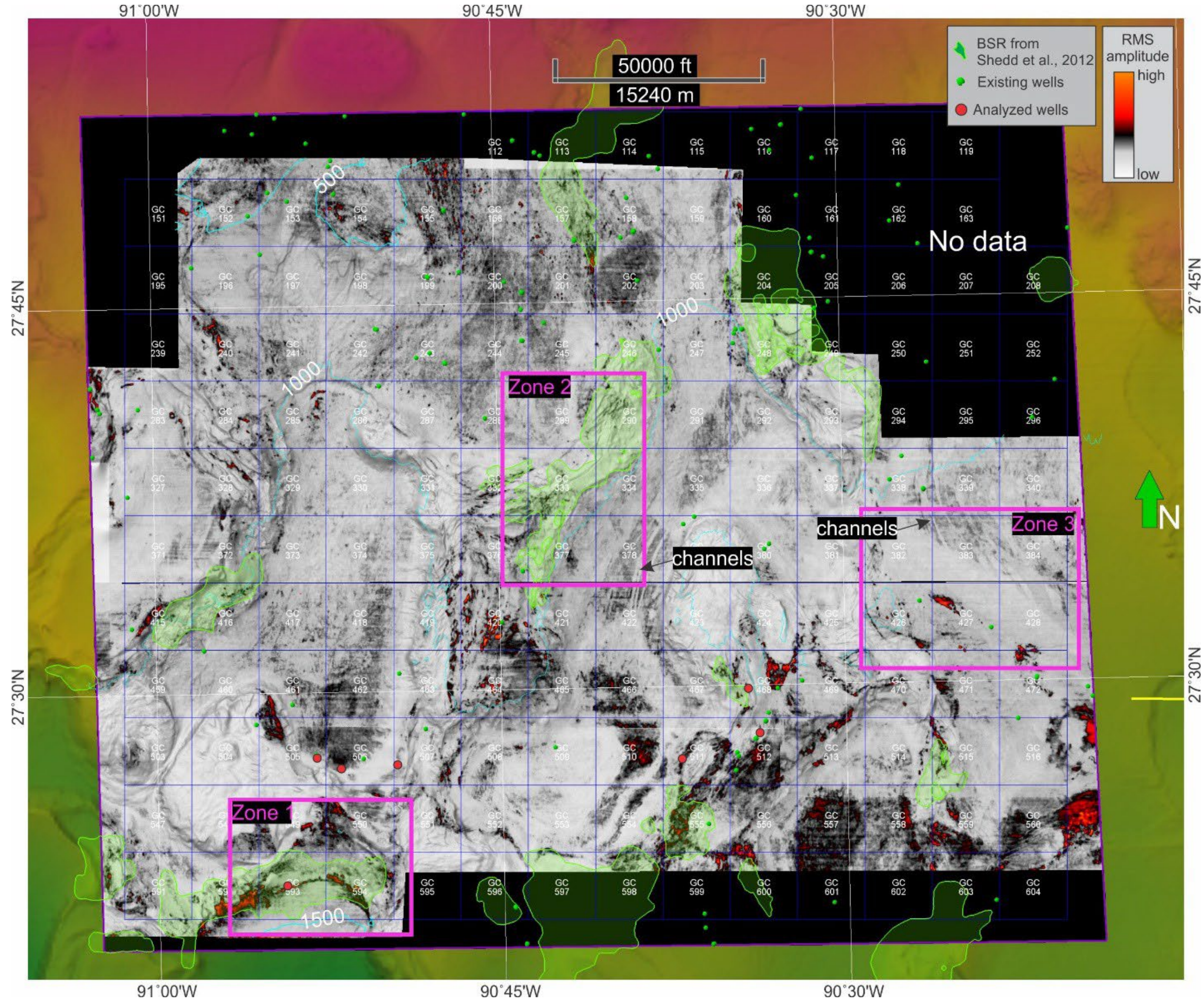

Figure 5. RMS amplitude map calculated for a subseafloor interval of 500-700 msec. Zones of interest, lease blocks, existing wells and known BSRs (Shedd et al., 2012) are indicated.

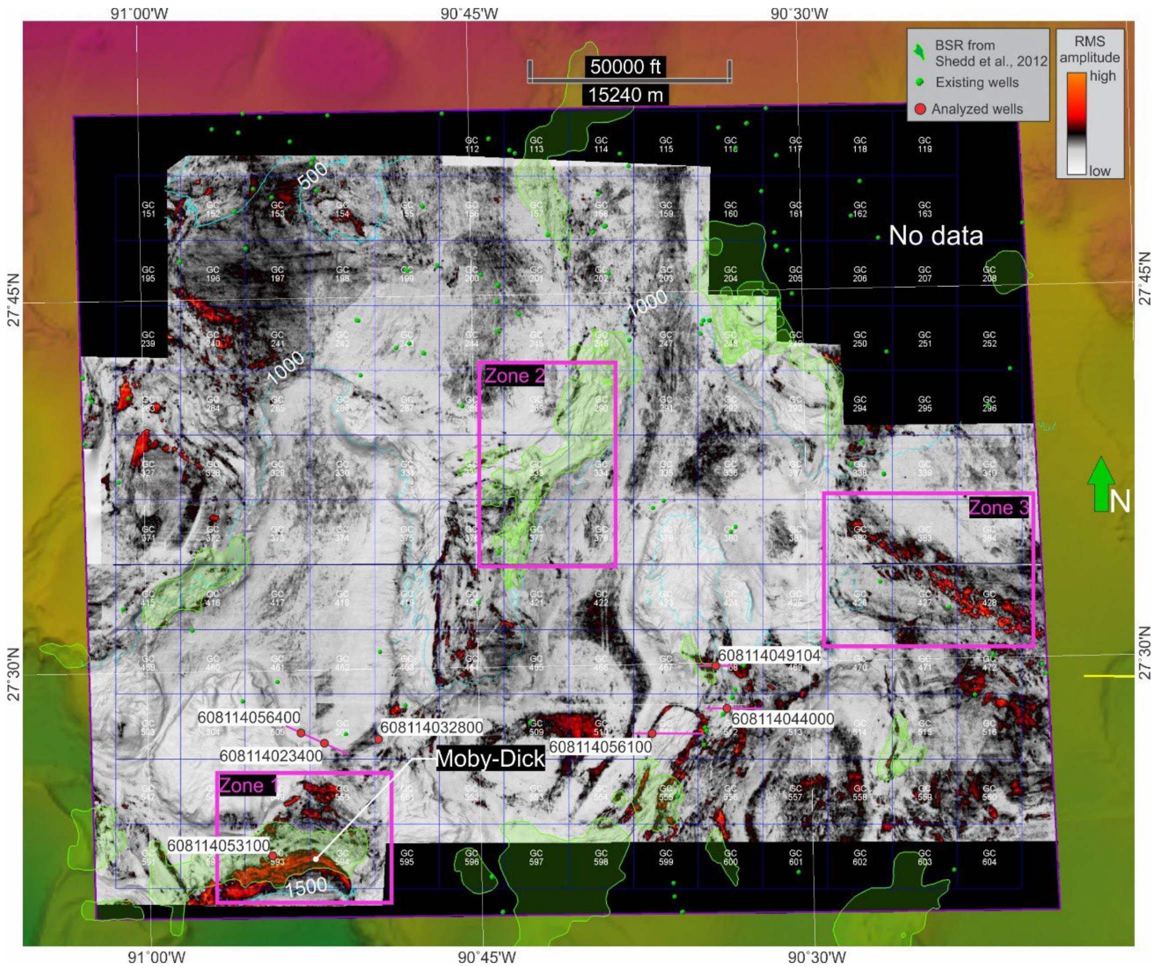

Figure 6. RMS amplitude map calculated for a subseafloor interval of 700-850 msec. Zones of interest, lease blocks, existing wells and known BSRs (Shedd et al., 2012) are indicated. Location of the high-confidence Moby-Dick prospect appears in Zone 1.

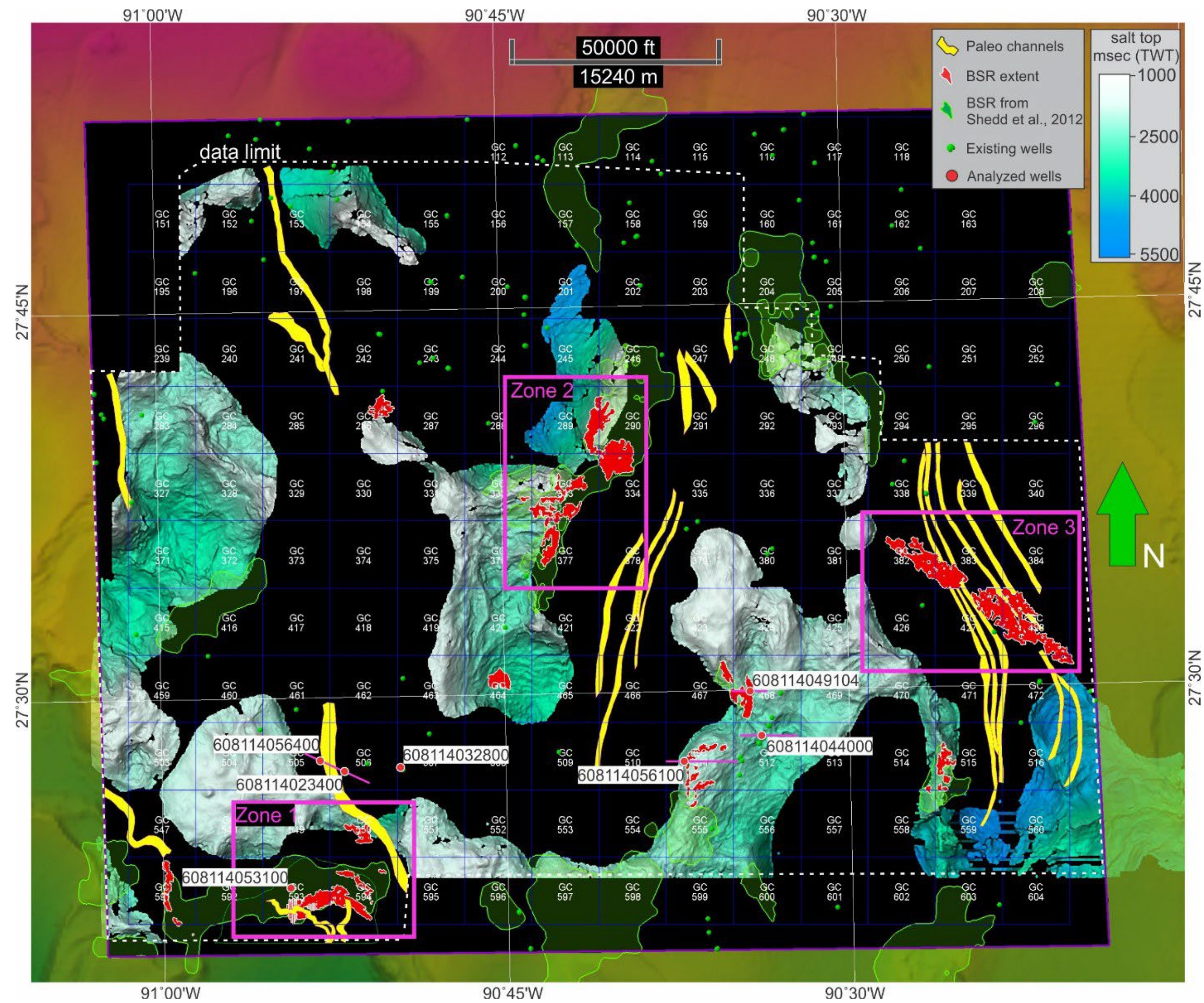

Figure 7. Depth of allochthonous top salt surface within Project Area 4. Extent of the BSRs identified in the current study is shown in red. Paleo channel systems are indicated with yellow polygons. Black background areas indicate sediment basins with no shallow salt present.

Figure 8. Map showing the depth of the BSRs (msec TWT) identified in the current study. Paleo channels are shown with yellow polygons. Location of a high-confidence Moby-Dick prospect is indicated.

3. Results in Project Area 4

3.1 High-confidence Moby-Dick prospect in Zone 1.

Zone 1 is located in the northern part of the salt-bounded Ship Basin extending southward beyond the limits of Project Area 4 (Figure 1a). In the seismic data, the shallow salt surface is evident at the basin margins, yet in the central parts of the basin it is not resolvable indicating its extremely deep location at the basin floor (>6000 msec TWT) (Figure 7). The Moby-Dick gas hydrate system occurs in the eastern outer levee of a paleo channel that crosses the northern margin of the Ship Basin in a NW-SE direction (Figures 8, 9). The BSR here extends over ~14.2 km^2, and a consistent phase reversal is observed for over 9,000 m (Figures 11-12).

3.1.1 Channel depositional system

The channel depositional system is characterized using multiple techniques which include: 1) seismic volume flattening along the basal horizon deposited immediately prior to the onset of the channel (Figure9, 10), 2) spectral decomposition analyses along the time slices in the flattened seismic volume (Figure 11b), and 3) gamma ray log data from well 608114053100 drilled into the flank of the channel system (Figure 13). Seismic data show that channel deposits extend ~3,500 m on both sides of a ~1,000 m wide sinuous channel fill and form up to 200-250 m thick levees (Figures 9, 10, 12a). Well 608114053100 drilled into the eastern levee shows a ~500 ft (150 m) thick interval with relatively low gamma ray (35-55 API) indicating a coarse-grained unit corresponding to channel deposits in the seismic data (Figure 13).

3.1.2 Evidence for gas hydrate in sand layers

As part of the Moby-Dick prospect, there is a clear phase reversal from a peak-leading reflection above the BSR to trough-leading below the BSR. The reversal is sharp and consistent (Figures 9a, 11a, 12a) along the major seismic horizon named Sand 1 (Figures 11a, 12a, c). The zone of high-amplitude peak-leading reflections extends over an area of ~8.5 km^2. Additionally, a less extensive phase reversal is observed along an underlying horizon Sand 2 occupying an area of ~2 km^2 (Figure 12a, c). Such a configuration indicates the existence of at least two coarse-grained gas hydrate-bearing intervals that are a minimum of 8 m-thick (based on vertical seismic resolution), but likely thicker. Potentially there are more hydrate-bearing intervals within the several hundred-meter-thick levee that are below seismic resolution. Unfortunately, resistivity logs from well 608114053100 are not helpful for confirmation of gas hydrate presence for two reasons: 1) the well was drilled just outside of the high-amplitude peak leading reflections and 2) casing between two drilling runs (cutting shoe at 6632 ft MD) coincides precisely at the base of the GHSZ and it was installed where hydrate-related resistivity increase could be expected. Instead, in this interval different resistivity logs show extremely chaotic values that are highly inconsistent between each other, suggesting a combination of poor data from casing and cementing (Figure 13a).

Resistivity logs show several small increases reaching 2-2.5 Ωm in the interval between 5050 and 6350 ft MD (Figure 13), likely indicating low-concentration gas hydrate in the sediments above the major channel system. Similar observations were made in Green Canyon Block GC955 and Walker Ridge 313 (Collett et al., 2012), where low-concentration gas hydrates were logged up-hole from the target reservoirs.

3.1.3 Evidence for gas at the base of GHSZ

The unfortunate location of casing exactly at the base of GHSZ (~ 6650-6720 ft MD) may not be just a coincidence. According to the well permitting documents, casing was initially planned deeper – at 6900 ft MD. However, the well activity report (WAR, included in the appendix) indicates that at 6720 ft MD the well showed slight flow (it was not stated if this flow was gas or water). For safety purposes, mud in the well was replaced with 14 ppg mud[1], which stopped the flow and stabilized the well. Subsequently, casing was installed and cemented at this depth. A flow observed at the wellhead may indicate excess formation pore pressure due to release of free gas at the base of GHSZ.

[1] As a side note, the high mud weight, 14 ppg, used on such a shallow well interval is interesting. At the very same time this well was drilled, the JIP2 wells were being drilled. Generally, mud weights were low, around 10.5 ppg mud during JIP2 drilling. At GC 955-Q a 13 and 16 ppg mud was used to control gas bubbles observed at the seafloor from the wellhead. It was thought that the 16 ppg mud may have fractured the GC 955-Q wellbore and increased the flow, and we were surprised a similar issue did not happen at the well near the Moby-Dick location.

3.1.4 BSR and variable geothermal gradient

Good seismic data quality allowed for precise mapping of the BSR within the Moby-Dick gas hydrate system. Interestingly, the base of GHSZ as defined by the depth of the BSR, deepens in the western part of the system increasing from ~600 msec bsf (~500 mbsf using 1700 m/s average sediment velocity) to 800 msec bsf (~680 mbsf) (Figure 12b). Our modeling shows that at 100% methane gas composition, this may indicate significant variation in the geothermal gradient between 23.7 °C/km in the eastern part and 19.3 °C/km in the western part (Figure 12b). Such change in the temperature regime over only ~9,000 m distance is surprising given that it occurs within one basin. Moreover, the heat-conductive salt bodies are equidistant from the eastern and western parts of the Moby-Dick system. Alternative explanations may be: 1) an unequilibrated geothermal gradient due to a more rapid sedimentation in the western part and 2) gradual gas composition change from 100% methane forming shallower structure I hydrate in the east to gas mix forming deeper structure II hydrate in the west. The first explanation requires additional modeling, however it will be highly complex and likely nonconclusive in a non-steady state domain where sediment packages get deformed by allochthonous salt movement.

3.1.5 Possible transition from structure I to structure II hydrate

The second explanation can be tested by trying numerous combinations of gas composition to match the BSR depth assuming transition to structure II hydrate in the western part of the Moby-Dick system. Such approach will produce numerous equally possible results. Yet, for the Moby-Dick prospect, gas compositions are available from the gas chromatographic logs in the well (608114053100) located only 750 m from the deepest observed BSR (Figures 12b, 14), indicating a 95.41% C_1, 0.02% C_2, 0%C_3, 4.40% C_4 and 0.15% C_5 gas mix. Surprisingly, this gas composition does explain the deeper BSR location using a geothermal gradient of 23.5 °C/km, which is very close to the modeled geothermal gradient assuming 100% methane in the eastern part of the basin. At the moment, both geothermal gradient variation and gas composition seem equally possible explanations; in support of the latter, multiple deep-rooted fluid flow features (gas chimneys) are observed close to the western part of the Moby-Dick prospect (Figure 11). These chimneys may feed the gas hydrate system with thermogenic gas, which is also supported by significantly higher negative amplitudes below the GHSZ potentially indicating higher gas concentration in proximity to fluid flow systems (Figure 11a). Additional drilling data is required for more conclusive analyses of the geothermal gradient, gas composition and gas hydrate saturation.

3.1.6 Gas-water contact

Evidence for a gas-water contact (GWC) exists in the eastern section of the Moby-Dick gas hydrate system. We observe a zone of flat peak-leading reflectors with the average amplitudes along the phase reversal just below the gas leg (Figure 11b inset). The GWC is not extensive and we only map it over a ~4000x750 ft (~1200x230 m) area within the northeastern distal levee.

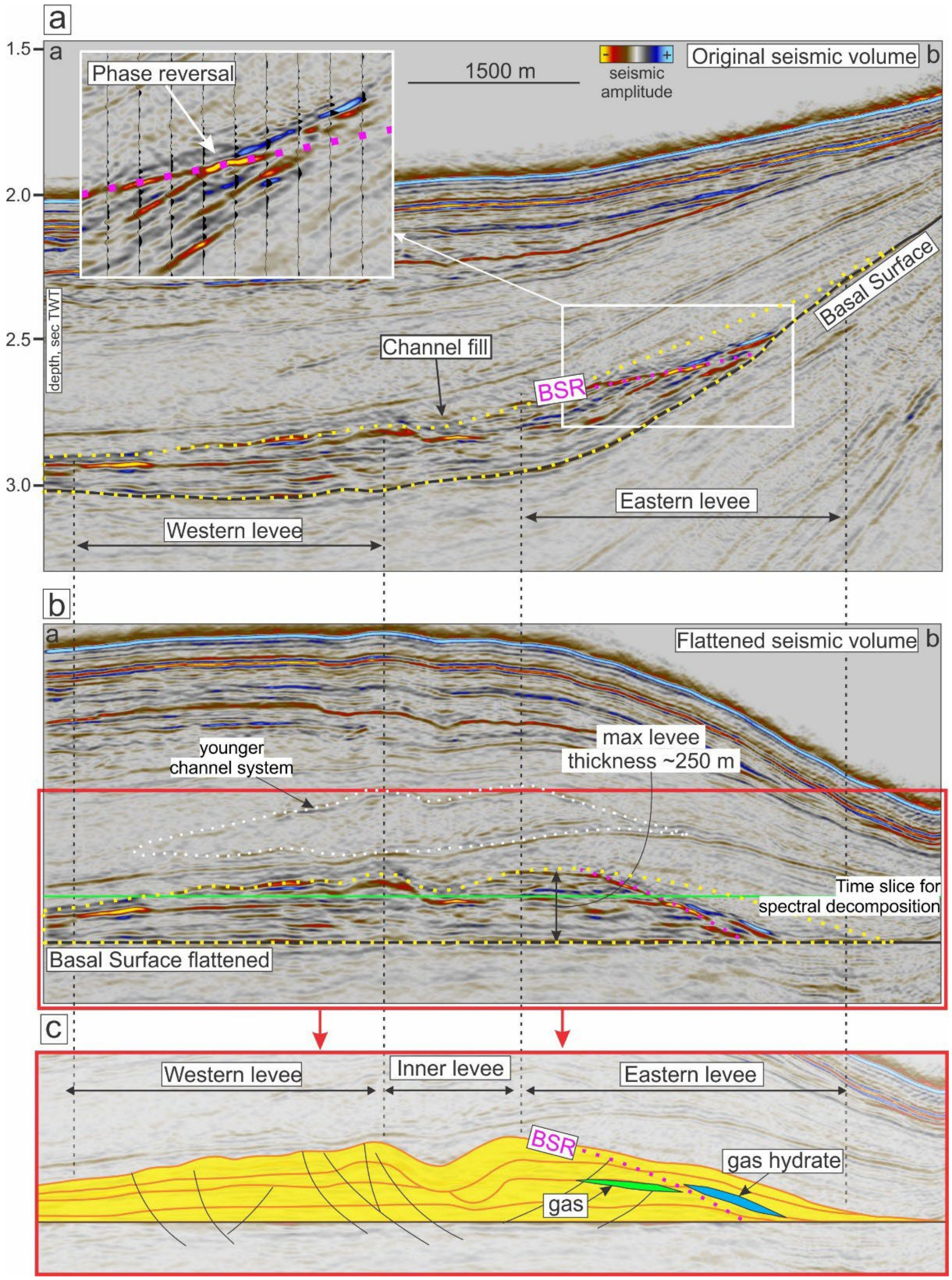

Figure 9. a) Cross-section a-b in the original seismic volume showing location of a phase reversal in the eastern levee of the channel system in Zone 1 (outlined with a dotted yellow line). Location of the cross-section a-b is shown in Figure 11. BSR is marked in pink. b) Cross-section a-b in seismic volume flattened relatively to a basal surface. c) Schematic drawing of major elements of the channel system, gas hydrate above the BSR and gas below in a flattened seismic volume.

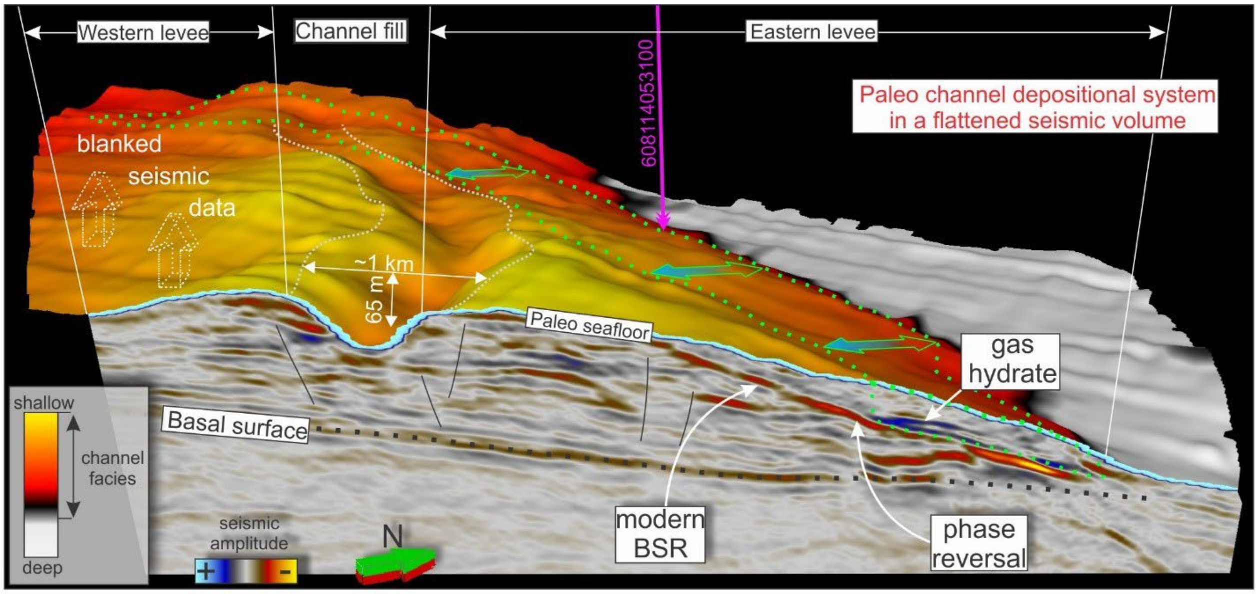

Figure 10. Model of the channel system in Zone 1. Original seismic volume is flattened relative to the basal surface and blanked above the approximate top of the channel system. Major elements are shown, location of the well 608114053100 is indicated.

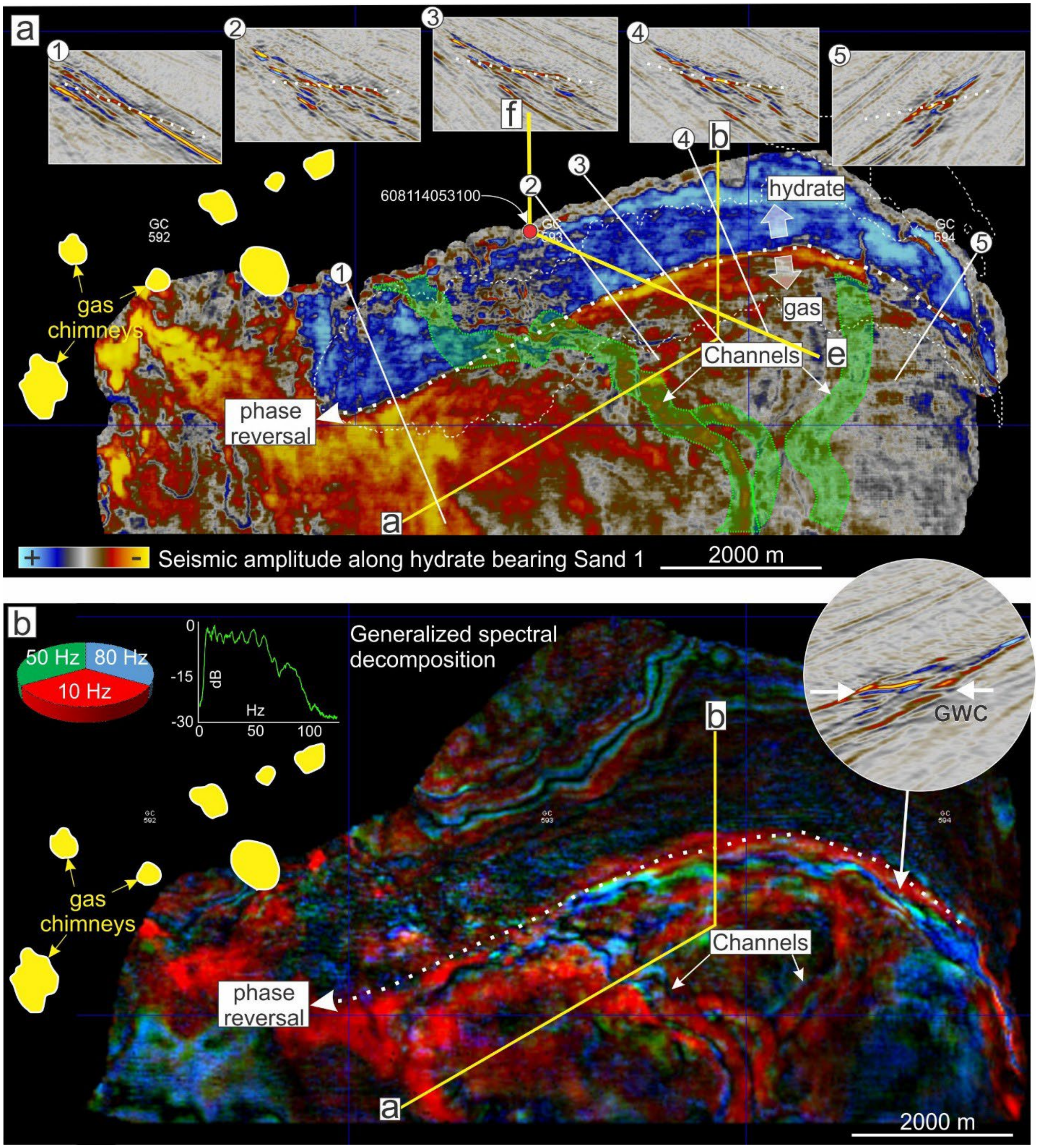

Figure 11. a) Seismic amplitude along gas hydrate bearing horizon Sand 1 showing phase reversal from peak-leading (blue) to trough-leading (red) reflection. Insets show examples of phase reversals from different parts of Moby-Dick system (locations indicated with numbers). Locations of cross-sections a-b and e-f, well 608114053100 and gas chimneys are indicated. Dashed white polygon shows extent of the BSR. b) Generalized spectral decomposition along a time slice marked in Figure 9b showing location of channels in Zone 1.

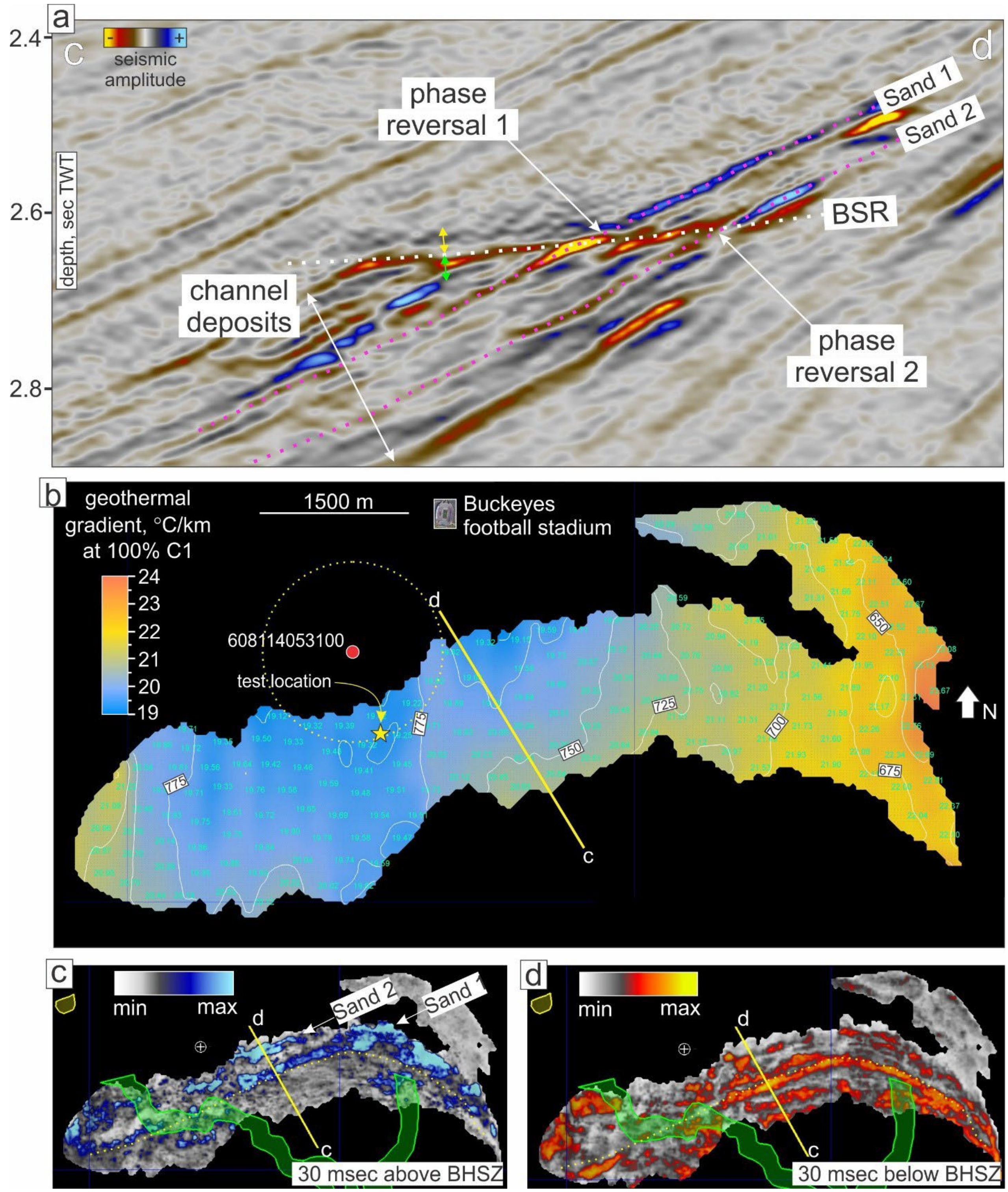

Figure 12. a) Seismic cross-section c-d (location is shown in Figure 12b, c, d.) showing two phase reversals along two horizons Sand 1 and Sand 2. Yellow and green double arrows indicate intervals from average positive amplitudes calculations above the BSR and average negative amplitudes below (see Figure 12c, d). b) Modeling of the geothermal gradient based on 100% methane composition and BSR depth. Labeled isolines show subseafloor depth of the BSR (msec TWT). A yellow star indicates proposed test location selected for 1D modeling of structure II gas hydrate. The proposed test location is selected based on the deepest BSR. c) Average positive amplitude map above the base of GHSZ. d) Average negative amplitude map below the base of GHSZ.

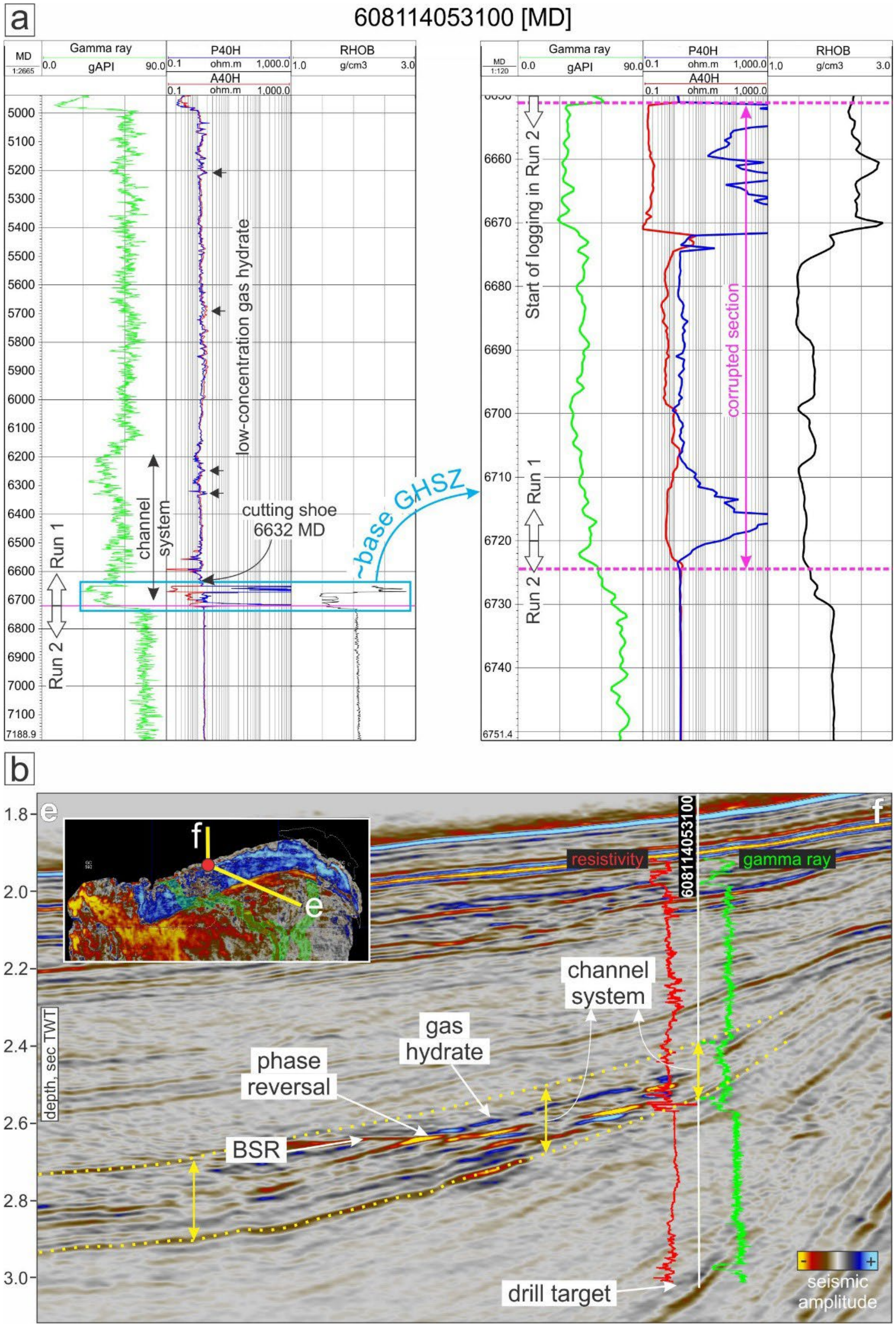

Figure 13. a) Gamma ray, resistivity (P40H and A40H) and density logs in well 608114053100. Right panel is a zoom in at the approximate base of GHSZ where casing between Run 1 and Run 2 was installed. b) seismic cross-section e-f showing channel system confirmed by low gamma ray and elements of the gas hydrate system.

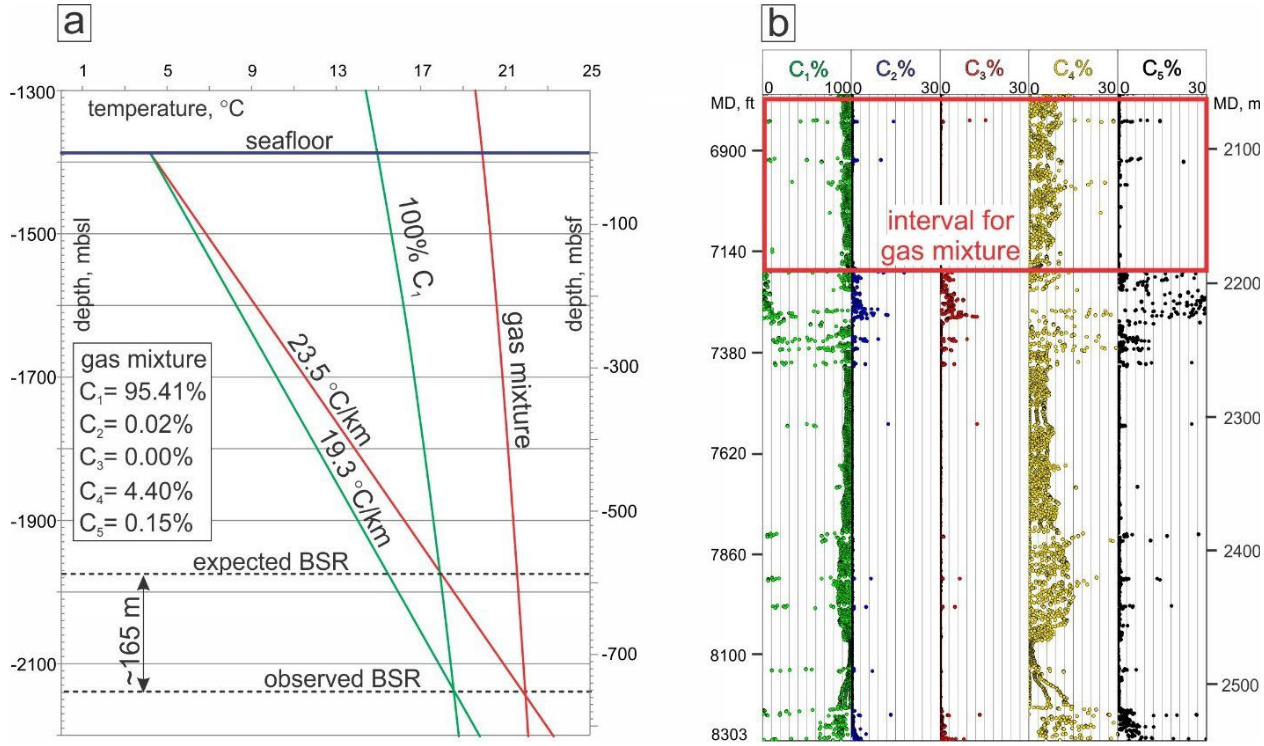

Figure 14. a) 1D modeling of the gas hydrate phase boundary using 100 % methane (green) and gas mixture from well 608114053100 (red). Geothermal gradients required to match the observed BSR in the test location (yellow star in Figure 12b) are indicated with the corresponding colors. b) Gas composition in the chromatographic logs in well 608114053100. Interval for average gas composition used in 1D modeling is from the upper ~100 m below the base of GHSZ.

3.2 Results in Zone 2

Zone 2 is located in the central part of Project Area 4 (Figures 1-8). There are no prominent channel systems crossing Zone 2, however RMS amplitude maps show extensive anomalies at the approximate base of GHSZ potentially indicating a BSR (Figures 15, 16). BSRs cluster in two major groups in the northeastern and southwestern parts of Zone 2 (Figure 15). We observe BSRs both above salt domes and in salt withdrawal minibasin (Figure 16). The average positive amplitude map above the BSR in the northeastern part of Zone 2 shows chaotic distribution confirming absence of any organized channelizing (Figure 16 e, f, g).

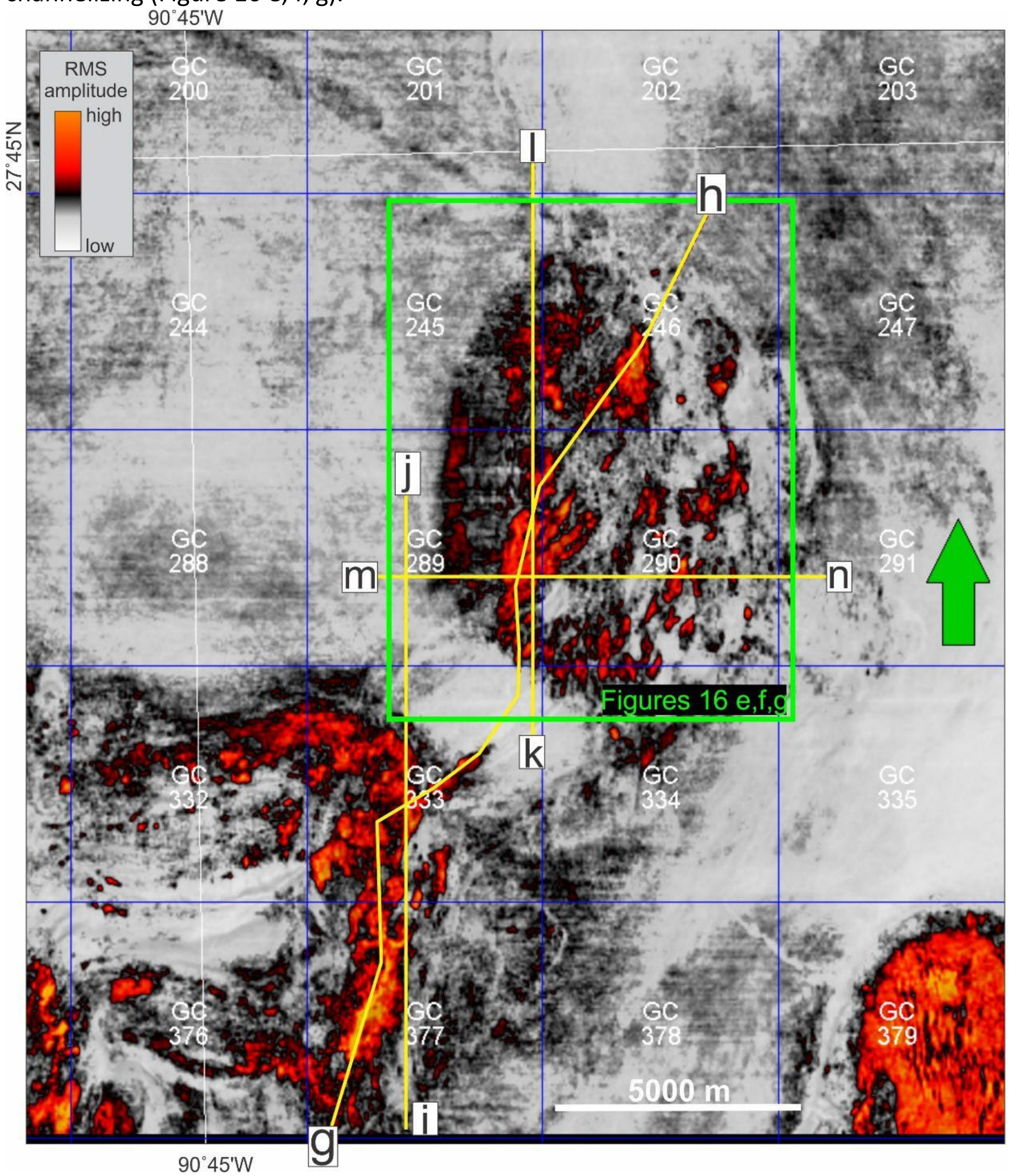

Figure 15. RMS amplitude map calculated for the interval 50-250 msec below the seafloor showing extent of gas-saturated sediments at the base of GHSZ in Zone 2. Yellow arbitrary line shows location of arbitrary seismic cross section displayed in Figure 16.

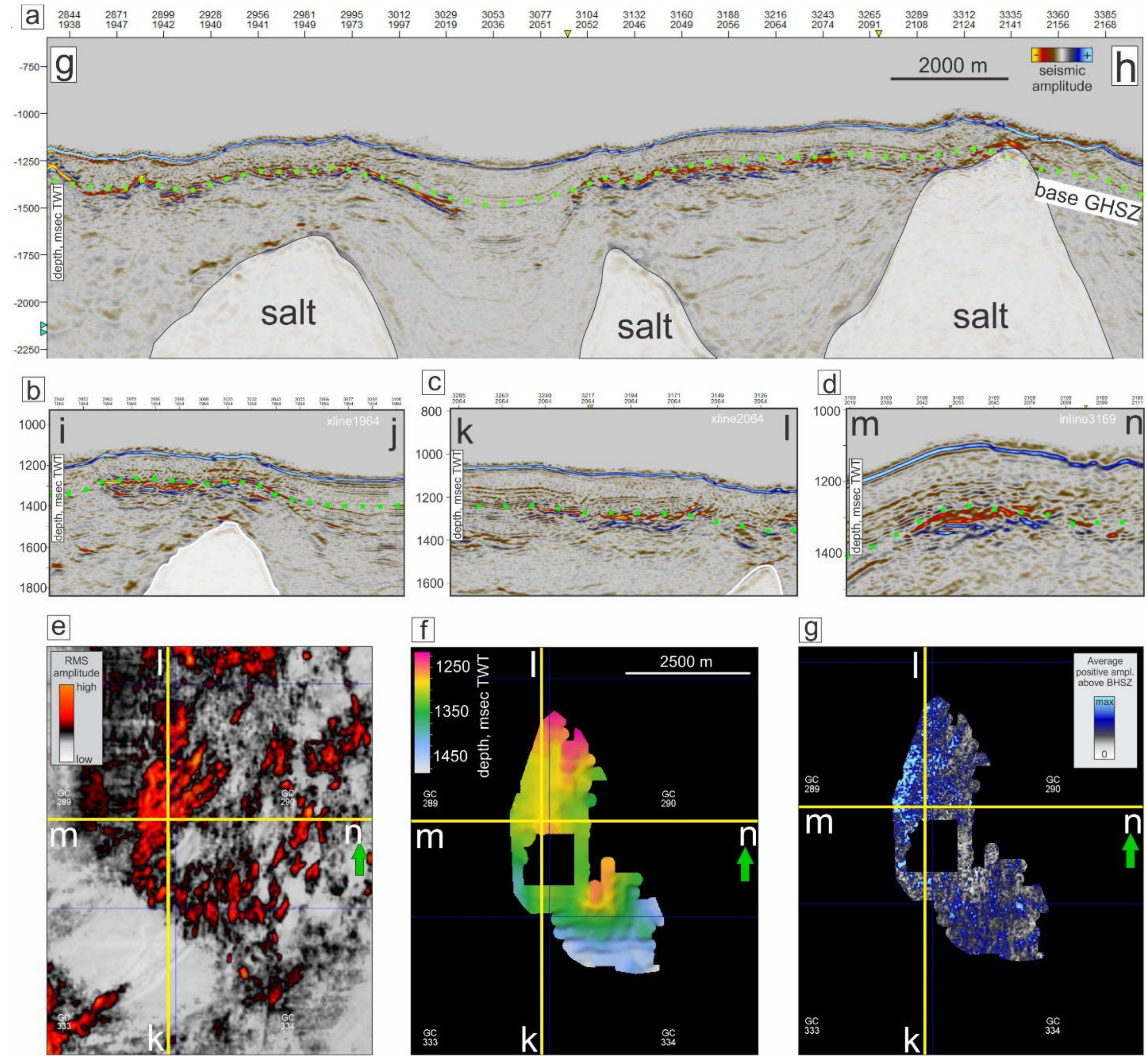

Figure 16. a) Arbitrary cross section g-h (location is indicated in Figure 15) showing BSRs in Zone 2. Seismic cross section in the southwestern (b) and northeastern (c, d) parts of Zone 2. Location is indicated in Figure 15 and Figure 16e, f, g. RMS amplitude map (e), approximate BSR depth (f) and average positive amplitude above BSR (g) for the northern part of Zone 2.

3.3 Results in Zone 3

Zone 3 presents an amplitude anomaly extending for over 10 km in NW-SE direction (Figure 17a, b). A high-amplitude BSR in Zone 3 is concentrated within a ~250 msec thick interval with chaotic seismic signature and generally low to average reflection amplitudes that may indicate presence of channel deposits. Accordingly, RMS amplitude maps show that Zone 3 is intersected by multiple heterochronous channels (Figure 7), some of them are coeval with the unit hosting the BSR. There are no robust indications of gas hydrate from strong peak-leading reflections or phase reversals (possibly due to prevailing sub-horizontal stratigraphy parallel to the seafloor).

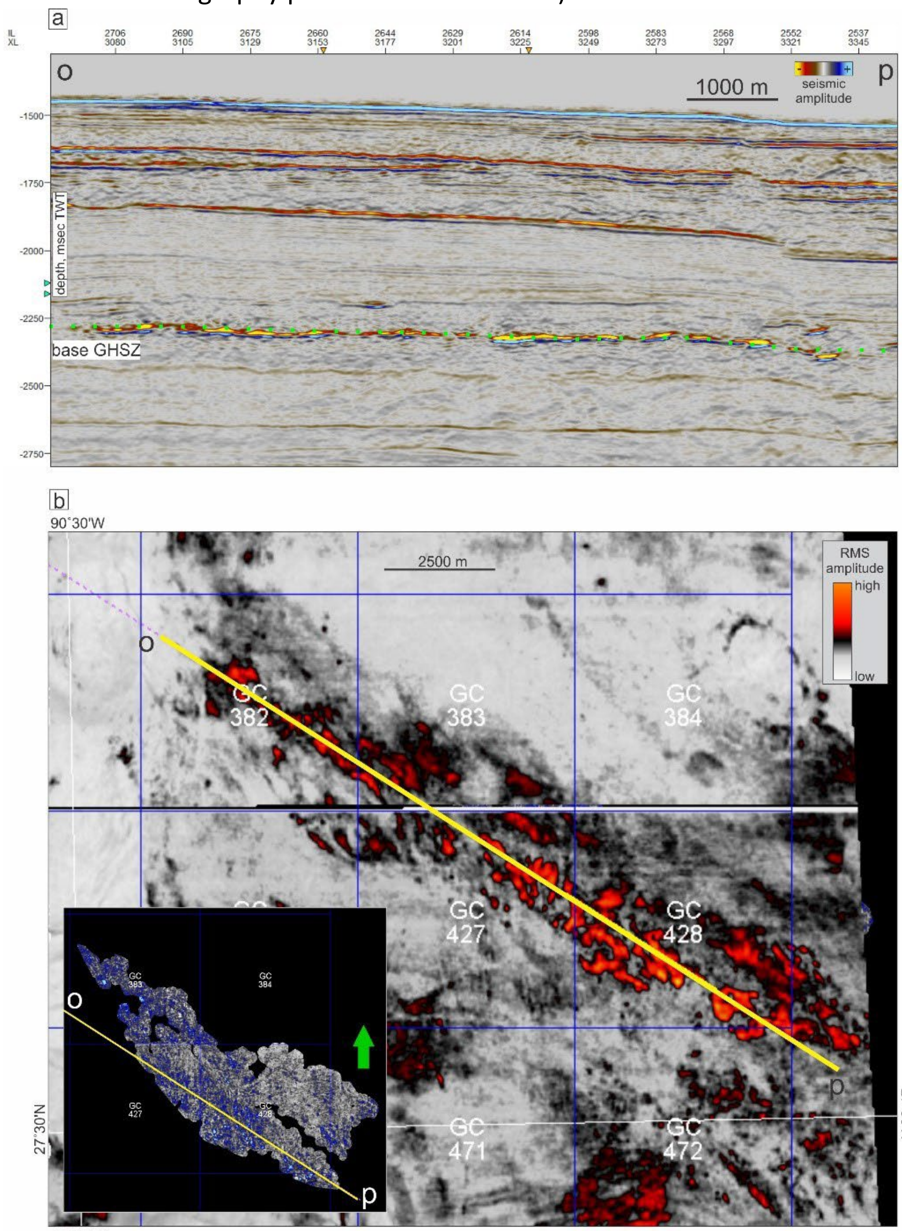

Figure 17. a) Seismic cross-section o-p showing potential BSRs in Zone 3. Location of the cross section is indicated in Figure 17b. b) RMS amplitude map showing the distribution of BSR in Zone 3. Inset shows map of average positive amplitudes above the approximate base of GHSZ.

3.4 Wells outside of Zones of interest

Based on the regional RMS amplitude maps (Figures 2-6) several additional sites were chosen for log data analyses. Two of these sites are next to possible BSRs (Figures 18, 20), others are located near gas chimneys and/or faults, which may provide fluid flow and gas transport into the GHSZ (Figures 19, 21). Locations of wells within all tested sites are shown in Figures 6, 7, 8. Neither of the analyzed wells showed clear resistivity anomalies within low-gamma ray units, indicating no high saturation gas hydrate were present. Figure 18 shows the only location with a slight resistivity decrease below the GHSZ relatively to the overlying section, however this decrease is only from 1 to 0.5 Ωm and is certainly retaliated conductivity increases from brine-enriched pore water from the underlying salt.

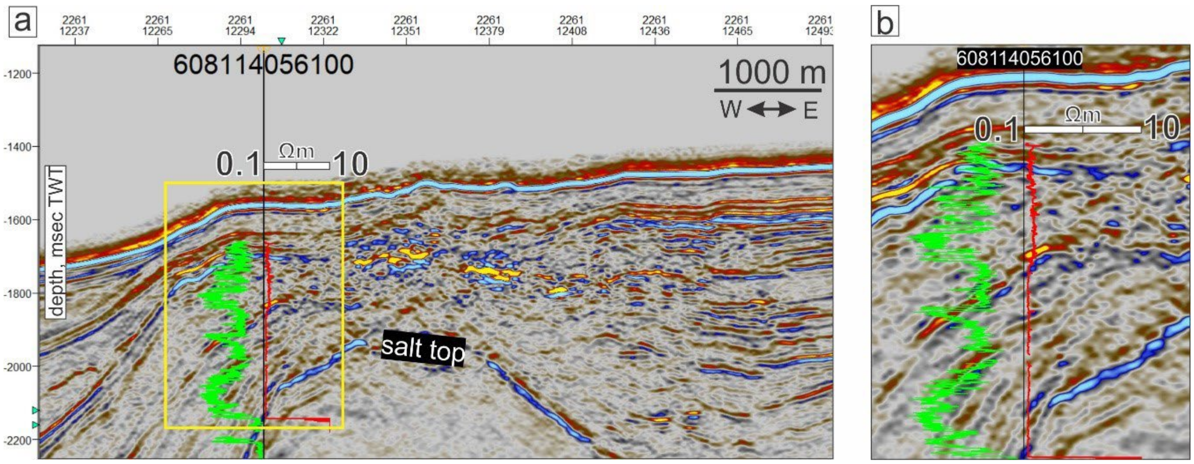

Figure 18. a) Seismic cross section showing well API 608114056100 near possible local gas accumulation at the base of GHSZ. See location of cross section and well in Figures 6, 7, 8. Negligible resistivity decrease from ~1 to ~0.5 Ωm is observed just below the approximate base of GHSZ (b).

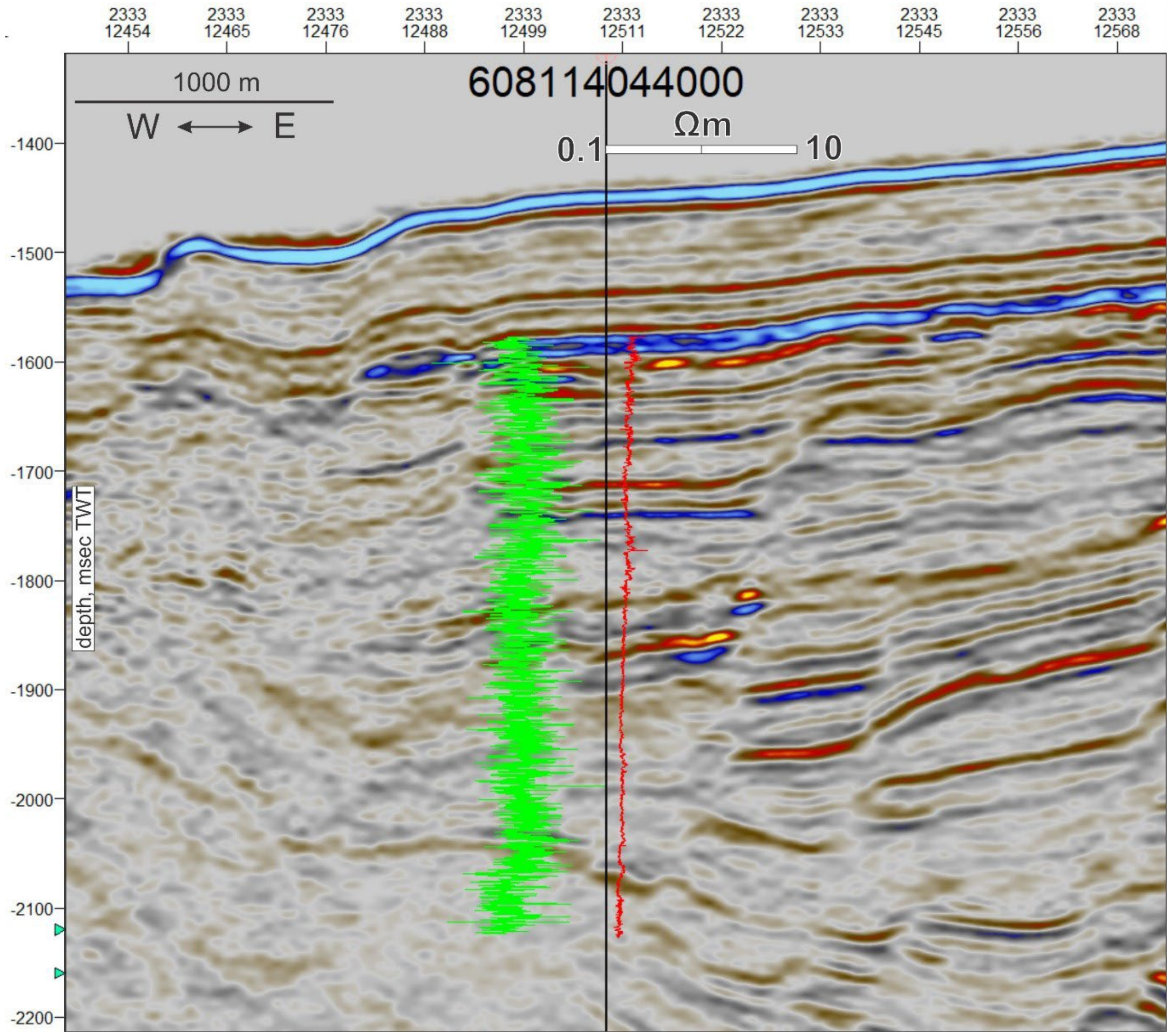

Figure 19. Seismic cross section showing well API 608114044000 chosen for analysis for its proximity to faults and fluid flow features based on general RMS amplitude maps (see Figures 6, 7, 8 for location). No significant resistivity anomalies indicating gas hydrate were identified in the shallow section.

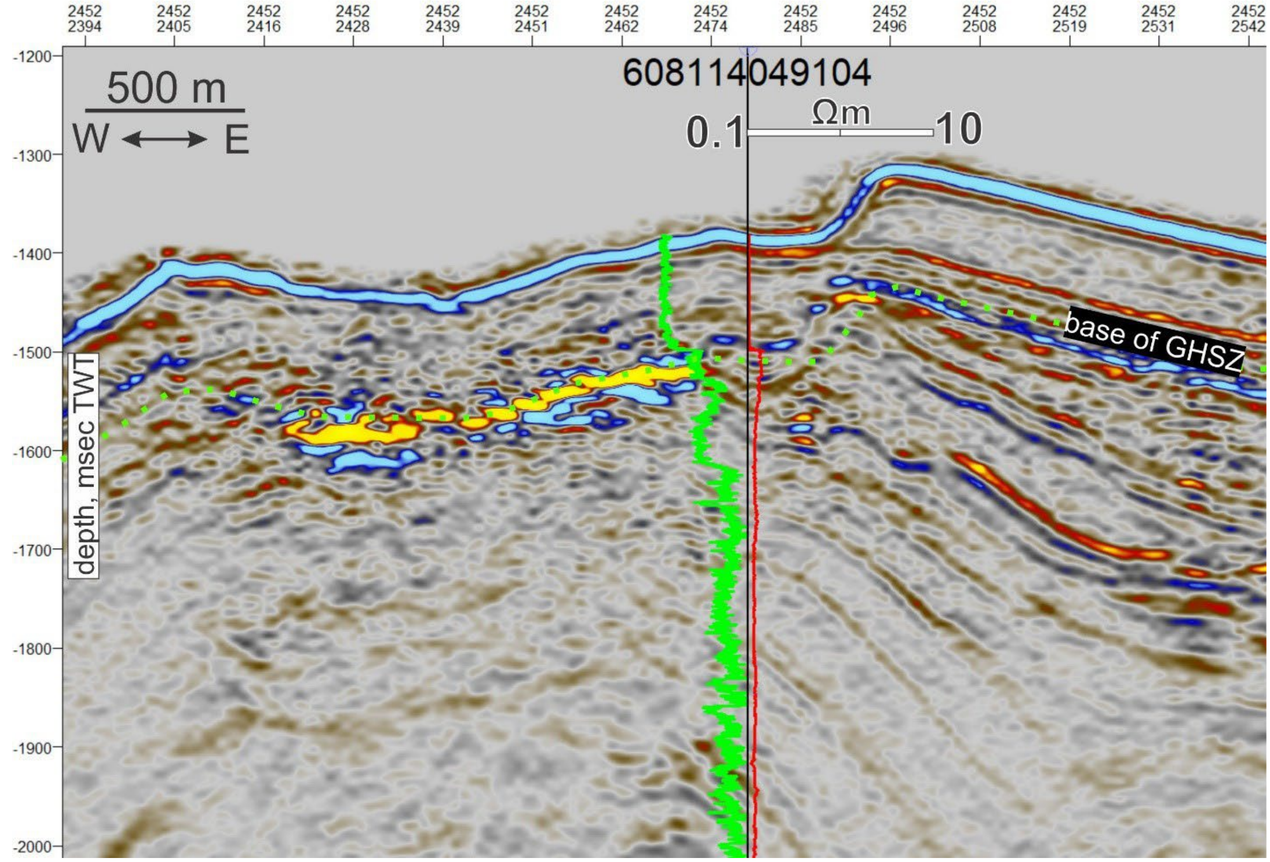

Figure 20. Seismic cross section showing well API 608114049104 chosen for analysis for its proximity to a prominent BSR (see location in Figures 6, 7, 8). Upper log section, approximately down to the base of GHSZ doesn't have valid resistivity measurements showing constant 0.1 Ωm.

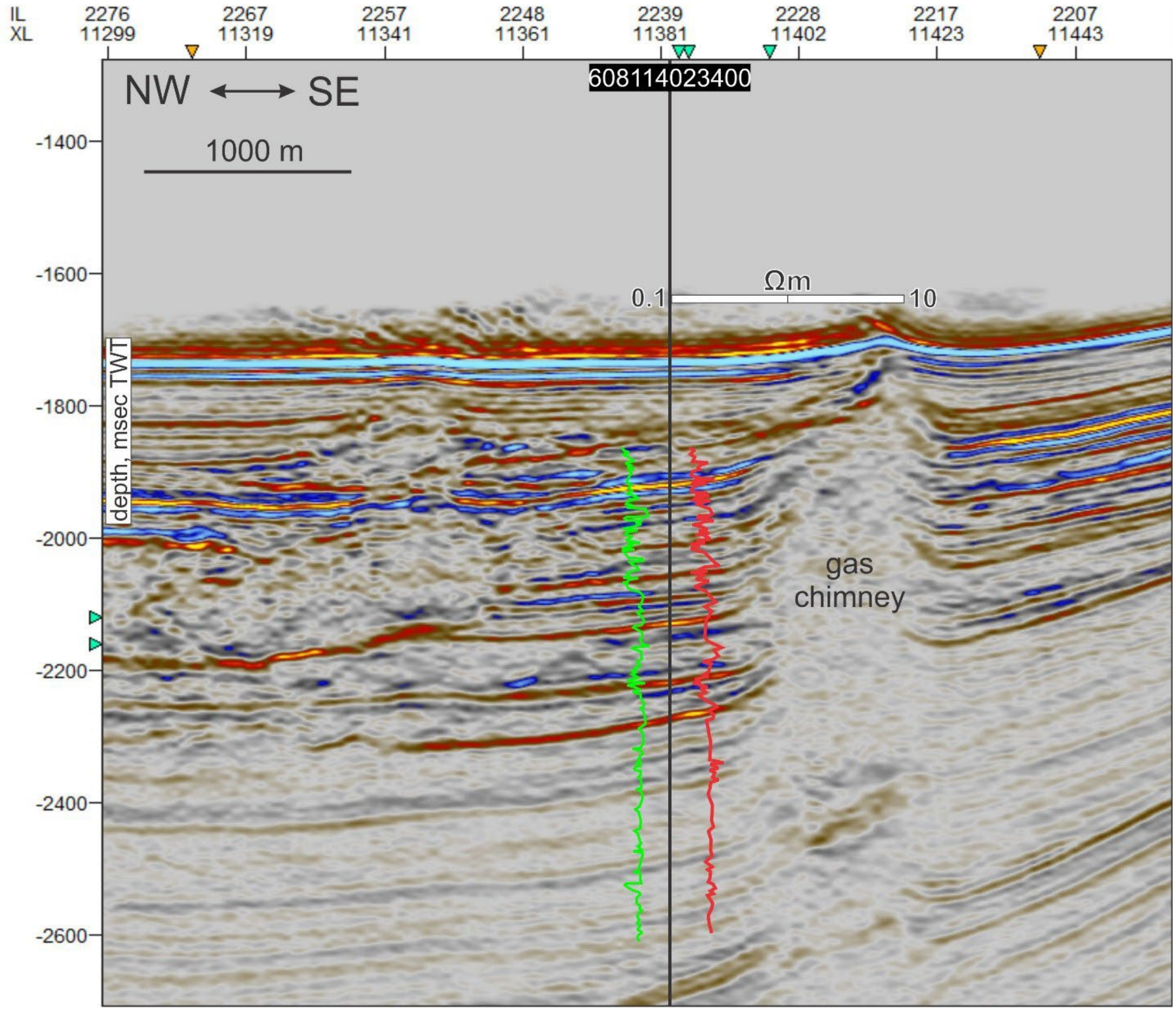

Figure 21. Seismic cross section showing well API 608114023400 chosen for analysis for its proximity to a gas chimney (see location in Figures 6, 7, 8). No significant resistivity increases were identified. Note that resistivity and gamma ray logs were digitized from analog data.

4. Gas resource estimates in high-confidence Moby-Dick prospect (Zone 1)

Gas resource estimates in Project Area 4 were calculated for the high-confidence prospect Moby-Dick where good evidence exists for presence and extent of gas hydrate in at least two coarse-grained reservoirs.

We used the same minimum and maximum porosity values (30% and 40% respectively) as in Project Areas 1, 2 and 3. We applied minimum and maximum sand thicknesses of 10 and 50 m. Similar to the Project Areas 1 and 2 we used minimum and maximum gas hydrate saturations within these sand units of 50 and 90%.

In the Moby-Dick location, we mapped peak-leading reflectors associated with two sand layers performing as potential reservoirs. Both reservoirs occupy ~10.5 km^2, which results in minimum and maximum gas resource estimates for both sands of 2.6 and 31 BCM respectively at STP (standard temperature and pressure) conditions using a gas hydrate to gas conversion factor of 164. For comparison, two major gas hydrate bearing sands (Blue and Orange) in the Terrebonne gas hydrate prospect (block WR313) contain 2.372 BCM of gas at STP (Frye et al., 2012).

5. Conclusions

High-confidence gas hydrate occurrence in Project Area 4 (Zone 1) is associated with a gas hydrate prospect named Moby-Dick. It is located in the southwestern part of Project Area 4 in OCS lease blocks GC592, GC593, GC594. Moby-Dick is characterized by extensive amplitude phase reversals at the BSR with two sand reservoirs occupying 10.5 km^2. Seismic data show that reservoir is likely coarse-grained because it is located in the outer levee of a pal0eo channel depositional system, which is confirmed by low gamma ray values in a nearby wellbore. Based on the BSR depth, the geothermal gradient in this area is estimated between 19 and 24 °C/km. Preliminary resource estimates in Moby-Dick range between 2.6 and 31 BCM.

Additional low-confidence gas hydrate accumulations were interpreted based on the BSR distribution in Zones 2 and 3. Seismic data in Zone 3 do show presence of paleo channels associated with the BSR, however in Zone 2 presence of channel deposits is not evident. No well data were available to confirm seismic interpretation in Zones 2 and 3.

6. References

Frye, M., Shedd, W., & Boswell, R. (2012). Gas hydrate resource potential in the Terrebonne Basin, Northern Gulf of Mexico. *Marine and Petroleum Geology*, *34*(1), 150–168. https://doi.org/10.1016/j.marpetgeo.2011.08.001

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Collett, T. S., Lee, M. W., Zyrianova, M. V, Mrozewski, S. A., Guerin, G., Cook, A. E., & Goldberg, D. S. (2012). Gulf of Mexico Gas Hydrate Joint Industry Project Leg II logging-while-drilling data acquisition and analysis. *Marine and Petroleum Geology*, *34*(1), 41–61. https://doi.org/https://doi.org/10.1016/j.marpetgeo.2011.08.003

7. Appendix

U.S. Department of the Interior
Minerals Management Service (MMS)

OMB Control Number 1010-0141
OMB Approval Expires 08/31/2008

Form MMS-133 - Electronic Version
Well Activity Report (WAR)

Base API Number 608114053100 **WAR Start Date** 19-APR-2009 **WAR End Date** 25-APR-2009

Accept Date 07-MAY-2009 **Operation Start Date** 17-APR-2009 **Operation End Date**

Operator 02815 Deep Gulf Energy LP

Acceptance Comments

GENERAL INFORMATION

Lease	Area	Block	Water Depth	RKB Elevation
G26323	GC	593	4397	79

Rig Name	Rig Type	Rig Water Depth	Rig Drilling Depth
DIAMOND OCEAN VICTORY	Semisubmersible	6515	29000

APPROVED WELLBORE(S) INFORMATION

CURRENT WELLBORE INFORMATION

	-- WELL --			-- BOTTOM LOCATION --			-- LAST BOP TEST --		
Wellbore	Name	ST	BP	Lease	Area	Block	Date	Low	High
608114053100	001	00	00	G26323	GC	593			

Operation Status	Spud Date	TD Date	MD	TVD	MW	KOP
Drilling	22-APR-2009		6720	6720	14	

OPERATION WELLBORE(S) INFORMATION

PREVIOUS WELLBORE(S) INFORMATION

SIGNIFICANT WELL EVENTS

Significant Events Narrative

Operation Narrative

04/19 - Ran anchors. PU 36" pipe.

04/20 - Continued running anchors. Ran 36" csg to btm.

04/21 - Jetted in 36" to 4821' - 315.73' penetration. Finished running anchors.

04/22 - TIH & drilled to 6200'.

04/23 - Drilled to 6720'. Displaced hole to 14.0 ppg mud. POOH to run 13-3/8" x 20" csg to 475'. Well started slight flow. Displaced hole w/ 14.0 ppg WBM. POOH. Checked flow - no flow.

04/24 - Ran 20" x 13-3/8" csgs. With 20" above 36" housing, conducted kill by pumping 700 bbls @ 14.0 ppg. Checked flow - well static.

04/25 - Cemented csgs. Ran riser & BOP.

Correction Narrative

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