

The Identification of Volcanics and its Application for Reservoir Prediction of Bioclastic Dolostone: An Example From Bohai Bay Basin*

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Abstract

Oilfield C is located in the west of Bohai Bay, China. It is an advantageous position for accumulation of hydrocarbon because it is a local block between the Nanpu depression and Shaleitian uplift. The main reservoir in this area is a buried hill draping bioclastic dolostone of Paleogene age, sandwiched between the basement lithology of Palaeozoic carbonate and a large set of Neocene claystones. These stratum form the effective combination of reservoir and cap rock.

There are four exploration wells in Oilfield C, among which two wells (C1 and C3) drilled the bioclastic dolostone with an average thickness of 20 meters ([Figure 1](#)). The low success rate of 50 percent confirms the bioclastic dolostone characteristic of limited extent and thickness, and high variation and heterogeneity, from which reservoir prediction of this bioclastic dolostone is very difficult.

Geologic Setting

From the exploration experience of the study area, the major control factor of the bioclastic dolostone is paleogeomorphology, in which the platform margin is the most favorable sedimentary position due to its high energy wave action, shallow water and sufficient sunshine, yet the upper and lower position is not suitable for reservoir development ([Figure 2](#)). The paleogeomorphic restoration can effectively predict the range of bioclastic dolostone and has been applied successfully to the peripheral oilfields, however, there is the premise that the structure of the marker horizon used for horizon flattening is true which cannot be met in Oilfield C.

The drilled wells revealed that a set of volcanic rock developed in shallow strata, characterized by complex lithology, high velocity and uneven distribution ([Figure 3](#)), because of which several lateral velocity variations occur in the volcanic-covered area. The structure of strata is distorted by the lateral uneven distribution of these volcanics, so the result of reservoir prediction obtained from paleogeomorphic restoration

cannot truly represent the distribution of bioclastic dolostone. As a result, drilling of the bioclastic dolostone reservoir has resulted in two dry holes due to the reservoir prediction error of the bioclastic dolostone.

Identification of volcanics

To solve the problem of time-depth conversion in the area covered with volcanics, an integrated workflow has been innovatively established to identify volcanics and improve the reservoir prediction accuracy.

- 1) First, the preliminary map-view distribution of the volcanics is obtained from the average amplitude attribute: high amplitude area is related to effusive basalt; low amplitude area is related to explosive tuff; the translation area with medium amplitude is related to mixed rock composed of basalt and tuff in varying proportions ([Figure 4](#)).
- 2) Second, the top and bottom interfaces of volcanics is interpreted based on the mechanism of volcanic eruption and the above results of map-view distribution ([Figure 5](#)).
- 3) Third, the lithology of volcanics are characterized by both high-speed basalt and low-speed tuff, however, only the portion of high-speed basalt causes the lateral variation of velocity, so we get the thickness of high-speed basalt by innovatively establishing the relation between the interval velocity of volcanics and the proportion of high-speed basalt.
- 4) Last, considering the fact that the thickness of basalt also affects the velocity, we introduce the binary regression to restore the true structure, by establishing the relation between velocity and T0 (representative of compaction), thickness of basalt ([Figure 6](#)).

By identifying the volcanics, we get the true structure and restore the paleogeomorphology of the bioclastic dolostone, based on which we predict the distribution range of bioclastic dolostone (red rim in the [Figure 7](#)).

Conclusions

The reservoir prediction calculated from the integrated workflow matches the new drilling results very well. Recently an appraisal well (orange star in the [Figure 7](#)) was drilled, which revealed 25 meters of bioclastic dolostone. This integrated workflow and its result not only improved the prediction accuracy of the reservoir distribution, but also provides valuable references for paleogeomorphic restoration in areas of false structure image.

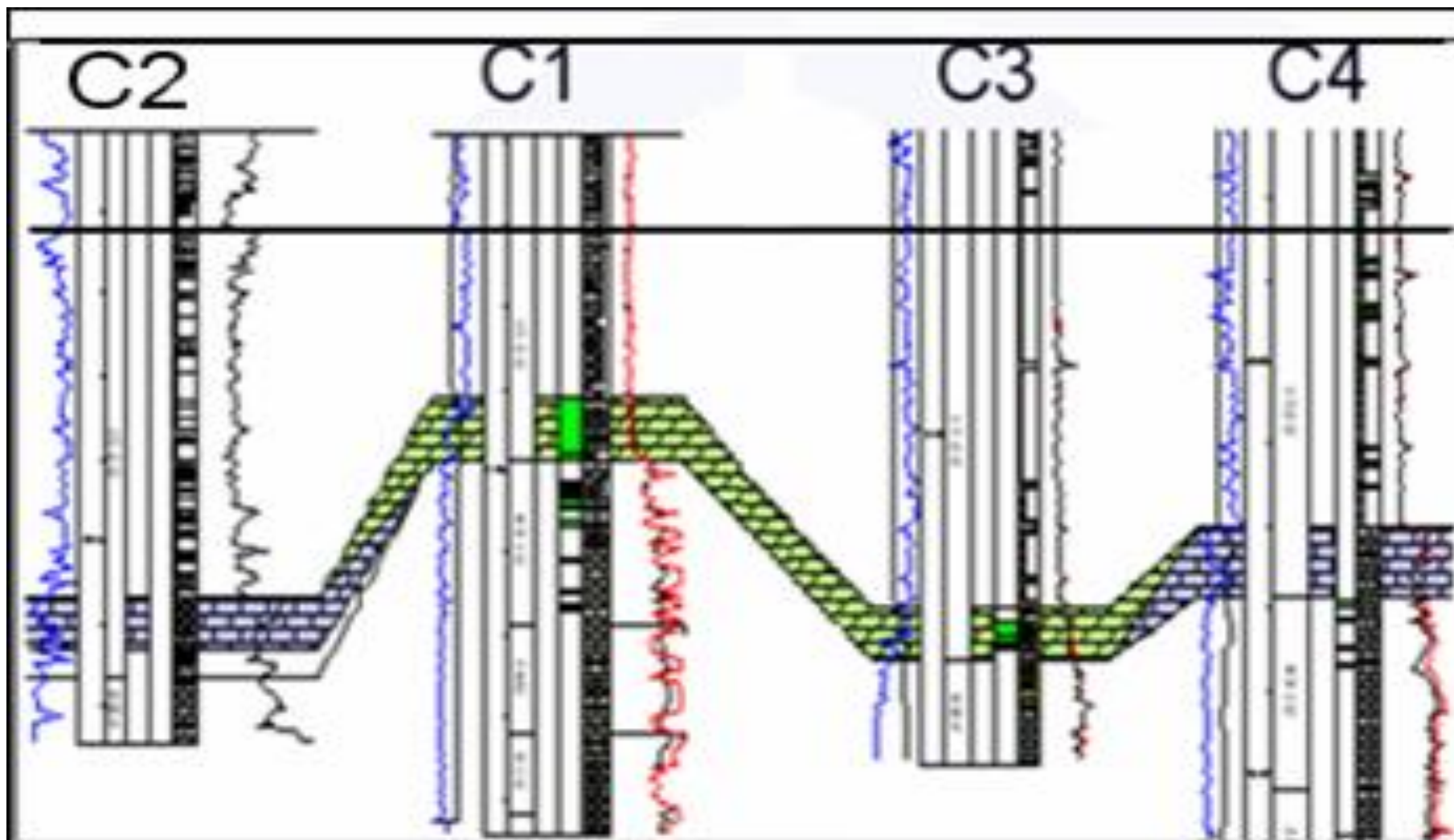


Figure 1. Cross section of four exploration wells.

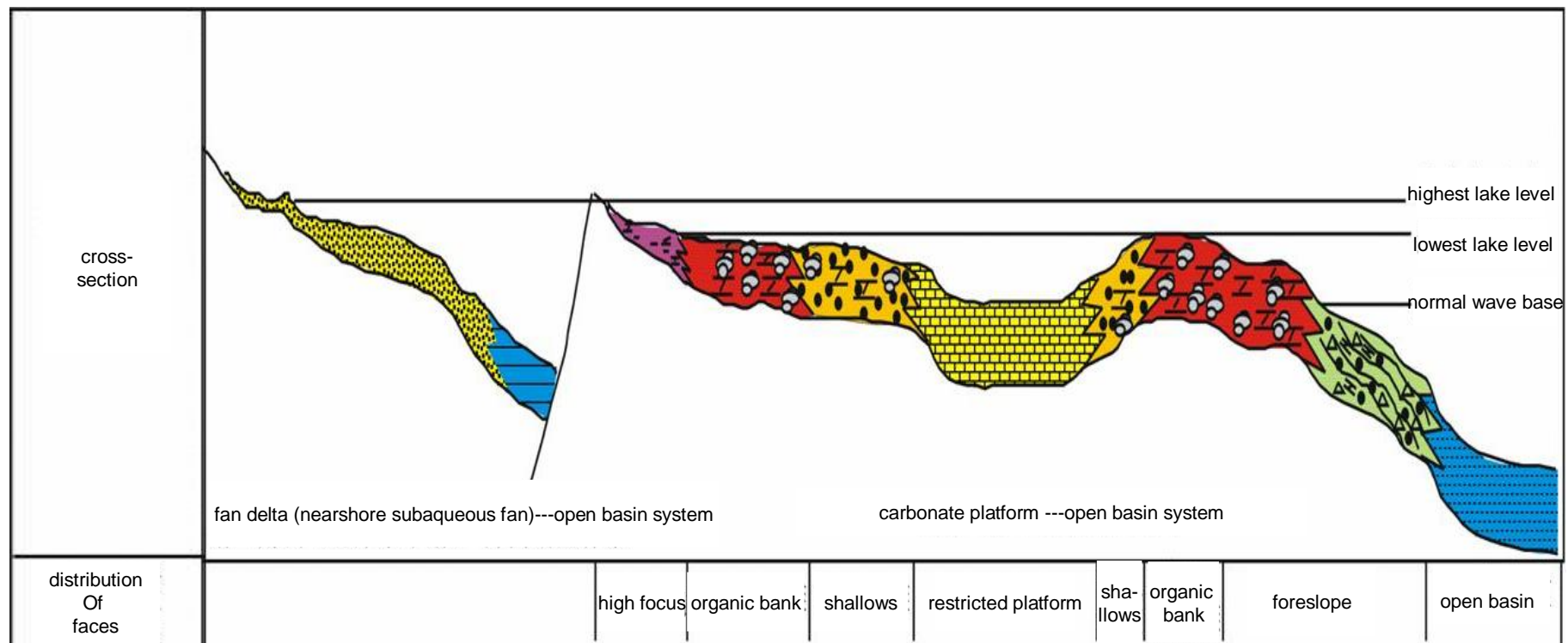


Figure 2. Sedimentary face of isolated carbonate platform.

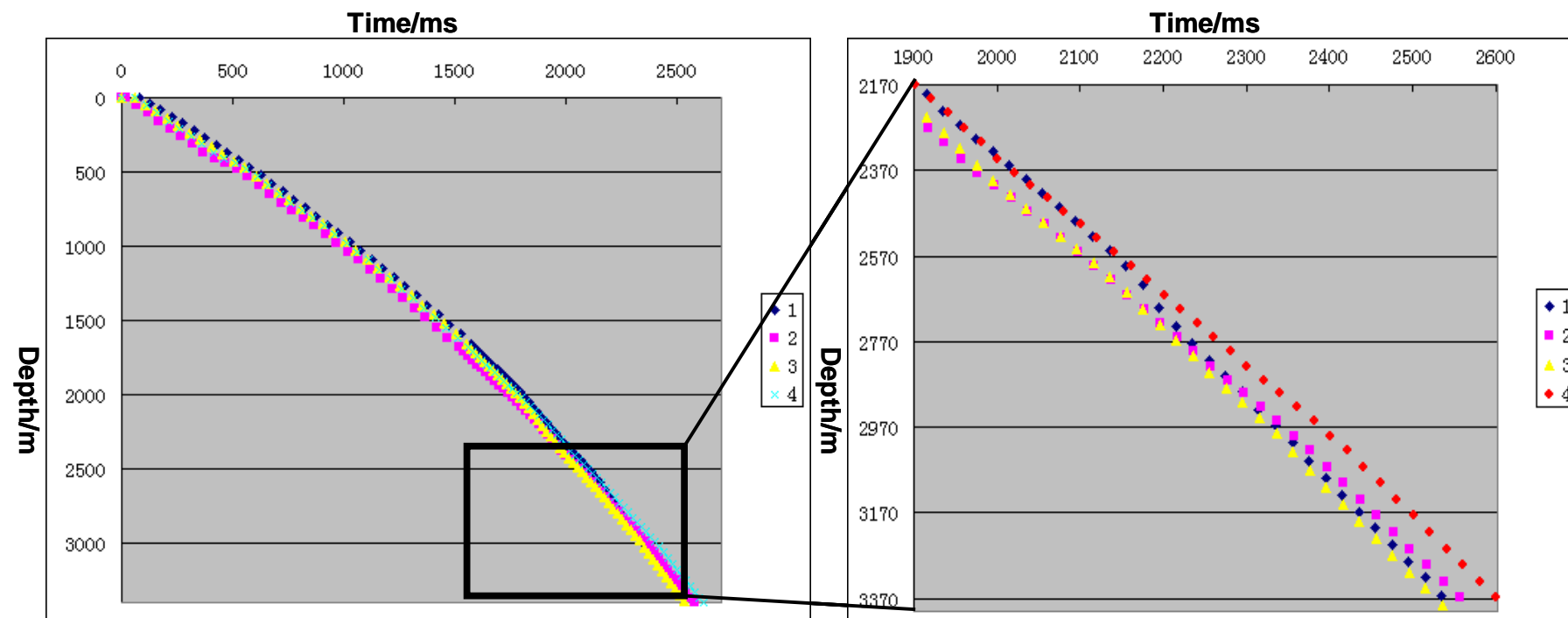


Figure 3. Time-depth relation of four exploration wells.

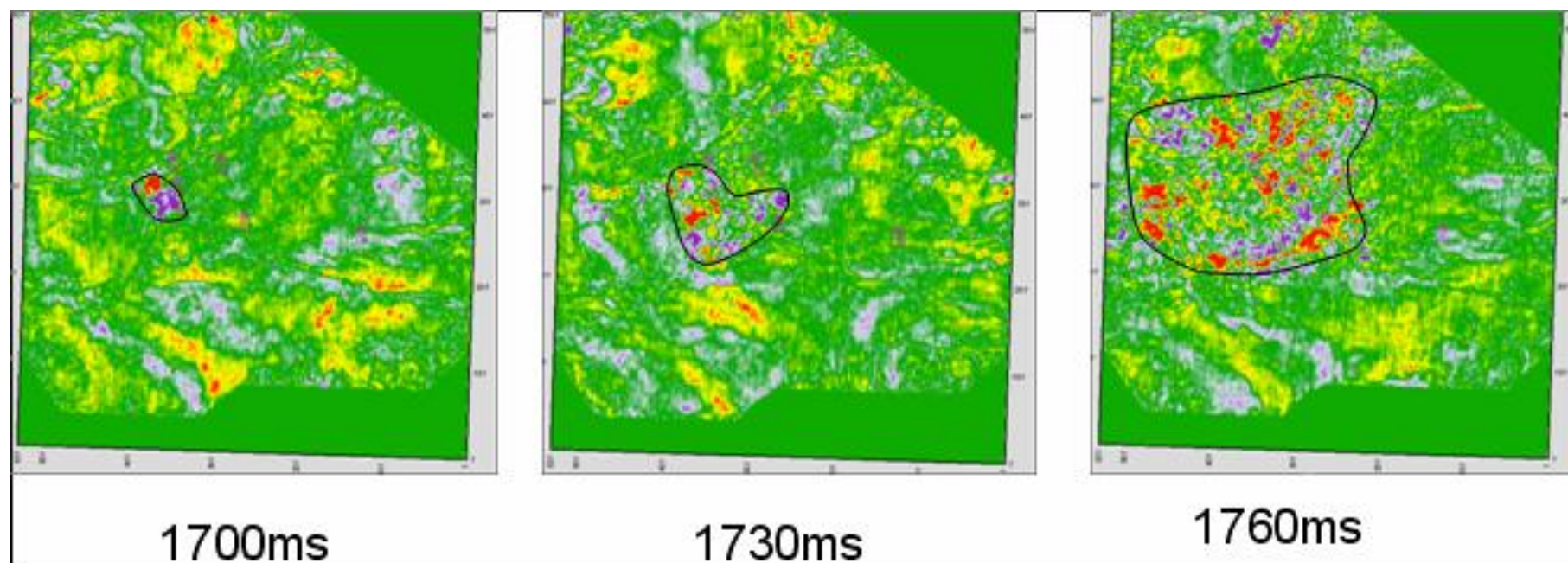


Figure 4. The average amplitude attribute images.

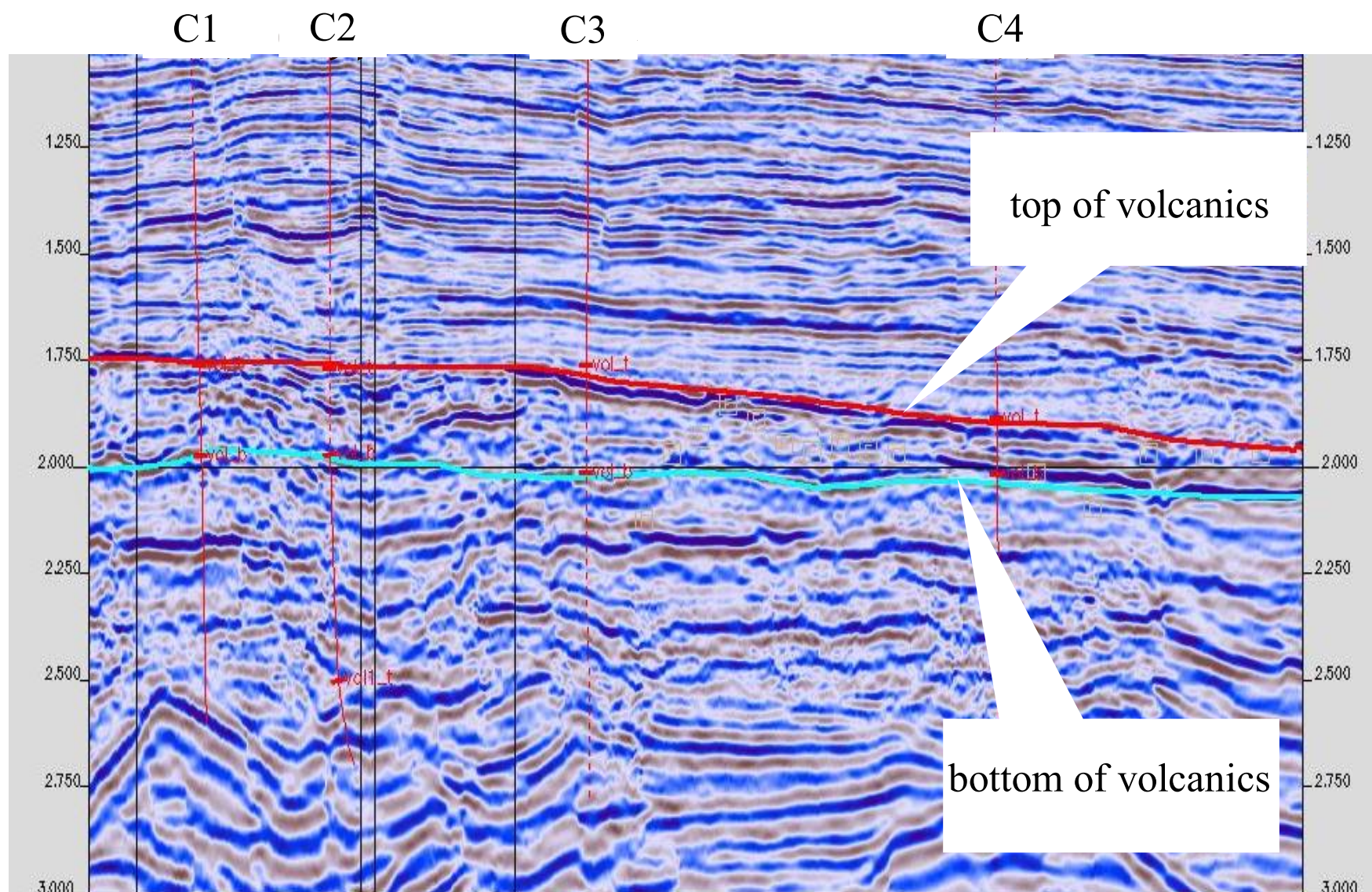


Figure 5. Seismic line showing the top and bottom interfaces of the volcanics.

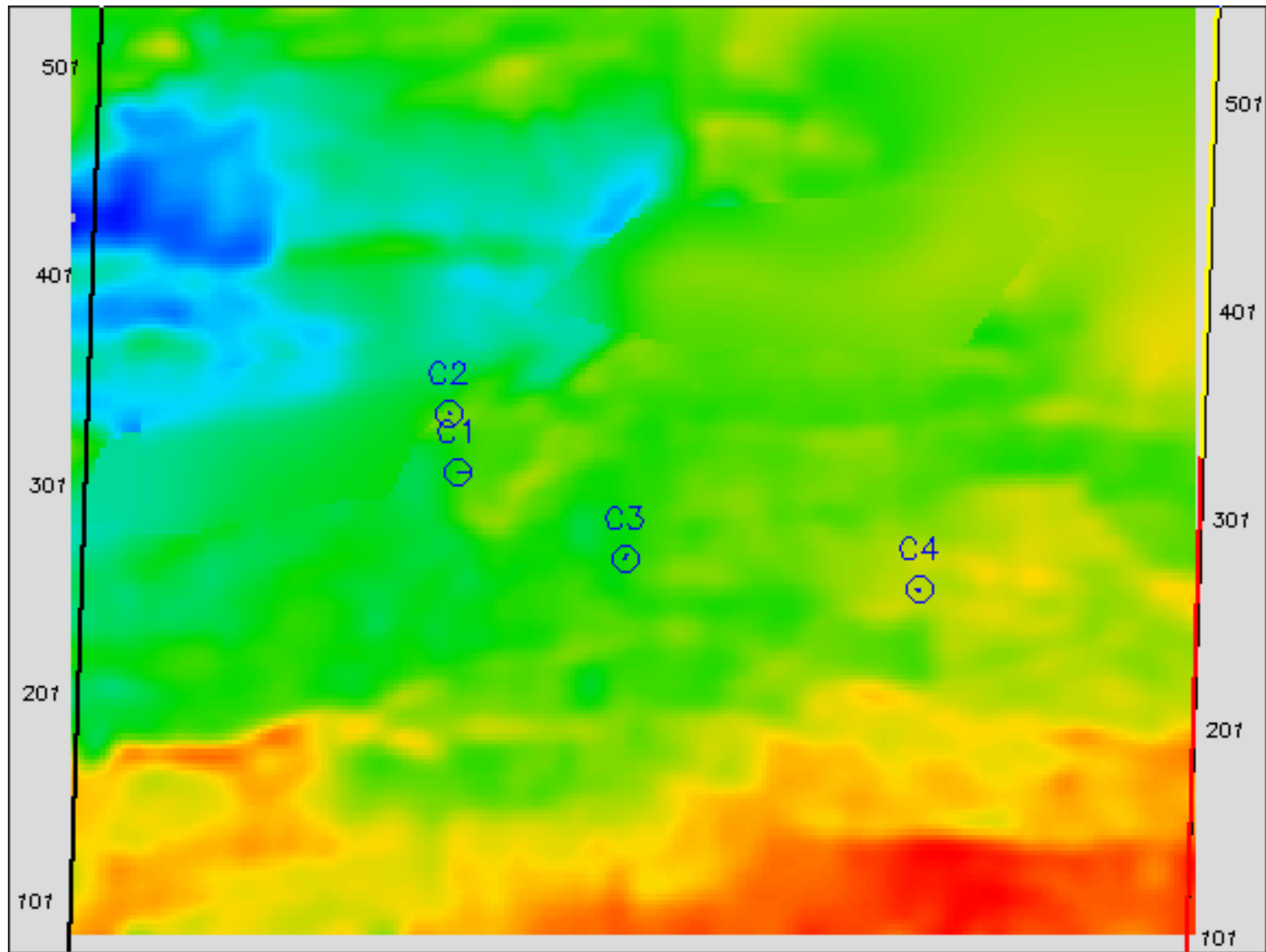


Figure 6. Thickness image of high-speed basalt.

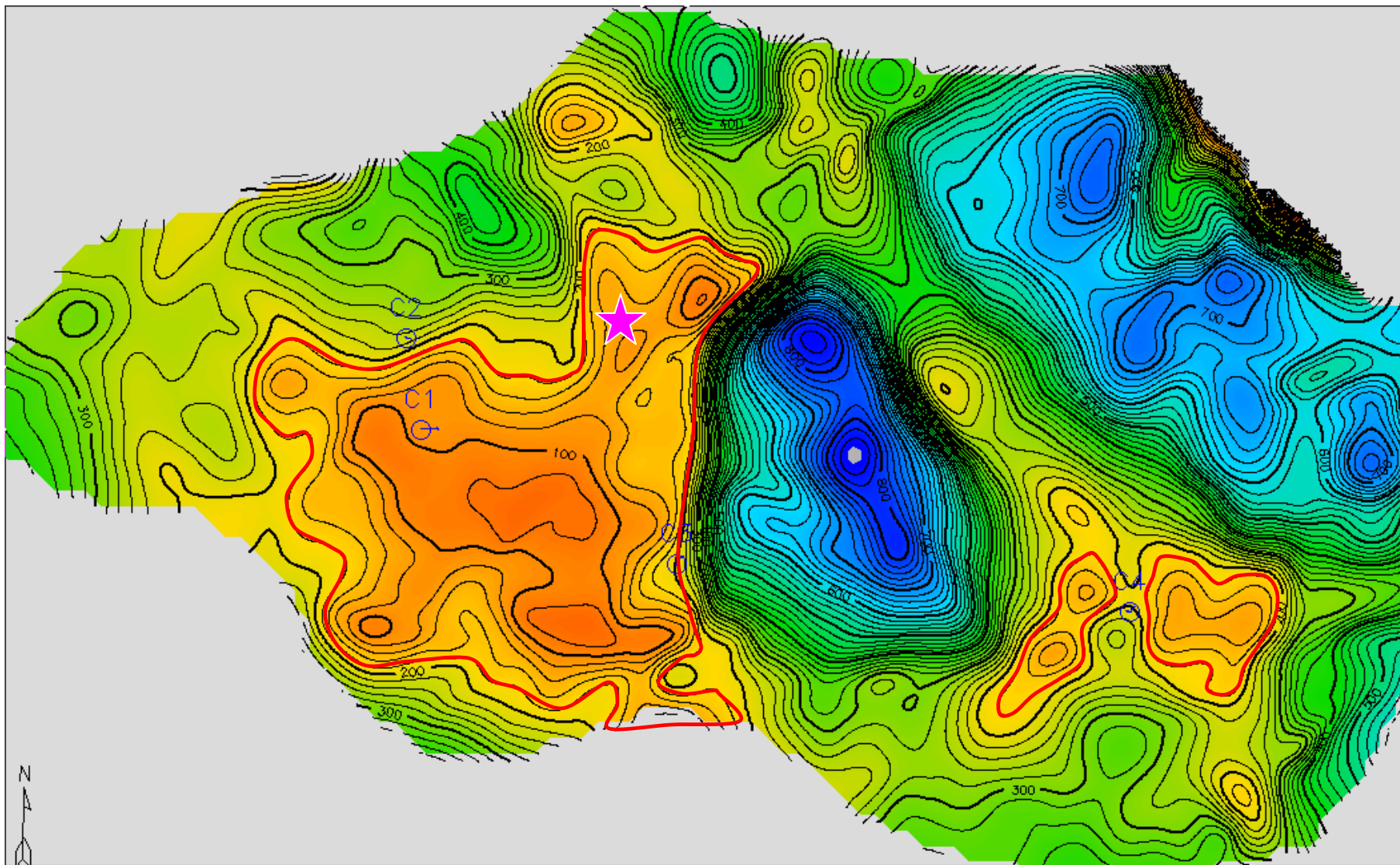


Figure 7. The prediction map result of bioclastic dolostone.