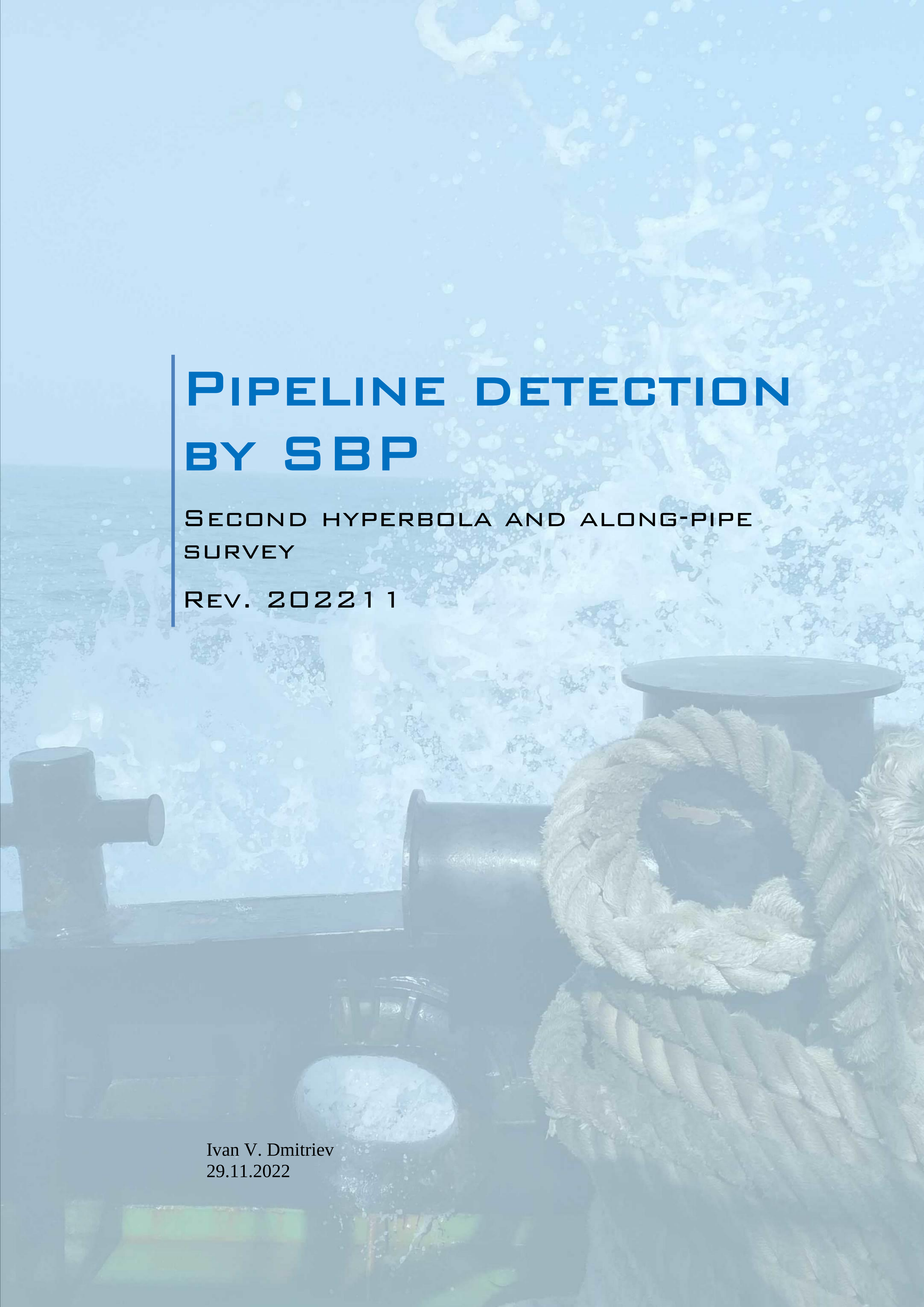

Pipeline detection by SBP

Second hyperbola and along-pipe survey

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Contents

Figures list

1. Overview

With SBP method, it was necessary to determine the position and depth of the following linear objects:

-- L12, 12-inch trenched gas pipeline;

-- L08, 8-inch trenched gas pipeline;

-- L03, 3-inch trenched control umbilical cable.

Assuming depth of burial is 0.6-2 meters, the sea depth is 30-36 m; the approximate location of linear objects in the plan is known ("as design"). Profiling was performed using an Innomar SES2000 Medium parametric profiler with the following specifications:

-- primary frequencies approx. 100 kHz (band 85-115kHz);

-- secondary low frequencies 4, 5, 6, 8, 10, 12, 15 kHz,

-- primary source level >247 dB/mkPa re 1m;

-- beam width @ 3 dB +-1 degree / foot print <3.5% of water depth for all frequencies;

-- pulse width 0.07-2ms;

-- pulse type CW, Ricker, LFM (chirp);

-- multi-ping mode,

-- motion compensation: heave, roll.

2. L12, 12-inch pipeline issue

1) Hyperbolas: pipe and channel's bottom

The depth of the 12-inch pipeline was determined from the SBP cross profiles. The position of the upper part of the pipeline corresponds to the position of the maximum of the hyperbola (diffraction point). An example of hyperbolas and determining the position of the upper part of the pipe (target L12) is shown in ***Figure 2.1***. Also, in the SBP section there are anomalies associated with the geological structure, probably with the features of excavation and backfilling of the trench during the pipeline laying (Target L12T).

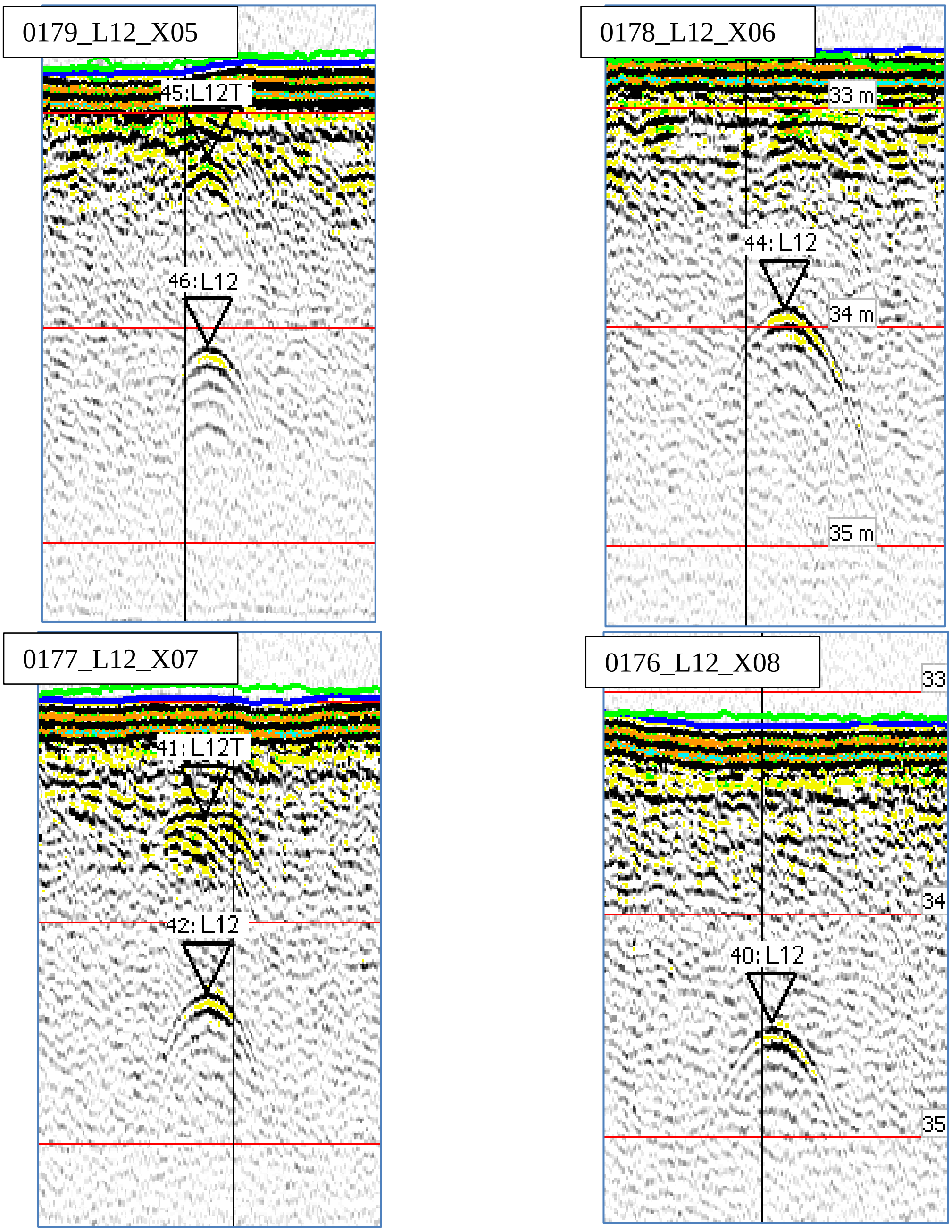


Figure 2.1 Trench-anomaly in the SBP-section with 12-inch pipeline: trench hyperbola's DBB is about 0.5 m, pipe hyperbola's DBB is about 1.3 m

It can be assumed that during the pipeline laying, part of the backfilling of the trench was carried out immediately at the time of laying (or in a short period of time after laying) with the sediments excavated during the excavation of the trench. The thickness of such backfill was about a meter. The rest of the backfill could be formed over a relatively long time as a consequence of natural geological processes. As a result, the upper part of the trench can be formed by interlayers of heterogeneous composition, which create "anomalies" of the geological nature in the SBP-sections. In the extreme case, the bottom of the "trench" (the top of the backfill) can create a "false" hyperbole. Due to the small size of the objects, the "false" hyperbola is hardly distinguishable from the hyperbola created by the pipe. For the L12 pipeline, such anomalies, which are a consequence of the geological structure, are weak and do not interfere with the identification of the hyperbola due to the pipeline.

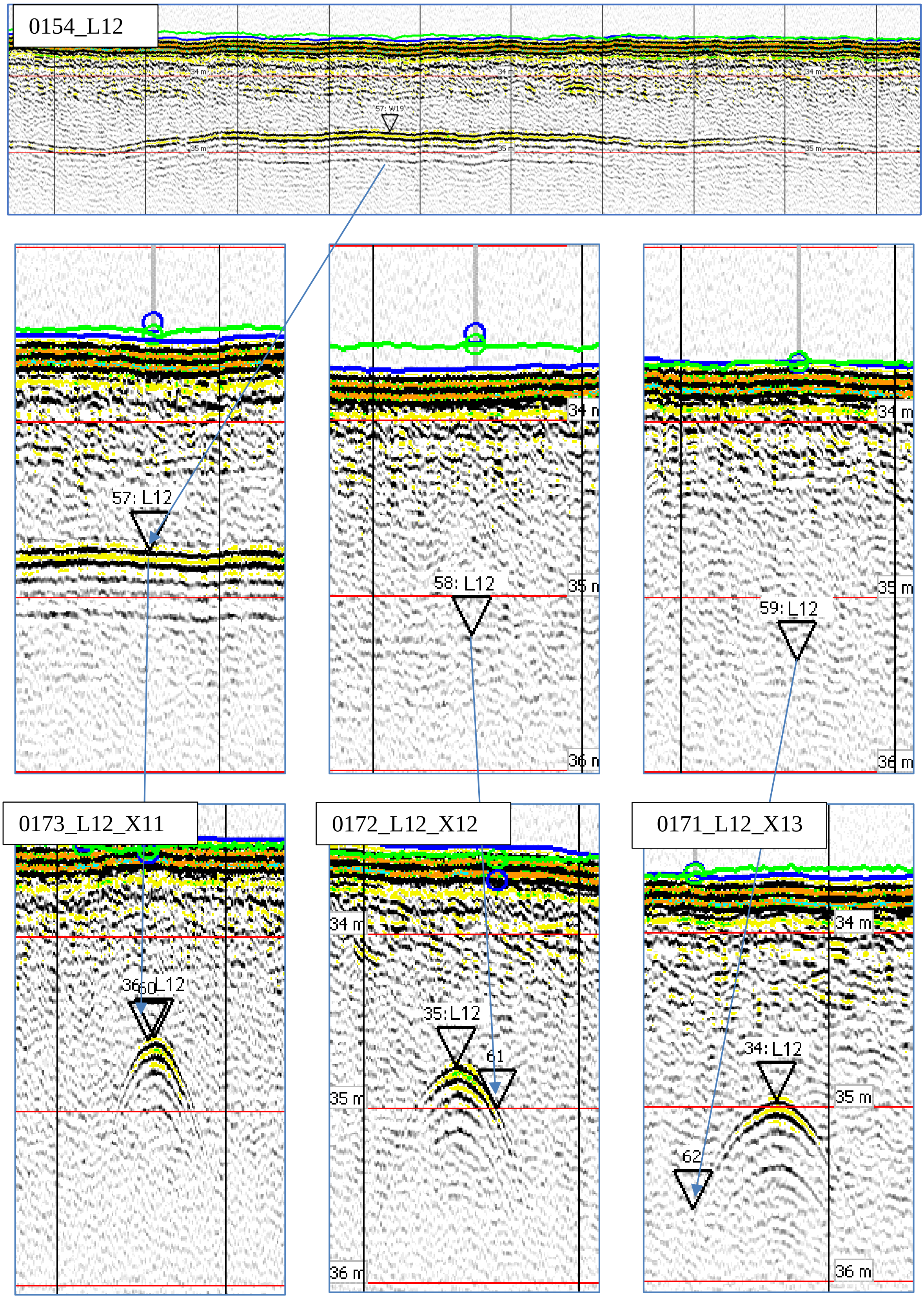
2) Along-pipe survey

In ***Figure 2.2*** is shown the SBP-profile 0154_L12 which was surveyed along the pipeline. The upper part of the ***Figure 2.2*** shows a part of the profile, on which the pipeline is distinguished on as a horizontal line-up, with a variable intensity of reflection.

The intensity of the reflection and the "depth" of the line-up are related to the offset between the SBP-profiler's transmitter and the position of the pipeline in the horizontal plane. The ***Figure 2.2*** shows sections of the along-pipe survey lines for three different offsets – 0.7, 4 and 6 meters. Three cross-profiles of the SBP corresponding to these sections are also given. As can be seen from the comparison of the figures, with an offset increase (the transverse distance between the profiler antenna and the pipeline), the line-up for the along-pipe profile "descends" to the asymptotes of the hyperbolas showed for the cross-profiles. In this case, the "depth" of the line-up increases and its intensity decreases.

At 0.7 meters offset, the intensity is practically the same as in the central part of the hyperbola, and the change in depth is 0.01 m. At the 4 meters offset, there is a significant decrease of the intensity, and the change in depth is 0.25 m; the line-up becomes almost indistinguishable against the background of noise.

The described patterns apply only to the current equipment configuration and current survey conditions. The value of the transverse offset at which the signal disappears will change depending on sea depth, noise level, equipment (the acoustic antenna directional pattern, the frequency of the transmitter signal and other characteristics). The shape of the hyperbola will be weakly variable (it will be corresponded to the diffraction point model and depend mainly on the sea depth and model's velocities).



"Visible" x-distance – 0.7m
Depth changed – 0.01m

"Low visible" x-distance – 4 m
Depth changed – 0.25m

"Invisible" x-distance – 6 m
Depth changed – 0.65m

Figure 2.2 Along-pipe survey features for 12-inch pipeline

3. L08, 8-inch pipeline issue

1) Hyperbolas: pipe and channel's bottom

The depth of the 8-inch pipeline was detected from the SBP cross sections. In comparison to the L08 pipeline, the level of "geological noise" for SBP-sections is higher. ***Figure 3.1*** shows examples of four cross sections. For two sections, there are no geological heterogeneities in the upper part and the hyperbola from the pipeline is clearly distinguished in a relatively homogeneous environment. For the other two examples, the upper part of the section is complicated by reflections from the sediments and the exact position of the hyperbola cannot be distinguished.

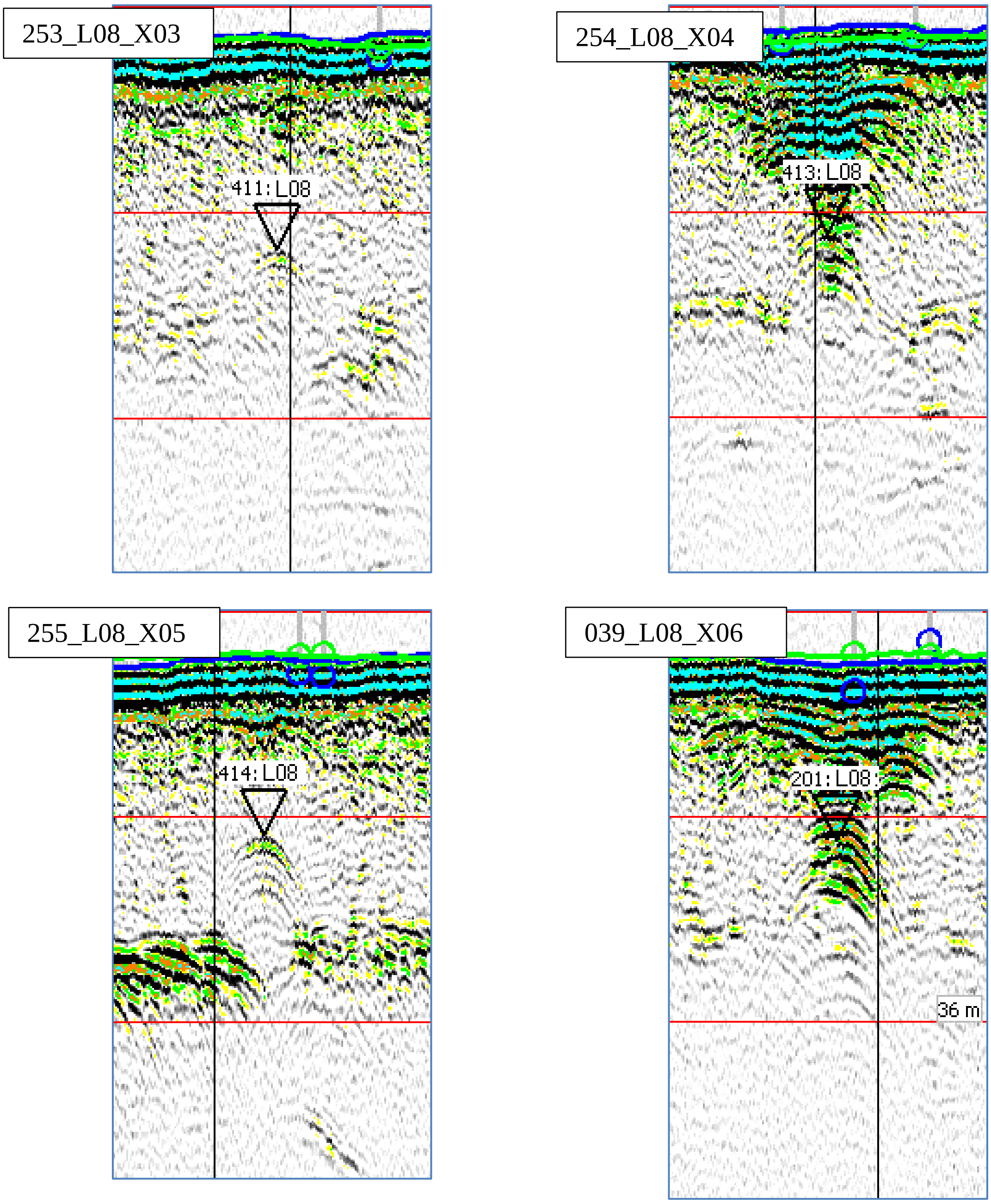


Figure 3.1 Trench-anomaly in the SBP-section with 8-inch pipeline: trench DBB is about 0.5 m, pipe's hyperbola DBB is about 1.3 m

2) Along-pipe survey

Figure 3.2 shows the line-up axis corresponding to a pipeline if the survey line is along the pipeline but at an angle to it. As can be seen from the figure, the intensity of the reflected seismic signal decreases with distance from the pipeline and at a distance of about 4 meters the reflection becomes weakly distinguishable (this corresponds to the estimations shown in *Figure 2.2*). Seismic reflections from the anomaly of a geological nature located in the upper part of the section decrease faster than the reflections from the pipeline.

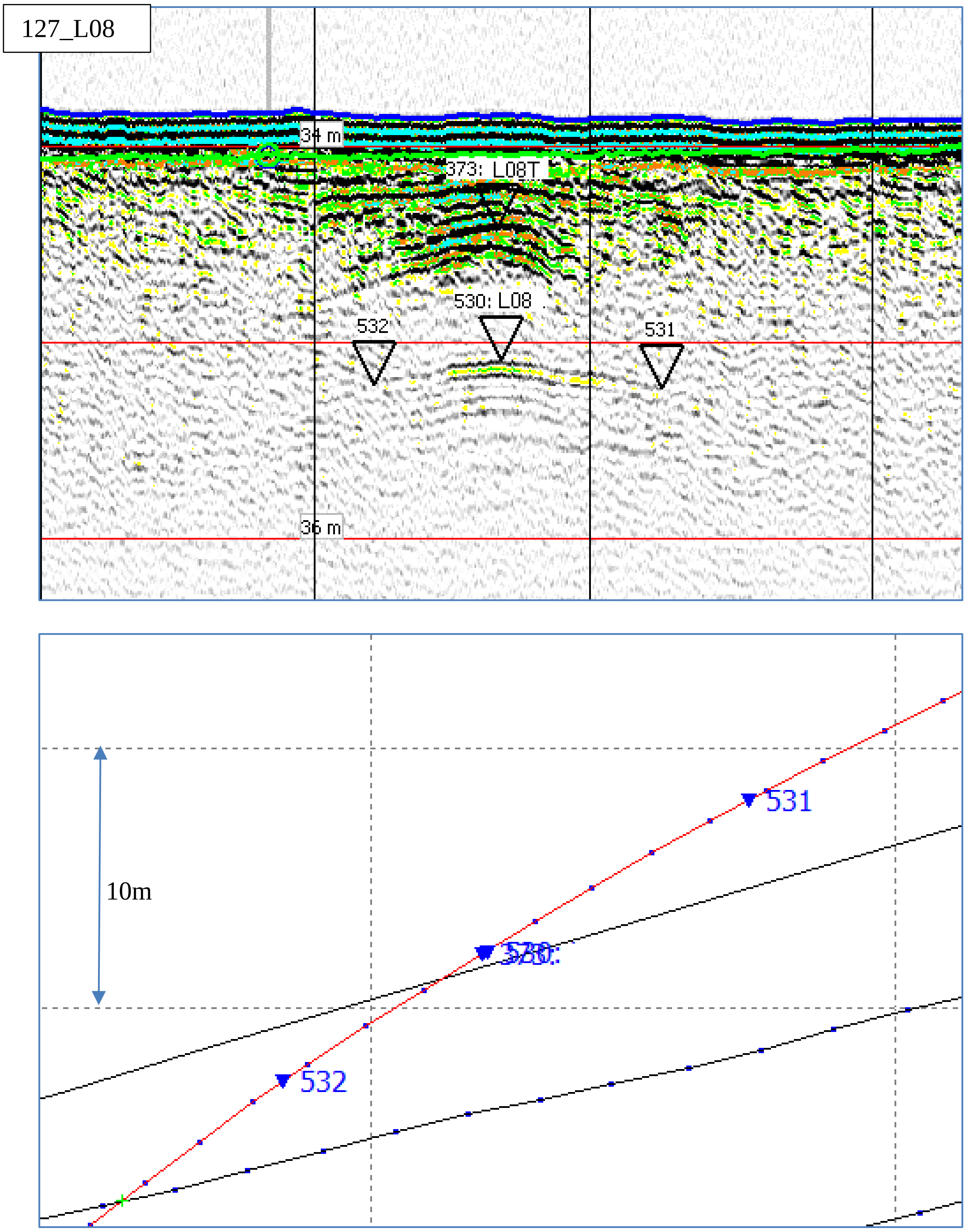


Figure 3.2 Along-pipe survey for 8-inch pipeline (visible x-distance 2.8m, depth changed 0.1m)

Figure 3.4 shows an example of SBP survey along the pipeline at two lines in the opposite directions. As can be seen from the figure, the line-up axis goes "deeper" and decrease intensity away from the pipeline. At the minimum distance to the pipeline, the axis is characterized by the greatest intensity and the least "depth". Having two along-pipe survey lines, we can determine the position of the pipeline in the horizontal plane and depth of burial (modeling the hyperbola so that it intersects two points corresponding to the along-pipe survey, also we can take into account the intensity changes). By having a number of along-pipe lines, calculations can be performed more accurately, with error estimates due to transmitter positioning, sound velocity, and other factors.

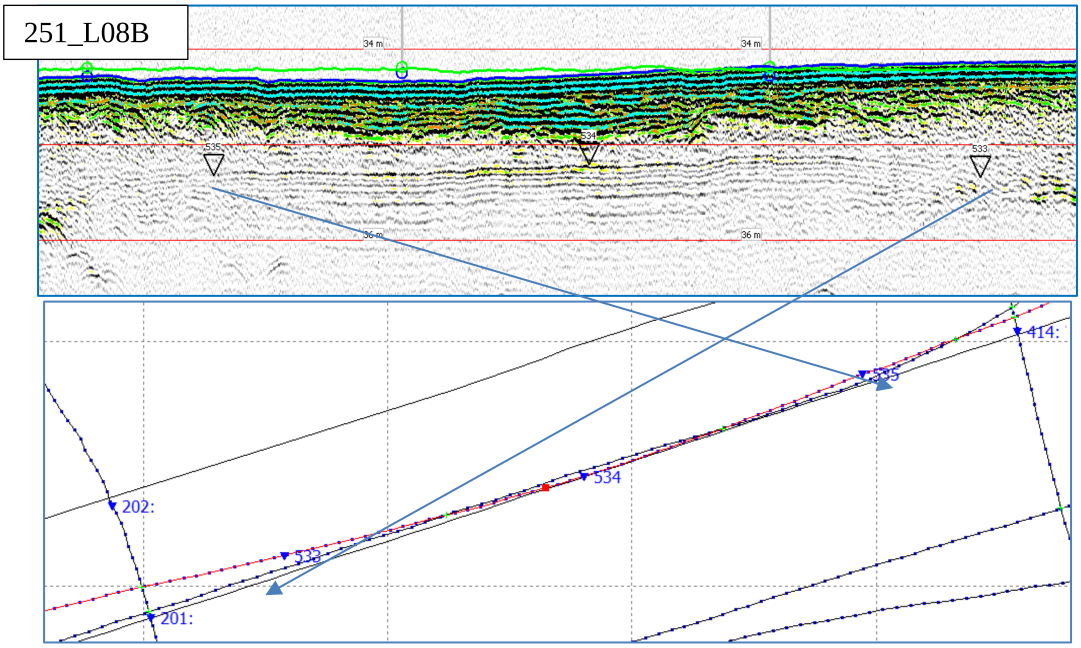


Figure 3.3 Along-pipe survey features for 8-inch pipeline

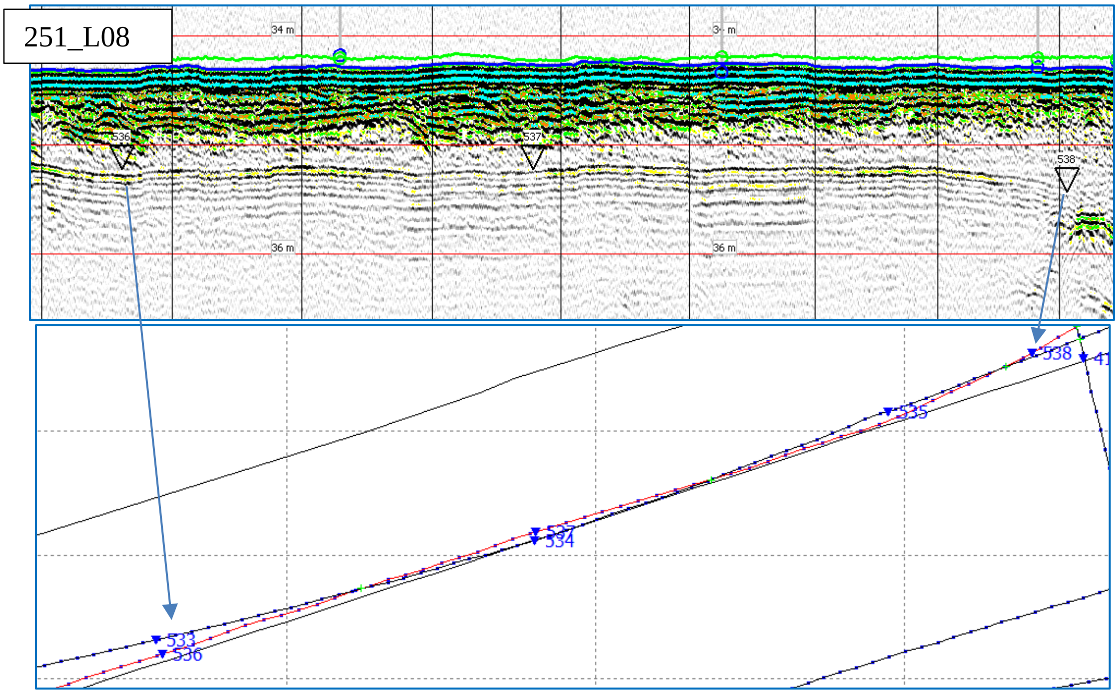


Figure 3.4 Along-pipe survey features for 8-inch pipeline

3) Hyperbolas: pipe and channel's bottom with a long-pipe survey

The ***Figure 3.5*** shows an SBP section complicated by geology. Two hyperbolas stand out, the lower of which has a much lower intensity (see inset in the ***Figure 3.5***). The upper part can be interpreted as a pipeline's hyperbola distorted by an anomaly from the trench, similar to the example in ***Figure 2.1*** or ***Figure 3.1***. It is possible to select the correct hyperbola corresponding to the pipeline by the position of the horizontal line-up axis using the along-pipe survey line.

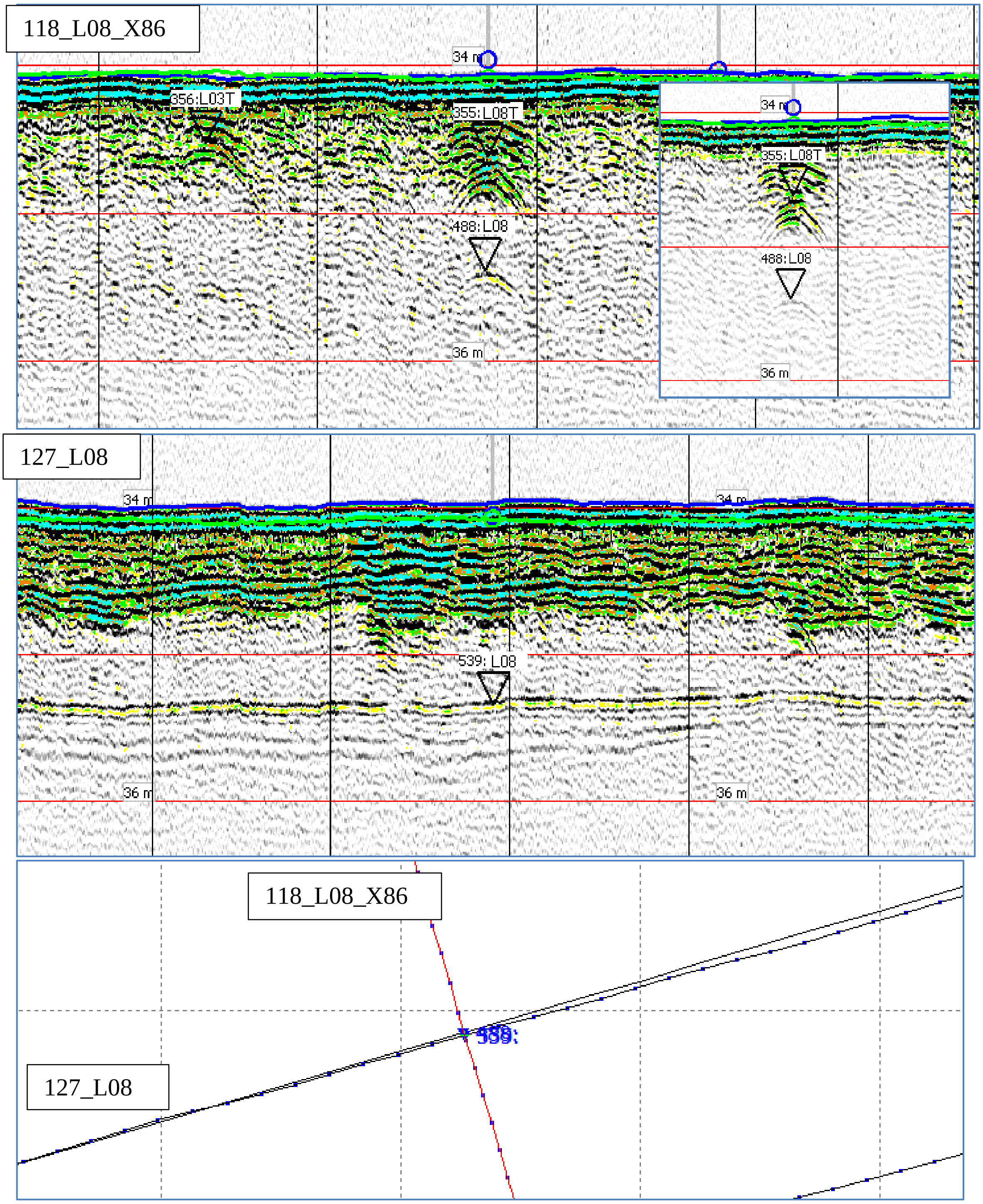


Figure 3.5 Pipe and channel's bottom hyperbolas; detection with a long-pipe survey

Figure 3.6 shows a comparison of the "identifiability" of the line-up from the pipeline on the crossing and along-pipe profiles, for SBP-sections complicated by geology. As can be seen from the *Figure 3.6*, on the crossing profiles, the line-up axis (hyperbola) from the pipeline is masked by hyperbolas from a geology (since any "point" inhomogeneity is a diffraction point and causes a hyperbola on the seismic section). On the along-pipe profiles, the line-up axis detected more clearly, due to the reason that geological objects do not form extended sub-horizontal reflections (line-up axes) for the section presented.

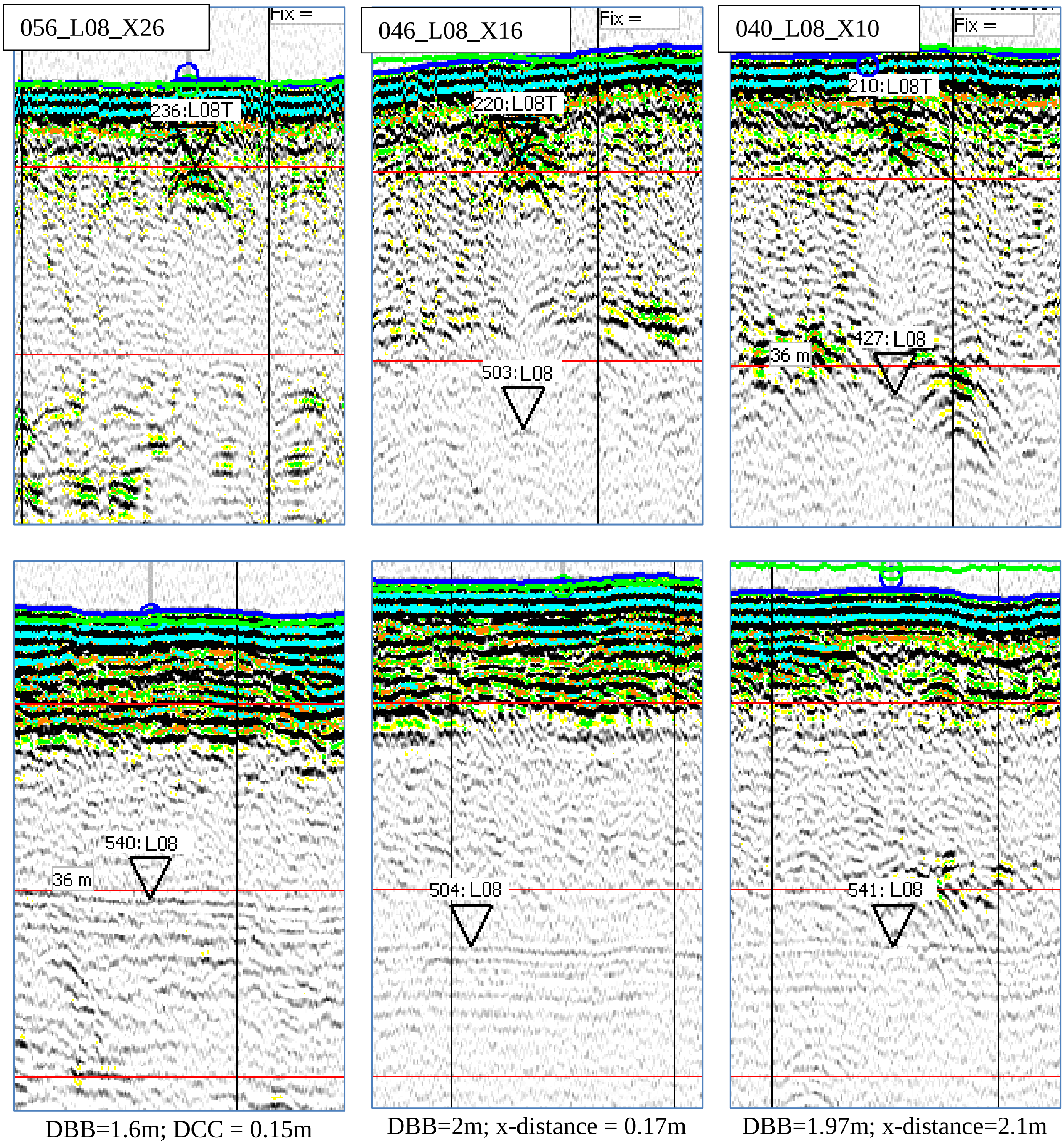
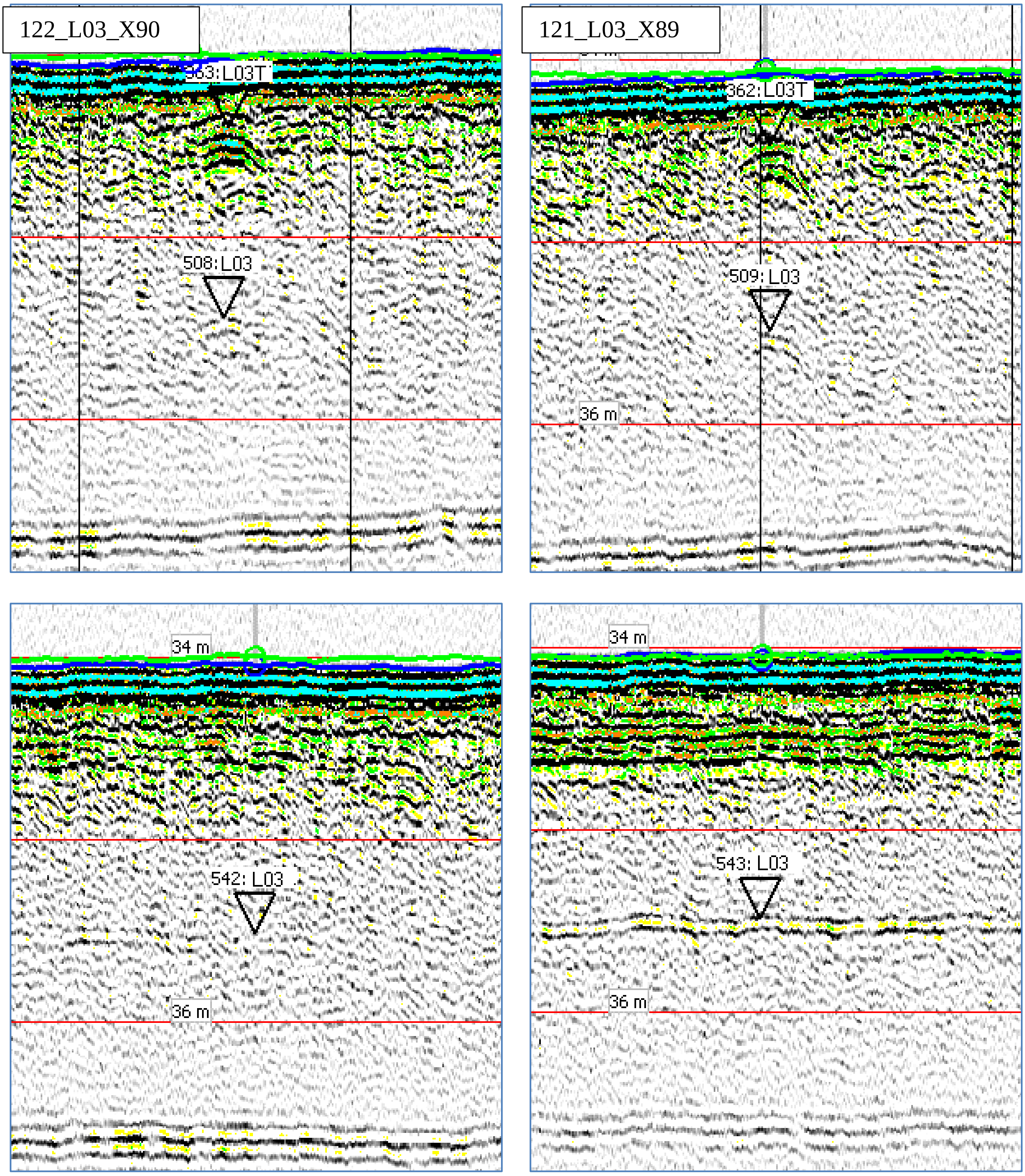


Figure 3.6 Pipe and channel's bottom hyperbolas; detection with a long-pipe survey (127_L08)

4. L03, 3-inch umbilical issue

The depth of burial for the 3-inch umbilical cable was determined from the SBP cross-profiles (*Figure 4.1*). Due to the small diameter of the cable, its detection is a difficult task. By analogy with *Figure 3.6*, the cable is displayed on the along-pipe and cross-pipe SBP-sections below. On the along-pipe profiles, the line-up axis for the pipeline can be detected easier.



DBB=1.5m; x-distance = 2.7m

DBB=1.5m; x-distance = 0.29m

Figure 4.1 Pipe and channel's bottom hyperbolas; detection with a long-pipe survey (152_L03)

5. Along-pipe survey possibilities

Let's consider the additional opportunities provided by along pipeline SBP survey.

Figure 5.1 shows the knee point of an 8-inch pipeline detected on SBP-section. The SBP-trackplot for the section is a straight line. Therefore, there can be two reasons for the shown line-up axis shape: (1) pipeline going sideways in the horizontal plane, or (2) pipeline burial. The value of the changes in depth for pipe is approximately 1 meter, that is, if the pipeline goes “sideway” (that is, when the line-up axis moved "down" along asymptote of the hyperbola), the line-up axis's intensity should decrease to the background noise level (that is, “disappear” - see *Figure 2.2*). Since the line-up axis remains visible, it can be assumed that the pipeline goes to depth; this is confirmed by two cross profiles. For one of the profiles, the hyperbola can be clearly identified only using the along-pipe SBP-data.

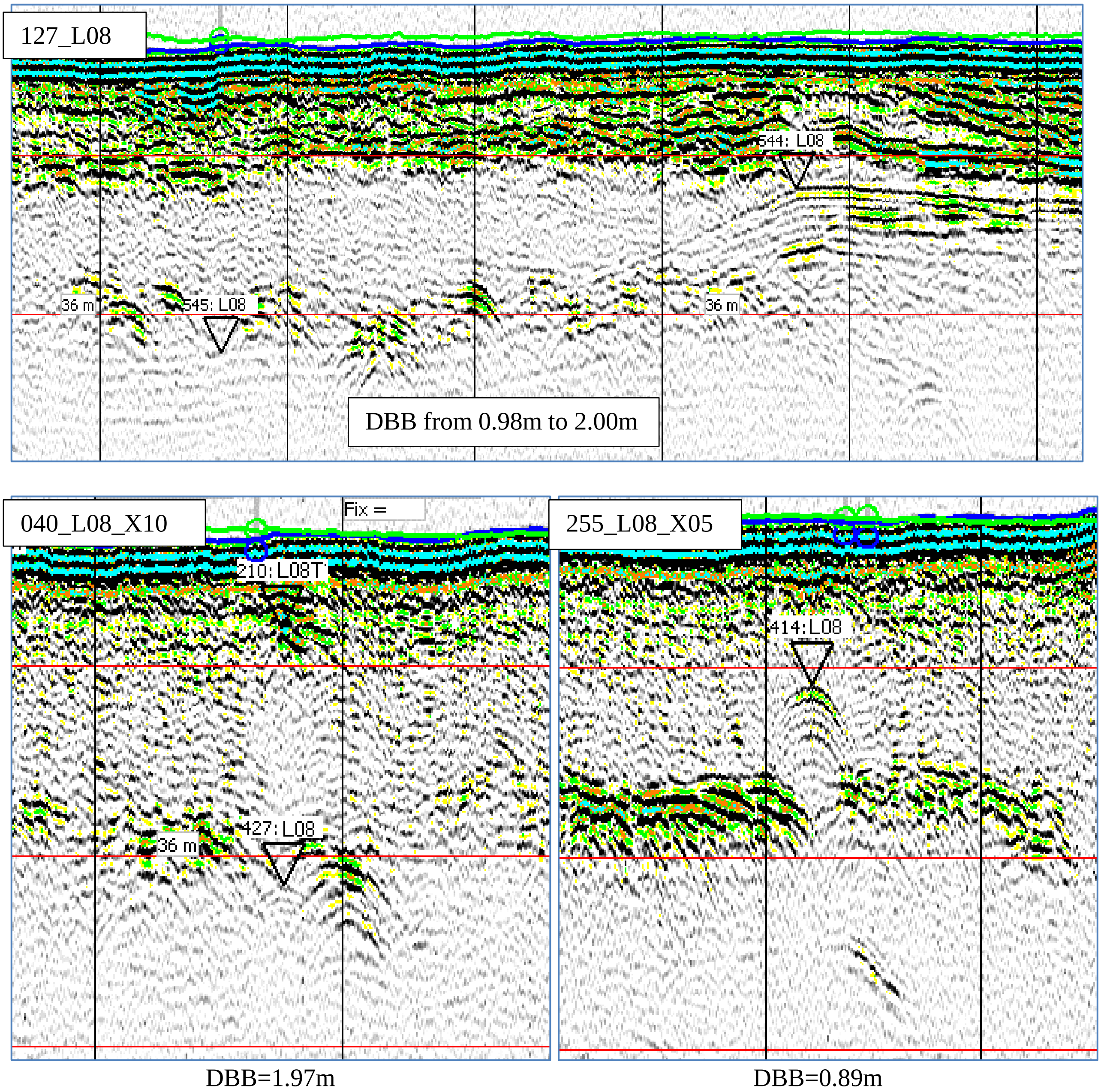


Figure 5.1 Along-pipe survey: pipe’s depth changes

Figure 5.2 shows a pipeline's bend (127_L08) with an assumed depth changes of 0.5 meters, which can also be due to both horizontal and vertical displacement. The along-pipe profile, located at a distance of less than 6 meters (251_L08B), eliminates the horizontal bend towards the north.

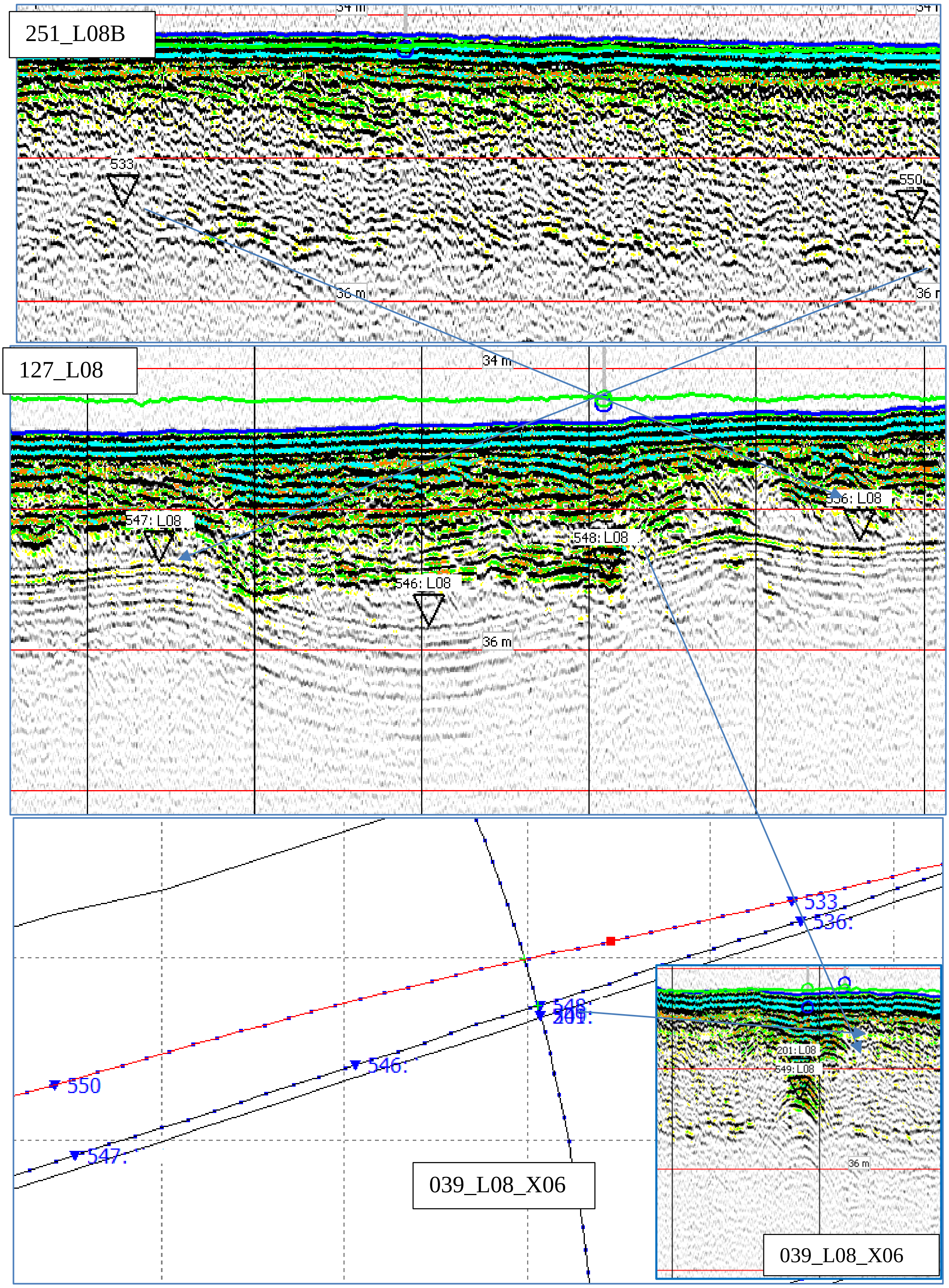


Figure 5.2 Along-pipe survey: pipe's depth or location changes (DBB_546= 1.5m; DBB_548= 1.15m; DBB_536= 0.94m)

By the reason of intensity level keeping for the line-up axis, a vertical “bend” in the pipeline is more probable. To confirm the vertical "bend", it is necessary to make a SBP cross-line in the center of the bend.

According to the work plan, the cross profile 039_L08_X06 was completed. The hyperbola from the pipeline on it is complicated by the hyperbolas from the geological structures. Nevertheless, taking into account the position of the “ringing” hyperbolas maximums from the pipeline (secondary re-reflections), it can be assumed that there was no displacement in the horizontal plane, that is, the line-up axis bending is due precisely to the change in the pipeline's depth.

6. Conclusions

The following conclusions can be drawn from the results of the SBP-survey analysis:

1) For the survey site, the depth of the pipes is within 0.9-2 meters. The cross-profiles of the SBP are complicated by geology. For example, the hyperbola, which presumably corresponds to the bottom of the "trench" (depth of 0.5-0.7 meters).
2) For part of the cross lines, the hyperbola corresponding to the pipeline can be confused with the hyperbola corresponding to the "trench". Along the pipeline survey, in most cases, allows to correctly detect the hyperbola corresponding to the pipeline (***Figure 3.5***).
3) Survey along the pipeline allows to identify the pipe and determine the depth of burial for a pipeline where it cannot be detected from the cross-profiles (***Figure 3.6***). At the same time, cross-profiles can perform the function of binding and verification for along-pipe profiles survey.
4) Surveying along the pipeline allows to localize bend points (changes in depth of burial or bend in plan). Additional cross- and along-pipe profiles will allow to determine the direction of the bend.

Thus, the current level of navigation support and the level of SBP equipment make it possible to survey the SBP-lines along the pipeline. Such a method significantly increases the effectiveness of the SBP-survey compared to surveying cross-lines only.

The methodic can be of interest in which the survey is carried out by two SBP simultaneously, which located on different vessel's sides. Due to the constant distance between the profilers' transmitters (which are located across the survey line), this method will more accurately determine the direction of local pipeline bends and separate pipeline and geological anomalies for a SBP section.

Follow document will be focused on the pipe's picking like seismic horizon and applying diffraction-point modelling to determine the location of the pipe continuously.