All about gas hydrates and heat flow offshore Chile

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From a geological point of view, Chile lies in an incomparable area of the globe, which include four tectonic plates moving against (Nazca, Antarctic, South American and Scotia plates), two triple junctions (Chile and Fuegian triple junctions), numerous mega-earthquakes and tsunami-related, more than 500 active volcanoes, the Andes, and several mineral resources. One of the last natural resources where the Chilean government and institutions have focused on is in gas hydrate, which is a solid ice-like form of water that contains gas molecules highly-concentrated in methane. Since Chile import most of its gas budget, hence the discovery of this new resource open a new window for the national economy, but also for geosciences, due to methane that escapes from sediments and enter to the ocean or even reach the atmosphere could pose a great environmental threat. To identify the presence of hydrates, in this thesis it was used the bottom-simulating reflector BSR, which has the half amplitude and opposite polarity relative to the seafloor.

Moreover, fluids play a key role in the nucleation and rupture propagation of earthquakes in convergent margins, since are a major agent of advective heat transfer from depth to the Earth’ s surface. If provide enough information for the regional heat flow we will improve our knowledge of these violent shakes of plate motion. For this purpose, it is crucial to know the BSR-depth, which serves to calculate the steady-state heat flow q (mW m^{-2}), and therefore, the heat flow can be envisaged in a regional overview.

This work aims to investigate the tectonic processes of the Chilean forearc through the calculation of the regional BSR-derived heat flow, identification of fluid escape sites, description of the distribution of gas hydrates and estimation of the gas hydrate and free gas reservoirs .

One of the major results is the regional overview of the thermal regime and BSR-based gas hydrate distribution along the Chilean forearc. Here, the BSR was identified into the marine sediments mainly along the accretionary prism between 33˚-57˚S, around 2000 m water depth, and between 90-600 m below seafloor. The heat flow estimated through the forearc on the upper and middle continental slope, from Valparaiso to Chiloe (33˚-43˚S), shows common values of heat flow for the continental basement and overlying slope sediments. However, on the lower slope of the actively deforming accretionary wedge, some places show unexpected values, which indicates that advecting pore fluids from deeper may transport a considerable part of the heat there.

Southern, a second approach was made over a large area of extremely anomalous heat flow that is associated with a major tectonic feature: the Chile Triple Junction. In this unusual place, the Nazca, Antarctic and South American plate converge in a common point; while an active spreading centre (the Chile Rise) is subducting beneath the continental plate. Here, gas hydrates are located in very shallow sediments and the extreme values of heat flow estimated (<280 mW m^{-2}) indicate that the overriding South American Plate is effectively heated by subjacent zero-age oceanic plate material. In order to improve the understanding of the geological risk, in case the methane is released to the ocean/atmosphere system, it was estimated the concentration of gas hydrate in this particular region.

Finally, in the southernmost tip of the continent (offshore Patagonia), the heat flow estimated once again shows a range of values typical for subduction zones of oceanic crust older than 10 Ma. Here, a high concentration of methane hydrate is present beneath the active margin. The average thickness of the gas hydrate layer modelled is almost 300 m and the volume of methane estimated is more than $3x10^{13}$ m^3 at standard pressure-temperature conditions, concluding that the active forearc of the Chilean Patagonia is an important reservoir of methane hydrates.

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