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SEALING EFFICIENCY OF GAS HYDRATES FROM SEISMIC AVO AND HYDROMECHANICAL APPROACHES

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ABSTRACT

Hydrates behave as a thermo-hydro-mechanical seal for both liquid and vapor hydrocarbons generated at great depth. The sealing efficiency of hydrates was tentatively assessed using a combined seismic and hydromechanical approach:

- Seismic-AVO (amplitude versus offset) anomalies and seismic velocities obtained beneath the base of the hydrates stable region (BSR) level or hydrates seal can help in detecting hydrocarbons (HC), evaluating the HC column height, and in some cases determining the nature of the fluid (Figure 1).

- HC accumulations depend on hydromechanical properties of the seal. The critical parameters that transiently control the maximum HC column are : the minimum principal stress (S3) at the bottom seal, the density of HC at reservoir conditions, and the hydraulic pressure regime (P) at the hydrocarbon-water interface (Figure 2). Thus, assuming reservoir hydrostatic conditions (P=Pn), the overpressure (dP) due to HC buoyancy effect cannot exceed the hydrates sealing integrity, which corresponds to a value close to the minimum effective stress (S3-Pn).

- As shown in Figure 3, the gas column height 1 is at seal capacity. When the hydrocarbon related buoyancy (dP) equilibrates, it equals the difference between the minimum principal stress (S3) and sea water pressure (Pn):

$$DP = S3\text{-}Pn$$

The results of a study carried out on the South American deep offshore margin led to the following conclusions:

- Hydrocarbon columns encountered within different reservoir layers are 300 to 350 m high.

- The hydrocarbon corresponds to a gas, with a fluid density value close to 0.25.

- The gas column height trapped beneath the BSR corresponds to a maximum with regards to the hydrates sealing integrity at such a depth. That provides a better quantitative estimate of the hydrocarbon maximum potential to be trapped by the hydrates seal.

- Combined AVO and hydromechanical approaches help discriminate the nature of hydrocarbon accumulations.

- The fact that the trapping potential of hydrates increases with sea floor deepening constitutes an encouraging factor for the hydrocarbon exploration in ultra deep offshore areas.

The methodology and conclusions in this study dealing with hydrate sealing efficiency problems can be applied in any offshore area.

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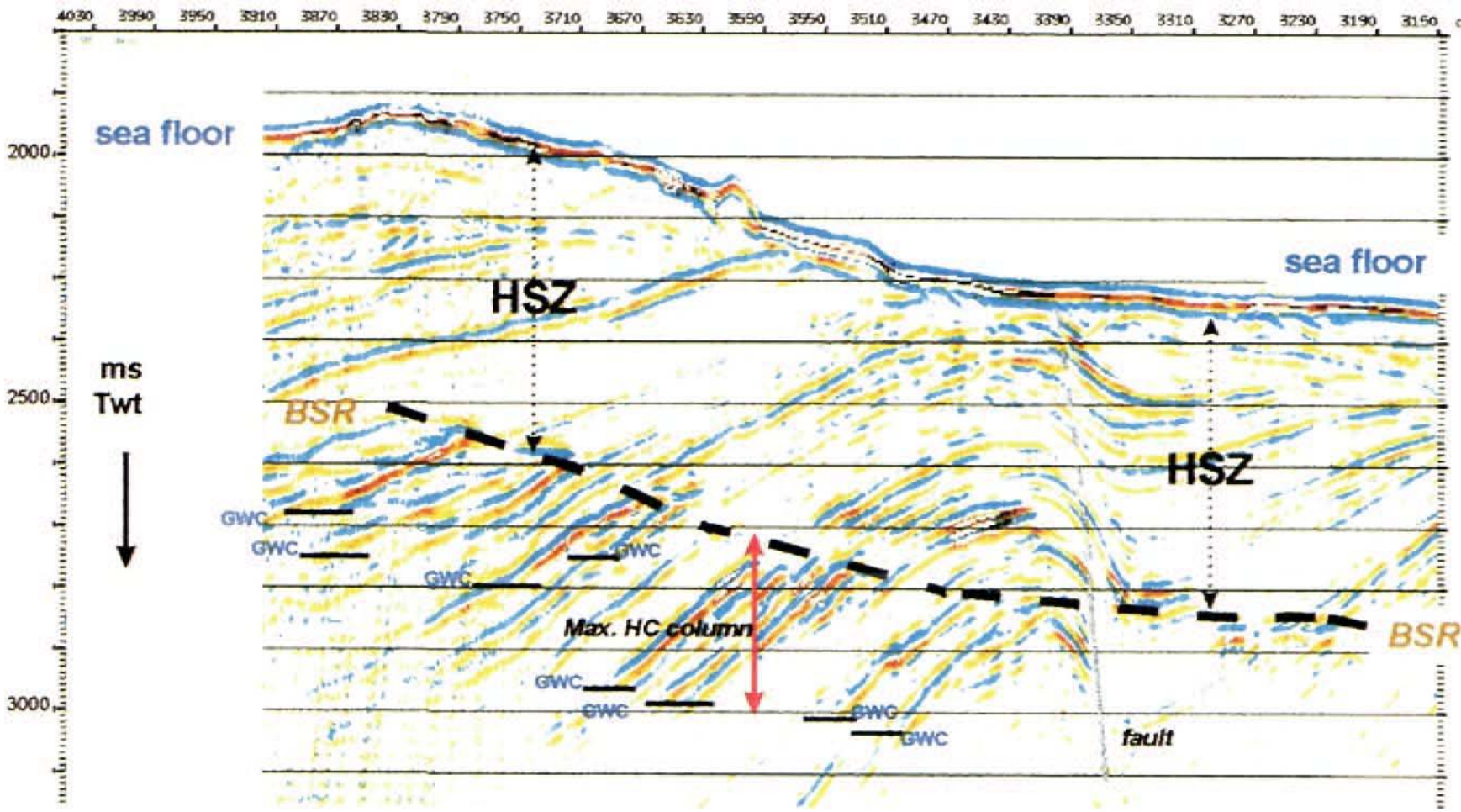

FIGURE 1 : Gas related amplitude vs offset (AVO) anomalies beneath the hydrate stability zone (HSZ). BSR marks the base of the hydrates stable region. The gas column reaches a maximum of 320 ms two way time.

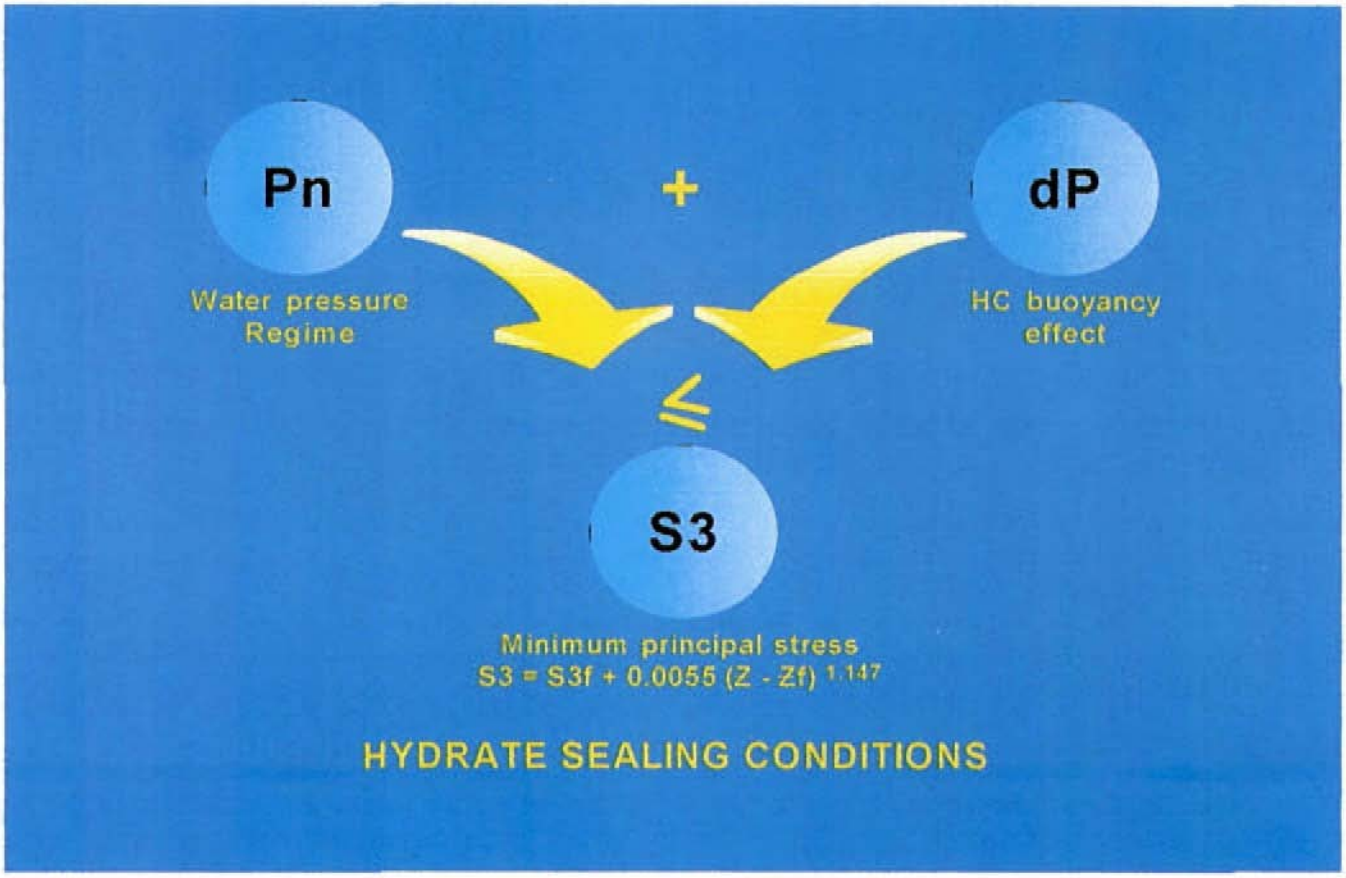

FIGURE 2 : Hydrate sealing conditions.

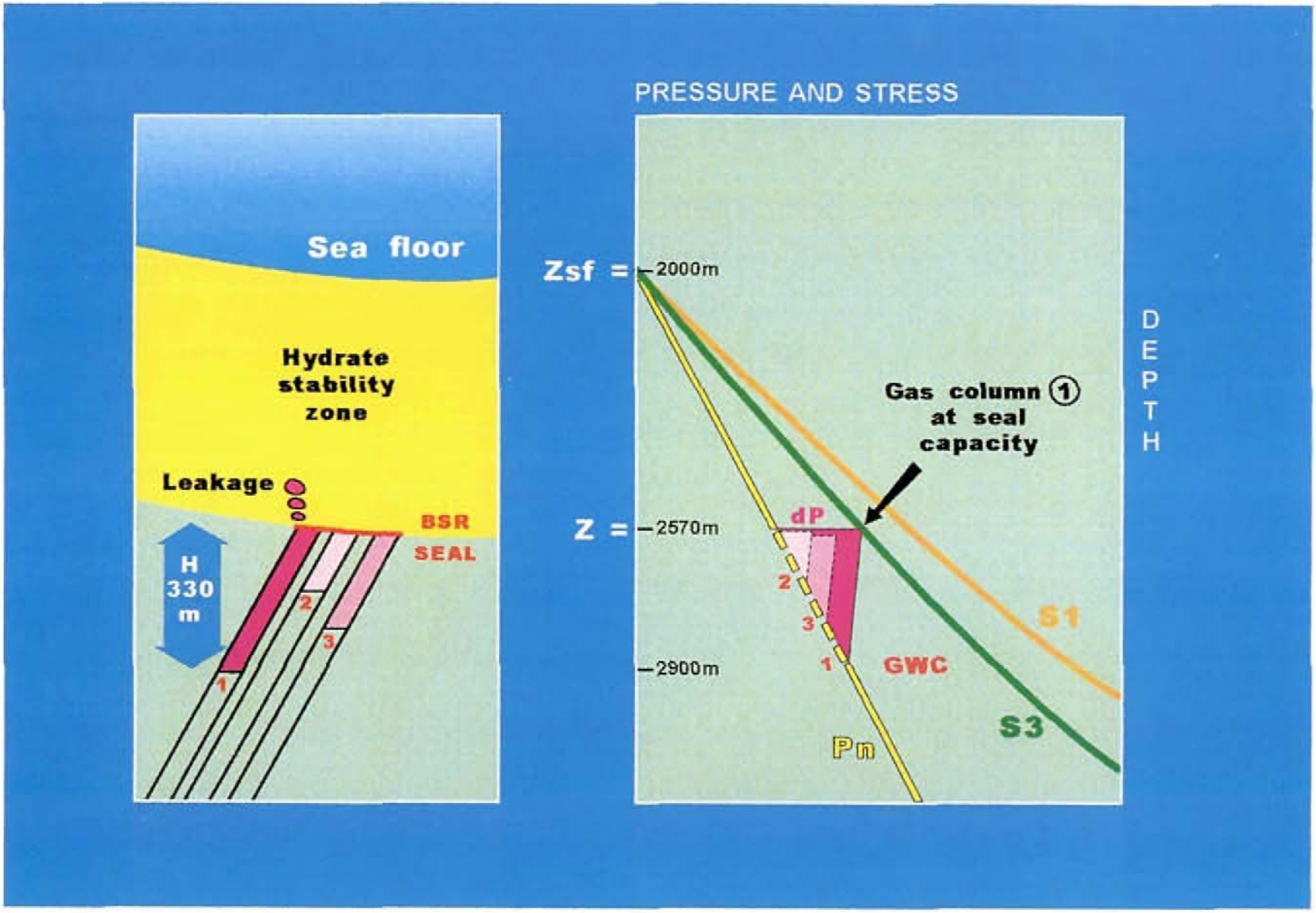

FIGURE 3 : Gas column beneath a hydrate seal. dP = Hydrocarbon related buoyancy, S3 = minimum principal stress, and Pn = sea water pressure.