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Gas hydrates and possible environmental risks offshore South Chile

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Gas hydrates and free gas presence was detected within marine sediments, offshore South Chile, by using seismic analysis. We analysed dataset located offshore South Chile; in particular, two seismic lines were analysed. The first one is located in the northern sector offshore Arauco (38°S) and the second one located in the southern sector offshore Coyhaique (44°S).We used the pre-stack depth migration method (Kirchhoff algorithm) to obtain an accurate velocity model and the real geometry of the Bottom Simulating Reflector (BSR), representing the base of the gas hydrate layer. The velocity was determined analysing iteratively the Common Image Gathers (CIGs) by using Seismic Unix and home code created ad hoc to convert the non-flatness of the reflections in the CIGs into velocity error. Moreover, we converted the final velocity model in terms of gas hydrate and free gas concentrations by using the modified Biot's theory, in which we compared the final velocity model with a theoretical model in absence of gas. Thus, the positive velocity anomalies were associated to gas hydrate presence, while the negative velocity anomalies were associated to free gas presence. In addition, the geothermal gradient was estimated by BSR and seafloor depths and relative BSR amplitude were calculated to correlate the hydrate/free gas concentration to the BSR characteristic.

The velocity model allowed us to detect the hydrate layer above the bottom simulating reflector, and the free gas layer below it. The velocity field is affected by strong lateral variation, showing maximum and minimum values in the southern sector.

In the southern sector, the highest gas hydrate and free gas concentrations are detected (23% and 2.4% of total volume respectively), even if the high velocity can be partially caused by overcompaction. Here, the BSR depth varies from 250 meter below seafloor (in the middle of the accretionary prism) to 130 meter below seafloor (in the structural high), reaching its maximum (330 m) in the fore-arc basin. This depth variability is partially due to the different water depth and partially to the variable geothermal gradient, from 35 to 95° C/km, caused by fluid migration that modifies the gas hydrate stability field.

In the northern sector, the highest gas hydrate and free gas concentrations are of 7% and 0.2% of total volume respectively, and the geothermal gradient results quite uniform and equal to 30° C/km.

Here, where the BSR is present, the BSR depth reaches 500 meters below seafloor. The higher BSR depth with respect to the southern sector can be justified by the high water depth and the presence of a lower geothermal gradient (about 30° C/km).

So, the potentiality of southern margin of the Chile, from the gas hydrate point of view, is important in first approximation.

Finally, it is worth to mention that, in our study area the presence of high amount of gas hydrate can involve environmental risks. For example a possible strong earthquake could generate anomalous sea waves, which represent important geohazard for human activities along the coasts. On the other hand, an earthquake can destabilise hydrates, amplifying the geohazard phenomena. Moreover, the high amount of the free gas, presumably in overpressure condition and present in correspondence of the structural high in the southern sector, could be abruptly released and trigger submarine slides toward the sides of the structural high, inducing hydrate instability. These scenarios should be taking in account in the environmental studies in this part of the Chilean margin.