Geophysical characteristics and interpretation methods of the buried hill surface in the west slope of Shulu depression

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Abstract. In the cause of the buried hill and conglomerate layer are carbonate rock type, there is no obvious difference between the wave impedance and the overlying strata. Therefor there is no strong reflection on the surface of the buried hill, and no obvious change in the logging curve. In order to solve this problem, taking west slope of Shulu depression as an example, the logging characteristics of the conglomerate surface and seismic reflection characteristics of the buried hill surface are summarized. The sedimentological characteristics of the buried hill surface are analyzed. The differences between the identification of the buried hill surface and the identification of the conglomerate surface are found. The interpretation method of the buried hill surface is defined. It provides a theoretical basis for better interpretation of buried hill reservoir.

Keywords: Buried hill surface; Seismic and well logging characteristics; Sedimentological characteristics; Interpretation methods.

1. Introduction
Shulu depression is located between Xinji City and Ningjin City in Hebei Province, adjacent to Shenzhou and Xinhe River in the east, Jizhong and Zhaoxian County in the west, Shenze County in the north, and Baixiang County in the south. [1] The west slope of Shulu is located in the southern margin of Jizhong depression, with the Shulu depression trough zone in the east, the Ningjin uplift in the west, the Xiaoliucun uplift in the south, and the Shenzhou depression in the north connected by the Hengshui fault. It is a typical NNE trending slope zone between the Ningjin uplift and the central trough zone of Shulu depression, with the east fault and the west super graben-shaped depression. From south to north, the west slope belt is Leijiazhuang structure, Caogu structure, Taijiazhuang structure and South Xiaochen structure.

Buried hill is a form of ancient landform. The tectonic movement caused the strata to suffer from weathering and denudation for a long time, resulting in uneven surface morphology, and then subsided again and was covered by Cenozoic sedimentary layers, among which the raised hills are called ancient buried hills. [2] Because of the formation mechanism of buried-hill, the three types of buried-hill traps all have good reservoir-forming conditions. [3] However, the buried hill surface is weathered and eroded to form conglomerate, so the rock type of the buried hill surface is carbonate rock, which is the same as
that of the conglomerate, leading to the difficulty in distinguishing the buried hill surface from the conglomerate layer. There are strong reflection characteristics between the buried hill surface and overlying strata. [4] When the buried hill surface is covered by conglomerate layer, the conglomerate layer and the overlying strata also have strong reflection characteristics, but there is no obvious reflection characteristics between the buried hill surface and conglomerate layer, and the logging curve does not change obviously, especially the time difference curve of acoustic wave, which leads to the multi-solution of seismic interpretation. To solve this problem, this paper identifies the buried hill surface based on the seismic response characteristics of the buried hill surface and conglomerate layer and the logging characteristics of rock contact relationship.

2. Seismic and well logging characteristics

According to the collected well information, the Wells can be divided into two categories: buried hill and buried hill. Buried-hill Wells are divided into drilled conglomerate Wells and undrilled conglomerate Wells, and their seismic profile and logging characteristics are shown in Fig. 1 and Table 1. The undrilled conglomerate buried hill well is located in the high part of the buried hill surface, and there is no sedimentary conglomerate. The wave impedance difference between the buried hill surface and the overlying strata is obvious, which shows strong reflection and continuous reflection axis in the seismic profile. In the whole slope, the energy of the strong reflection axis on the buried hill surface is basically uniform. There is obvious difference between the acoustic time difference between the buried hill surface and the overlying strata. The conglomerate appears in the buried hill Wells when drilling, and the conglomerate body is mainly deposited in the middle and upper part of the slope, while the conglomerate is difficult to be deposited in the high part of the buried hill. There is obvious wave impedance between the conglomerate layer and the overlying strata, which shows strong reflection in the seismic profile. However, the development of strong reflection axis on the conglomerate body is discontinuous, and the energy of the strong axis is different in different parts of the conglomerate body, and the seismic reflection characteristics inside the conglomerate body are disorderly. There are obvious changes in the acoustic time difference curve and gamma curve at the boundary between the top surface of conglomerate and the overlying strata, but no obvious changes in the conglomerate limestone curve.

![Fig. 1 Characteristics of the buried hill surface and the conglomerate surface](image-url)
3. Sedimentological characteristics

In terms of the origin of the buried hill, it was uplifted to the surface by the crust to be denudated, and then subsided to the surface to be deposited after tectonic movement. Therefore, the buried hill surface and the overlying strata mostly show the phenomenon of superposition, and the underlying strata mostly show the phenomenon of cutting. As shown in Fig. 2, Tg is the buried hill surface, and the stratum Ng pinches out layer by layer towards the top of the buried hill, while the underlying strata of Tg disappear to the top of the buried hill as a whole, showing a truncation phenomenon.

4. Identification of the buried hill surface

On the basis of analyzing the characteristics of conglomerate body and summarizing the characteristics of the buried hill surface, the interpretation of the buried hill surface is carried out. The main ways to accurately calibrate the buried hill surface are as follows:

A) Buried hill Wells were calibrated using synthetic seismograms. As shown in Fig. 3, the buried hill surface is located below the strong discontinuous axis of the conglomerate layer.
B) When no buried-hill Wells are encountered: the interpretation results are determined according to the extension of calibration results of adjacent Wells. According to the existing calibration results, the position of the reflection layer on the buried hill surface can be determined by pulling any line section of the well through no well. As shown in Fig. 4, the interwell profile is established according to the in-phase axis trend between the two Wells to predict the position of the buried hill surface.

![Fig. 4 Identification of buried-hill Wells without drilling](image)

C) Adjustment of interpretation results of the buried hill surface: According to the calibration of the buried hill surface and the summarized seismic reflection characteristics of the buried hill surface, the existing interpretation scheme of the buried hill surface is adjusted. Fig. 5 shows the reasons for the formation of the buried hill. The identification interface of buried hill is adjusted by the phenomenon of superposition and cutting between buried hill and overlying strata.

![Fig. 5 Interface adjustment diagram of the buried hill surface](image)

5. Summary and conclusions
Based on the analysis of seismic and logging characteristics of the buried hill surface and conglomerate layer, combined with sedimentological characteristics of buried hill, this paper identifies the buried hill surface. The identification method is as follows: When the seismic profile with synthetic seismological records of buried-hill Wells is drilled, whether the strong and weak reflection axes are continuous and the energy of the reflection axes is unified is explained according to the reflection characteristics of the reflection axes. At the same time, the sonic time difference curve, spontaneous potential curve and gamma curve are used to assist interpretation. When there is no calibration of synthetic seismogram, the
interpretation results are determined by extending the calibration results of adjacent Wells. Then explain the characteristics summarized from the existing data. Combined with the buried-hill top surface and overlying strata showing the phenomenon of superposition, and with the underlying strata showing the phenomenon of cutting. Then the buried hill interpretation of the whole work area is completed to provide strong evidence for the search of buried hill reservoir.

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