



The results and traps of the archive 2D seismic data reprocessing

Case study, Hungary



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1. Summary

In my thesis, I would like to introduce that, how much the new processing techniques can help the old 2D seismic data, in order to create a new database, which has better quality, and prove at the same time how much the reprocessing helps the geological and geophysical modelling. Almost every country, - including Hungary - which has older, archive, low-quality seismic data is facing the same problem. Geoscientists have to make new and appropriate decisions based on these data to create fresh, reliable geological – geophysical interpretations, to build models for hydrocarbon explorations. However, the required information necessary for the modern exploration can not be obtained simply from the existing old data due to the development of the measurement technologies and the research philosophy, as time goes by.

There are two solutions for this problem. One of these is to re-execute a modern seismic survey in the same area but this is an expensive solution and not every relevant company can afford this. Furthermore, there are exploration areas where the expected profit does not cover the costs of a set of new 2D lines or a modern 3D seismic volume. The other option is to re-process the previously measured seismic data with the available modern tools, algorithms and concepts adapted to the current research approach. The latter method is expedient in most cases, but in this case, we have to prepare ourselves for numerous difficulties. Ignoring them can cause, that the result may not correspond to the facts.

In my thesis I present an investigated area, where 600 kms of 2D seismic profile has been reprocessed for hydrocarbon exploration purposes. The seismic measurements were made from the 1970s until the mid-2000s, thus the lines have different ages. The technique of the measurement and the signal generation (vibrois and dynamite) were completely different in the different eras, not to mention the signal recording techniques. Depending on the current level of the detection, signal recording technology and the recording geometries, the concerned lines were recorded by dissimilar types of instruments. As a result, the measurement parameters are significantly different from each other. At the given area until present day the unified processing of the seismic profiles has not been done yet, which existence is essential to produce a coherent interpretation of seismic point of view.

In my dissertation I compare the characteristics of the original and reprocessed seismic profiles and present the improvement in their quality (resolution power and coherence) by a

modern and unified processing method. Furthermore, I highlight the circumstances, the difficulties and the pitfalls of the reprocessing as well. In the first part I introduce the seismic method, the 2D and 3D measurements and after this, in the second part I outline the problem and the processing steps.

2. Introduction

Seismic methods are probably the most expensive, but also the most effective geophysical techniques. They can be used to investigate layered media. Due to the expected high profit, they are used mainly and generally in hydrocarbon exploration, because drilling wells for hydrocarbon exploration purpose without investigation the area with the help of the geophysical methods is heavily risky process. Companies want to be as sure as possible about the potential profitability of their property and seismic surveys can help them primarily to be able to estimate properly the volumetric numbers behind of their planned exploration objects. Essentially the method is nothing more, than generation of seismic waves on the surface or under it and registering the re-arrived signals. A seismic wave can be considered as an acoustic energy transmitted by vibration of rock particles. Nowadays there are two primary ways to generate seismic waves. The one is with dynamite and the other is a process called vibroseis. In the investigated area both happened during the nearly 30 years of the measurements.

3. Types of Seismic Acquisition

3.1. Two Dimensional (2D) Seismic Survey

The two dimensional seismic survey is one of the oldest and simplest seismic exploration methods. It is possible to make maps of the subsurface structures with its help. This is a typical seismic method. It means that, the generated seismic waves travel through the subsurface and then they reach the receivers. The seismic data is collected along lines on the surface (which is the surface projection of the 2D seismic section), over a loose grid pattern, consequently getting a good but only general geological understanding about the area, with structural uncertainties between the measured lines. It was really common until the 1980s, when the 3D method became into the practice. 2D method has not been forgotten thanks to its benefits. It is cheaper than the 3D method and can be measured along long lines (few tens' of

kilometers) to investigate better the geological/ geophysical behaviour of the rocks, till the 3D acquisition is always be used for developing a smaller area with higher the details. This is the other reason why the 2D is still in the practice, but mainly in the less matured exploration areas.

3.2.Three Dimensional (3D) Seismic Survey

The Three Dimensional (3D) Seismic Survey has been developed in the end of the 1970s with the help of the technological advances. The measurement is really similar to the 2D method. The difference is in the geometry of the lines. Dense array of geophones provide a much more detailed set of seismic information so it is possible to make a more reliable concepts about the area. Thanks to the available computer processing power and the denser data not only the structural elements but the direct hydrocarbon indicators (DHI) can be found with higher details and better geometry on these type of data versus 2D seismic information (Rig Zone). The 3D method became very common today. It is more expensive than the traditional 2D seismic acquisition but its increased effectiveness and reliability makes it well worth the price.

4. Seismic Sources

The seismic sources have two types, these are the natural and the artificial sources. We ourselves generate seismic waves with every steps we make, but these are not big enough to be registered, properly miles away from the source point. Earthquakes can be considered to natural seismic sources. An artificial source can be a hammer, a dropped heavy weight, dynamite or a vibrator. The hammers are versatile sources for small-scale surveys. They can be used for refraction works, where the energy does not have to travel more than 50 meters (usually 10-20 meters). The hammer is aimed at a flat plate, the purpose of which is to stop the hammer abruptly and not to improve the pulse. The plate needs to be ‘bed down’ into the soil (Tolson, 2014). Explosives are effective and crude sources. One of this group is the dynamite. They are traditional artificial seismic sources, which has been used in the investigated area. Generally the explosive charges are placed in a hole with a depth between 5 and 80 metres below the ground (Milsom, 2003). They are still quite commonly used. Nowadays impact and vibratory sources are the most popular sources. The latter was used mainly in my case study area too.

5. Standard Processing Flow

During a standard 2D or 3D seismic data processing the first step is to gather the raw field files, then reform or demultiply them. The demultiplexing operation resets the detected sequence of each geophone group. After this step the geometry assignment happens: the people - who carry out the processing - read the coordinate information from the trace headers (.SEGP1, .SPS, or .UKOOA files) or enter them manually into the software used for processing. Crooked line binning is applied (Geo mage, 2014). The next move is to pick the first breaks for each shot. An automatic interactive picker runs through the recordings, but sometimes manual editing is required. Thereafter the geometry has to be checked. It is followed by trace editing on raw records. For gain recovery typically a simple time squared correction is applied. The next step is the surface consistent deconvolution. It is a full five component solution, including line shot and receiver components. Spiking or predictive operator can be applied during the process. The time variant spectral balancing is optional. It can be applied based on data bandwidth, if improved frequency content is desired. The refraction statics analysis and application is the next step, if it is applicable. Subsequently the preliminary velocity analysis occurs. Then surface consistent residual statics and velocity analysis are implemented. Noise attenuation is important to do, it is required in many instances. For this process FK, principle component decomposition, radon transformation or radial trace filtering can be applied. Application domain is based on the highest efficiency of the applied algorithm. Noise attenuation may be applied earlier, possibly even transparently based on signal to noise of the data. Additional passes of surface consistent statics and velocity analysis needs to be done as following steps - if it is required - until the convergence of the surface consistent static solution. The common depth point (CDP) output is essential for the multifocus processing. The upcoming step is the final normal move-out (NMO) correction and muting. If it is necessary, CDP trim static and spectral whitening has to happen accompanied by FX/FXY prediction filtering for random noise suppression (Geo mage, 2014). Some of the final steps are the implementation of the post-stack migration (STM), final filtering and scaling. After all these steps the CDP output file is a client specific SEG-Y format. If the NMO is removed, the CDP output file is also a client specific SEG-Y format, but without NMO.

6. Presentation of the project

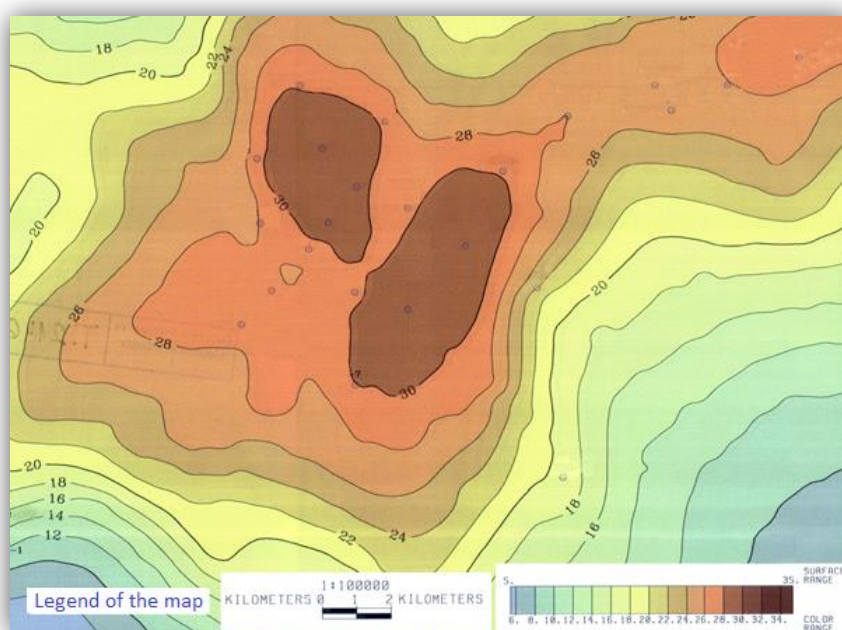
The main purpose of my thesis is to review the old 2D seismic lines and compare them with the re-processed surveys and illustrate the processing steps at the same time. I put forward (pro and contra) arguments with the help of some featured seismic lines. RAG Kiha Ltd. has made available the essential data for my essay. Due to business privacy reasons, the name of the area is classified and that is why geological review can not be made. However, it can be said that the area is located in our country and the measurements began in the 1970s. Until the year of 2000 more than 600 kilometers of seismic lines have been measured. In the different eras, the technique of the measurement and the signal generation (vibroiseis and dynamite) were completely dissimilar, not to mention the signal recording techniques. The following table summarizes the features (length, date and source) of the seismic lines.

2 D line length [km]	Fold	Source*	Date
24,272	50	v	1998
18,149	12	d	1987
11,524	24	d	1979
8,287	12	d	1986
10,74	12	d	1986
14,365	12	d	1989
9,932	12	d	1990
19,262	80	v	1994
52,125	45	d	1994
21,92	50	d	2003
10,088	50	v	2003
9,502	50	v	1998
8,129	50	v	1998
28,03	50	v	1998
8,915	50	v	1999
12,53	50	v	1999
12,267	50	v	1999
18,645	50	v	1999
16,73	50	v	1999
10,45	45	v	1996
11,023	45	v	1996
16,663	45	v	1996
6,609	45	v	1996
6,887	45	v	1996
17,745	12	d	1985
18,183	12	d	1985
9,646	12	d	1985
19,77	12	d	1989
10,974	40	v	1995
15,862	45	v	1997
16,83	45	v	1997
18,888	45	v	1997
10,741	50	v	1999
19,93	50	v	1999
13,074	50	v	1999
9,585	55	v	1999
12,143	50	v	2003
15,386	50	v	2003
21,189	12	d	1978

1. Table: The features of the 596,99 kilometers seismic lines
*(*v=vibroiseis, d=dynamite or explosive source)*

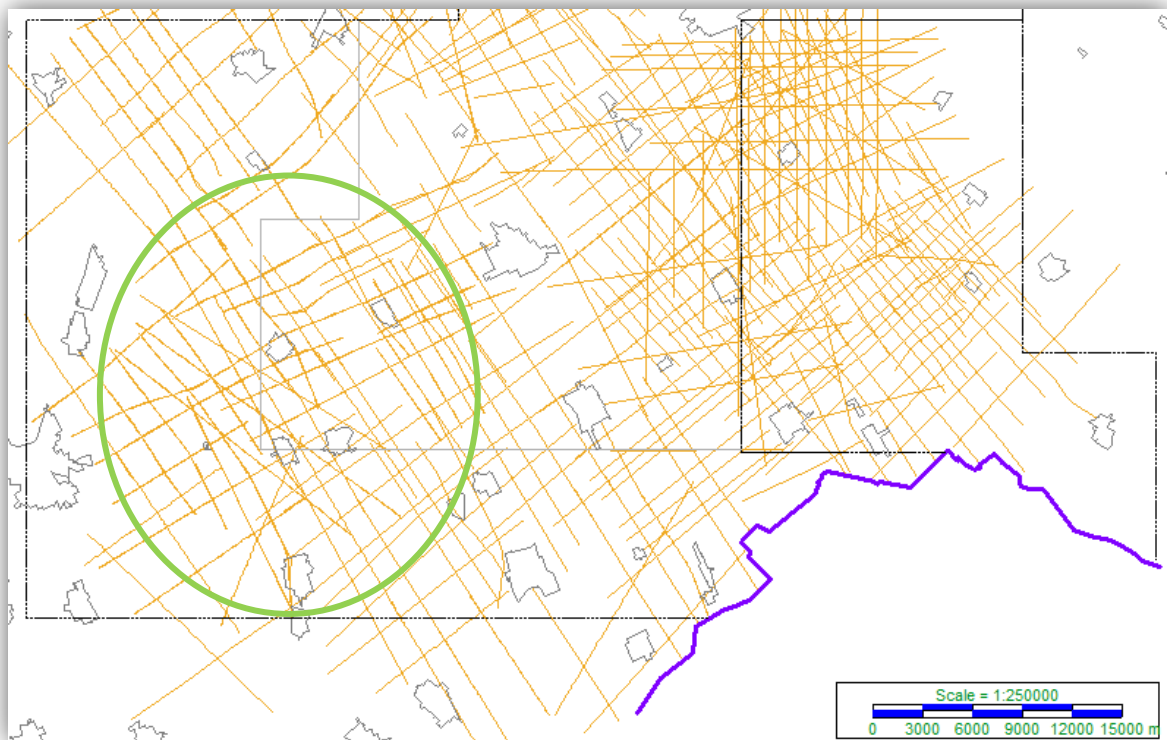
Depending on the current level of the detection, signal recording technology and the field geometries, the concerned lines were recorded by different types of instruments. In order to obtain an appropriate interpretation, reprocessing is the best available solution. In this area a lot of well was drilled and the historically discovered - more than 2 billion cubic meters of - hydrocarbon volume possibility of the presence of DHI related traps (which can significantly de-risking the evaluation of an or a set of opportunity) inspired the idea of the reprocessing. In the investigated acreage biogenic gas generation province is realized. Biogenic gas is a type of natural gas, which is generated by methanogenic organisms generally in shallow buried sediments. However it can be read in the old well files in some cases the smell of the cores was like gasoline and some gas shows (bubbles) were found in them, but the UV light and the solvent tests did not prove the presence of the hydrocarbon. This result does not mean that the area do not contain HC gas at all. There are two facts, which can not be forgotten and ignored. At first, the biogenic gas do not contain the heavier gas components (like propane, butane), which respond to the previously mentioned tests, and the second one is the measurements are much more sophisticated today for simple methane gas.

Looking over the time sections significant amplitude phenomena appears immediately even in the old sections. These facts inspired my thesis and my purpose is to highlight how much easier it is to find the bright spots (which is one type of the DHIs family) and other amplitude phenomena with the help of the re-processed data.



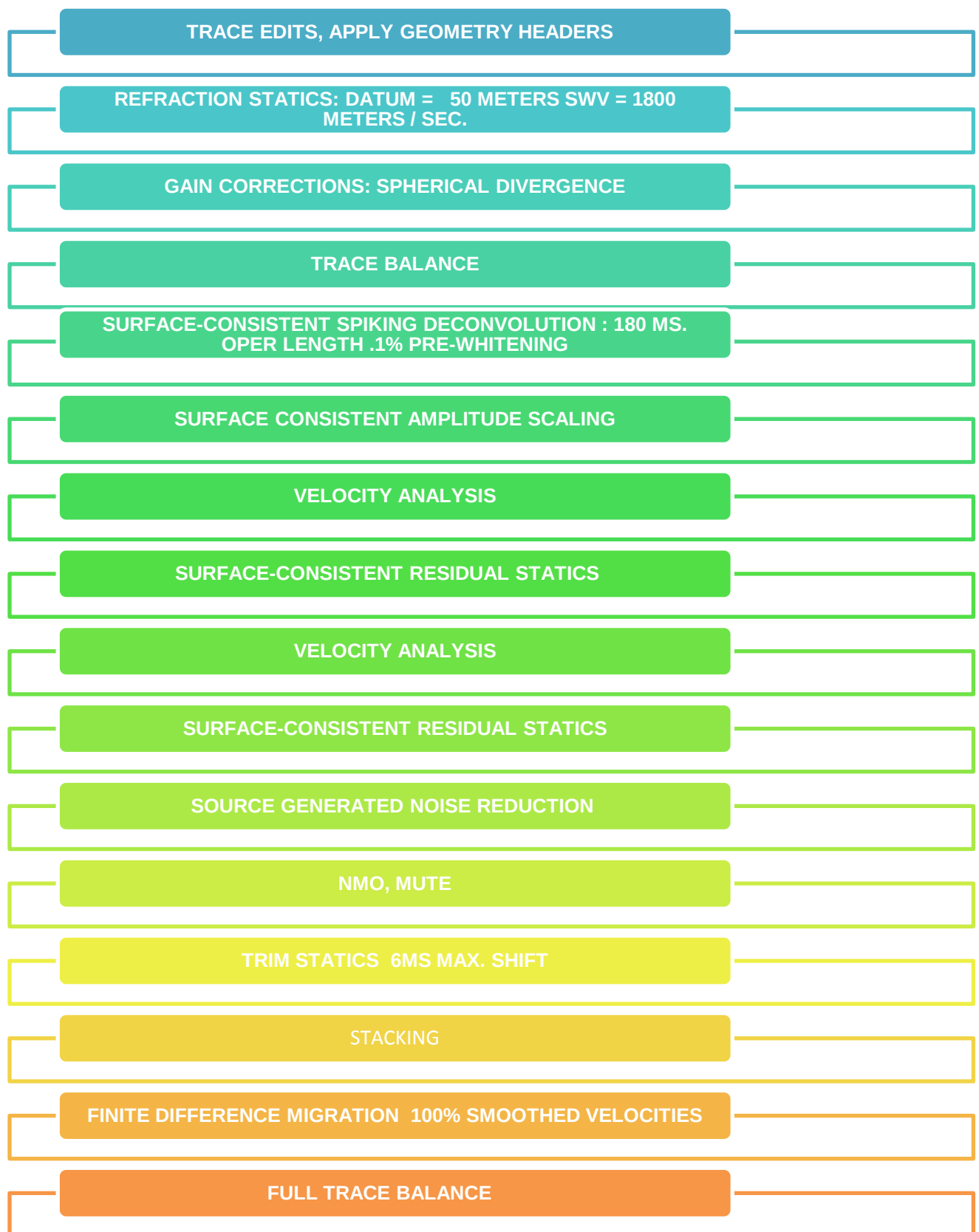
1. Figure: The Bouguer anomaly map of the investigated area (MOL, Final report, 2006.)

In the historical pre-research phase, the Bouguer anomaly map of the area was also the basis for setting the 2D lines. This map can be found above. Recently we are in a detailed exploration phase, which based on the interpretation results of previously measured 2D lines. In this phase the main issue is to find the still unexplored or undrilled possibly HC bearing structures, stratigraphic traps, to carry out a more comprehensive fault pattern analysis for compiling more detailed contouring maps, and apply DHI (in this case AVO) technology. The network of the 2D lines are shown in the following base map with the outlines of the villages and the exploration area. Inside the green circle, the investigation area of mine is located.



2. Figure: The investigated area (in the green circle) and its environment

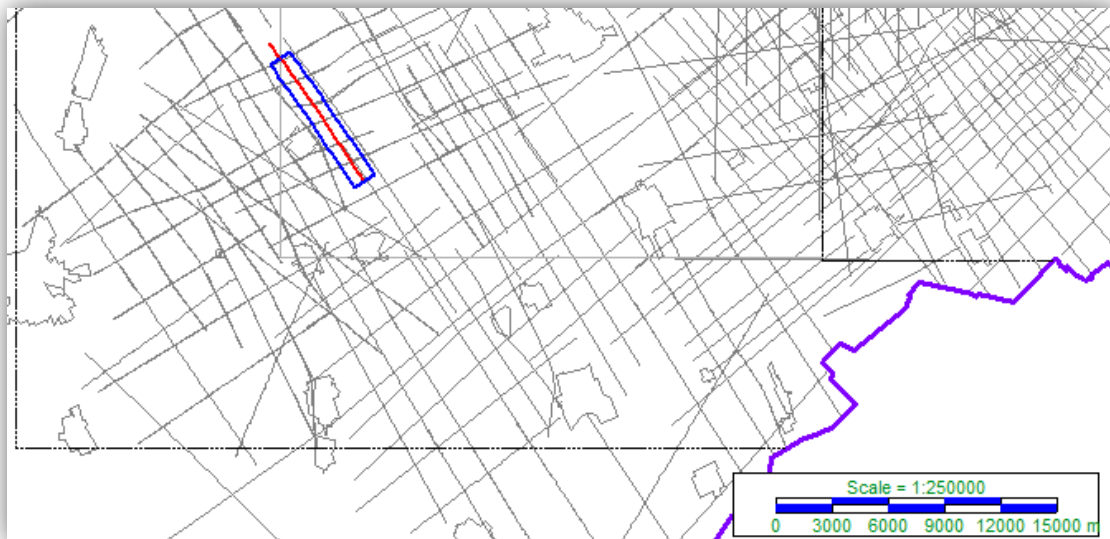
The re-processing of the data was conducted by an US based company, Tricon. During the re-processing, they carried out the usual steps just like static correction, normal move out correction and muting. The main aim was to remove the effect of the low velocity layer (LVL) and a final unification from the different records. The processing chart, which summarizes each of the processing steps of the investigated 2D sections can be found below in details.



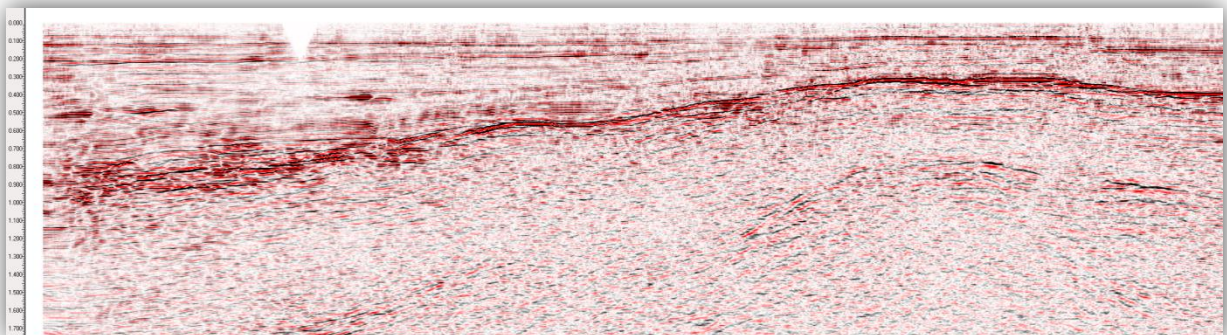
3. Figure: Processing flow of the area

7. Mistie analysis

In terms of processing, it is important to eliminate the time shifts from the connected reflections. This analysis is trying to resolve this connection problem, which is essential to a combined, unified interpretation. As a first step, a reference seismic line has to be found, which has one or more coherent reflection surface on its time section. The choice of this line is a very critical issue, because all the other lines will be calibrated to this. In this task a line, from here mention as L-1 was considered as a reference line. Whereas this line satisfies the previous criterias and it has a lot of crossing connections with other 2D lines, the most appropriate method is to pose it under mistie analysis. The picture below shows the place of the selected line and its time section.

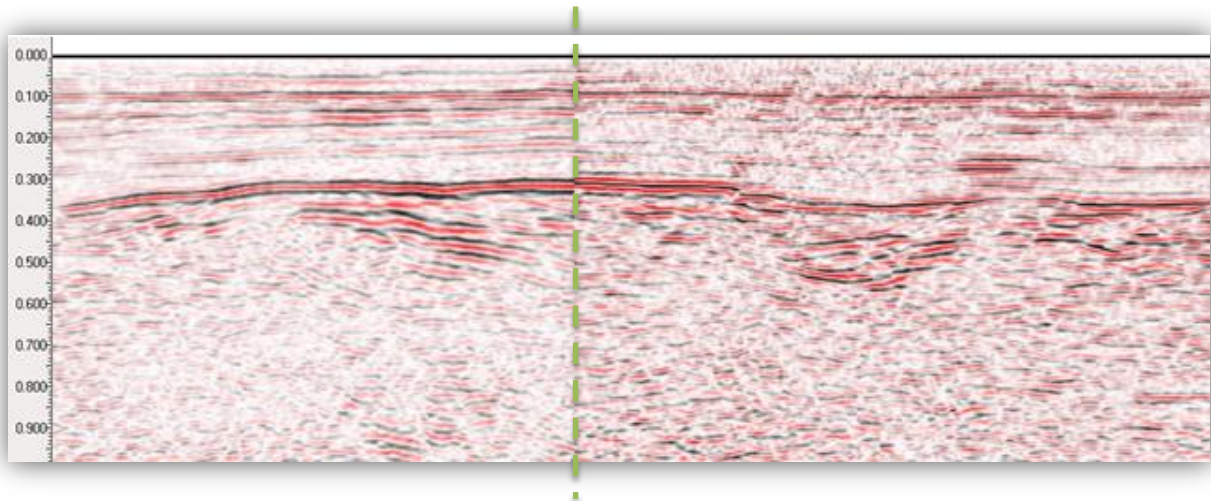


4. Figure: The trace of the L-1 line



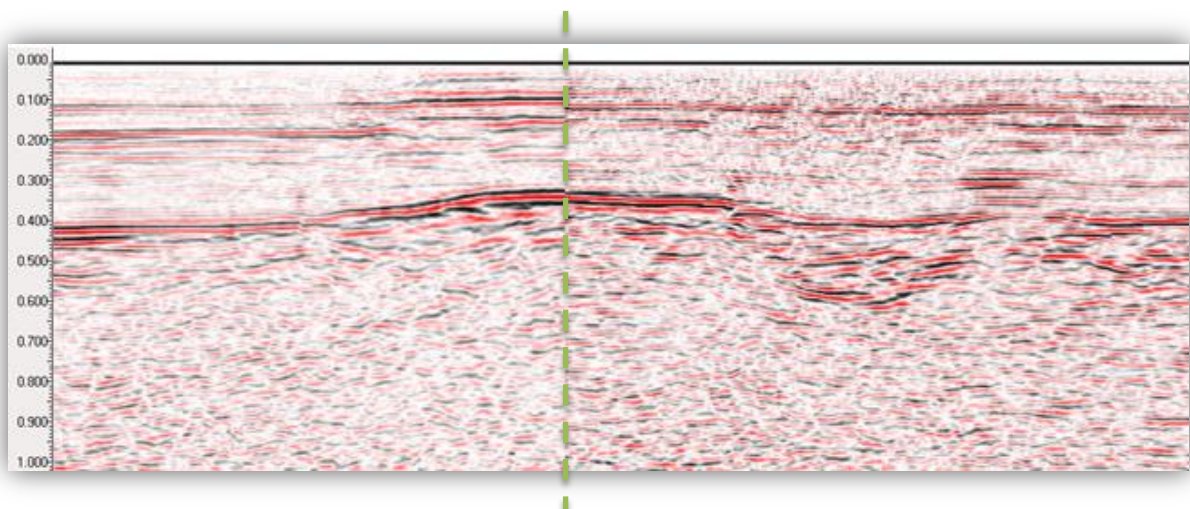
5. Figure: The time section of the L-1 line
(The units of the vertical axis are given in milliseconds in every time section!)

The step after the selection is to make correction on the crossing lines. The next figure shows two crossing sections, which encounter is nearly perpendicular. On the left side the etalon (L-1) line and on the right side, the other section - which needs to be matched - can be seen. The two profiles have the same gain but they are completely different. The polarity of the reflections and their position in time are the main differences between them.



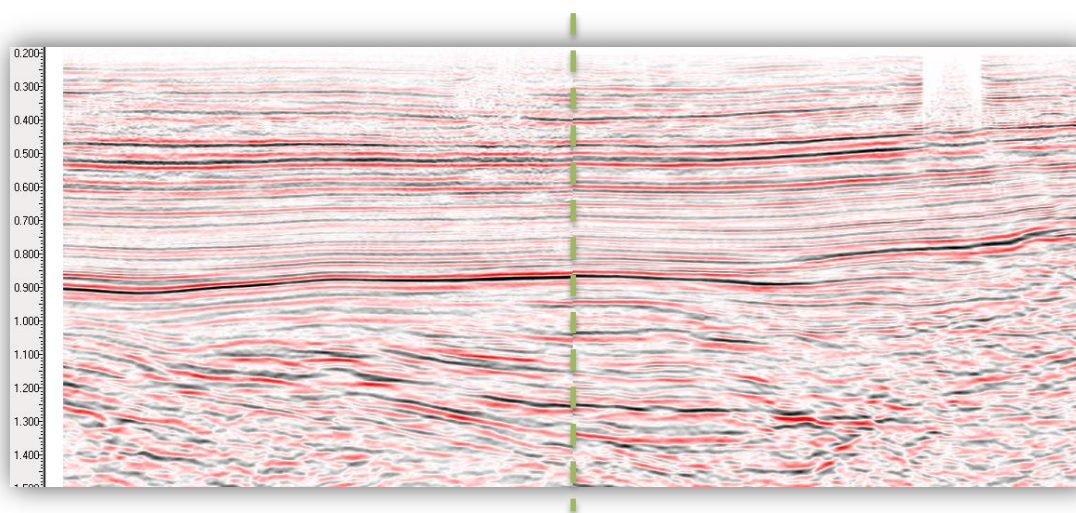
6. Figure: The time sections of the L-1 line (left side) and the crossing line (right side) before mistie analysis

After a phase rotation and a bulk shift the main reflection has been placed to the appropriate location. The repaired sections are shown below. It can be seen how much the polarity changes and the time shift helped in the sections. These steps have to be done in the whole area including each of the 2D sections. Almost every line has a connection with other lines, which can be improved with the help of the previously restored section.



7. Figure: The time sections of the L-1 line (left side) and the crossing line (right side) after mistie analysis

It is not negligible to check mistie analysis on the reprocessed surveys as well. The below exemplified arbitrary line is a good example for a really effective mistie analysis. This is a picture, which has been taken after mistie correction (time shift and polarity change) between two surveys. The border – where the sections are crossing – is barely noticeable. Almost every main reflection surface and amplitude phenomenon can be traced both the upper and the lower part of the sections without interrupting the continuity.



8. Figure: Two reprocessed time sections after mistie analysis (the etalon one is on the left side and the crossing section is on the right side)

The table 2. summarizes the values of the time shifts and the necessary polarity changes, which were essential to be carried out at the investigated area in order to get appropriate sections to the later stages of processing. It is clear, that many changes have been made, in the lack of these changes the interpretation would not have led to a corresponding result.

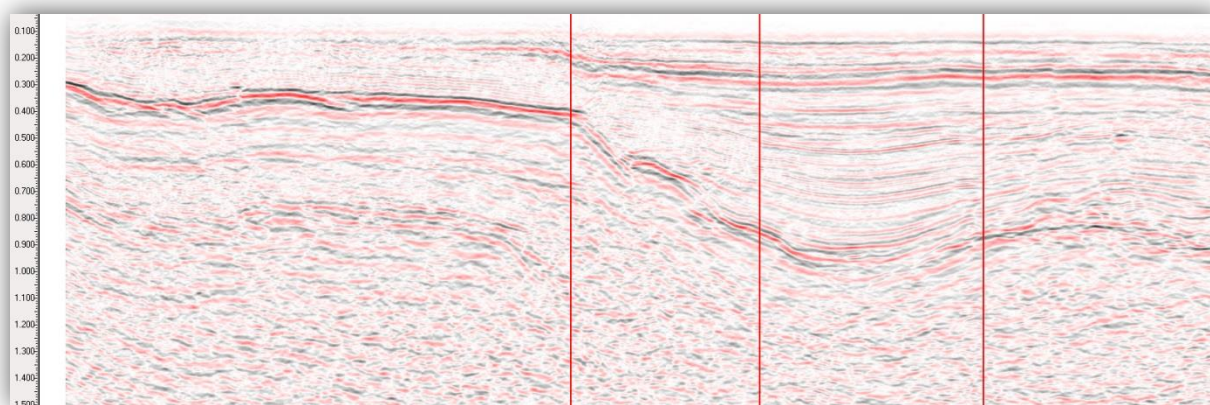
Name of the line	Time shift [msec]	Polarity
1	-20	
2	-18	
3	-20	reverse*
4	-10	reverse
5	-10	reverse
6	-10	reverse
7	-35	
8	-3	
9	-37	
10	0	
11	-25	
12	-20	

2. Table: The necessary time shifts and polarity changes
(* Reverse means 180° phase rotation)

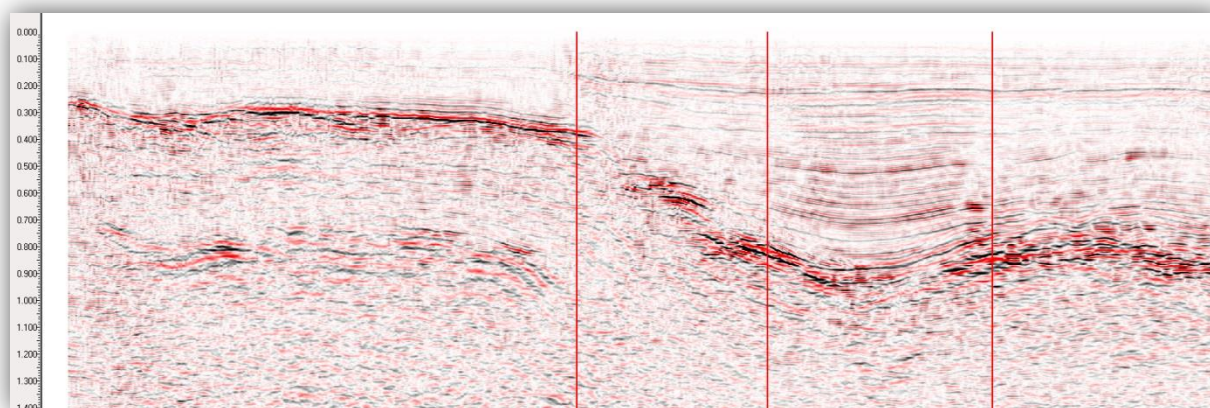
8. Advantages and disadvantages of the reprocessing

In the next chapter I would like to introduce the advantages and disadvantages of the reprocessing. Both the benefits and handicaps will be shown in examples. My method is to compare the original old sections with the new ones, mainly emphasizing some details with the same gain power in every section. Several lines have been reprocessed not only once, in these cases I present more results.

The following line (mentioned as A-1 from here on) is a good example to prove how much a reprocessing can improve a profile. The figures below show the original and the reprocessed versions of the entire sections. At first sight the difference is visible despite the fact, that the gain is equal at the two sections. It can be said about the investigated line that, it was measured in 1994 and its source was a vibrator.

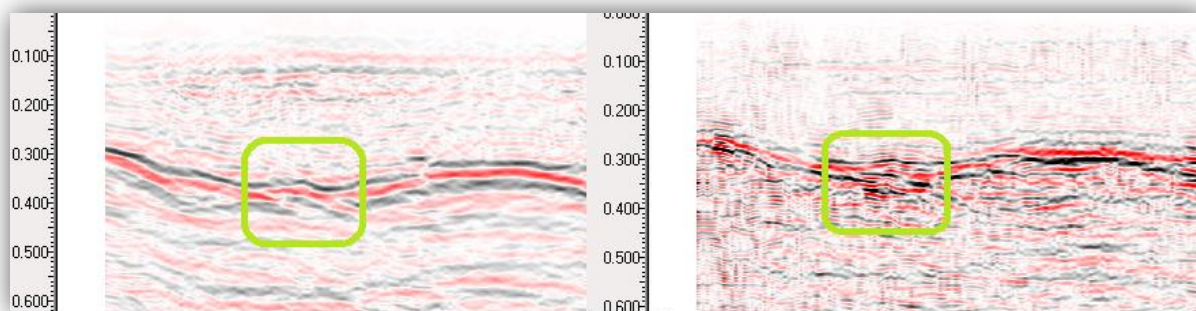


9. Figure: The original time section of the A-1 line



10. Figure: The reprocessed* time section of the A-1 line
(*Reprocessed by Tricon)

In the next part I will present the improved coherence and resolution power by focusing on certain details of the sections. The first example perfectly shows the improvement in the resolution power. This image is emphasized from the beginning of the sections. The left image is the old version, while the right is derived from the reprocessed version. The improvement is conspicuous. It can be seen that, the new version is much more detailed despite being cut out with the same amount of gain.



11. Figure: The improvement of the resolution power in the time sections
(The original one is on the left side while the reprocessed one by the Tricon is on the right side)

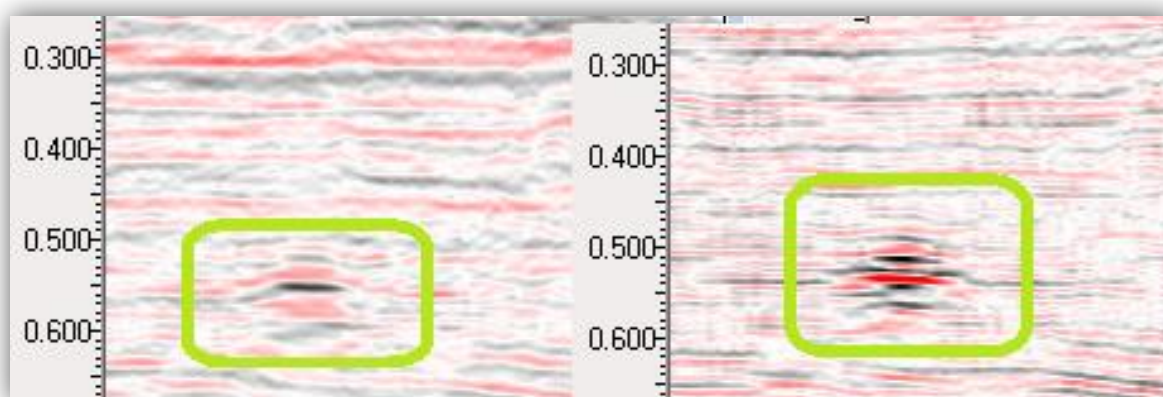
The framed parts show the main scene of this comparison. In the older section we can observe maximum five reflection packages, while in the new one this number is approximately eleven, in a 70 msec wide time window. It means that the frequency of the reprocessed line improved (became higher one) with more than 50 percent in the Pannonian / Miocene Sarmatian or Badenian sediments.



12. Figure: Two time sections about the A-1 line with (left side) and without (right side) automatic gain controlling
(The original one is on the left side while the reprocessed one by the Tricon is on the right side)

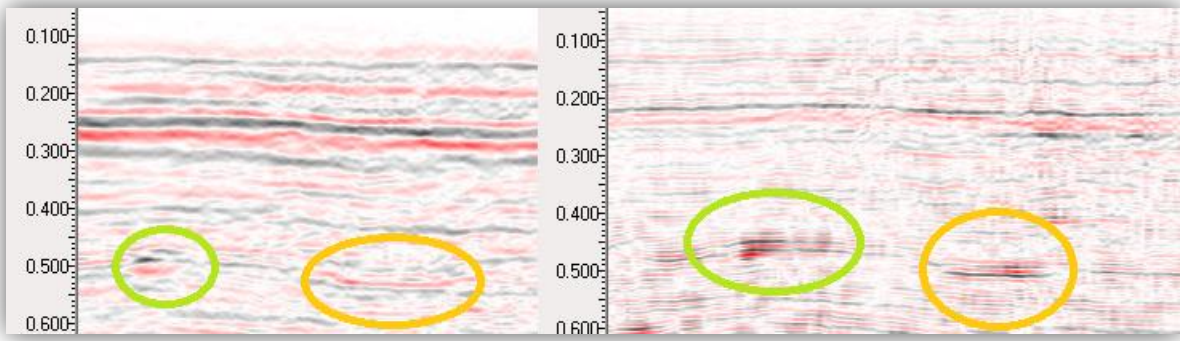
It is true that, the main reflection is not so much coherent but nonetheless it is still easy to follow clearly. In the past, probably automatic gain control was used on the old section, because mostly equalized amplitudes can be observed. The new sections show definitive variation of strongness of the different reflections, as it is shown above.

The aim is to notice these little phenomena, because they are holding meaningful information about the subsurface structures, lithological and sedimentological variations. These bright spot events - in the picture below - not only can be seen more clearly in the sections, but also the extension of them is wider. The re-processed 2D data is simply richer in details.



13. Figure: An amplitude phenomena -the improvement of the resolution power
(The original one is on the left side while the reprocessed one by the Tricon is on the right side)

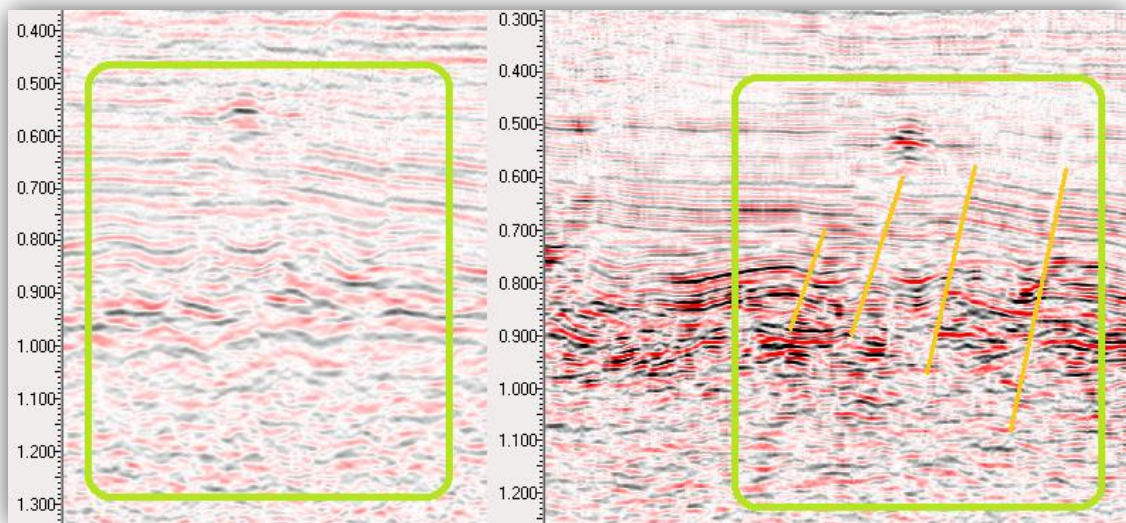
As it happens often a lot of amplitude phenomenon has been masked in the old sections, because of the improper amplitude preservation technique in the old processing sequence (Note: this is partially coming from the aim of the geoscientists from that age: they wanted to interpret 4-way dip structures, not amplitude related exploration objects). The better quality of the reprocessed seismic lines (wider frequency range, higher resolution, variable amplitude characters and more detailed and different reflection pattern) provide more information for the interpreters to prepare better geological/geophysical model and finally more precise volumetric estimation and geological probability calculation for each selected exploration object.



14. Figure: Amplitude phenomena

(The original one is on the left side while the reprocessed one by the Tricon is on the right side)

Another feature can be noticed easily in the new section. The tilted blocks - like tilted books - appear in the older section too (left picture), but due to the reprocessing they stand out from their environment. The higher resolution power helped in this case too. The difference of the inner structure is striking. The previously mentioned problem is appropriate in this case too. In the left section the phenomenon is masked and hard to notice.



15. Figure: The tilted blocks are more visible in the new section (right side)

(The original time section is on the left side while the reprocessed one by the Tricon is on the right side)

9. Overflow phenomenon and other problems

The reprocessing of the two oldest sections presented a lot of difficulties. These seismic lines have been measured in 1978 and 1979. The technology in this era was far not as developed as it is today. Fortunately, either the original field records or the last correctly processed (by old

processing sequence and method most likely by MOL daughter GES company) data remained intact. It helped a lot solving the emerging problems. Because of the difficulties, more reprocessing happened by Tricon, and Hungarian Geoinform Ltd. companies. Whereas the names of the lines are classified, in the followings I will mention them as O-78 and O-79 line. I present the oldest section first. The original trace of the O-78 line can be seen below (left side) and the next picture shows the reprocessed line (right side) as well.

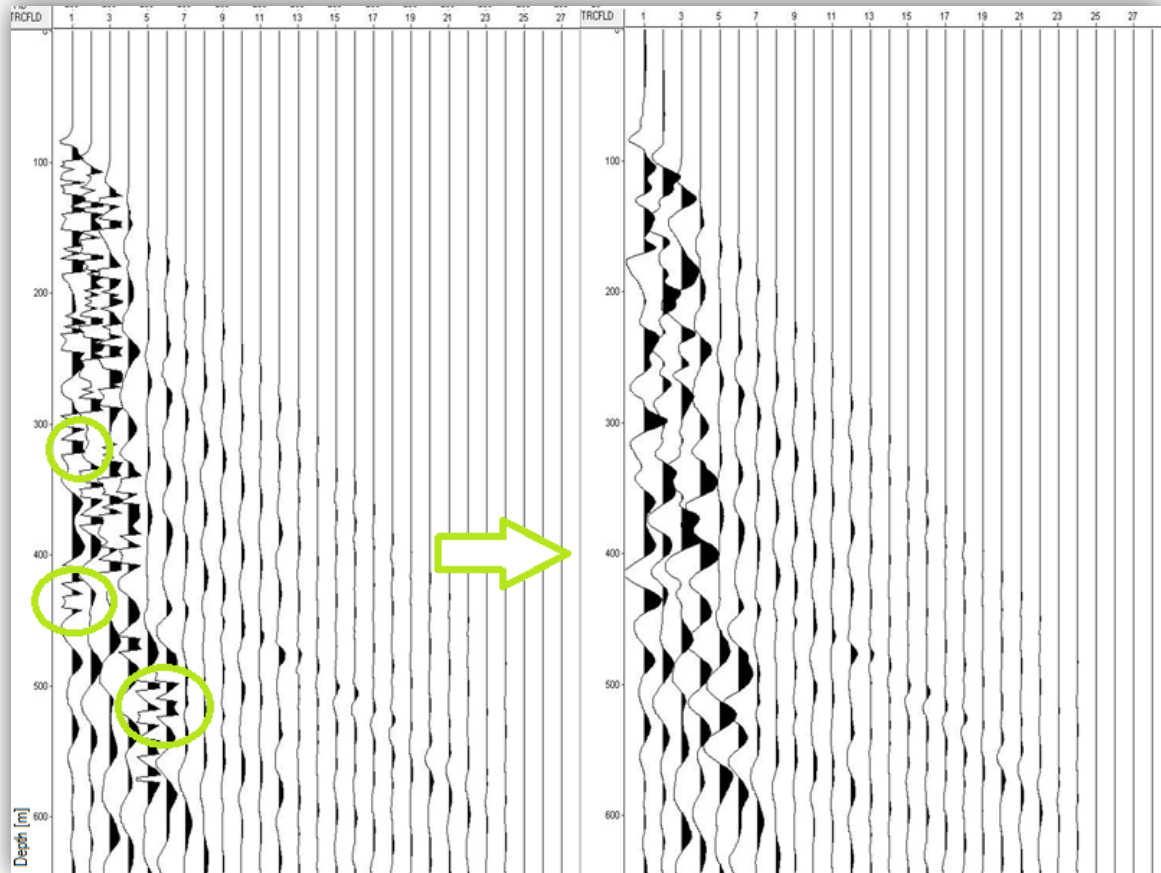


16. Figure: The original (left side) and the reprocessed* (right side) trace line
(*Reprocessed by GES)

It can be seen at first glance, that the reprocessed line is longer than the original one. This observation caused the first question. As the original records were available, the two companies - which executed the reprocessing - used these original files for their processing sequence.

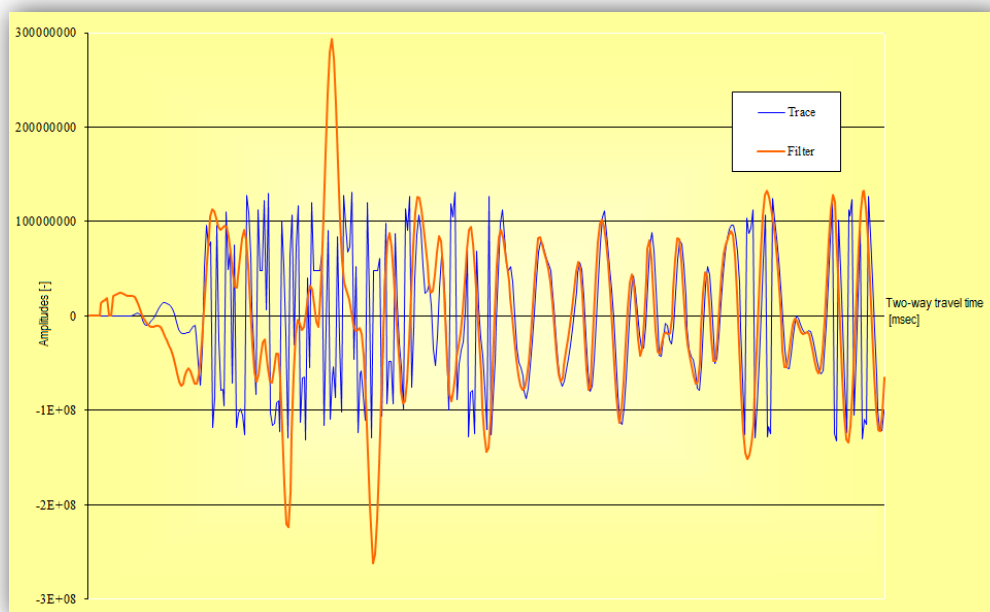
In 1978, the processing was probably deemed unsuitable and not reliable due to the technical barriers. That is why they made the decision that the best solution is to cut the end of the section. I have inspected the original coordinates of the line and its trace coincides with the reprocessed line, so it can be stated, that the longer line is suitable for the interpretation.

This line was reprocessed more times as I mentioned previously. During the processing an interesting phenomenon was observed. The maximum amplitude values of the signals are not the real maximum values. The explanation of this is the overflow phenomenon. When a signal, which has to be registered needs more space, than it has, the top of it has to be cut. This is a very familiar process to the low pass (high cut) filtering.



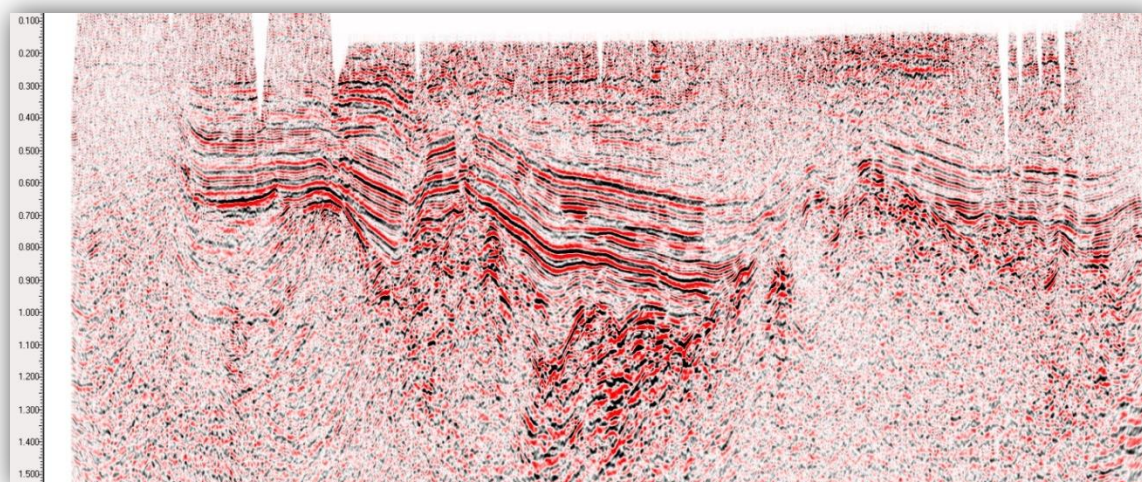
17. Figure: The overflow phenomenon: the circled parts show the torn of the signals
(The raw file is on the left side, while the processed one is on the right side. *Made by Geoinform.)*

In case of the old instruments the overflow phenomenon often occurred because of the narrow dynamic range. If the explosions were bigger than the planned ones, the data have overflowed. It can be seen in the picture below, that the top of the large amplitude signals has torn. Other explanation is the overflow happened during the transcription of the old, analog dataset to the new digital format (AD conversion). Both explanation is possible, and one of them are not negligible with 100 % confidence.



18. Figure: The overflowed (blue) and the filtered (orange) signals (MOL, Report, 1999.)

The next figure shows the original processed O-78 section from 1978. Despite being a nearly 40 years old section, it shows coherent reflections, which can be observed and followed easily.

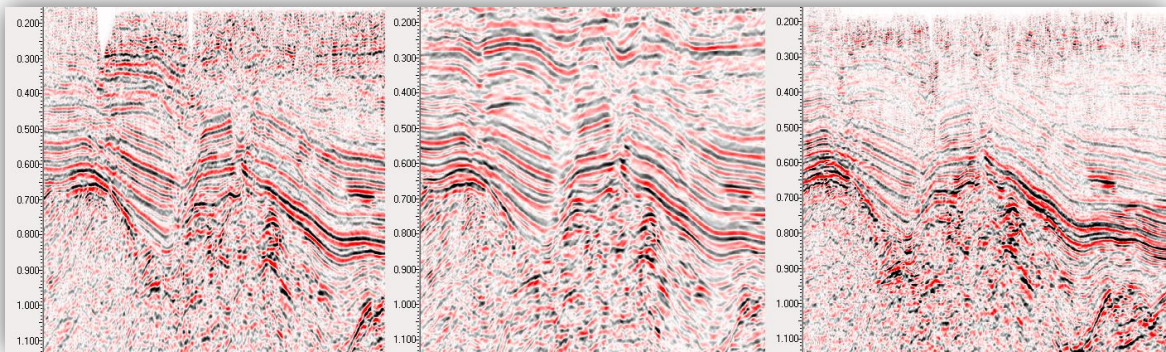


19. Figure: The time section of the O-78 line

The phenomenon was realized by Tricon during the processing of O-79 line. Because they were not able to solve this overflow issue, RAG geoscientists decided to go back to the source of the troubles and tried to fix this problem even on the field data. For this reason Geoinform

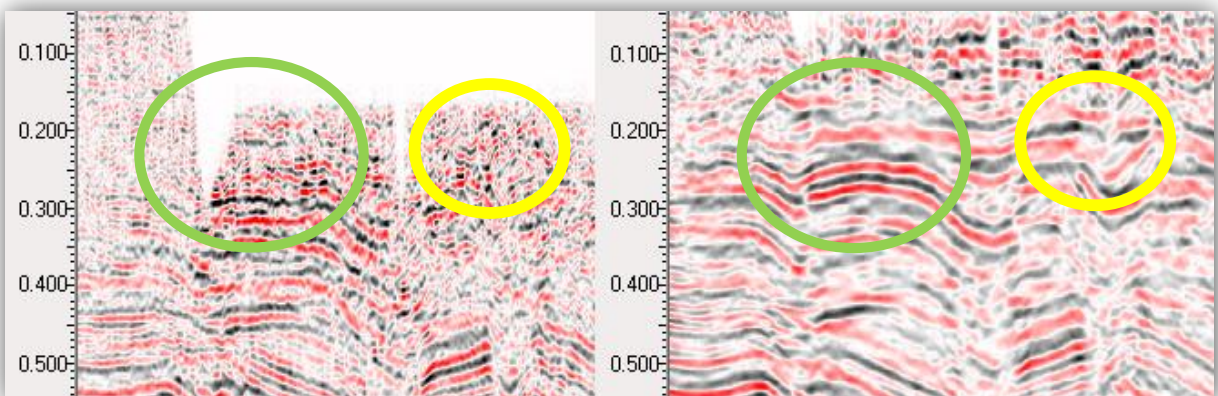
experts (GES Ltd was involved under Geoinform Ltd. meanwhile) were asked to re-construct the original field data because they have practice with a management of such a problematic data. They tried to remove the effect of the „overflow” from the original field data.

After the reconstruction of the field records both Geoinform and Tricon reprocessed this line with a debatable result. The reprocessing equally has benefits and disadvantages but in this case, it does not help much but as previously I will start the presenting with the benefits. The first advantage is the length of the section.



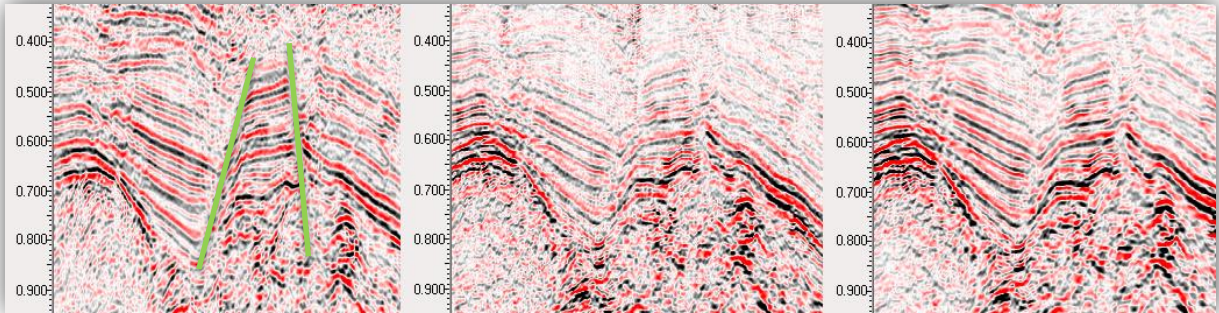
20. Figure: The time sections of the original (left side) and reprocessed* O-78 line
(*The middle section was reprocessed by the Geoinform, while the right one was made by the Tricon)

Due to the new process techniques the full length of the section was processed. However the resolution power became worse, some reflection surfaces became more traceable and coherent as the framed part of the figure shows below.



21. Figure: A coherent and more traceable reflection
(The left time section is the original one, while the right section was reprocessed by the Geoinform)

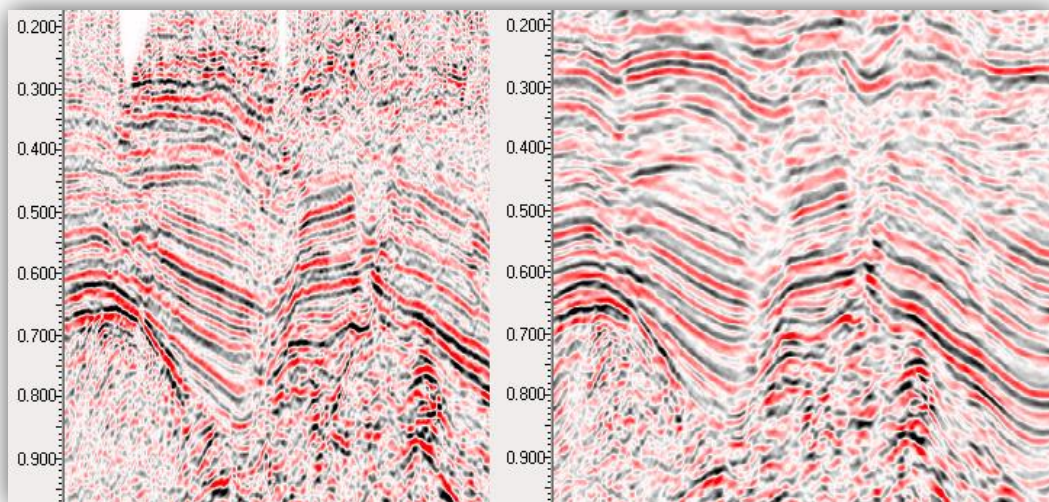
Concerning the faults, most of them are not so clear. In the original section they can be observed easily, while the reprocessed ones do not show them so clearly. Probably on the old section automatic gain control was used, because equalized amplitudes can be seen. However almost all the reflections are stronger, the faults are still striking. In the previous chapter I mentioned the phenomenon of the masking in connection with the old sections and here, it can be seen in the re-processed ones.



22. Figure: Some faults in the time sections

(The middle section was reprocessed by the Tricon_1, while the right one was made by the Tricon_2)

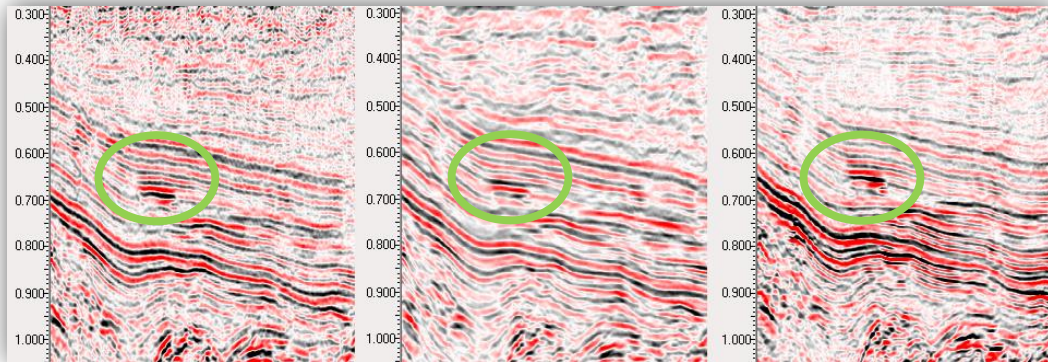
Some of the lines were reprocessed more than one times by the Tricon. The reason for this was the overflow phenomenon. As the previous figure shows the company could not eliminate the phenomenon during the first processing (Tricon_1). That is why they had to make a second reprocessing (Tricon_2).



23. Figure: The effect of masking

(The left time section is the original one, while the right section was reprocessed by the Geoinform)

In the new sections the bright spots are more clearly visible. In the old one - thanks to the automatic gain controlling - this amplitude phenomenon, which can be an important hydrocarbon indicator blends into the environment. This is the reason why processors should apply carefully this procedure (AGC). The framed parts shows these amplitude phenomena.



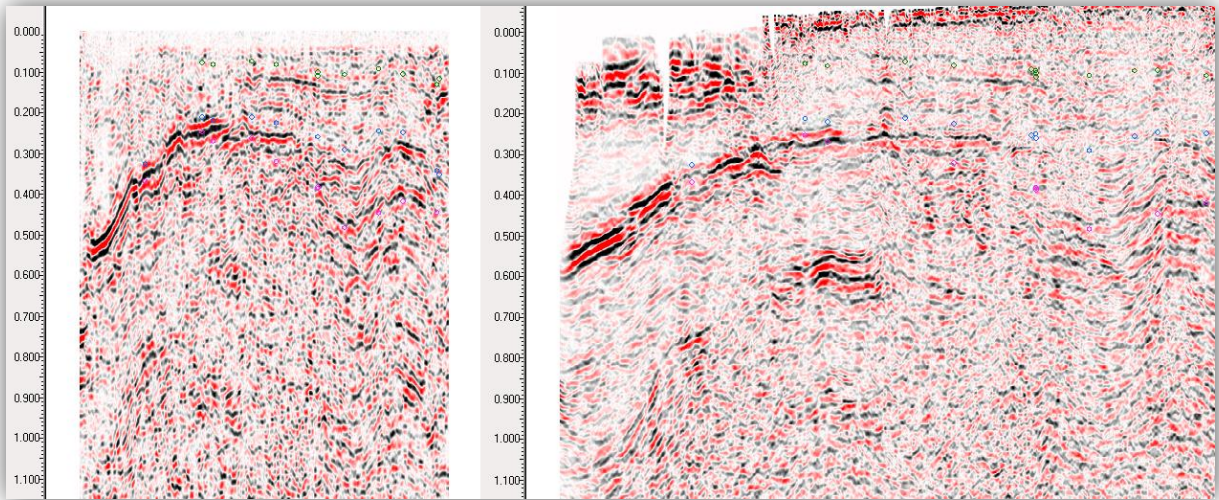
24. Figure: Amplitude phenomena in the time sections

(The left one is the original one, the middle section was reprocessed by the Geoinform, while the right one was made by the Tricon)

Some reflection surface was lost, but at the same time some of them can be easily traced. The green arrow shows a weaker reflection in the original figure, however the same reflection surface can be observed much more easily. The blue arrow shows a stronger reflection in the first part of the figure, while the same reflection can not be noticed as obviously.

The O-79 line is also a very interesting example. This is the second oldest measured line. It has been reprocessed several times. The length of the measured line did not change but the length of the section did.

It can be seen, that the length of the new file – which was reprocessed by the Geoinform - is double of the old one's. The number of the CDPs is halved. Presumably its reason was a simply geometrical reason or maybe two CDPs had been merged – but it happened in any way, the CDP number of the new processing is correct. In addition to this, a negative time shift can be observed, which value is approximately 200 milliseconds. Both in the first and second section, the main reflection surface can be traced. Concerning resolution power considerable improvement can not be noticed. However, some amplitude phenomenon are more noticeable.



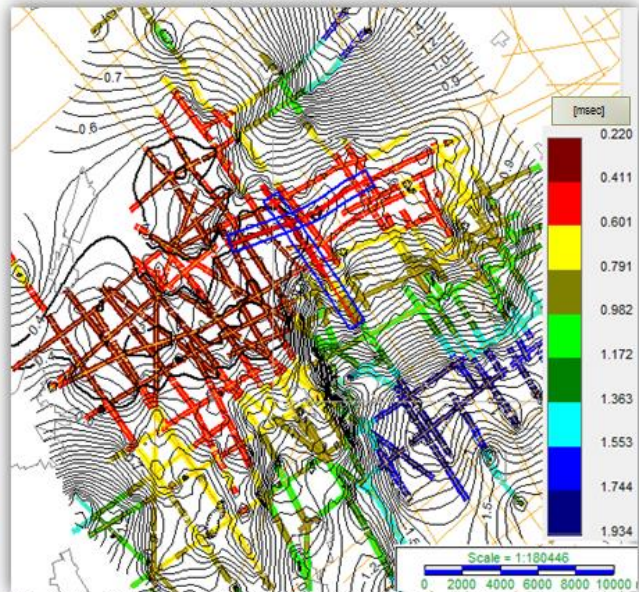
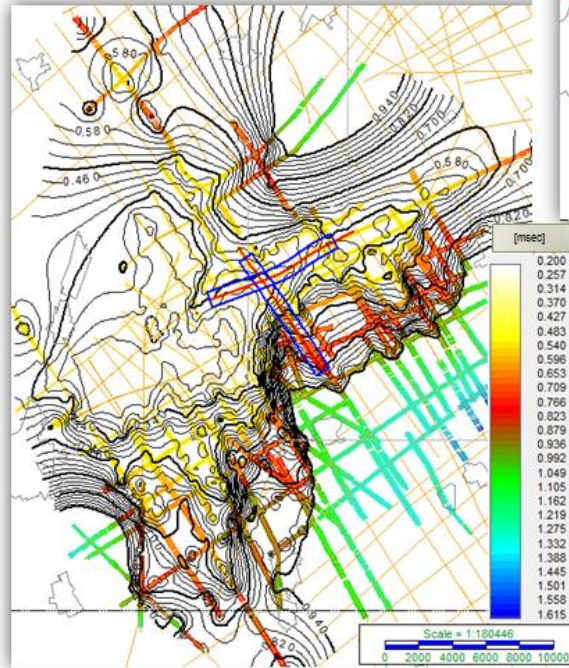
25. Figure: Time sections of the O-79 line
(The original one is on the left side, while the reprocessed one is on the right side. *Made by Geoinform.)*

10. Conclusion and closing thoughts

The reprocessing of the time sections helped a lot to improve the geological and geophysical knowledge of the investigated area thoroughly. As a result of this process, the resolution power improved a lot and more coherent and traceable reflection surfaces appeared. Thus the Pannonian basement and the Neogene one could be picked easier. After all the important reflections had been picked, I was able to create TWT (two-way-time) maps of the area. (Figure 26. and 27.)

According to the reprocessing, the improvement is mainly noticeable in the resolution power and in the coherence. The observation of these phenomena is very important to create a new, reliable interpretation, furthermore to find new possible hydrocarbon trap positions in such an area, where the structure of the subsurface were believed well known before.

26. Figure: Sketch of TWT map of horizon base Neogene →



← 27. Figure: Sketch of TWT map of horizon base Pannonian

The most important message of my thesis is to prove that, the old recordings should never be disposed, because they contain irreplaceable information about the investigated areas. Furthermore, it is not be forgotten that, the key of the development is the permanent research. The new methods and techniques are very important, not only in the geoscience but also in the whole life. The reprocessing of the old 2D seismic data - as a new method - was the key in this case, which leads to a fresh geological and geophysical interpretation.

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Eredetiség nyilatkozat

Alulírott Hegedűs Réka, a Miskolci Egyetem Műszaki Földtudományi Karának hallgatója büntetőjogi és fegyelmi felelősségem tudatában kijelentem és aláírásommal igazolom, hogy ezt a dolgozatot saját magam készítettem, a benne leírt vizsgálatokat – ha ezt külön nem jelzem – magam végeztem el, és az ismertett eredményeket magam értem el. Adatokat, információkat csak az irodalomjegyzékben felsorolt forrásokból használtam fel. Minden olyan részt, mely et szó szerint, vagy azonos értelemben, de átfogalmazva más forrásból átvettem, egyértelműen, a forrás megadásával megjelöltem.

Miskolc, 2014.10.27.

.....
a hallgató aláírása

Konzulensi nyilatkozat

Alulírott Dr. habil. Ormos Tamás, a Miskolci Egyetem, Geofizikai Intézeti Tanszékének magántanára a TDK dolgozatot beadásra alkalmasnak ítélem.

Egyéb megjegyzések, ajánlás:

Miskolc, 2014.10.27.

.....
a konzulens aláírása