

# ГЕОЛОГИЧЕСКИЕ НАУКИ

## THE ROLE OF COSMIC DUST IN THE FORMATION OF STRONG REFLECTIVE BOUNDARIES (ON THE EXAMPLE OF INDIVIDUAL AREAS OF AZERBAIJAN)

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### ABSTRACT

The paper underlines that reserves in anticline traps are exhausting both in Azerbaijan and around the globe and in this respect the priority today is exploration for hydrocarbon resources in non-anticline traps, which are formed with a certain role of non-depositions or in other words - breaks in sedimentation process. In this respect, it is natural that in the recent years the geoscientists pay a close attention to researches on non-anticline traps and non-depositions, since they were not covered by specific studies until now. It should be noted, that studies held at the "Geophysics" Department of Azerbaijan State Oil and Industry University are some kind of exception. In this paper, results of some studies are given, including outlined boundaries of unconformities, related to non-depositions under various seismogeological conditions in onshore and offshore areas. It has been also indicated, that no specific studies of non-depositions by use of seismic survey have been held in Azerbaijan. This paper is devoted to outlining and tracking of boundaries related to breaks in sedimentation process analyzed by use of various seismic survey data acquired in various oil and gas regions of Azerbaijan.

First of all, the paper considers the brief geological and geophysical characteristics of non-depositions and it is noted that a special role in their study is attributed to high-resolution seismic survey and electric survey. It is specially underlined that under the non-depositions the geoscientists mean the absence of terrestrial depositions and outlining and tracing of regional and reference seismic horizons are not complicated task. According to the latest studies, during the periods of global and local breaks in sedimentation process, the depositions of terrestrial origin are absent, however deposition of cosmic dust is continuously going on and this has been proved by various studies.

The paper also indicated the role of some researchers in studies of depositions of cosmic origin and their reflections in seismic data. The results of studies of depositions of cosmic origin by use of modeling held in Azerbaijan have been also displayed.

**Key words:** non-depositions, high-resolution seismic survey, ranked seismic horizons, unconformity boundaries, cosmic dust.

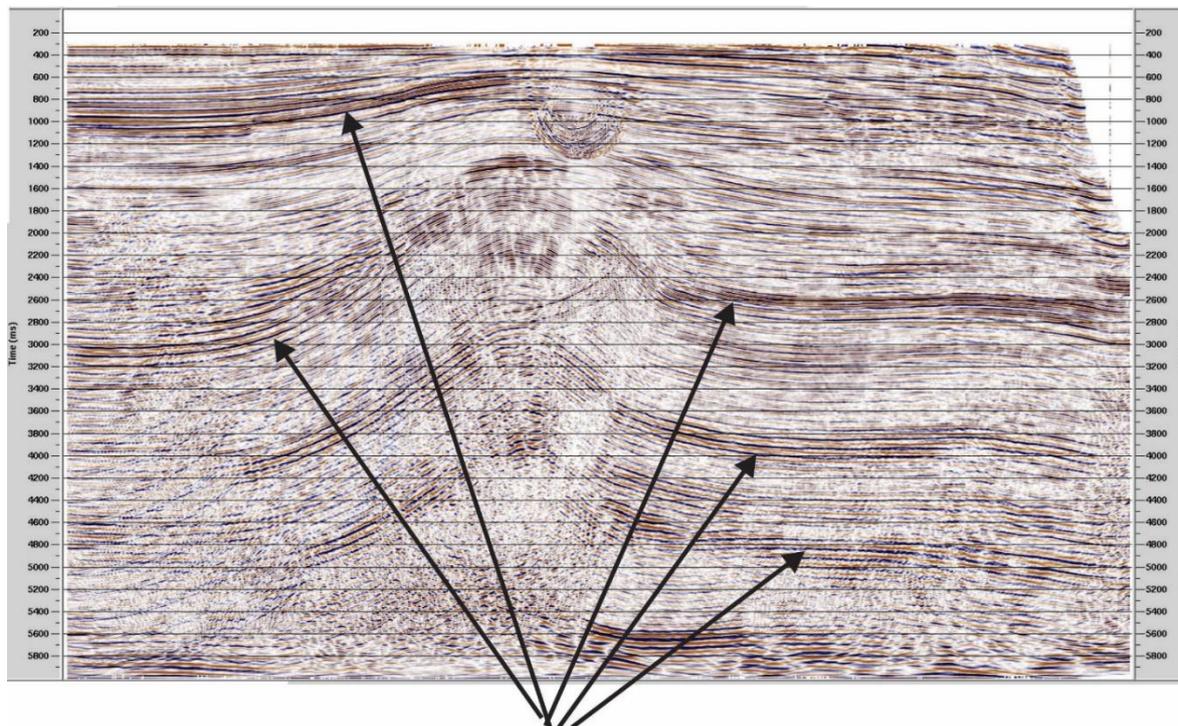
**Introduction.** The sharp decline of the world's oil and gas reserves related to anticline traps is a well-known issue, and in this sense, Azerbaijan is no exception. Due to this, the attention of geologists and geophysicists are currently focusing on non-anticline traps. It is known, that non-deposition or hiatus processes play a very important role in formation of such traps. Significant progress has been made in studies of non-deposition periods by use of seismic survey. Some researches in this area have been done at the Department of Geophysical Exploration Methods of Azerbaijan State Oil and Industry University.

In this respect, the researches of P.Z.Mammadov devoted to study of unconformity boundaries created by non-depositions under various seismogeological conditions onshore and offshore Azerbaijan are noteworthy [3]. However, no thorough researches have

been conducted in Azerbaijan in order to study the boundaries of non-depositions by seismic survey.

First of all, let us consider briefly geological-geophysical nature of breaks in sedimentation process. It must be noted that high resolution seismic and electrical surveys have an important role in the study of non-depositions [4,5,6]. When talking about non-depositions or hiatus the geologists and geophysicists understand the absence of terrestrial sediments in the section [1,2]. Similar to sedimentary geological objects, non-depositions are ranked according to spatial and temporal characteristics [1,4,6].

The ranks of non-depositions are very well matched with the ranks of isolated geological sedimentary bodies. Regional and reference non-depositions are very clearly traced in seismic time sections and their study is not too complicated (Fig. 1).



*Reflective boundary formed by cosmic dust during sedimentation hiatus*  
 Figure 1. Seismic time section

Regional and reference non-depositions are existing for a long time and embrace a large part (about 90%) of sedimentary process [9,12]. Local non-depositions are relatively short, and their study by seismic survey has certain complications. Absolute spectral-time analysis (SVAN) must be used in the study of this type of non-depositions. It should be noted that from the point of view of seismic exploration, non-depositions cause mainly thick stratification of the section [10,11].

**Problem Statement.** This paper deals with identification and tracking of reflective boundaries (seismic horizons, conformity layers) associated with non-deposition intervals based on seismic survey data acquired in oil and gas regions of Azerbaijan.

**Research Questions.** According to previous assumptions, non-depositions generally mean the cease of the sedimentation process. According to modern studies while the global or local non-depositions, rocks of terrestrial origin do not really precipitate, however during this period, sediments (dusts) of cosmic origin settle continuously [7,8]. Estimates of the amount of matter of cosmic origin reaching the Earth's surface vary.

According to V.V. Fedinsky [8], approximately 10 million tons of space dust per year falls on the surface of the Earth. This is 10,000 times less than sediments of terrestrial origin. Therefore, the presence of cosmic dust in ordinary sedimentary layers falls out of the attention of geoscientists.

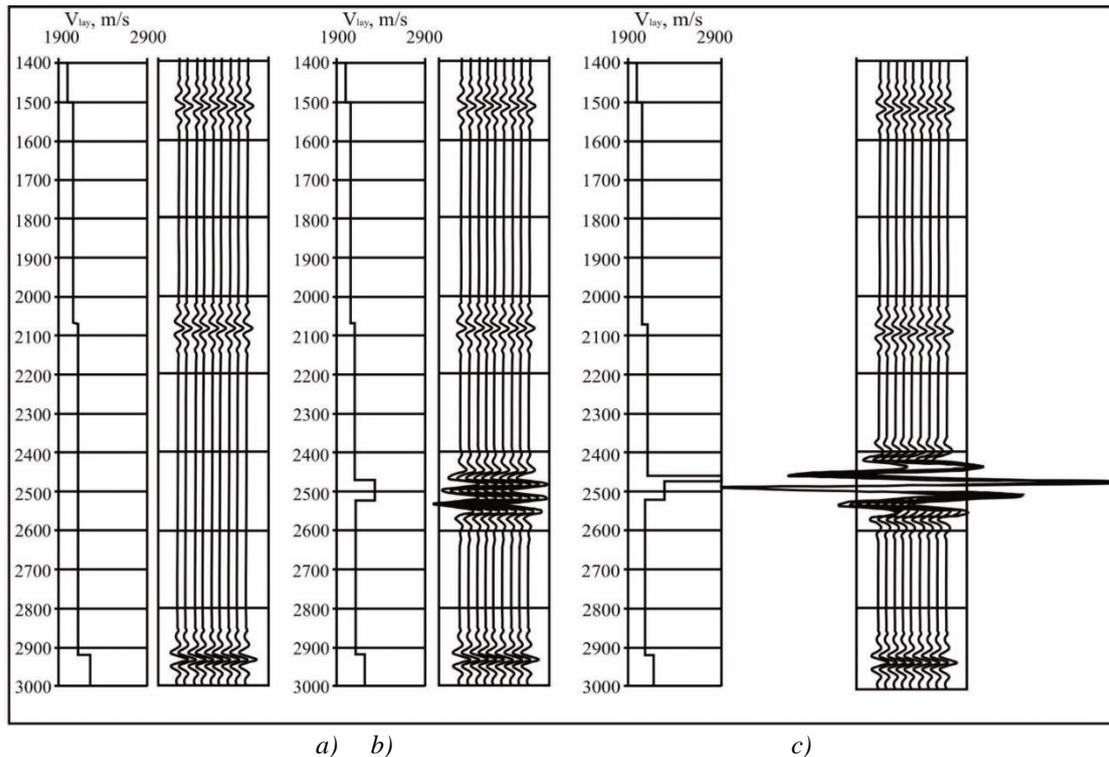
Thus, very thin layers of cosmic dust correspond to the breaks in sedimentation process. Approximately 0.02 grams of space dust per square meter of the earth's surface settles in a year. They are spherical grains with a diameter of  $10^{-6}$  m. The outer layer of these grains

consists of iron-manganese, and the core consists of graphite and silicate; the density is  $7.0 \text{ g/cm}^3$  [2].

In brief, the Earth is covered by a thin cosmic dust of  $0.3 \cdot 10^{-5}$  mm per year. Of course, such sediments are not visible. However, the breaks last for hundreds of thousands to millions of years and during these periods, i.e. during the absence of sediments of terrestrial origin, the layers were also formed, albeit very thin. According to A.S.Safonov and other researchers the structured layers of the particles of the cosmic dust curtain form an electric capacitor at the boundaries of the layers [2,6]. When such a layer is under the effect of elastic waves, its plates are deformed, displaces the charged particles of the carcass and the fluid, resulting in an additional (second) electromagnetic field, which in turn excites the second elastic wave (seismo-electric and electro-seismic effects). Due to this the dynamic clearly visible reflections (seismic horizons) are derived from non-depositions in time sections of CDP. According to A.S.Safonov et al. [6] when modeling the non-depositions the reflection coefficient should be included in the model only once - from top of non-deposition (Fig. 2). If there is a thick layer of sand of 50 m ( $v_{\text{lay}} = 2530 \text{ m/s}$ ) in the section, the strong reflections are obtained from its top and foot. The presence of non-deposition area near the top of this sand layer leads to the screening of that layer, and this must be taken into account when predicting the filtration-volumetric characteristics of reservoirs.

**Purpose of the Study.** It is important to mention one more issue. The second elastic wave generated by the seismic effect has no reflections except from the top and the foot. The cosmic dust layer behaves like a one-sided (single) active surface, i. e. like a hemisphere in the elastic field. Therefore, only one reflection

coefficient (from the top of non-deposition area) must be included when modeling non-deposition area.



*a) outside of reservoir area; b) sand lense c) sand lense and non-deposition*

*Figure 2. Modelling of seismic section:*

The concentration of all energy in a very thin layer and the pulsed nature of seismoelectric effects cause a very short strong pulse (close to the Dirac pulse) in non-deposition. This pulse has a very wide range of frequencies in the spectral area. I.A.Mushin underlined such behavior of non-deposition in SVAN columns [4]. In SVAN sections the non-depositions in sedimentation process display themselves depending on frequency as reflections with unvariable arrival times  $t_0$  [13,14]. In other words, non-depositions create such a reflection horizon (more precisely, pulse), which possesses the whole frequency spectrum (that is spectral components) at some fixed time  $t_0$ . According to many researchers, except for the rare cases such as the angular unconformity, sharp lithological variance, absence of entire stratigraphical intervals, erosion and restoration of sedimentation process the major part of

non-depositions are lying conformably with reference boundaries (Figure 3).

In practice, the elastic seismic wave field is the result of superposition of the signals generated by boundaries of non-depositions and reflections from boundaries of lithology change [4]. Namely these boundaries lead to generation of micro-, meso- and macrolayers of the sedimentary layer. Such conformingly buried non-depositions are hard to be detected and traced by geophysical survey. Despite that non-depositions are a small part of geological time, they constitute the important elements or tools of seismostratigraphy. If the acoustic (lithological) compound of reflections is described by the traditional theory of seismic survey, there are no velocity columns (models) for non-deposition compound [15,16].

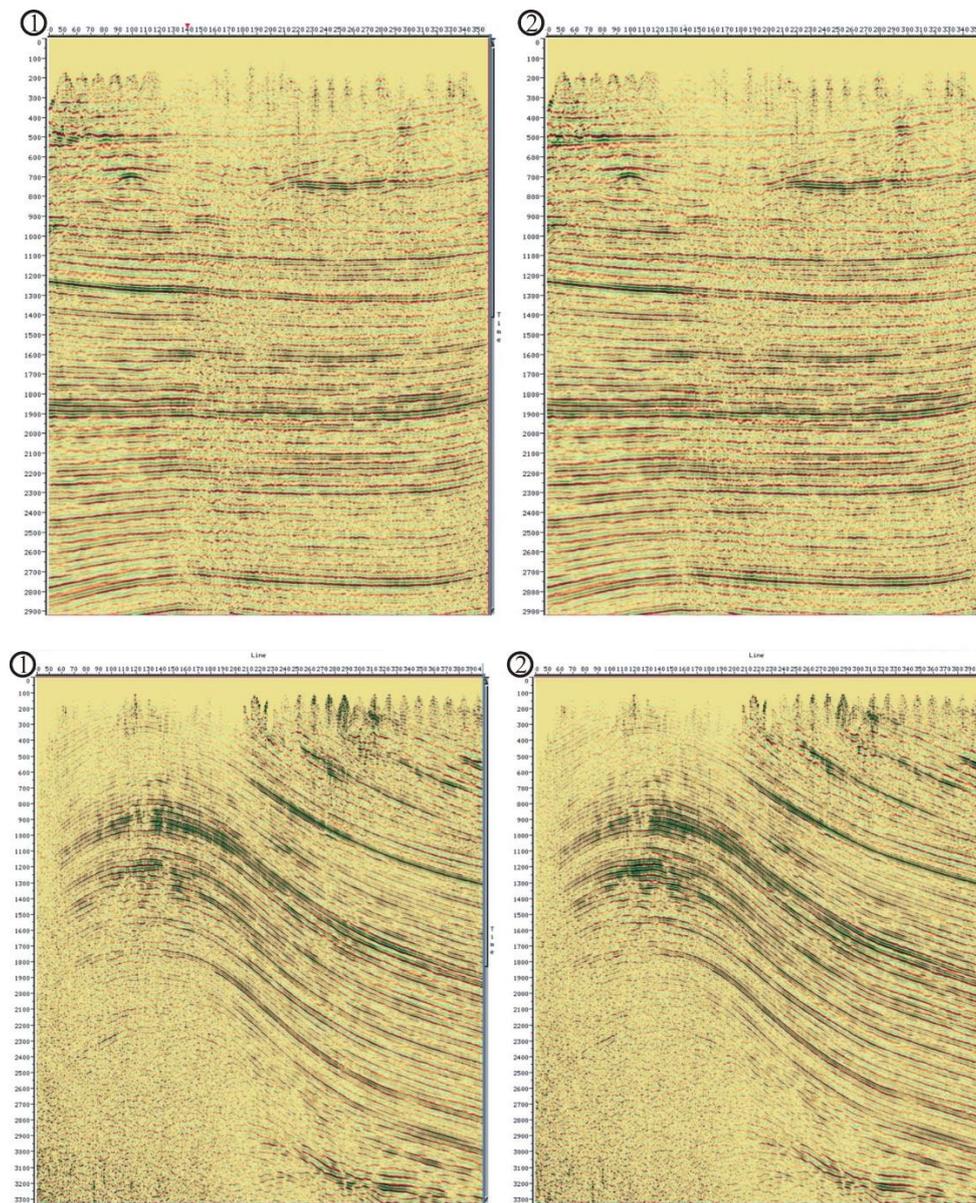


Figure 3. 3D seismic time sections prior (1) and after (2) applying of static and cinematic corrections (boundaries of non-depositions conformingly laying with major reference borders)

**Research Methods.** Non-deposition and acoustic compounds are not related to each other and exist completely independently. Since lithological compound of the wave field is studied by well logging techniques, dynamic interpretation of seismic data and electric survey, it is not the exception that non-depositions will also be studied by these techniques.

3D seismic survey conducted recently in one of the oil and gas fields of Azerbaijan allowed to reveal the internal structure of the seismic wave field observed

here and clarify some features of geological setting of the study area (Fig. 4).

In one of vertical sections of the cube of 3D seismic survey held in the study area the quasi-synchronous seismic sedimentation units have been outlined. Boundaries of non-depositions coincide with boundaries of these quasi-synchronous seismic sedimentation units. In some cases, non-depositions are observed within outlined units and they reflect the top and foot of separate smaller ranked units (Seismocycle, seismic layer series, seismic layer, etc.) (Fig.4).

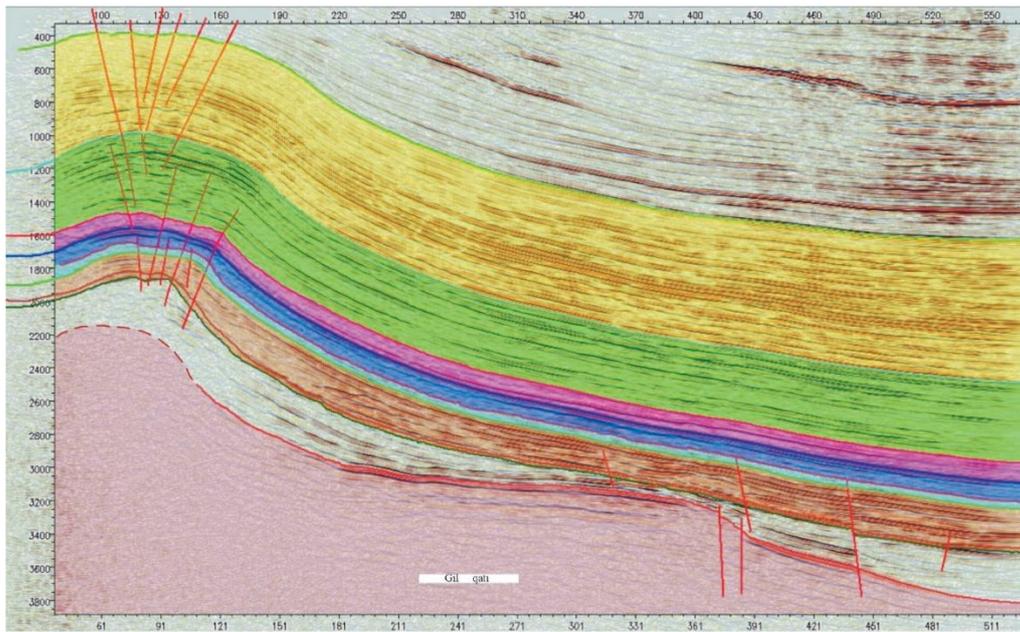


Figure 4. Identification of seismo-stratigraphic units in the vertical section of 3D seismic survey cube (Azerbaijan)

The role of non-deposition boundaries in generation of seismic wave field is varying. The part of time section displayed in the figure clearly reflects this. Despite that in some seismic horizons (or references) characterised by intensity no significant differences are observed in the seismic wave field, i.e. despite there is no strong differentiation of geological environment in regard of acoustics, the gain of strongly reflected seismic pulses proves that they are tied with non-depositions [14,17]. Several of these boundaries are not traced along the profile continuously and this displays variable nature of their role in the formation of the wave field. When the influence of non-depositions is too small, it can be said that all registered seismic signals are formed by lithological compound and the results of traditional interpretation are well conformed with later

drilling data. However, in the most cases it is not like this.

**Findings.** The hydrocarbon presence in geological section of the area are tied to several horizons of Gala layer series (lower part of Productive Series). Their relatively thick parts are poductive and featured by gas presence in some places. The area is considered as the area with high perspectives.

It must be noted that acquired deep drilling and seismic data do not allow to design geological model of oil traps of Gala layer series in the area covered by 3D seismic survey. Oil fields (to say more correctly - traps) can be roughly tied to lithofacies alteration of Gala layer series attributed to hiatus in top and foot of the field (Fig.5).

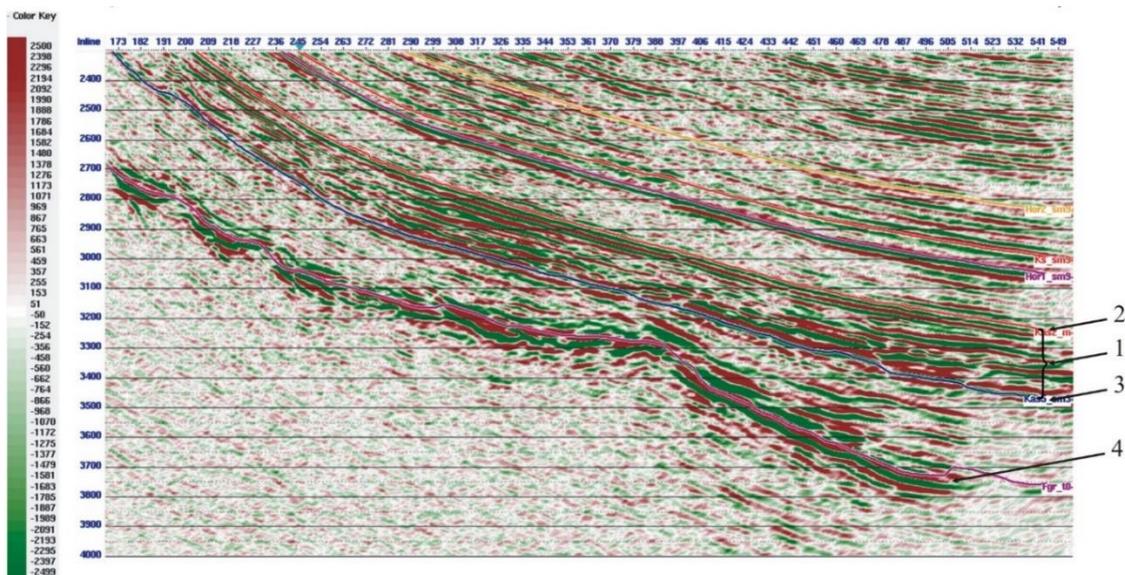


Figure 5. Vertical section of 3D seismic cube: 1 – seismic record interval reflecting Gala series; 2,3 – seismic horizons related to non-depositions and attributed to the top and foot of Gala series; 4 – seismic horizon related to non-deposition and attributed approximately to the top of Miocene

According to the AVO analysis applied to the seismic horizon referred to the top of Miocene the area with possibly reservoir properties was outlined on the slope of the uplift. It can be seen from time section shown above that this horizon is characterized by high intensity on seismic record on the background of relatively weak reflections.

**Conclusion.** In the summary, the following can be derived:

1. It can be supposed that most of the intensive seismic horizons observed in time sections except for the strong references in thin layers created by parallel interference are tied to non-depositions and most of these horizons belong to the medium or strong references; there are rather no weak references related to non-depositions;

2. Angular unconformities, sharp lithological alterations, absence of several stratigraphic intervals, with absence of rare cases as restart of sedimentation, the large number of non-depositions lay in conformance with reference borders;

3. The most of seismic horizons are developed as a result of superposition of signals created by reflections from borders of lithology change and by boundaries of non-depositions. Namely these boundaries create mikro-, meso-, and macrolayers in sedimentary cover. Conformingly buried non-depositions are not identified and traced by exploration (seismic) and well logging techniques; only in rare cases when these boundaries create reflection pulses close to the Dirac pulse (in other words the needle-shaped pulse), its existence in the wide frequency range proves that it is related with non-deposition border;

4. Non-depositions and lithological compounds of reflected wave field are not related to each other and exist independently. Lithological compound of the wave field is studied by well logging tools, dynamic interpretation of seismic data acquired in interwell area is studied by electrical logging while we can not state the same about non-depositions;

5. The influence of non-deposition must be taken into account while evaluation of filtration-capacity characteristics of reservoirs by use of seismic data.

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