IIETA International Information and Engineering Technology Association
Advancing the World of Information and Engineering

*ENVIRONMENTAL AND EARTH SCIENCES RESEARCH JOURNAL*
*Vol.2, No.2, 2015, pp.13-18*
*http://dx.doi.org/10.18280/eesrj.020203*

# PREDICTION OF FLUVIAL SAND BODY USING THE TECHNIQUE OF FREQUENCY DIVISION INTERPRETATION

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## ABSTRACT

Seismic events not only reflect lithology interface but also the isochronous interface, instead they are affected by the frequency of seismic data, different frequency seismic data reflects different levels of geological phenomenon. Seismic data in time domain transforms into a new frequency domain by using frequency division interpretation, then extract the frequency slice of the data volume in different frequency bands, analyze the slice which represents different geological significance and combines slice with single well facies, clear slice attributes represent the actual geological significance, at last definite the sedimentary boundary and depict the concept of sedimentary bodies. Based on frequency division interpretation technique, this paper characterizes the Akshabulak formation sedimentary system in 1057 area of South Turgay Basin, Kazakstan. The results show that seismic data in different frequency reflects different levels of geological information, The SQ8-1 cycle sensitive frequency range is 20~25Hz, the frequency slice displays channel sand bodies clearly, and the SQ8-2 cycle range is 22~27Hz, the SQ8-3 cycle range is 25~30Hz. Another finding is that by using frequency division interpretation slice can characterize fluvial boundary, plane geometry and discontinuity accurately. This method can provide favorable geological evidence for oil and gas exploration and development.

**Keywords:** Frequency division interpretation, Fluvial sand body, 1057 area, Seismic attributes.

## 1. INTRODUCTION

Geophysical technology of seismic sedimentology rise rapidly along with the widespread application of 3d seismic technology, it was first put forward by foreign scholars and gradually paid widely attention by petroleum geologists. The concept of seismic sedimentology is proposed by Professor Zeng[1-2] in 1988. The American geologist Posamentier put forward the concept of seismic geomorphology during 2001. Then Professor Zeng point out that seismic stratigraphy is the study of stratigraphy and depositional facies as interpreted from seismic data.

Seismic frequency division interpretation processing transfers time domain seismic data into frequency domain seismic data in certain time window by using mathematical method such as the maximum entropy or Fourier transformation. Through observing different frequency slice changes in horizon and in vertical, different frequency of seismic data has great difference on the same scale, type and the same geological body. This technology is not only effective to avoid the mutual interference between the frequency components, but also through different frequency amplitude superposition, the largest extent, depict the different scales of geological body[3-4]. The reason that frequency division interpretation technique can effectively identify thin layers is due to the thin layer reflection system can produce resonance reflection, the reflection characteristics of thin layer effectively reflects the thin layer plane distribution characteristics of geological body, therefore, frequency division interpretation is to identify and describe effective technical means of thin layer of sedimentary bodies, especially for river channel and distributary main channel, turbidite in geological characterization has good application effect[5]. This paper characterizes the Akshabulak formation fluvial sedimentary system in 1057 area of South Turgay Basin by using this technique.

## 2. FREQUENCY DIVISION TECHNIQUE

Using maximum entropy method or discrete Fourier transform to convert seismic data in time domain to frequency domain, and generate a new frequency domain data volume (tuning). Taking the frequencies of different frequency tuning body section analyzes their respective representative geological significance, it can be ruled out the disruption by other geological factors caused by the different frequency in the time domain[6-7]. Generally speaking, the high frequency data is more sensitive to thin and shallow strata, and the low frequency data for thicker and deeper strata is more sensitive on different frequency bands show different levels of geological phenomenon. Through seismic frequency division technology can separate complex information, on different frequency bands show different levels of geological phenomenon. Depend on the research of sequence stratigraphy and sedimentary petrology, the three-dimensional

seismic data are fully exploited to study the sedimentary characteristics and the distribution of depositional system of 1057 area using the key technologies of seismic sedimentology, such as 90°phasing convertion, strata slice and frequency division. Frequency division is a key technique in seismic sedimentology. As shown in figure 1, the deposition on the margin of the river and center will have different thickness in river deposition process, different thickness of sedimentary bodies of discrete frequency parameter is also different (Fig.1). The different frequency section (15Hz and 30Hz) shows that the difference in channel is more obvious. As shown in Figure 1b, channel plane sketch (30Hz) only reflects the thin part of fluvial sedimentary bodies, as shown in Figure 1c, channel plane sketch (15Hz) only reflects the thick part of fluvial sedimentary bodies, as shown in Figure 1d, channel plane sketch (15Hz and 30Hz) reflects all parts of fluvial sedimentary bodies, it can get complete fluvial sedimentary characteristics of sedimentary system[8].

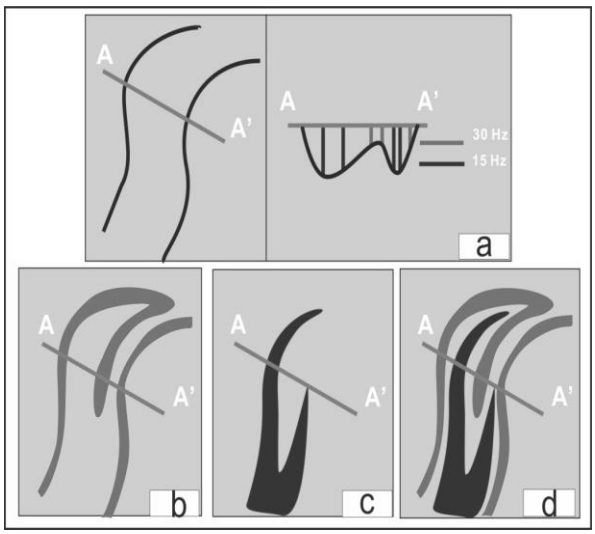


**Figure 1.** The fluvial model in different frequencies

## 3. GEOLOGICAL SETTING

South Turgay basin is located in the south of kazakhstan, on the regional tectonic shear zone in the urals and tianshan suture end, Turgay basin can be divided into South Turgay basin and North Turgay basin, South Turgay basin is the main part of Turgay basin which covers about 3×104 km2. The basin with graben-horst geological structure and it can be divided into four grabens and three horsts, from west to east are Aryskum graben, Akshabulak graben, Sarylan graben and Bozingen graben in the order, the graben is separated by Aksay horst, Ashchisay horst and Tabakbulak horst.The 1057 area is located in the south of the Aryskum graben.

1057 area which covers about 1250 km2 is located in the north of Aryskum graben, South Turgay Basin. At present, the 1057 area has low exploration degree and limited seismic and drilling data that 3d seismic coverage area is only 480 km2, 35 two-dimensional lines and 15 drilling wells. Due to the limited drilling wells, it is difficult to establish the sequence stratigraphic framework and sedimentary facies distribution characteristics. Therefore, in the early stage of studying sequence stratigraphy, the scope of the study area is on a certain degree of expansion, the distribution and seismic sedimentology analysis and favorable exploration targets prediction are in 3d work area (Fig.2).

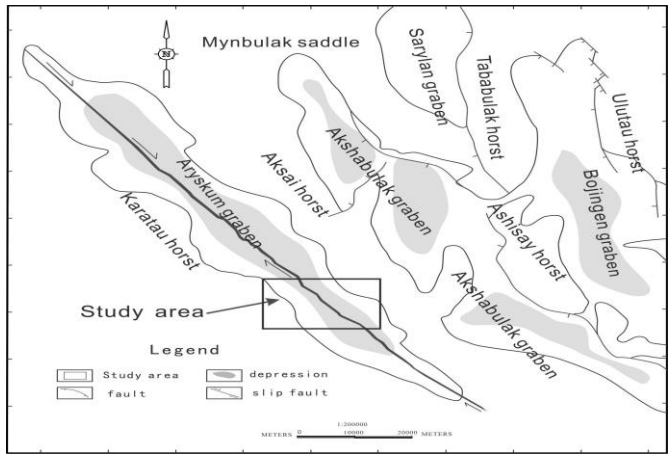


**Figure 2.** Sketch map of structural location of studied area

Under the constraint of the third-order sequence interface, after setting out the logging sequence interfaces and lake flooding surfaces, combining with synthetic records to realizate well -seismic calibration, then tracking fourth-sequence interface. The bottom interface of SQ8 (Akshabulak group) is the local scour unconformity surface between Kumkol group and Akshabulak group, for a channel incised scour surface, as braque qom cole group and gram of the local scour unconformity surface between; The top interface of SQ8 (Akshabulak group) is the biggest unconformity surface in the whole basin between the Jurassic and cretaceous the truncation unconformable surface, it shows apparently the truncation unconformable contact on seismic section. According to drilling and seismic data, we can divide SQ8 into three fourth order sequences SQ8-1, SQ8-2 and SQ8-3 (Fig.3). The top interface of Akshabulak group on KET11 drilling Wells erode seriously, SQ8-3 cycle is completely denudation, SQ8-1 cycle develops palm red or gray sandstone, SP or GR log curve shows high amplitude cube type. SQ8-2 cycle develops thick layer-fine sandstone and stuffed with gray-green mudstone, logging curves shows box or bell type. On seismic section, seismic events show strong amplitude accompanied by bending or incised phenomenon, seismic reflection is characterized with weak amplitude weak continuity, it is mainly response characteristics of fluvial facies or delta facies.

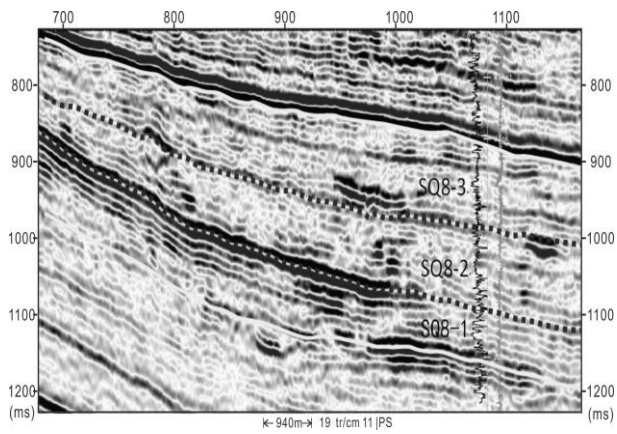


**Figure 3.** Fourth-order sequence division in 1057 area

## 4. APPLICATION OF FREQUENCY DIVISION

Conventional seismic data is zero phase achieved by geologist, it is not only with high resolution but also the maximum amplitude value corresponding to the formation interface. But the lithology of strata and seismic phase is no corresponding relationship between the event and well log especially in thin layer, it is difficult to build relationship model of lithology logging data and seismic data, it is not well for the following research work such as wave impedance inversion. 90 degrees conversion can sovle the problem because that seismic reflection main lobe center and the corresponding formation interface has a good corresponding relationship, it makes the phase event has the lithologic significance. Ultimate purpose is to improve the amplitude correlation with porosity and lithology information that convenient for geological interpretation.

The interest interval in the study area is cuneate, it is suitable for choose strata slicing technology in this case. This kind of slice is more reasonable than time slice and along the layer and closer to such as depositional interface, then reflected the deposition more accurately [9]. The seismic data in the study area have been 90 ° phase conversion and the seismic amplitude have good corresponding relation between logging lithology, SQ8 (Akshabulak group) of this area interpolation of proportion between two reference layer income via any strata slice represents the corresponding geological response of the geological time.

Making strata slicing is the basis of the slice attribute extraction and frequency division interpretation, it is also very important process to analyze different frequencies [10]. Take the following SQ8 internal section production process as an example to illuminate the principles and steps of making strata slicing.

The first thing to mention is to select reference seismic event, it is the key to select the isochronous stratigraphic interface. If the event does not change with frequency such as bifurcate, mergers and so on, you can identify the seismic event is isochronous interface. Then Clear and widely distributed reflection event can be tracked regional identification such as SQ8 top interface (SB9) is obvious regional unconformity interface and the bottom interface SQ8 is widely distributed continuous tracking can clear sequence interface , therefore, we can choose the top and bottom of SQ8 interface as reference seismic events.

Secondly, we need to establish a geological time model. So-called geological time model refers to in the selection of reference seismic event between the proportion of interpolating geological horizon, without considering the formation of tectonic inversion and the difference of deposition rate. The resulting slices closer to the actual situation formation can be thought of stratigraphic section on behalf of the isochronous stratigraphic interface or nearly parallel to the geological interface.

Thirdly, we need to establish strata slicing data. Select linear interpolation or adjust the relevant parameters. Making software operation needed to get the isochronous stratigraphic section of body. We can extract directly along the stratigraphic section of all the required properties multi-attribute comprehensive analysis.

Selecting linear interpolation or adjust the relevant parameters to make the isochronous stratigraphic section, then we can extract directly along the stratigraphic section of all the required properties and multi-attribute comprehensive analysis. According to the steps above, we select 3 strata slicing from each cycle eliminate the slices obviously does not match the seismic events. The deposition of Akshabulak group is mainly river-delta sedimentary system, the channel stretching direction has been a north-south east to west combined with the topography of the basin and the pattern of tectonic units.

The seismic data quality of 1057 area in South Turgay Basin is good, before using frequency division interpretation we need to analyze the frequency spectrum of the 1057 seismic data. The figure shows frequency spectrum for 1057 area on Jurassic is about 30Hz, effective frequency spectrum is between 10-80Hz (Fig.4). In the effective frequency range for different frequency attributes slice. The main frequency will decrease as the filtering effect can reduce the frequency of seismic data.

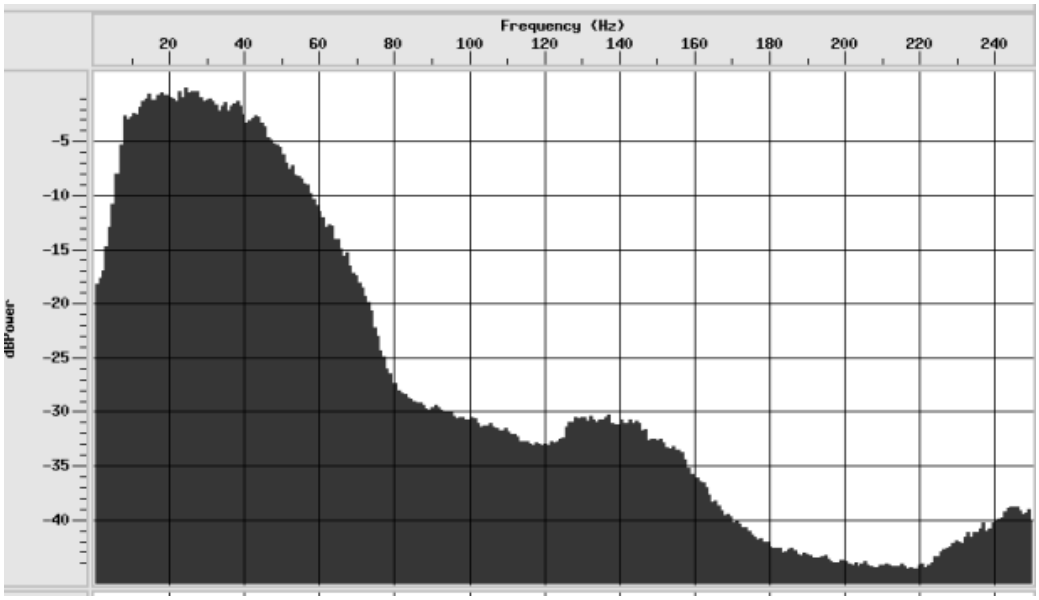


**Figure 4.** SQ8 seismic data spectrum analysis diagram

Through the spectrum analysis of seismic data in Akashabulak group in 1057 area, the effective frequency range is 0~ 90Hz. From SQ8-1 to SQ8-3 make frequency division processing respectively, Frequency step size to choose 1 to analyze the effective frequency band range of different frequency on the corresponding characteristics of sand body, then each frequency corresponds to a drawing of the energy distribution characteristics (Fig.5, Fig.6, Fig.7), Although, every single frequency section figure cannot reflect the whole picture of sedimentary bodies, but by a series of continuous frequency section of animation browsing combined with previous regional facies sedimentary analysis and the understanding of the geological background, we are able to lateral variation of objective interval sedimentary bodies to conduct a comprehensive analysis.

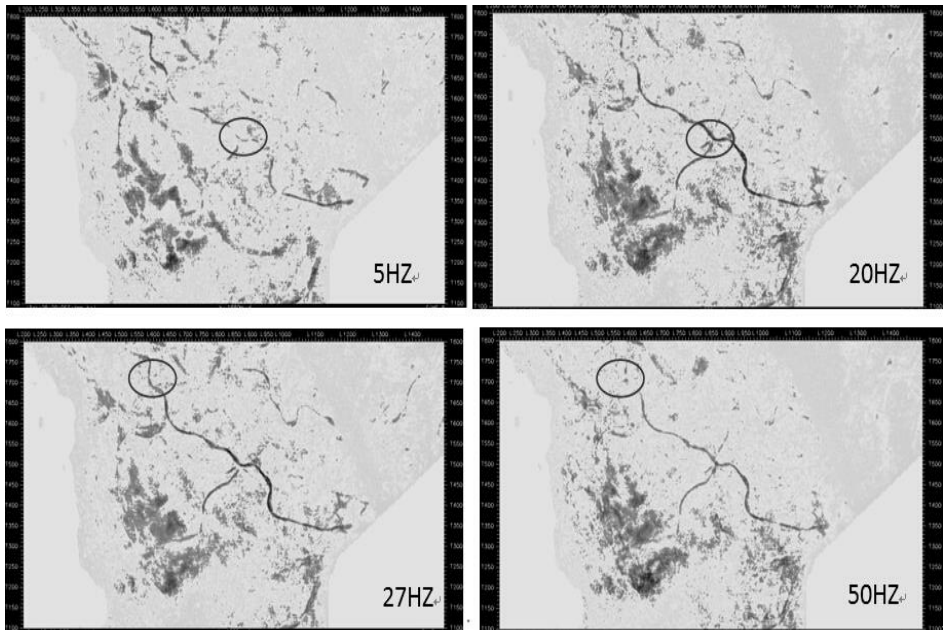


**Figure 5.** The amplitude slice in different frequency of SQ8-1

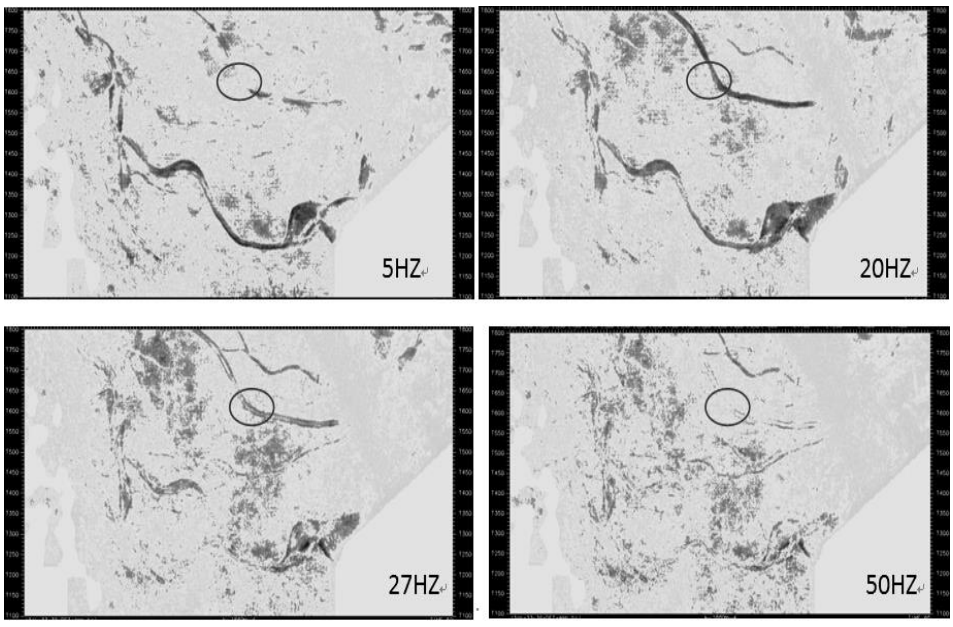


**Figure 6.** The amplitude slice in different frequency of SQ8-2

Due to the different buried depth and reservoir absorption attenuation effect, three fourth-order sequences of sensitive frequency range is slightly different, what is more, it presents a bottom-up sensitive characteristic of the frequency increase. In SQ8-1 cycle the sensitive frequency range is 20 ~27Hz. Within the scope of the amplitude of energy plan it can depict the distributary channel clearly, not only the main outline is clear but also under branch channel display. In SQ8-2 cycle the sensitive frequency range is 22 ~30Hz. In SQ8-3 cycle the sensitive frequency range is 25 ~35Hz. Due to the different frequency amplitude response different geological characterization, with superposition different frequency amplitude characteristics respectively we can get more comprehensive distribution characteristics of sedimentary system, it can be used as important basis analysis of characteristics of sedimentary facies. With the analysis of

sedimentary facies, single well facies and slice attribute in the early stage of the large area which combine with regional sedimentary regularity and tectonic background, we can determine the delta sedimentary system and sedimentary facies.

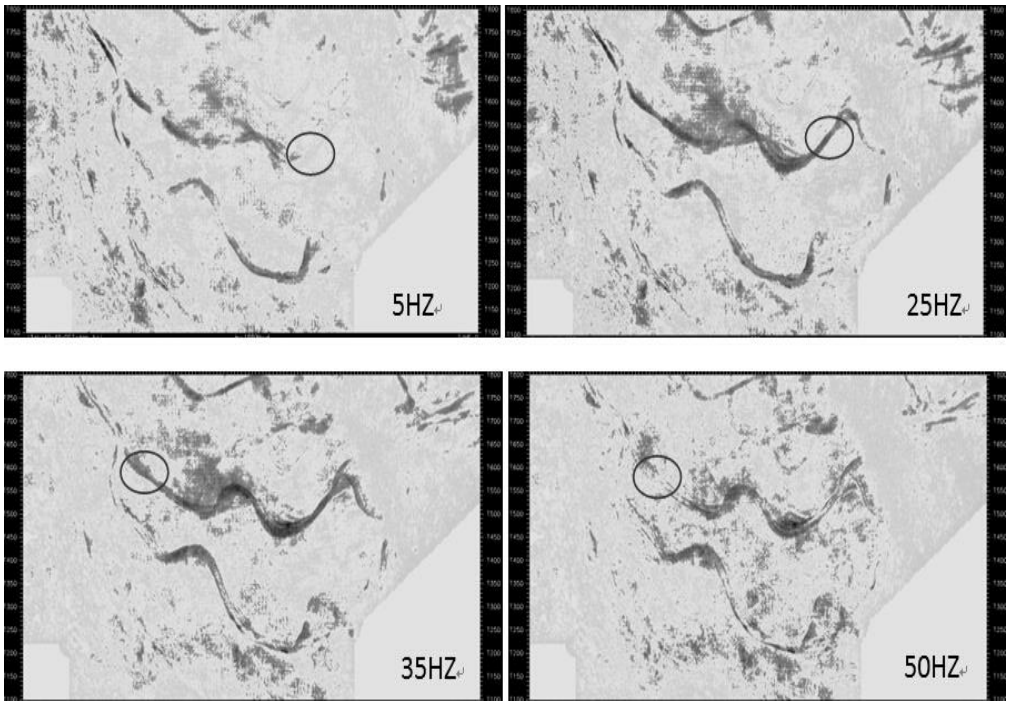


**Figure 7.** The amplitude slice in different frequency of SQ8-3

## 5. CONCLUSIONS

Through analysis of seismic data in the 1057 area by using frequency division interpretation technique, it reveals the distribution characteristics of the complexity fluvial and old channel development, we find many sets of distributary channel and trace their extension. Seismic events not only reflect lithology interface but also the isochronous interface, instead they are affected by the frequency of seismic data, different frequency seismic data reflects different levels of geological information, the ability of depicting sedimentary system varies from each other. Using frequency division interpretation technique can characterize fluvial boundary, plane geometry and discontinuity accurately. In SQ8-1 cycle the sensitive frequency range is 20~27 Hz. In SQ8-2 cycle the sensitive frequency range is 22~30 Hz. In SQ8-3 cycle the sensitive frequency range is 25~35 Hz that can depict fluvial boundary. Thus, frequency division interpretation has good prediction effect in fluvial sand body interpretation, especially suitable for the limited drilling wells or constraint data regions, this method can provide abundant reliable geologic evidences for oil and gas exploration.

## ACKNOWLEDGMENTS

I would like to express my gratitude to my friends who helped me during the writing of this thesis. In writing this paper, I owe much to my partners for their valuable suggestions and critiques which are of help and importance in making the thesis a reality. Last but not the least, my gratitude also extends to my family who have been assisting, supporting and caring for me all of my life.

The authors declare that there is no conflict of interests regarding the publication of this article. What is more, there is no professional or other personal interest of any kind in any product, service or agency.

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