

2.2. The submarine geomorphology of the Chilean Patagonian fjords and piedmonts

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Information about the submarine geomorphology of the austral region was obtained by analyzing records from a sub bottom profiler. The characteristics of the longitudinal profiles of the fjords and the longitudinal depression or fracture have been published for the area between Puerto Montt and Laguna San Rafael (northern zone) and from Golfo de Penas to Strait of Magellan (central zone), along with preliminary information on the submarine piedmont of Chiloé (Araya-Vergara, 1997, 1998, 1999a, 1999b). A longitudinal profile of the Strait of Magellan (Araya-Vergara, 2001) and the characteristics of submarine piedmonts (Araya-Vergara, 2000a) between Strait of Magellan and Cape Horn (southern zone) have also been published.

The specific information on this austral area revealed the genetic importance of submarine moraines (morainal banks) in fjords (Araya-Vergara, 2000b) and uncovered the possibility of a submarine glacial phase in the western part of the Strait of Magellan (Araya-Vergara, 2003). The objective of this work was to present a simplified, preliminary generalization of the information obtained for Western Patagonia.

The material presented herein was obtained during the CIMAR 1 to 3 Fjords cruises in the northern, central, and southern zones (Fig. 1). The use of these divisions is justified since each area presents substantial differences in the type of bottom landforms observed in the submarine profiles of the fjords and piedmonts. The profiles for each zone were compared, considering the acoustic nature of the features presented by the depositional landforms and their relative combinations; the echograms were obtained using the same instrument and procedures in all three zones.

In the northern zone, the sediments at the bottom of the fjord basins had a laminar structure

(rhythmites). Morphologically, these are very flat esplanades produced by the ponding of the sedimentation (Figs. 1 and 2). In some exceptional cases, these so-called ponding esplanades are found alternated with submarine moraines.

The most typical aspect of the central zone is a characteristic duality of shapes resulting from the presence of ponding esplanades with rhythmites or horizontal laminated layers of sediments alternating with submarine moraines, known as morainal banks (Figs. 1 and 3). The stratigraphic analysis shows that the sets of laminated layers making up the plains were formed at the expense of the chaotic sediments of the morainal banks. These banks are only present in the deepest troughs of the fjords and the corresponding sedimentary structures are subterraneously visible up to 100 m beneath the present bottom.

In the southern zone, the fjords are relatively shallow; in general, they are the most shallow in the entire austral area (Figs. 1 and 4), which is consistent with the absence or scarcity of depositional shapes observed on the bottom. The western section of the Strait of Magellan, however, is an exception, suggesting that this area acted as a fjord during the late stage of the Last Glaciation. Here, as in the central zone, the deepest part (even beyond 1000 m) has gigantic morainal banks alternating with ponding esplanades. The corresponding subterraneous sedimentary structures can be observed to beyond 100 m beneath the present bottom.

In conjunction with the fjord areas, glacial-originated submarine piedmonts indicate a lobular expansion of ice as it exited the mountain valleys (Figs. 1 and 4). Two categories of piedmonts, both prototypes, have been identified in this area: those from Chiloé and those from Magallanes.

Figure 1: Geographic location of Fiordo Aysén, Canal Baker, and the Strait of Magellan sections used as examples of the sub bottom fjord and Patagonian piedmont structures.

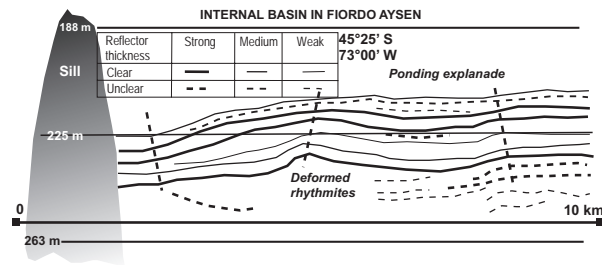


Figure 2: Fiordo Aysén in North Patagonia, an example of the sub bottom structure of a ponding esplanade. The total thickness of all the laminated layers is unknown. Vertical scale magnified x 50.

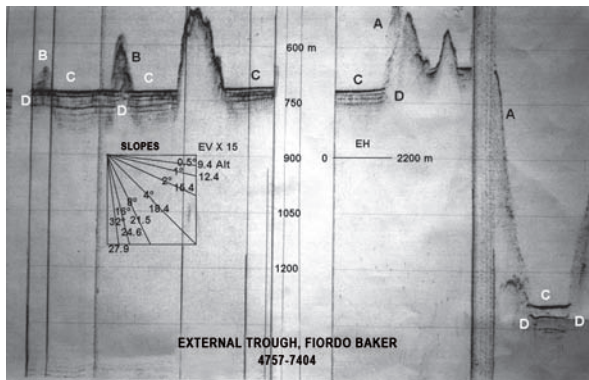


Figure 3: Section of the external zone of Canal Baker. A: Morainal bank on the slope of a rocky sill, B: morainal bank interrupting the continuity of the ponding esplanade, C: ponding esplanade, D: interstratification between the chaotic material of the morainal bank and the rhythmites of the esplanade.

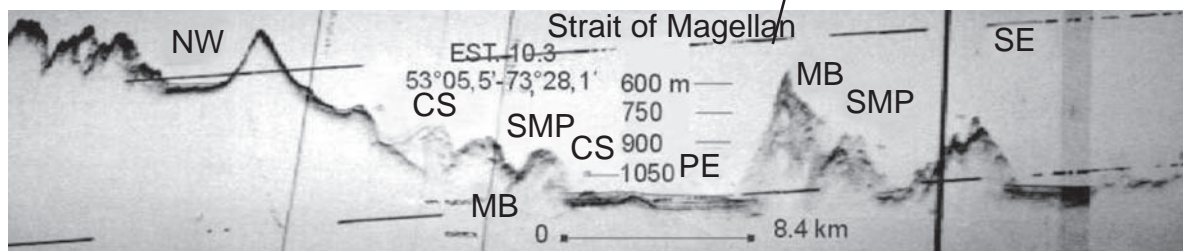
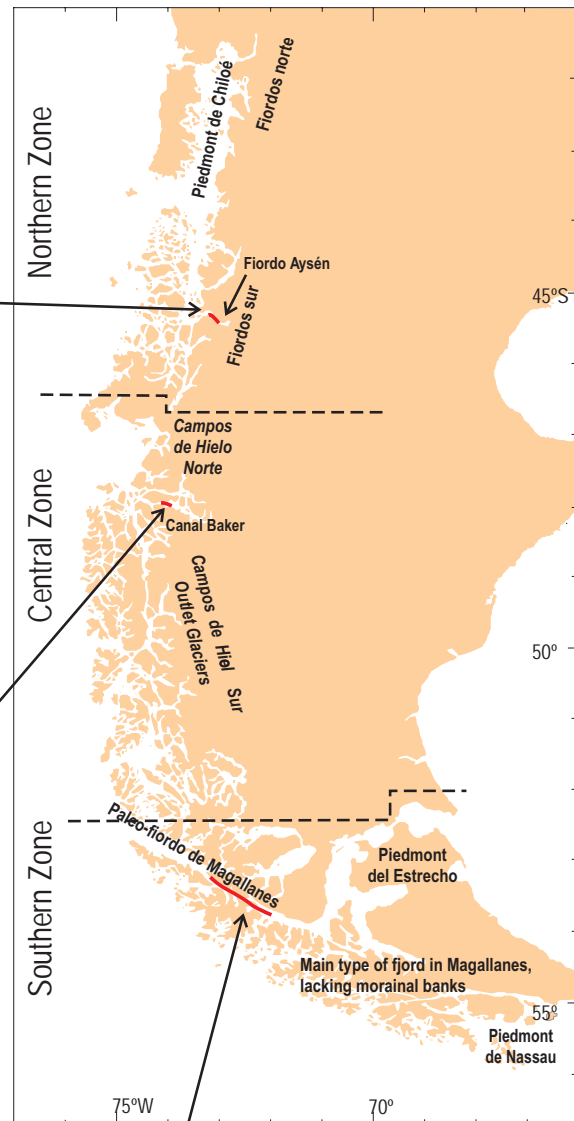


Figure 4: Acoustic section of the western part of the Strait of Magellan, Bahía Upright, and Golfo Xaultegua. Vertical scale magnified x 9. MB: morainal bank with chaotic material, SMP: slopes formed by multiple pulses due to successive dumping of glacial sediments, CS: convex slopes due to important dumpings, PE: ponding esplanade composed of rhythmites interstratified with the chaotic material of the morainal banks.

The Chiloé piedmonts extend into the interior waters of Isla Chiloé and present two types of zones: a) a basement zone, or sunken rock platform and b) a zone with varied submarine depositional shapes, probably related to the operation of glacial lobes during the Last Glaciation. These are terraces, deltas, and possibly moraines, related to thick sedimentary deposits. The terraces are more dissected to the north and better preserved to the south.

The piedmonts from Magallanes also have two zones: a) an internal zone, with features indicating that the zone was subglacial in the last maxima of the Last Glaciation and b) an external zone, which appears to have been subaerial during the same age. The bottoms of the piedmonts are slightly uneven and have thin sedimentary covers. Clearly, the Magallanes and the Chiloé piedmonts are very different in structure and morphology.

The ^{14}C dating of sediment cores obtained during the R/V Polar Duke cruise (Levender et al., 1995) from some ponding esplanade sites related to moraine banks (Fig. 4), indicate that these subbottoms must have begun to form before the end of the Last Glaciation (Araya-Vergara, 2003). The ages of the surface layers show that the process also continued during the Holocene. In addition, ^{210}Pb dating demonstrated that sedimentation in the fjords of the northern zone has continued until at least the last century (Salamanca, 2003).

The formation of the submarine depositional landforms has lasted at least from the Last Glaciation, with the construction of morainal banks and the consequent uninterrupted embanking of the ponding esplanades. All these processes have been discussed in studies carried out in the austral channels (Araya-Vergara, 1997, 1998, 1999a, 1999b, 2000a, 2001, 2003).

It would be interesting to elucidate the causes of the interregional differences occurring in the fjord bottoms and piedmonts of the three zones studied herein. This could be done by focusing on zonal differentiation and applying a temporal-spatial analysis, which would require a more elaborate study.

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