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# Exploration on the Causes of Concealed Faults in Huawa Area of Gaoyou Sag

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# Exploration on the Causes of Concealed Faults in Huawa Area of Gaoyou Sag

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**Abstract**. Most of the Huawa area in the Gaoyou sag is a fault block of the Suining Formation, and a NNE-oriented concealed fault is developed. At present, the research on the mechanism of concealed faults is still controversial. In this paper, four sets of sandbox physical simulation experiments are designed to verify that the concealed fault is formed under the influence of the NW tensile force and the pre-existing structure. The experimental results show that under the joint influence of boundary fault, NW extension force and pre-existing structure, the EW-trending fault is formed firstly, and the NNE-concealed fault is formed in the EW fault in the case of continuous motion of the late fault.

**Key words:** Gaoyou sag; Huawa area; concealed fault; sandbox physical simulation.

## 1. Foreword

Concealed faults are faults that are often found in fault basins that are difficult to find by conventional means. Such faults are characterized by low levels, small breaks, and poor seismic data quality that are difficult to identify [1]–[2]. The exploration of fracture-controlled reservoir formation in the Gaoyou depression is at a mature stage. With the successful drilling of wells Hua 3, Hua 4, Hua 11 and Hua 12 in the Huawa area of Gaoyou Sag in recent years, it is gradually found that there are concealed faults in this area. At present, scholars are still controversial about its formation mechanism. In this paper, the sandbox physical simulation experiment method is used to simulate the formation process of concealed faults, and the genetic mechanism is analyzed according to the experiment.

## 2. Regional geological overview

The Subei Basin is located in the eastern part of the Yangtze Platform, the Huaiyin-Shengshui Fault is bounded in the northwest, and the Huayu Fault Zone is separated from the North China Platform in the west. The Gaoyou sag is a braided fault basin in the south-south super-type [3]. It is located in the southern part of the Subei Basin, with a NEE trend as a whole, a Tongyang uplift in the south, and a lake uplift and low-lying bulge in the north. It is divided into three sub-structural zones: the north slope, the deep concave zone and the southern fault zone. The north slope includes six sub-structural units such as Liulu sub-concave, Wusonghe structural belt and Huawa structural belt. The Huawa structural belt is located in the eastern part of the north slope and is divided into two sub-structural areas, Huahua and Wazhuang. The fault system in this area is relatively complex. The faults in the Huawa area are mostly EW and NE (Fig. 1).

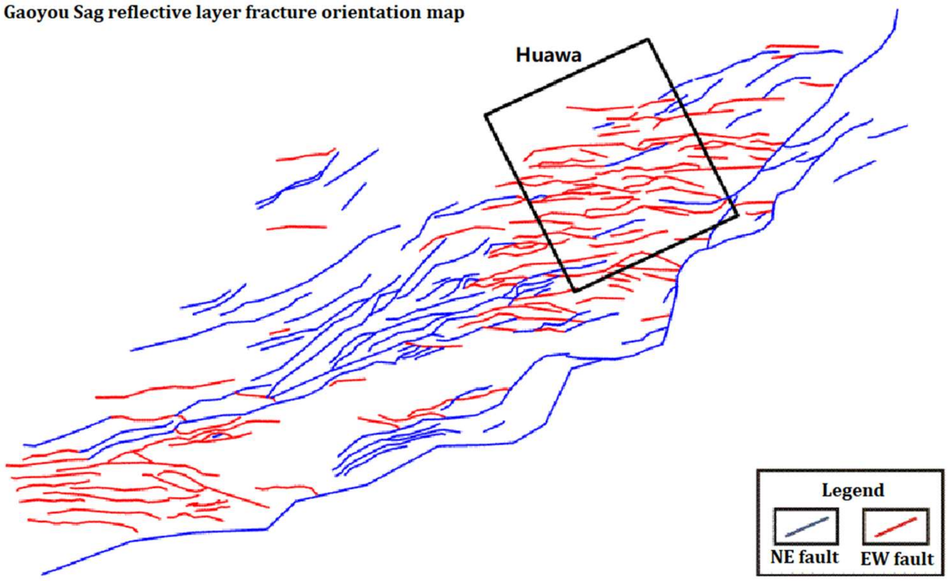



**Figure 1.** Fault orientation of the Huawa area

## 3. Design sandbox physical simulation experiment

The structural physics simulation experiment is an experimental method to simulate and study the deformation characteristics, genetic mechanism and dynamics of natural geological structures [4]-[5]. According to the predecessor's point of view [6], the hypothesis analysis is first made on the mechanism of the concealed fault: Based on the regional extensional stress of Paleogene, the near EW fault in the Huawa area of Gaoyou Sag belongs to the new fault, which is caused by the tensile stress in the north-south direction of the area. Later, due to the resurrection movement of the basement fault zone, it is affected by the NW stress. It produces some NNE-oriented faults between the near EW faults. These faults is not long, and the oblique stretch in an unfavorable orientation makes the drop smaller, thus forming a concealed fault in the Gaowa sag area (Fig. 2).

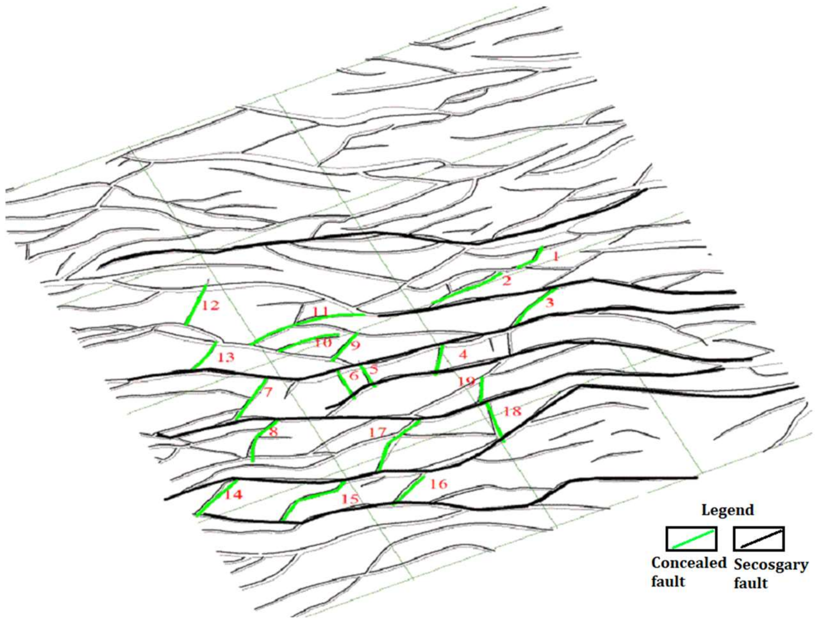



**Figure 2.** Concealed faults in Huawa area

### *3.1. Experimental instruments and materials*
This experiment was completed by a multi-functional experimental instrument independently developed by the School of Earth Sciences of Northeast Petroleum University (Fig. 3). The experimental instrument is mainly composed of a test bench and a console. There are six sets of movable motors on the test bench to complete the stretching and compression process at different angles and directions in the simulation experiment. According to different geological characteristics of different regions, many different types of sandbox simulation experiments such as extrusion structure experiment, extension structure experiment, reverse structure experiment and strike-slip structure experiment can be designed [7]-[8]. In this experiment, high-purity quartz sand with fine processing of natural quartz stone is used, and its main component silica content is higher than 99.5%.

**Figure 3.** physical simulation experimental instrument

### *3.2. Designing an experimental model*
The experiment uses the uniformly deformable malleable rubber to simulate the weak zone of the base in the study area [9]-[10]. The plastic sheet is used to simulate the pre-existing structure, and the rubber sheet is deformed by the stretching baffle to reach the base stretching motion and strain and the motion is transmitted into the overlying sand layer. In the experiment, the direction of the stretching is fixed and the direction of the rubber is changed, which is equivalent to changing the direction of the tensile stress field in the case where the weak band of the substrate is fixed. The baffles at both ends are connected to the rectangular rubber, and the thickness of the sand is 4cm. During the experiment, the movable baffles on both sides are retracted at the same time to provide displacement for the deformation. The experimental sandbox has a height of 5 cm and a width of 60 cm. In order to verify the hypothesis of the mechanism of the concealed fault, four sets of experiments were designed as follows:

Experiment I: A single layer of stretchable rubber was used as the base at the bottom of the sandbox, and a double-layer stretchable rubber with a fixed shape was applied around it to simulate the boundary fracture, and the size was 60 cm×50 cm. The base connecting baffle is applied with a tensile external force from the NW direction, and the retreating speeds of both baffles are set to 0.5 cm/min, and pushed outward for 9 min. During the experiment, a digital camera is used to take a record change process every 1 min. A single source of light is applied from the middle of the baffle using a light source to clearly identify small-scale faults on the surface of the sand body(Fig. 4a).

Experiment II: On the basis of Experiment I, four faults were set on the base single-layer rubber with plastic sheets. This is a simulated pre-existing structure, in which two faults are parallel with the Zhener and Hanliu faults, and the other two faults are The Zhenyi and Wubao period faults are parallel(Fig. 4b).

Experiment III: On the basis of Experiment II, the two pre-existing structures on the right side were set to east-west direction, and other design parameters were unchanged(Fig. 4c).

Experiment IV: According to Experiment III, a set of SN-direction tensile control experiments were designed for the overall NW stretching of the substrate, and the other parameters were unchanged(Fig. 4d).

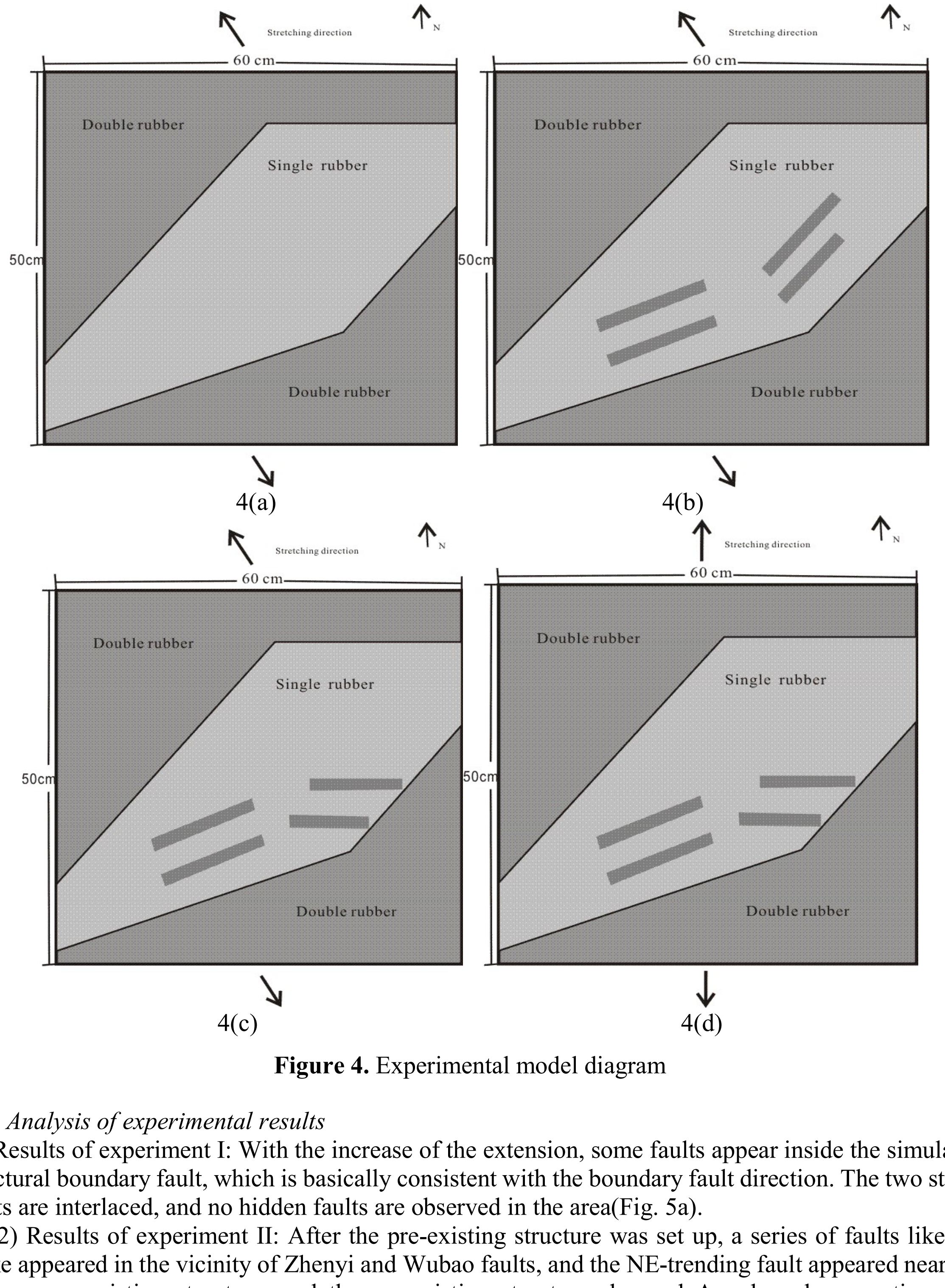
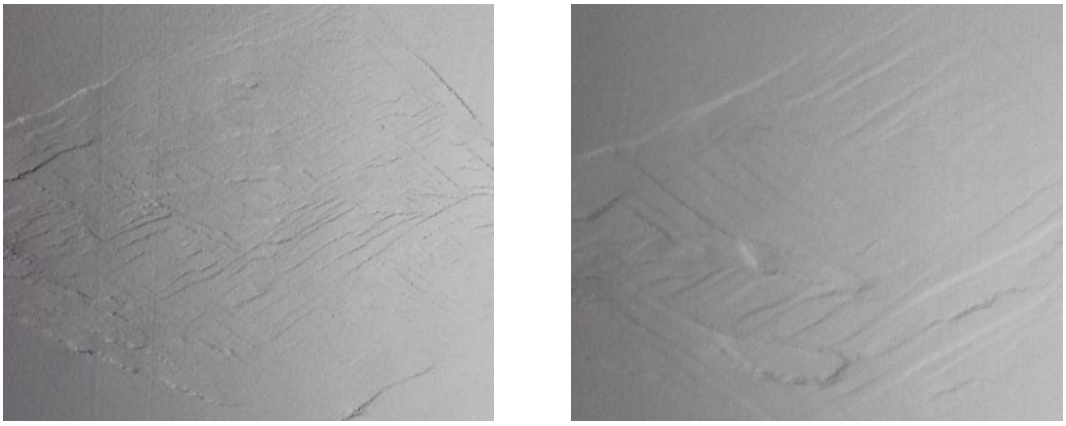



**Figure 4.** Experimental model diagram

### *3.3. Analysis of experimental results*

(1) Results of experiment I: With the increase of the extension, some faults appear inside the simulated structural boundary fault, which is basically consistent with the boundary fault direction. The two strike faults are interlaced, and no hidden faults are observed in the area(Fig. 5a).

(2) Results of experiment II: After the pre-existing structure was set up, a series of faults like the strike appeared in the vicinity of Zhenyi and Wubao faults, and the NE-trending fault appeared near the western pre-existing structure, and the pre-existing structures loomed Arc-shaped connections, no concealed faults were observed (Fig. 5b).



5(a) 5(b)

**Figure 5.** Experimental results

A comprehensive analysis of the results of four sets of experiments: a series of faults consistent with the boundary fault strike will occur when only the pre-existing structure is not simulated, but the fault has no connection and no other structural phenomena, and it can be judged that the stretching of the substrate does not cause the direction of the torsion force, so that the NNE concealed fault does not occur. After setting the pre-existing structure, there will be an arc-like connection trend between the prior structures, and the experimental III arc-shaped connection is the most obvious. The orientation of the pre-existing structure affects the torsion of the tensile force of the substrate, resulting in an NNE concealed fault in the EW formed in the middle of the fault. Therefore, the correctness of the presupposition conditions is verified: the north-south tensile stress in the area produces the EW-to-new fault, and in the later stage, due to the reactivation of the basement fault zone, it is affected by the NW-direction stress, and a series of NNE-trending faults are generated between the near EW faults.

## 4. Conclusion

(1) The regional tectonic form is not enough to affect the formation of internal faults, and the boundary large faults and pre-existing structures are the main controlling factors affecting the internal fault development;

(2)Influenced by the pre-existing structure, the new faults can be deformed and twisted and stacked in different periods, and they are connected in an arc.

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