# Geological Settings and Gas Hydrate Distribution Offshore Southwestern Taiwan

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*Abstract* - **Offshore southwestern Taiwan, the Luzon accretionary wedge complex overrides the passive China Continental Slope in an incipient collision, and presents a rare opportunity to study gas hydrates, as BSRs have been widely observed in both the active and the passive continental margin settings in this area. The Central Geological Survey of Taiwan has initiated a 4-year gas hydrate investigation program starting 2003, involving seismic surveys, geological and geochemical analyses of bottom water and sea floor sediments, and heat flow measurements. This study presents the initial results of these surveys.**

## I. INTRODUCTION

The area offshore southwestern Taiwan is the place where the northern termination of the Luzon subduction system encroaches on the eastern edge of the passive China continental margin. Distinctive fold-and-thrust structures of the convergent zone and horst-and-graben structures of the passive margin are separated by a deformation front that extends NNW-ward from the eastern edge of the Manila Trench to the foot of the China continental slope (Fig. 1). Based on the analyses of seismic reflection profiles and interpretation of various morphologic features revealed from high-resolution bathymetry maps, it appears that the frontal portion of the accretionary wedge has extended to the passive China continental margin, and covers the lower portion of the China continental slope near Taiwan. The Tertiary Tainan Basin lies on the China continental

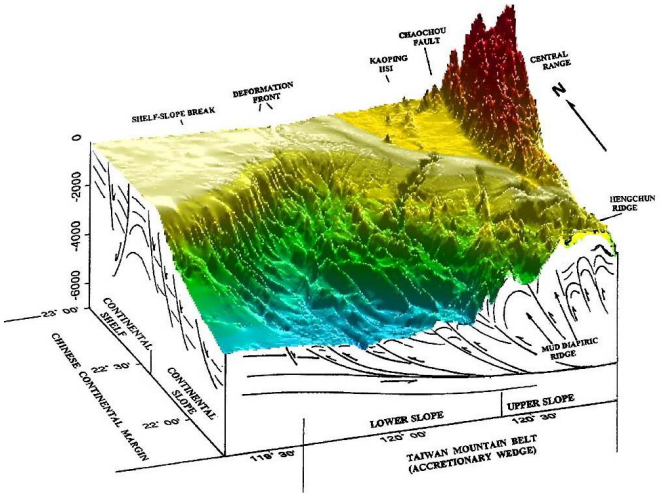


Fig. 1. Tectonic Setting: Distinctive fold-and-thrust structures of the convergent zone and horst-and-graben structures of the passive margin are separated by a deformation front that extends from the eastern edge of the Manila Trench and Penghu Canyon NNW-ward to the foot of the Chinese continental slope, then turns N and NE-ward across the continental slope and the Kaoping Shelf

shelf where sediments rich in organic material derived from Mainland China have been deposited. At the present time, a gas field is being developed in the Tainan basin. East of the deformation front, thick Pliocene-Pleistocene sediments derived from the active Taiwan mountain belt were deposited on the submarine Taiwan accretionary wedge offshore SW Taiwan. Mud volcanoes and mud diapiric anticlines are abundant in this region. Natural gas has been produced on land SW Taiwan from shallow gas fields, while offshore SW Taiwan, bottom simulating reflector (BSR), a strong indicator of presence of gas hydrate, has been widely observed.

## II. GEOPHYSIACAL AND GEOCHEMICAL OBSERVATIONS

In order to better understand the gas hydrate distribution and its characteristics offshore SW Taiwan, the Central Geological Survey of Taiwan has initiated a 4-year integrated gas hydrate investigation program in 2003. Over 4,000 km of multi-channel seismic data have been added recently to the existing seismic database. BSRs have been observed along 2/3 in length of the profiles. A new BSR map has been generated which indicates that gas hydrates are presented in an area over 20,000 $km^2$ offshore SW Taiwan, in water depths of 700 to over 3500 m, extending from the passive margin of the China continental slope to the submarine Taiwan accretionary wedge (Fig. 2). Seismic characteristics typically associated with the presence of gas hydrate, such as blanking zones above BSR, high amplitude reflections beneath BSR, negative polarity and amplitude increases with offset for BSR reflections, etc., have all been observed (Fig. 3). Velocity structures derived from pre-stack depth migration and from analyzing the wide-angle reflection and fraction data collected by the ocean bottom seismometers show that the hydrate-bearing sediments generally have velocity ranges from 1750 to 2000 m/s, with most values around 1900 m/s. Low velocity zones observed beneath the gas hydrate bearing sediments clearly indicate the presence of free gas below.

Geochemical data also provide strong supports of gas hydrate existence in the region. Unusually high methane concentrations (up to 600,000 nL/L) in the dissolved gases in bottom water have been measured at several sites on top of diapiric ridges (Fig. 4). Methane concentrations in

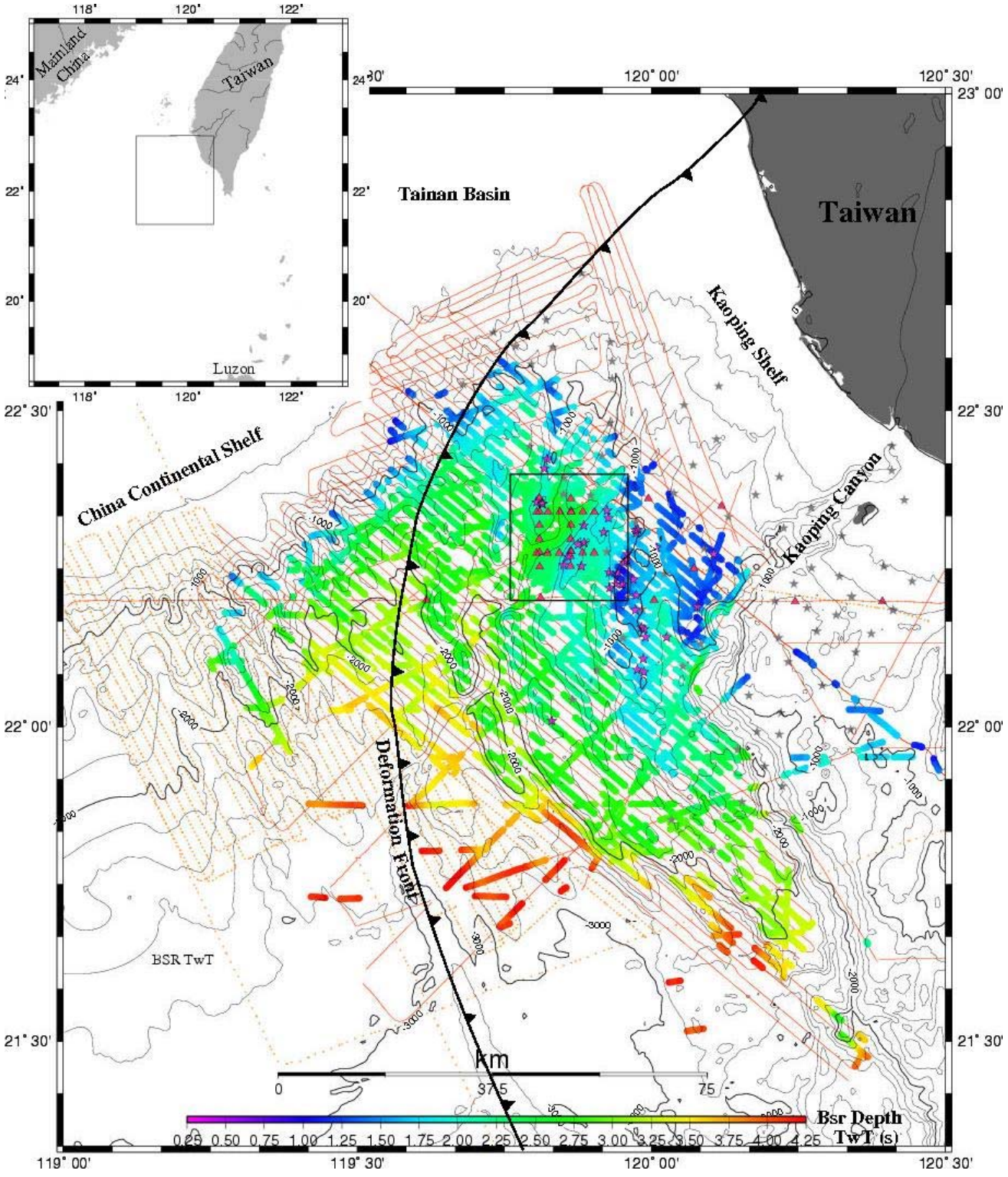


Fig. 2. BSR depth (two-way travel time in s) offshore southwestern Taiwan. Thin lines show ship tracks of the analyzed seismic cruises. Coring locations for this study are indicated with stars. Small box shows the area where closely spaced (400 m line spacing) multichannel reflection and ocean bottom seismometer (triangles) data have been collected.

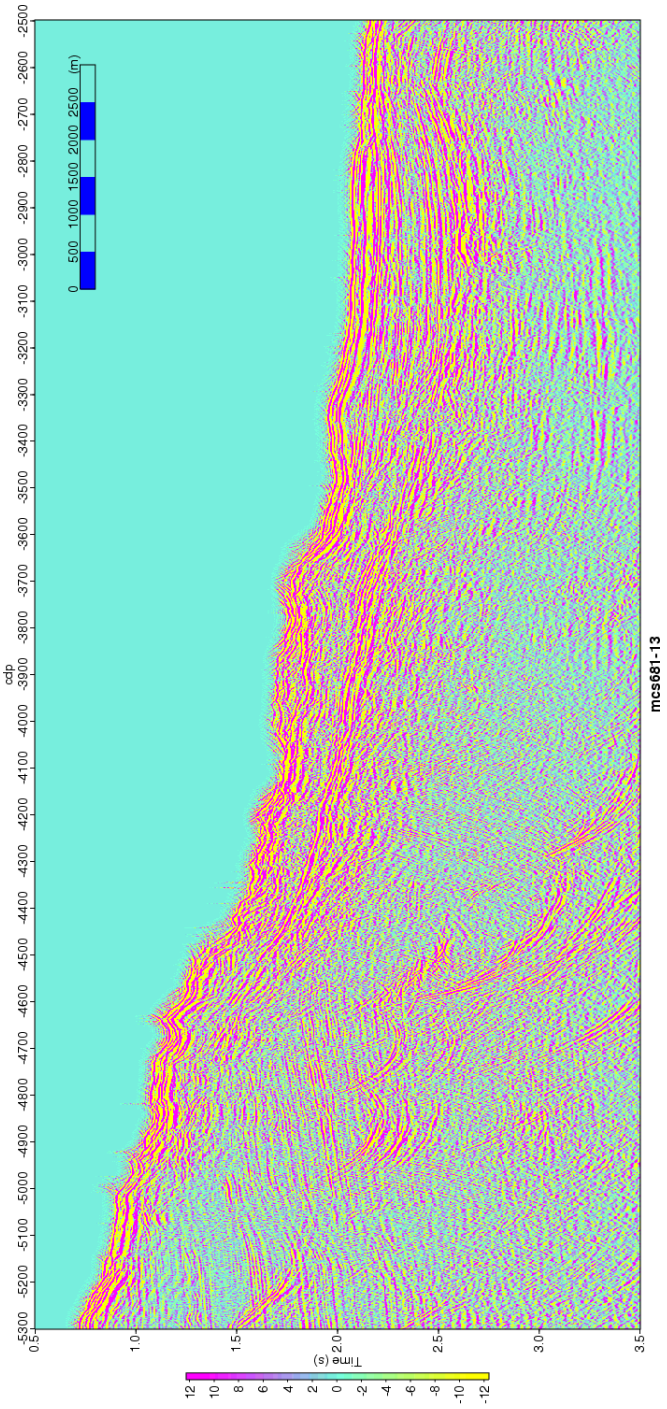


Fig. 3 a). Acoustic signature of the BSR on the eastern flank of the China continental slope along NW-SE MCS681-13.

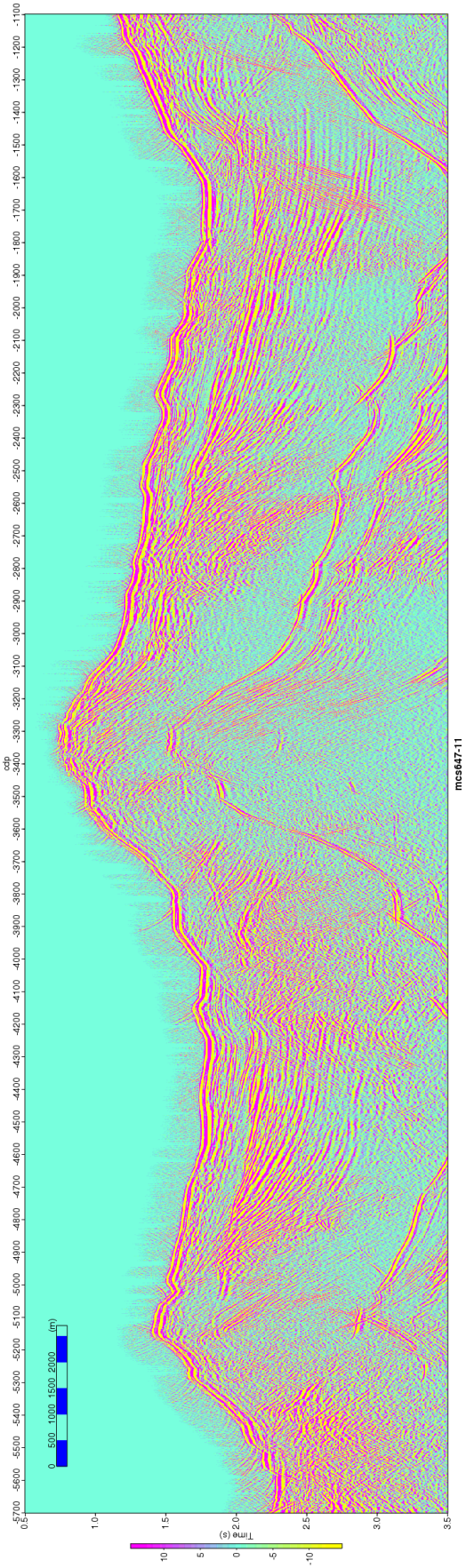


Fig. 3 b). Acoustic signature of the BSR across the acretionary prism along NW-SE MCS647-11.

the piston core samples give similar results. Further more, total sulfate depletion are observed as shallow as one meter beneath the sea-floor at these locations, often associated with high concentrations of dissolved sulfide and pyrite. It is suggested that free gases generated from dissociated gas hydrate below might be emitting into the sea water at these sites. Gas samples analyzed using the headspace gas analysis technique indicate that both biogenic and thermogic gases are detected, inferring multi-gas origins.

## III. CONCLUSION

As gas hydrates exist on both passive margin and active margin settings offshore SW Taiwan, this area provide a rare opportunity to address some fundamental questions regarding the formation, occurrence and stability of gas hydrate in different tectonic setting.