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The biogenic gas potential of the submarine canyon systems of Plio-Peistocene foreland Basin, southwestern Taiwan

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ABSTRACT

Biogenic gas was accidentally discovered and produced from the Plio/Pleistocene formation of the Hsinying gas field in southwestern Taiwan in 1989. A stratigraphic trapping mechanism related to the evolution of submarine canyon systems in the Plio-Peistocene foreland basin has been proposed in a previous study which explained underestimated recoverable gas reserve before drilling. To verify this shallow gas exploration hypothesis and to systematically evaluate the biogenic gas generation and entrapment potential of the submarine canyon systems, seismic interpretation, high-resolution sequence stratigraphic interpretation, seismic attribute analysis and geochemical analysis were performed and integrated in this study. Twenty-nine submarine canyons mapped mainly trend in a NE direction, except the NW trending Eurchungchi submarine canyons located near the Chiali paleo-high. Bright seismic amplitudes were often observed at the incised valley heads of the canyon systems. The shales located near the incised valley heads and deposited during flooding stage possess the highest biogenic gas generation potential, as canyon fill reveals the second highest. Due to the high sediment accumulation rate in the foreland basin, organic matter in such a depositional environment tends to become diluted. A Class III AVO anomaly, inverted impedance lower than 4.7 e + 6 kg/M^3*M/S and *A*/*B* (the ratio between the target horizon amplitude and the RMS amplitude from the background strata) greater than 1.78 were identified as valid direct gas indicators as sand is buried shallower than 1000 m. Class IV AVO anomaly and *A*/*B* greater than 1.4 were concluded to be the indicators of gas sand in the case that sand is buried deeper than 1600 m. Based on the results of sequence stratigraphic interpretation and the consistency between spatial geometries of seismic attributes and those of the submarine canyons, a stratigraphic trap associated with the incised valley heads was concluded to be the original gas entrapment style of the Hsinying and the Kuantian gas fields. Biogenic gas migrated after being trapped startigraphically, hence contributing to the present-day gas field structure. Due to the prevalent erosional features of the submarine canyons on the time structural maps, different types of stratigraphic traps formed in combination with faults and submarine canyons can be recognized easily.

1. Introduction

Taiwan is located at a site where ongoing arc-continent collision between the Eurasian continent-plate and the Philippine sea-plate commenced about 5 Ma ago (Teng, 1990; Lu and Malavieille, 1994; Fuh and Liu, 1997; Lin, 2001; Lin and Watts, 2002). The study area extended between Potzu and Tainan (Fig. 1) is in the southwestern plain of Taiwan where the distal part of Plio-Pleistocene foreland basin is located (Covey, 1986; Van Wangoner, 1995; Chen et al., 2001; Huang et al., 2004). About 60 km off the southern margin of the study area, the present-day Kaoping (KP) Canyon is located on the Kaoping slope and connected to the Kaoping River inland (Yu et al., 1991; Yu and Wen, 1991; Yu et al., 1992; Yu and Chiang, 1997). The major seismic interpretation and mapping in the area were focused in the pre-Pliocene sequence boundaries in the last two decades due to their higher hydrocarbon exploration potentials. Gas of the Pachangchi field discovered in 1985, located in the horst bounded to the south by the hinge fault (A fault in Fig. 1) of Peikang High (Leu et al., 1985), was produced mainly from the Peiliao formation of Miocene age. The Plio-Pleistocene sequences have been paid attention for some years when the shallow biogenic gas was penetrated accidentally in the S1 well of the Hsinying area from the base Eurchungchi formation in 1982 at the depth of about

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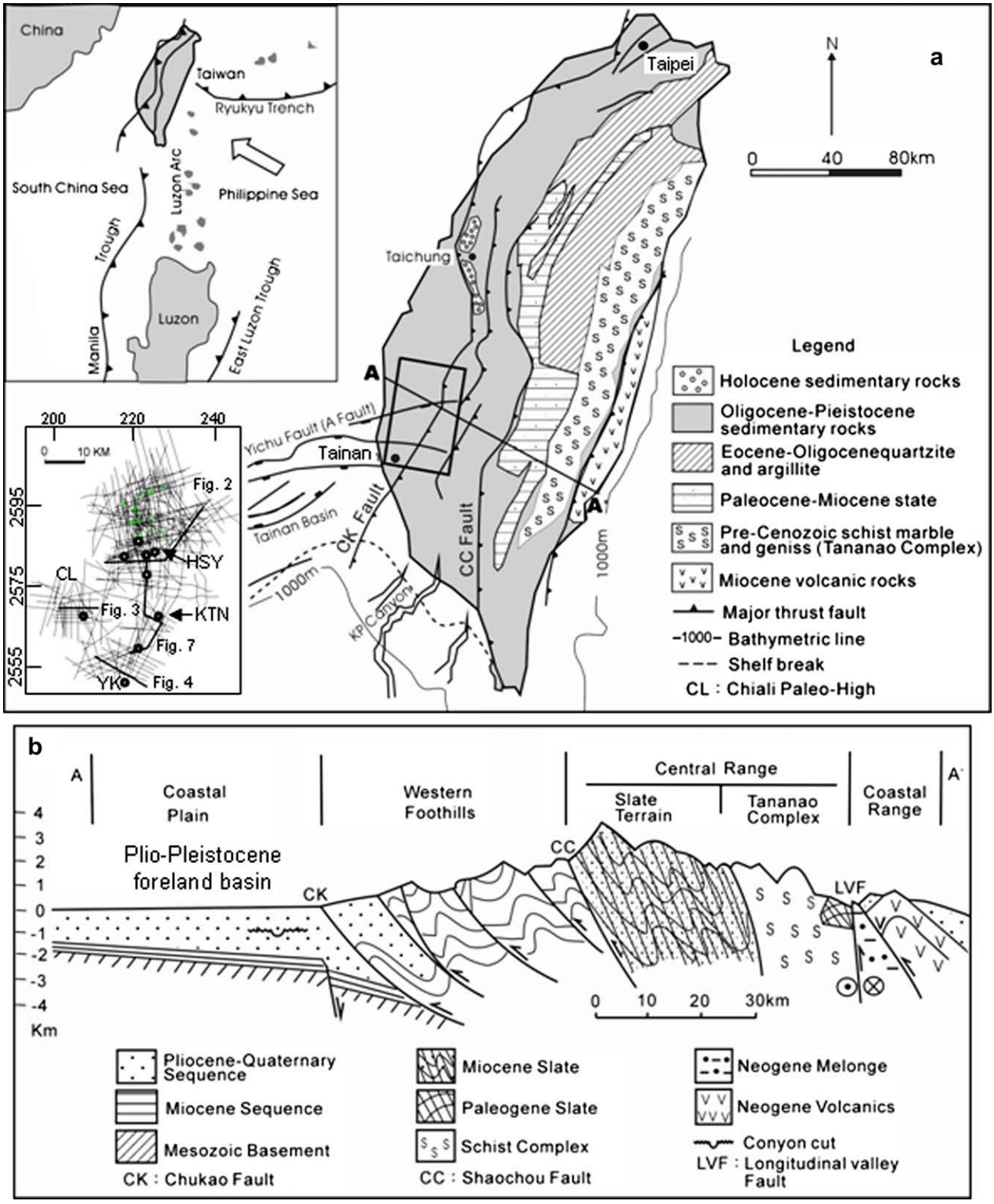

Fig. 1. The (a) Regional map showing the major tectonic elements of the Taiwan region (modified from Chen et al., 2001 and Teng, 1990). The study area is shown as heavy block box in (a). The seismic line and well location map is show in the lower left inlet. The heavy lines in the inlet are show line locations for seismic interpretation and seismic attributes analysis in this study. Biogenic gas is produced from the Hsinying (HSY) and the Kuantian (KTN) gas fields. (b) Schematic cross section of southern Taiwan showing major tectonic elements. See (a) for location of the cross section.

1000 m. On the contrary, the original Miocene target proposed for drilling was dry. Consecutive drillings of the near structural traps targeting at shallow biogenetic gas failed. The gas field was not produced until 1989 with the originally estimated recoverable reserve of 60 million cubic meters. Up to now, about 90 million cubic meters of gas have been produced from the Hsinying field. The structure of the gas field is quite gentle in the EW direction with relief less than 125 m over 10 km and the thickness of net gas