International Journal of Oil, Gas and Coal Engineering
2023; 11(3): 64-68
http://www.sciencepublishinggroup.com/j/ogce
doi: 10.11648/j.ogce.20231103.12
ISSN: 2376-7669 (Print); ISSN: 2376-7677 (Online)

Study on the Mechanism of Siliceous Dolomite — A Case Study in a Field of Sichuan Basin

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To cite this article:
Wang Jie, Zhang Tieqiang, Sun Desheng, Li Jianhua, Zhang Sheng, Yan Zhenhua. Study on the Mechanism of Siliceous Dolomite — A Case Study in a Field of Sichuan Basin. *International Journal of Oil, Gas and Coal Engineering*. Vol. 11, No. 3, 2023, pp. 64-68.
doi: 10.11648/j.ogce.20231103.12

Received: June 6, 2023; **Accepted**: June 21, 2023; **Published**: July 8, 2023

Abstract: This study mainly explores the genesis of regional siliceous dolomite. Previous research was mainly based on petrological observations, conventional elemental analysis, stable isotope analysis, and elemental geochemistry, but the genesis of siliceous rocks is controversial. Based on quantitative analysis of siliceous rocks, this study investigated the source of siliceous dolomite through seismic data, curvature attributes, and paleogeography, and analyzed genetic mechanism of siliceous dolomite. The study found that siliceous dolomite gradually thickens from west to east, with a maximum thickness of 60 meters. Multiple volcanic channels are distributed in the well1 area, which spewed siliceous hot springs. Controlled by the ancient structural background, siliceous hot springs flowed from the high plateau to the low-lying area inside the plateau. Under the action of seawater, siliceous hot springs and dolomite underwent metasomatism to form siliceous dolomite. The innovation of this study lies in the use of multiple methods, such as seismic data, curvature attributes, and paleogeography, to study the genesis of siliceous dolomite. The research results provide new ideas and methods for further exploring the genesis of siliceous rocks.

Keywords: Siliceous Dolomite, Volcanic Hydrothermal Origin, Volcanic Channel, Curvature Attribute

1. Introduction

The fourth section of the Silurian Dengying Formation gas reservoir in a certain research area of the Sichuan Basin is a large-scale ancient karst gas reservoir affected by weathering crust [1-3]. The reservoir has a huge resource base, and a stable distribution of siliceous dolomite is developed in the fourth section of the Dengying Formation. The thickness of a single layer of rock is 3-10 meters, and the total thickness can reach 60 meters. It is widely distributed in the entire area, and is generally dense and hard with poor permeability. It is still unclear what relationship this set of siliceous rocks has with the distribution of reservoirs. Siliceous rocks contain significant information on paleogeography and paleotectonics [4]., Previous studies on the origin, formation environment, and formation time of siliceous rocks have proposed different genetic models by different scholars in different research areas based on petrological observations, stable isotope (C-O-Sr) analysis, and elemental geochemistry and other technical means [5-10]. According to the geochemical analysis, the siliceous rocks in Kara area of western Sichuan are derived from biological deposits [11], Tang Xuesong et al. analyzed the thin sections of siliceous dolomite in the Permian Maokou Formation in the eastern Sichuan Basin and found that siliceous dolomite contained silica replacement of calcite and the latest stage of calcite cementation, accompanied by typical hydrothermal minerals such as fluorite, suggesting that the silica in siliceous dolomite came from hydrothermal genesis [12]. Luo Wenjun et al. studied the fourth section of siliceous rocks in the Dengying Formation in the Gao Shiti area of the Sichuan Basin through core and thin section observations and elemental analysis, and believed that the relative enrichment of Fe and Mn and the relative depletion of Mg, Al, and Ti indicated that the siliceous rocks were of hydrothermal sedimentary origin [13]. There is still controversy over the genetic models of silica in siliceous rocks and siliceous dolomite. Based on the analysis of rock physics and inversion methods, the authors quantitatively analyzed the spatial distribution of siliceous dolomite and studied the origin of silica in siliceous dolomite through seismic data, curvature attributes, and paleogeography, and analyzed the formation model of siliceous dolomite.

2. Logging Characteristics of Siliceous Dolomite

The lithology of the research area mainly includes agglomerated dolomite, powder crystalline dolomite, mud crystalline dolomite, microcrystalline dolomite, algal debris dolomite, siliceous dolomite, and a small amount of carbonate rock. Among them, the thickness of a single layer of siliceous dolomite is 3-10 meters, and it is interbedded with dolomite. The logging curve characteristics are high gamma ray, high resistivity, low velocity, low density, and low neutron, and the imaging logging shows a white striped pattern with poor physical properties, mainly as interlayer. The logging characteristics of siliceous dolomite are obvious and can be used as a basis for stratigraphic correlation (Figure 1). Figure 2 is a cross-plot of velocity and resistivity for various rock types. It can be seen that the resistivity of siliceous dolomite is high and the velocity is low. Therefore, resistivity inversion can be used to infer the distribution of siliceous rocks.

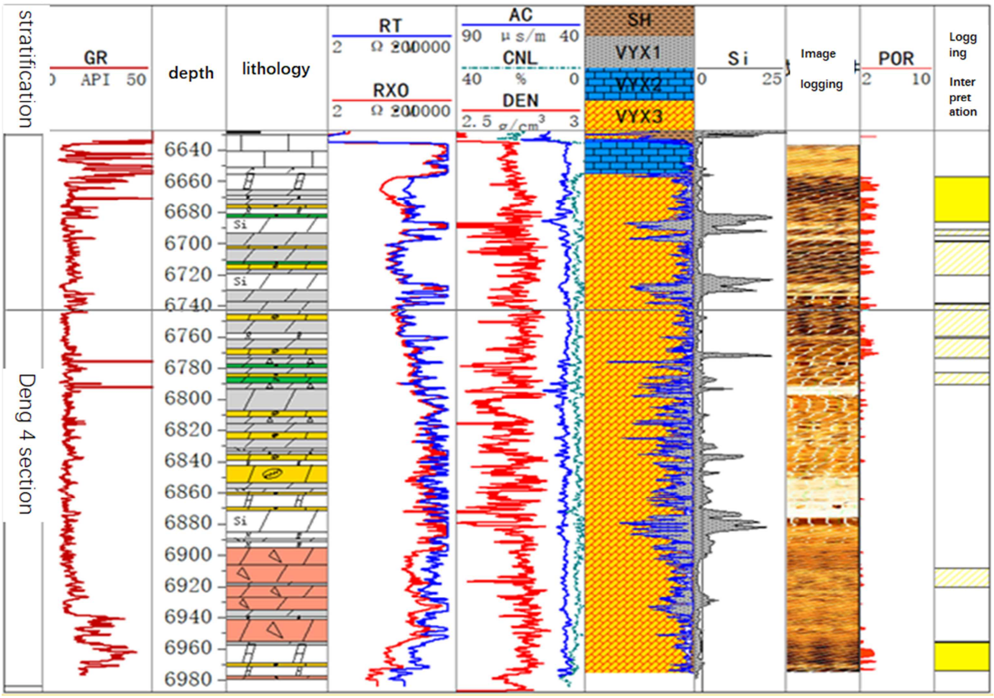

Figure 1. Single well characteristics of siliceous dolomite.

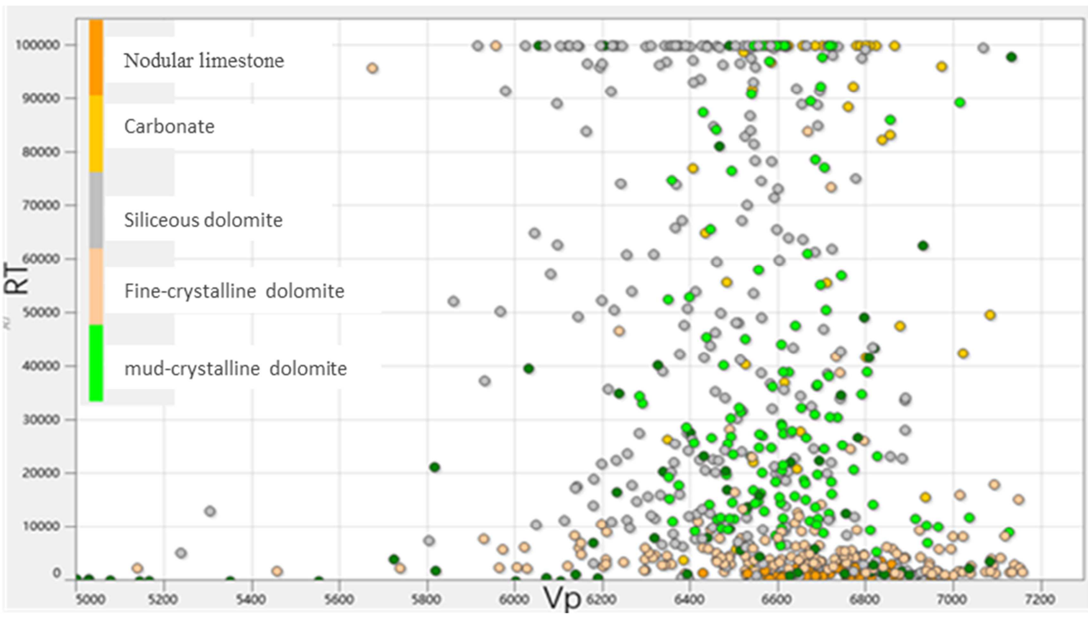

Figure 2. Intersection of VP and RT of Siliceous Dolomite.

3. Quantitative Study of Siliceous Dolomite

The siliceous dolomite has high resistivity. By using resistivity simulation, the siliceous dolomite profile can be obtained. In the Dengying Formation, the siliceous dolomite mainly distributes in the top and middle-lower parts, and the continuity is relatively good in the top part, interbedded with dolomite. The thickness of siliceous dolomite in the target layer gradually increases from Well 1 to Well 2. On the plane, the siliceous dolomite is distributed in patches with a thickness ranging from 0 to 60 meters. It mainly distributes in the east of the study area (Figures 3 and 4).

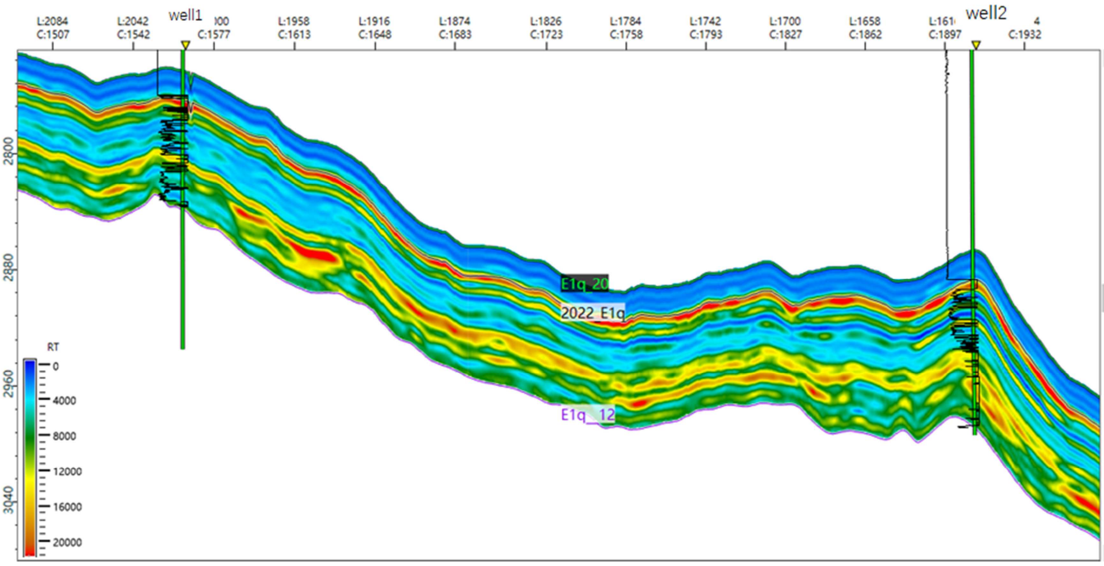

Figure 3. *Planar distribution of siliceous dolomite.*

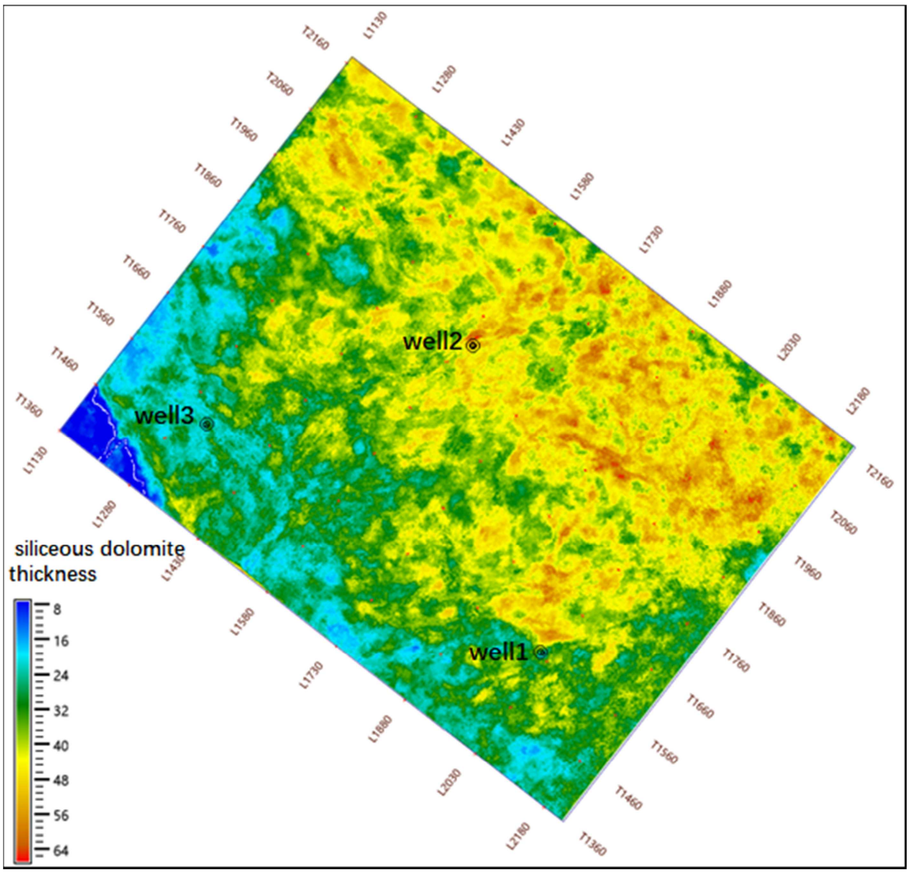

Figure 4. *Planar distribution of siliceous dolomite.*

4. Analysis of the Origin and Source of Siliceous Dolomite

4.1. Comprehensive Analysis of Petroleum Geology

Seismic and Curvature Attribute Characteristics of Volcanic Channels Figure 5 (a) shows the seismic profile across the volcanic channel. It can be seen from the figure that the volcanic channel is characterized by chaotic and upward reflection, with strong positive curvature attribute energy and a long development period from the Dengying Formation to the Mako Formation. The volcanic channel is consistently developed, and the volcanic vents mainly distribute in the Well 1 area on the plane (Figure 5c).

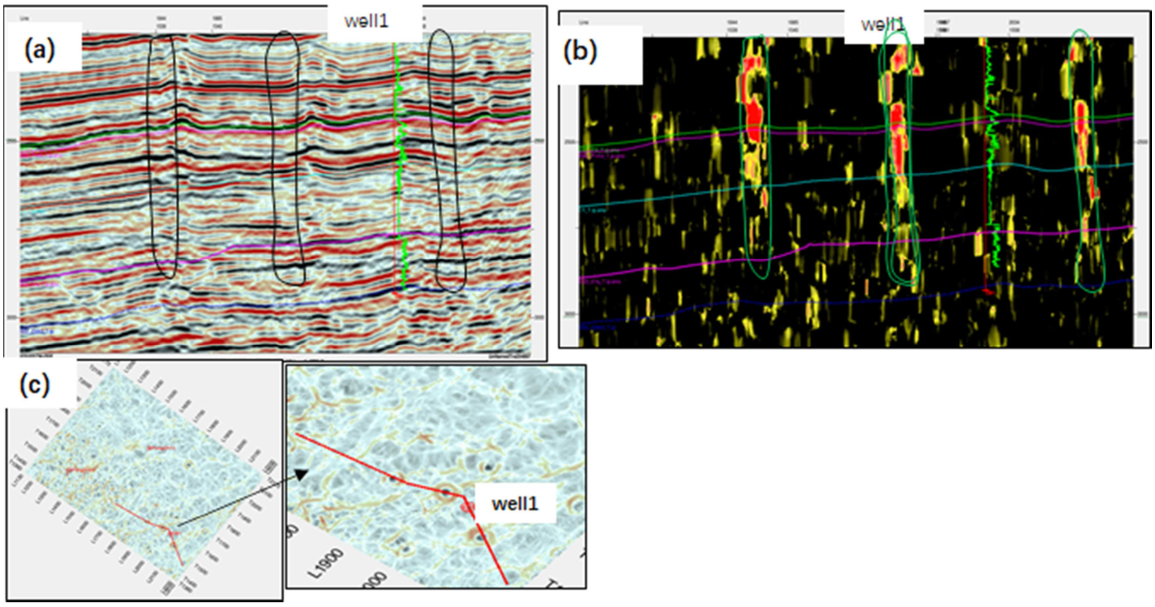

Figure 5. *Characteristics of volcanic channels: (a) seismic features of volcanic channels, (b) curvature attribute of volcanic channels, (c) planar curvature attribute.*

4.2. Study on Controlling Factors of Siliceous Dolomite

The source of silicon in the siliceous dolomite is mainly from the volcanic channel hydrothermal origin. A large amount of siliceous hydrothermal fluid is discharged from the volcanic channel. The siliceous hydrothermal fluid flows from the ancient structural high to the ancient structural low. Under the action of seawater, it undergoes metasomatism with dolomite to form siliceous dolomite. Therefore, the thickness of siliceous dolomite in the Well 2 area is greater. The volcanic channel and ancient structure jointly control the thickness of siliceous dolomite.

The source of silica is mainly from the siliceous hydrothermal fluid, which has been confirmed by previous studies of geochemistry by authors such as Luo Wenjun and Tang Xuesong. However, the formation model of siliceous hydrothermal fluid was inferred through geological modeling by previous researchers.

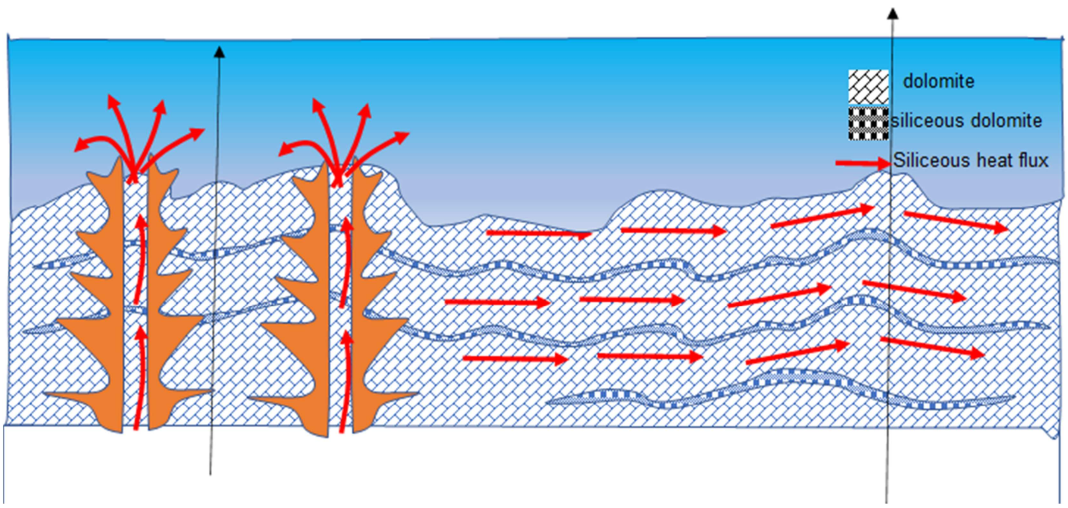

Figure 6. *Formation model of siliceous rocks.*

5. Formation Model

Figure 6 shows the formation mode of siliceous dolomite. Siliceous hydrothermal fluid is ejected from volcanic vents, flowing from ancient tectonic highs to ancient tectonic lows, and metasomatizing with dolomite to form siliceous dolomite. In addition, volcanic hydrothermal fluid also promotes the formation and development of dolomite [14-15]. In addition, the melting effect of volcanic hydrothermal fluid has a constructive transformation effect on reservoir physical properties. Therefore, the well 1 area in the research area has relatively good reservoir physical properties and relatively high production area are relatively good, and the production is relatively high.

6. Conclusion

Based on rock physics analysis, obtain sensitive properties of siliceous dolomite. Based on sensitive attributes, the spatial distribution pattern of siliceous dolomite was obtained through inversion. Based on the distribution patterns of ancient structures and volcanoes, the genetic model of siliceous dolomite is obtained, and the genetic mechanism of siliceous dolomite is analyzed.

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Biography

Wang Jie (1978-), female, Dr, senior engineer, is engaged in research on comprehensive analysis of petroleum geology.
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