

# **PS Formation Mechanism and Distribution of Lacustrine Carbonate Reservoir in Yingxi Area of Qaidam Basin, Northwest China\***

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## **Abstract**

The upper member of Xiaganchaigou formation in the Yingxi area of Qaidam Basin is located in the source sag, which is rich in hydrocarbon resources. However, exploration in the past three decades has not resulted in significant oil and gas discoveries. One reason is that there is not a good understanding of reservoir rock types and distributions. This study, based on an integration of outcrops, cores and experimental data, proposes that the carbonate banks and flats were controlled by paleo-highs in the sag and that carbonate reservoirs with matrix porosity, contrary to carbonate reservoirs with fracture porosity claimed in previous studies, exist in the study area. These findings, listed as follows, change the exploration strategy in the study area. Six sets of large-scale lacustrine carbonate reservoirs deposited in banks and flats were developed in the upper member of Xiaganchaigou formation in Yingxi area, of which carbonates with fractures and dissolution vugs are highly efficient reservoirs. Carbonates with granular, porphyritic and laminated textures are the preferential lithologies that have dissolution vugs. It is suggested that there are inherited paleo-highs developed in the sag. Carbonates of bank-flat facies deposited in paleo-highs were frequently leached by meteoric water due to lake-level changes, resulting in dissolution vugs. Furthermore, intercrystalline porosity was created during penecontemporaneous dolomitization produced by hyper saline lake water. Overall, paleo-highs in the sag controlled the formation; distribution and oil-gas accumulation of these carbonate reservoirs. Log and seismic related methods developed in this study shed light on the distribution of lacustrine carbonate reservoirs. It is predicted that the favorable exploration area is approximately 150 km<sup>2</sup> in Yingxi area. These findings supported petroleum exploration in Yingxi area. More than 10 exploration wells obtained high oil and gas production during 2014 and 2016, and predicted oil and gas reserves are up to 100 million tons.

# Formation Mechanism and Distribution of Lacustrine Carbonate Reservoir in Yingxi Area of Qaidam Basin, Northwest China

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## Introduction

- The upper member of Xiaganchaigou formation in the Yingxi area of Qaidam Basin is located in the source sag, which is rich in hydrocarbon resources. However, exploration in the past three decades has not resulted in significant oil and gas discoveries. One reason is that there is not a good understanding of reservoir rock types and distributions. This study, based on an integration of outcrops, cores and experimental data, proposes that the carbonate banks and flats were controlled by paleo-highs in the sag and that carbonate reservoirs with matrix porosity, contrary to carbonate reservoirs with fracture porosity claimed in previous studies. On this basis, a new facies-constrained inversion technique is adopted to predict the distribution of high quality reservoirs. These findings, listed as follows, change the exploration strategy in the study area.

## Geological understanding

- Six sets of large-scale lacustrine carbonate reservoirs deposited in beaches and flats were developed in the upper member of Xiaganchaigou formation in Yingxi area (Figure 1), of which carbonates with fractures and dissolution vugs are highly efficient reservoirs. Carbonates with granular, porphyritic and laminated textures are the preferential lithologies that have dissolution vugs (Figure 2).
- It is suggested that there are inherited paleo-highs developed in the sag. Carbonates of bank-flat facies deposited in paleo-highs were frequently leached by meteoric water due to lake-level changes, resulting in dissolution vugs (Figure 3). Furthermore, intercrystalline porosity was created during penecontemporaneous dolomitization produced by hyper saline lake water. Overall, paleo-highs in the sag controlled the formation, distribution and oil-gas accumulation of these carbonate reservoirs.
- Because of the complex lithology, poor physical properties, strong heterogeneity and thin layer thickness (1-8 m) of the reservoir, it is difficult to find out geological “sweet spots” in study area. The formation, distribution and oil-gas accumulation of lacustrine carbonate reservoirs are controlled by the sag paleo-highs in the study area. Therefore, we propose a facies-constrained and frequency-divided inversion method based on sedimentary cycles, paleo-terrain and seismic logging facies constraints. The results show that the high quality reservoir area of the target layer is changing with the migration of the paleo-highs northward (Figure 4), and the favorable reservoir area is about 150km<sup>2</sup> (Figure 5).

## Application effectiveness

- These findings supported petroleum exploration in Yingxi area. In 2014-2016, a total of more than 10 exploration wells have obtained high oil and gas production during the oil production test. Among them, the S38 well, the S208 well and the S1-2 well tested production more than thousand tons per day, and submitted 100 million tons of oil and gas geological reserves.

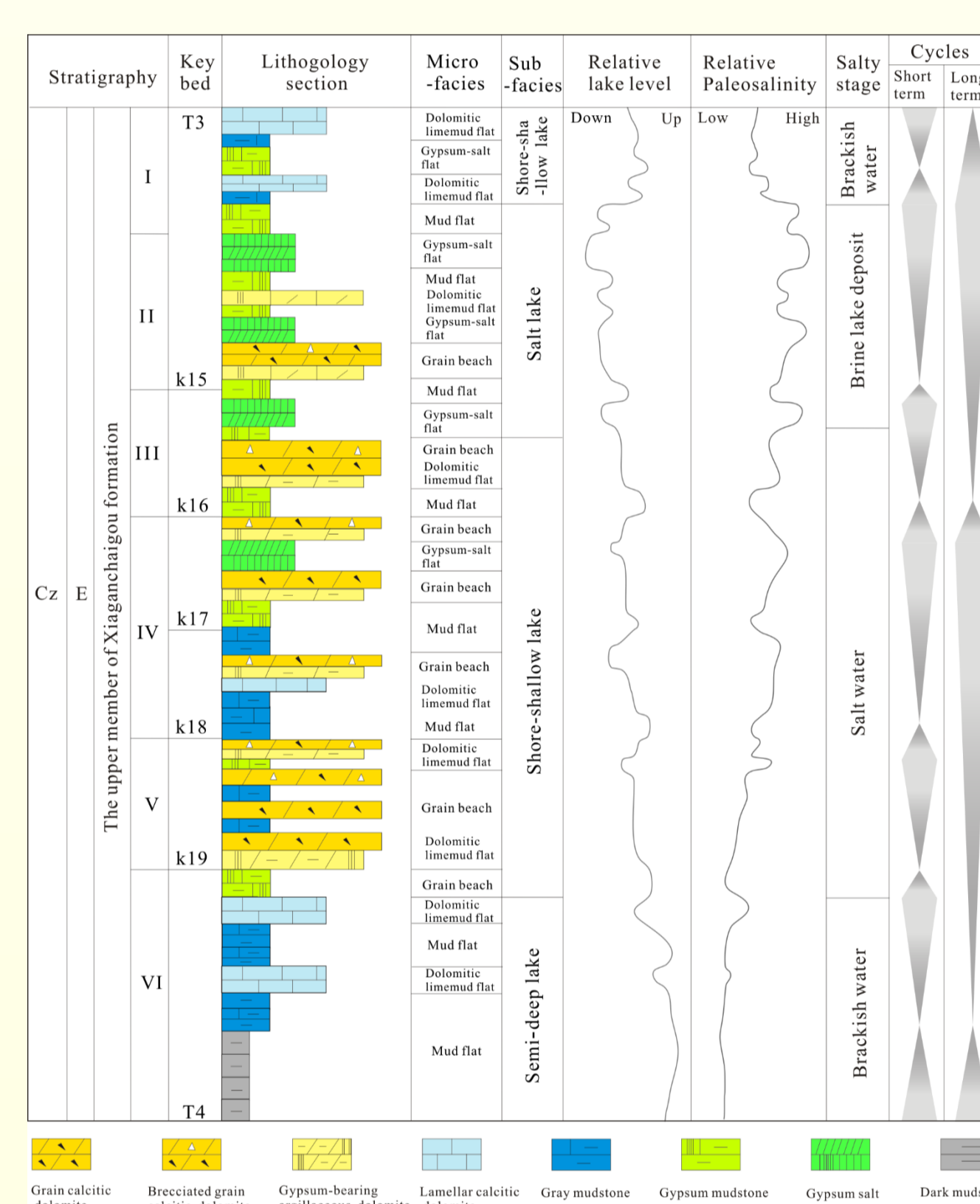


Figure 1. Comprehensive histogram of sequence and sedimentary evolution of Yingxi area.

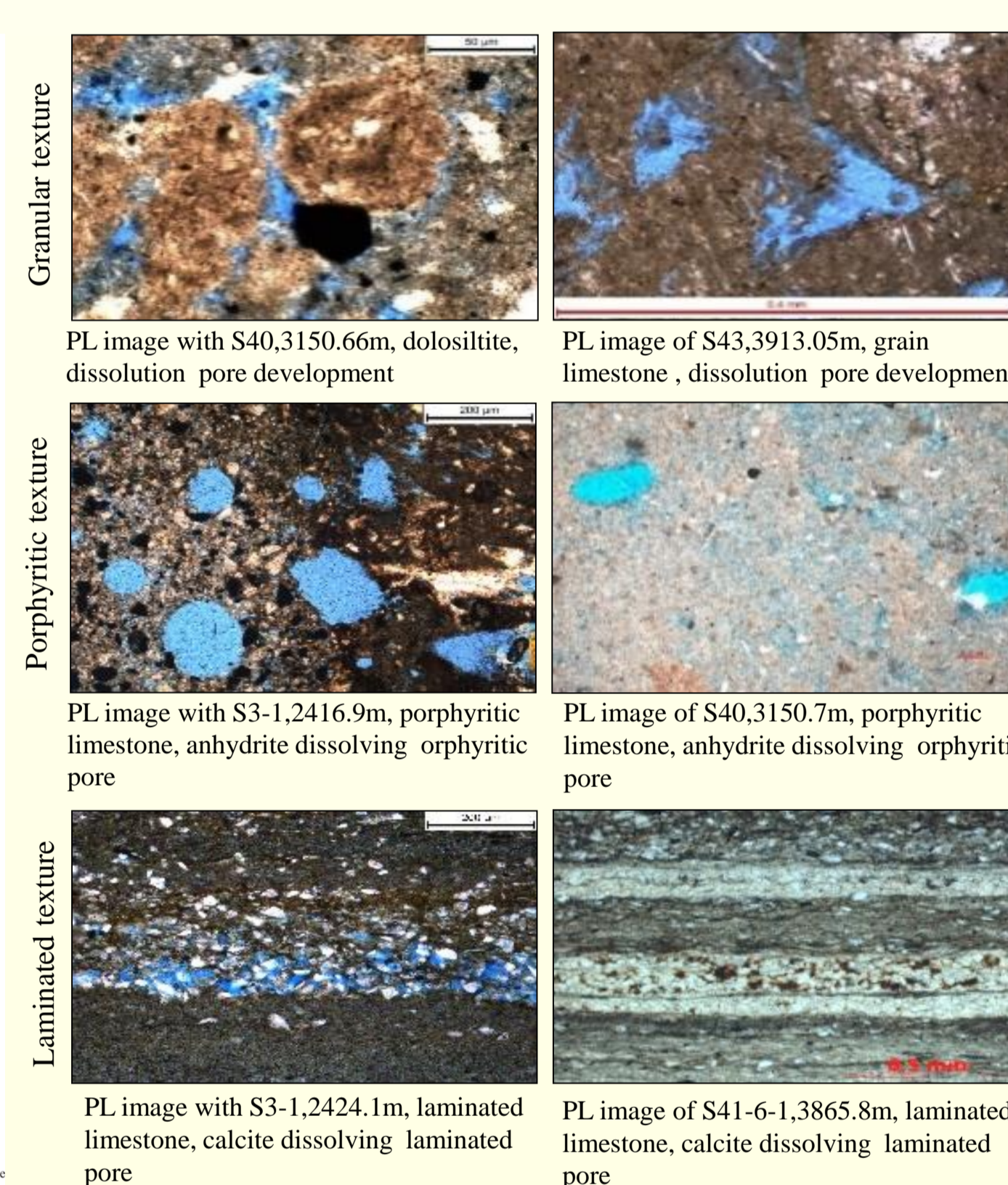


Figure 2. Microscopic characteristics of reservoir in three types of rock textures.

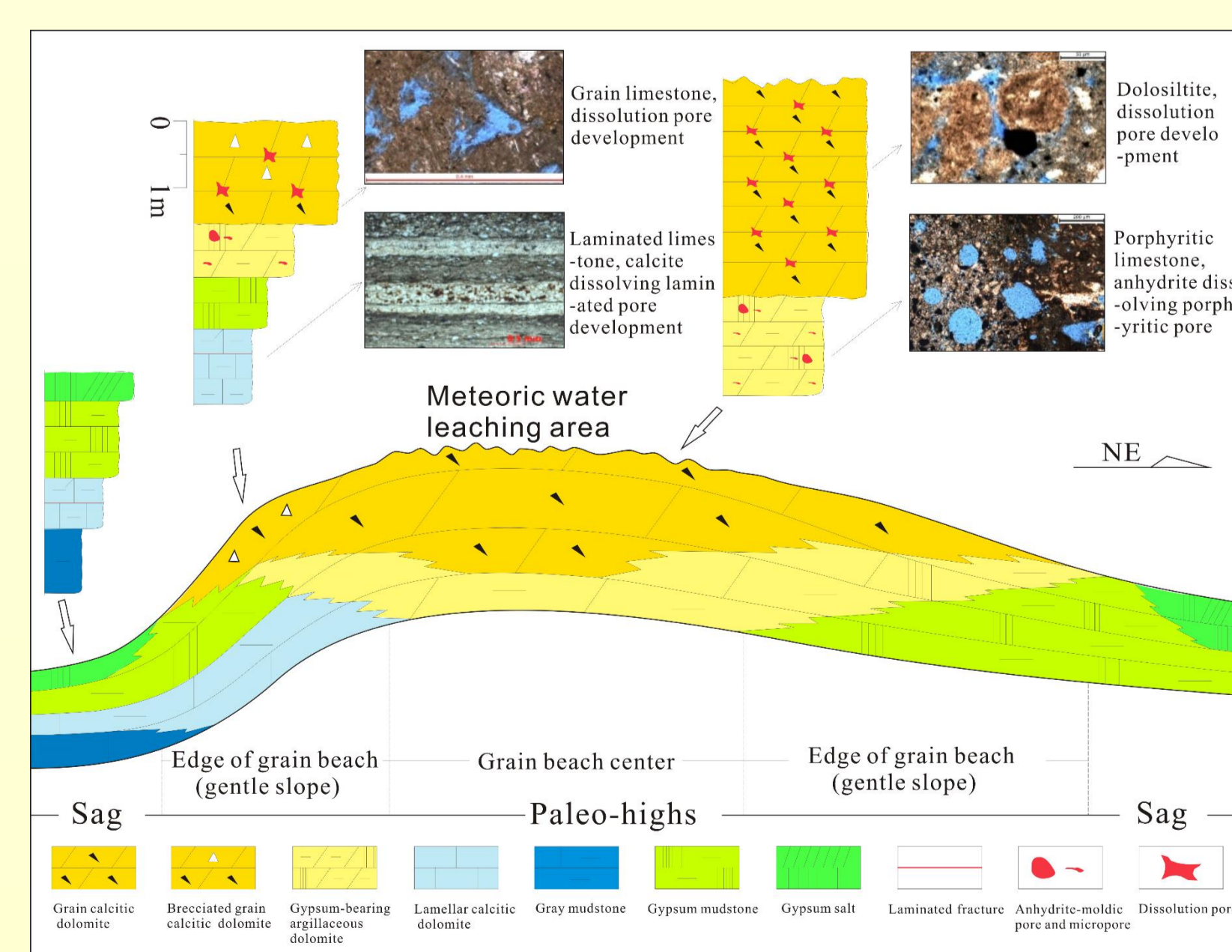


Figure 3. Sedimentary model of lacustrine carbonate in Yingxi area (only a single cycle).

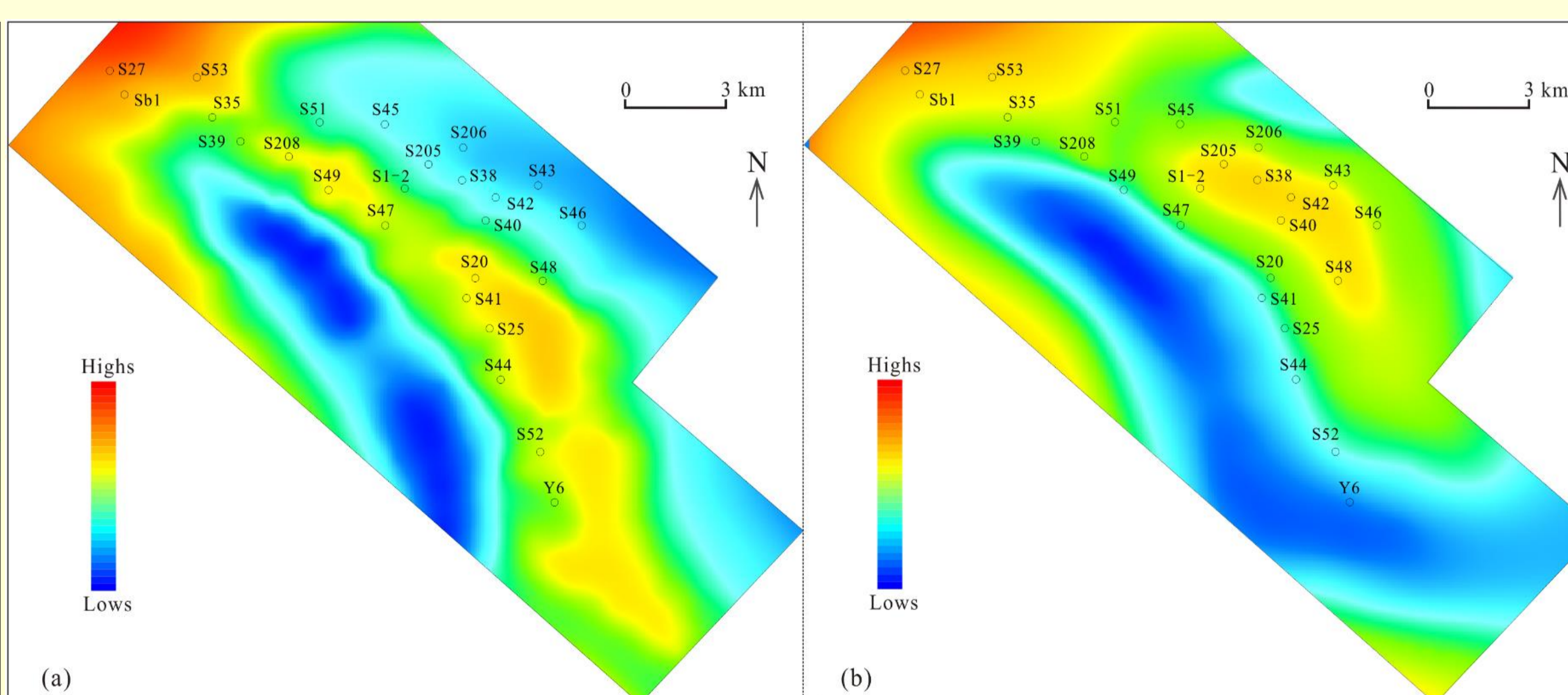


Figure 4. Restoration of paleomorphology in key intervals. (a) is the V interval and (b) is the IV interval; red and blue represent the relatively paleo-highs and paleo-lows respectively.

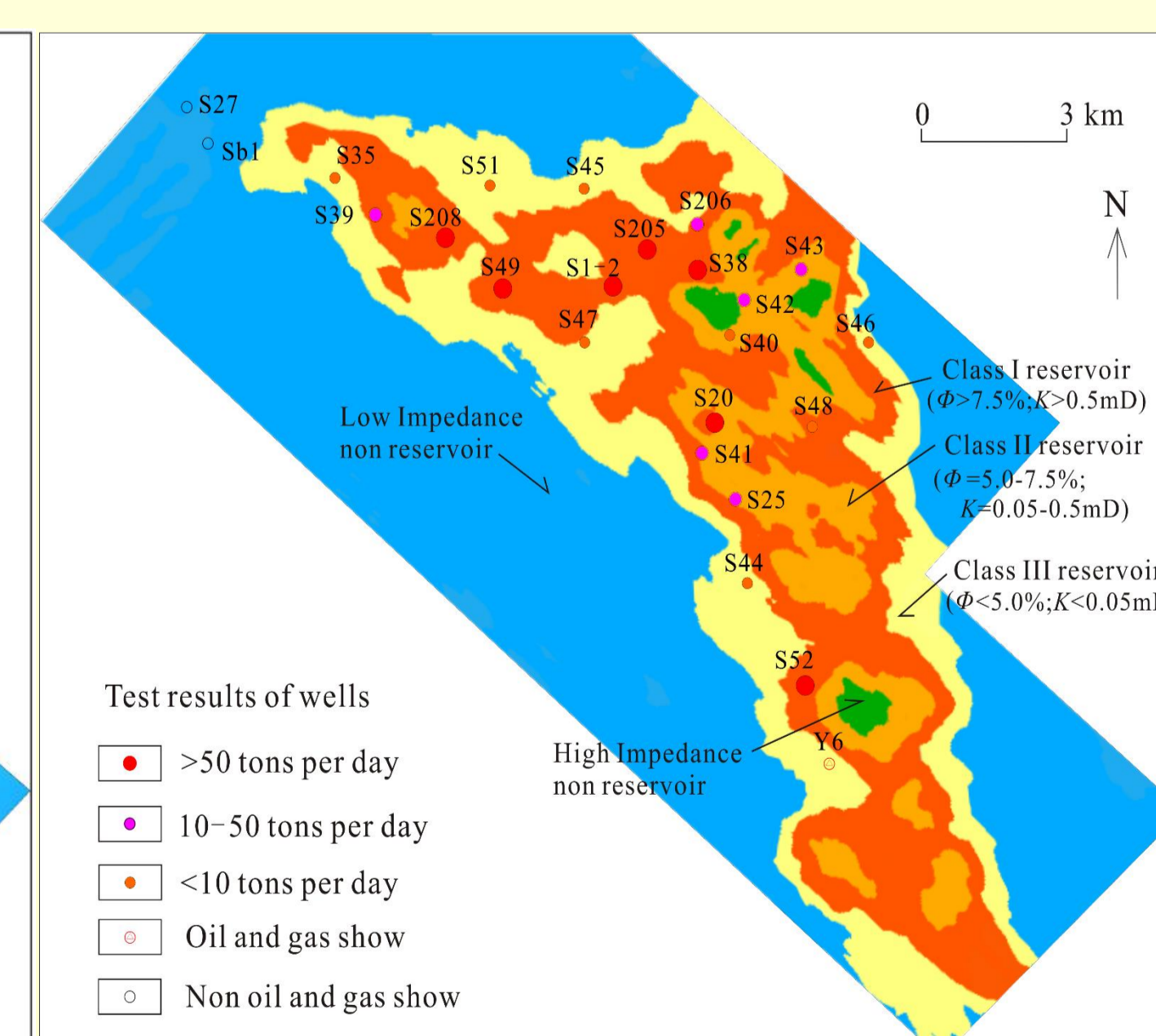


Figure 5. Reservoir prediction results of seismic facies-constrained.  $\Phi$ =Porosity;  $K$ =Permeability.