Enhancing LANDSAT TM to update the structural analysis of the Mirs Bay Basin, Hong Kong, China

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Abstract: The coastal provinces of South China have been uniquely shaped by various tectonic events. During the mid-late Mesozoic tectono-thermal event, the oblique subduction of the Paleo Kula-Pacific plate beneath the Eurasian plate has created a complicated tectonic setting for the whole region. However, the mechanism of this event is not completely understood. In this paper, we discuss the advantages of using LANDSAT TM satellite imagery over a small part of the region - the Mirs Bay Basin which is largely covered by dense vegetation and where limited outcrops is seen. The use of satellite imagery complements field mapping and the result shows a prominent sinistral offset along the eastern margin of the Mirs Bay Basin, which was not previously recognized on land.

Keywords: Geochemical Signatures, Digital Imagery, Structural Mapping.

1. Introduction

In South China coastal provinces, more than a hundred of red bed basins have been recognized and are collectively termed as the South China Basin group. It is widely held that they were resulted from intense tectonic movements in Mesozoic times. The majority of these basins trend predominantly ENE to NE and were primarily controlled by the mega-scale NE-trending Linhuashan Fault Zone (LHFZ). The Mirs Bay Basin, an offshore red bed basin, is one of the examples located along the SE margin of South China. The purpose of the present study is to document, through a detailed structural analysis, the tectonic structures associated with the formation of the Mirs Bay Basin.

2. Geological Setting

The tectonic framework of the maritime provinces in South China is dominantly characterized by the NE- to NNE-trending ductile shear LHFZ which was the locus of Upper Jurassic to Lower Cretaceous calc-alkaline magmatism and presumably the controlling fault of some red bed basins (Fig. 1).

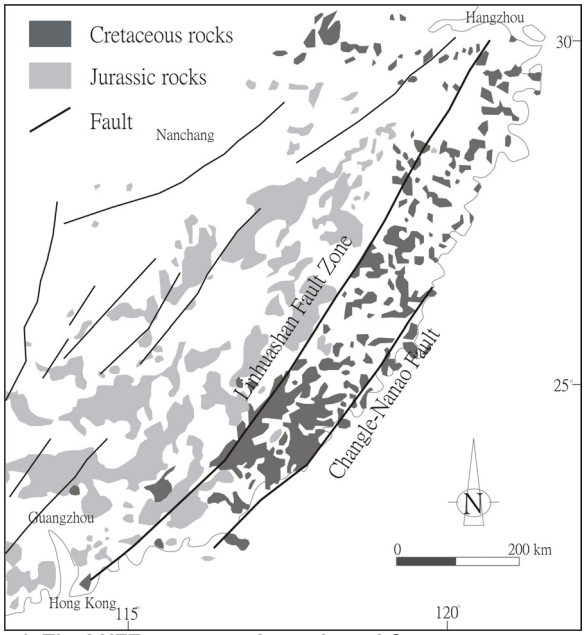

Fig 1. The LHFZ separates Jurassic and Cretaceous magmatic rocks.

The kinematic history of the LHFZ is complex and only its post-Jurassic movement can be distinguished. Throughout the Jurassic and Early Cretaceous, the fault zone demonstrated a substantial sinistral motion in response to the NNW oblique subduction of the Paleo Kula-Pacific plate beneath the Eurasian plate [4] [5]. Although the slip-sense of the LHFZ in the Late Cretaceous and Cenozoic is not completely understood, Li [1] claimed that the region to the east of the LHFZ exhibited a 10° clockwise rotation with respect to the inland section of South China, suggesting a dextral motion for the LHFZ in the Late Cretaceous. Nevertheless, the causative mechanism for such a change of slip-sense of the LHFZ remains sketchy.

3. Methodology

In this study, due to limited quality outcrops, Landsat TM data is integrated with extensive field mapping for a comprehensive structural analysis of the Mirs Bay Basin. We adopted the following approach to achieve this:

- Field structural mapping along the southwestern and eastern margins of the basin;
- Geochemical analysis (ICP-MS analysis) of dyke and volcanic rocks; and
- Generation of a False Colour Composite (FCC) image using three bands of Landsat 7 TM imagery.

4. Results

Extensive field surveys, in the study area, indicate that along the southwestern margin of the basin, a series of NW-trending normal faults dip towards the NE at 60° to 80° and cut the Late Cretaceous Ngo Mei Chau Formation. A fine-grained acidic aplite dyke is also present in an orientation parallel to these NW-trending faults. Fault breccias, fault gouges and silicified zones are commonly developed along strike. The widespread presence of brecciated zone suggests that brittle deformation is characteristic of this NE-SW extensional regime. In addition, several fault planes exhibit an opposite dip direction such that the NE- and SW-dipping normal faults constitutes the small-scale horst-and-graben structural style. On the other hand, along the eastern margin, field mapping shows that the basin is marked by the N24°W Fung Muk Long fault which is a high-angle, W-dipping normal fault. WNW-striking S-C fabrics were also observed, indicating right-slip tectonics. However, the temporal relationship between the extensional and right-slip tectonics is not entirely clarified by field structural mapping.

Rare Earth Element (REE) analysis was also conducted to examine the geochemical signatures of the aplite dyke and volcanic country rocks of the Late Cretaceous Ngo Mei Chau Formation. The REE plots normalized to Nakamura [3] for the aplite dyke and Ngo Mei Chau Formation are highly comparable, suggesting presumably a similar magmatic origin and evolution process. They, in addition, display a significant negative Eu anomaly chiefly controlled by the removal of feldspar from a felsic magma by crystal fractionation. This indicated that the origins of the aplite dyke and country rock s may bear a close relationship. However, this cannot d efine the structural history of the basin. Thus to understand the structural aspects of the study area, further inve stigation of the fault zones was undertaken employing satellite images.

Landsat TM images were processed to obtain an enhanced image to trace the structural detail of the basin (Fig. 2). The enhanced Landsat image indicated that the northwestern tip of the Fung Muk Long fault displaced an ENE-striking sandstone ridge with a 150 m-sinistral offset. The image additionally shows an en echelon array of N24°W second-order faults along the principal displacement zone. Such a secondary fault pattern suggests sinistral-slip of the fault zone in addition to the NE-SW extension. This sinistral offset has not been cited previously and is a new finding from the present work.

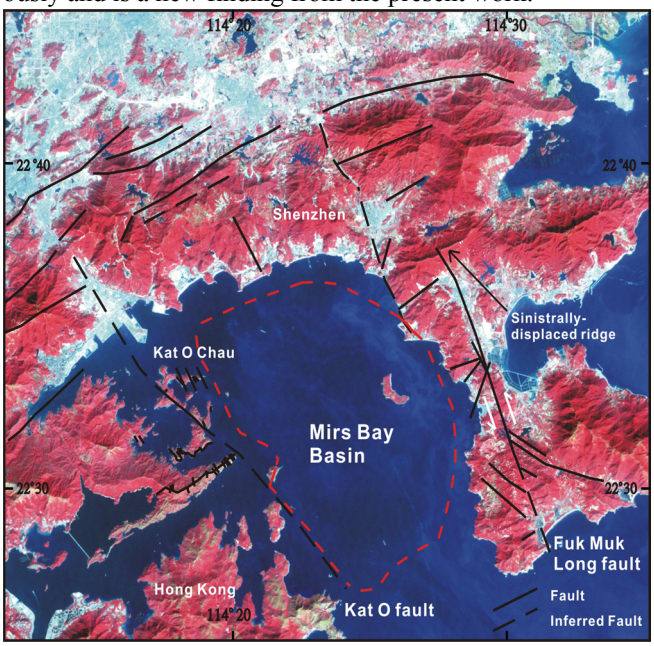

Fig 2. A False Color Composite image (combination of Landsat TM bands 4, 2 and 1) of the Mirs Bay Basin showing various structural features.

5. Discussions and Conclusion

The well-marked extensional tectonic features along the southwestern and eastern margin of the Mirs Bay Basin suggest an overall rhomboidal geometry for the basin (Fig. 3), which resembles the mature stage in the classic model for pull-apart basins [2]. We therefore attribute the opening of the Basin to the dextral-slip of the LHFZ during the Late Cretaceous as suggested by Li [1].

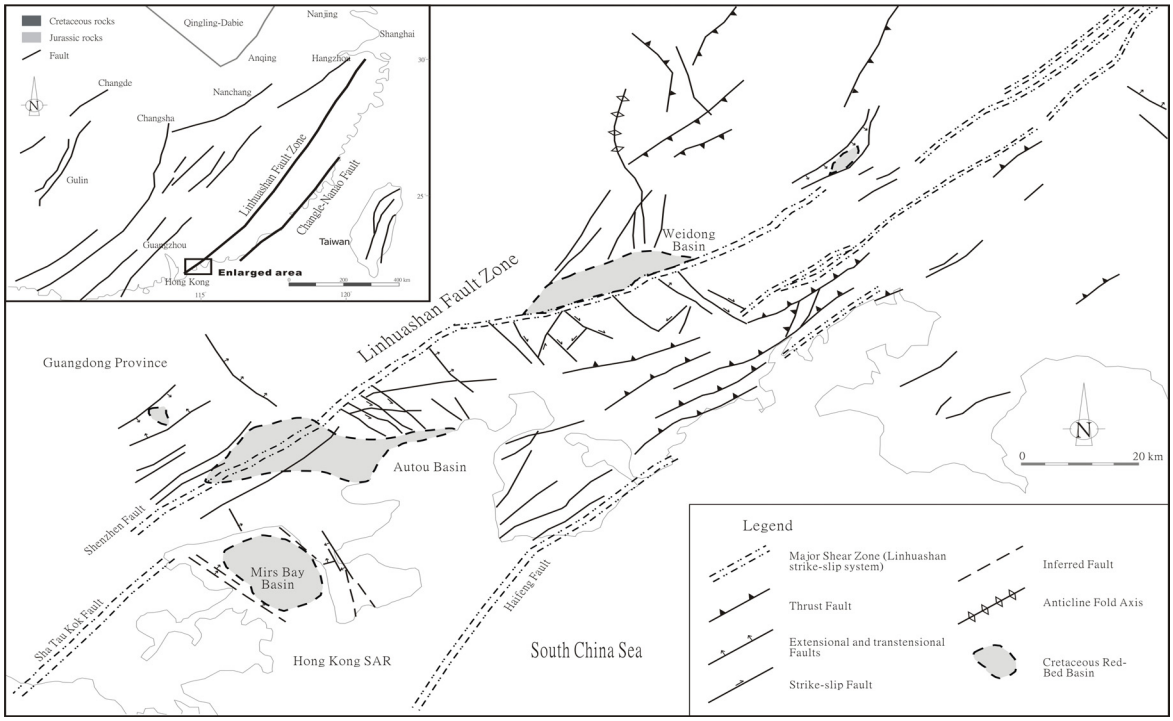

Fig 3. The Mirs Bay Basin, Autou Basin and Weidong Basin display a left-stepping pattern within the LHFZ.

The en echelon array of second-order faults as shown in enhanced satellite images supplements the lack of field evidence for the sinistral-slip movement of the Fung Muk Long fault, suggesting that the extensional fault zone was subsequently reactivated as a sinistral strike-slip fault. Such a structural characterization cannot be fully recognized on the ground without the use of satellite images.

Further NE from the Mirs Bay Basin are the Autou Basin and the Weidong Basin which are both Late Cretaceous red bed basins lying within the LHFZ. Their well-defined geometry in the Landsat imagery exhibits a prominent lazy z-shaped structure (Fig. 3), which is equivalent to the transitional stage in the pull-apart model of Mann [2]. It is clear from the present work that field structural mapping is less likely to trace such basin geometry due to limited outcrops and dense vegetation. Structures can be better understood with the combination of field mapping and using enhanced Landsat TM imagery.

It can be concluded from the above discussion that the opening of the Mirs Bay Basin together with the adjacent Autou Basin and Weidong Basin may be attributed to the dextral-slip tectonics of the LHFZ during the Late Cretaceous and it is clear that satellite data could play an important role in structural mapping on a regional scale in this part of South China.

Acknowledgement

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