GEBRA-MAGIA Complex. Recent Mass-transport processes affecting the central Bransfield basin (Antarctica)

GEBRA-MAGIA Complex. Procesos de inestabilidad sedimentaria reciente en la Cuenca de Bransfield (Antártida)

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Abstract: The GEBRA-MAGIA complex is an important example of submarine mass-movement located in the lower continental slope of the the Central Bransfield Basin (CBB) in the Antarctic Peninsula. Based on the identification of the main features, repeated slope failures are inferred to have affected the area configuring the GEBRA-MAGIA complex. It is therefore classified as a mass-movement composite that has contributed to the outbuilding of the lower continental slope by merging different mass-transport deposits.

This complex is composed of the GEBRA valley to the east and an irregular area to the west (MAGIA area) where numerous instability features affect the seafloor. The GEBRA valley has been defined as a Quaternary Debris valley formed as a result of repeated large-scale mass transport processes. This evolution has determined its striking relief and the architecture of this part of the continental slope. Although sedimentary instabilities are also the main processes, in the case of the adjacent area of MAGIA, the resulting sedimentary architecture and morphology are completely different. The new data recorded in the poorly known area of MAGIA allowed defining the occurrence of flows intercalated with mass transport of diverse magnitude as the main recent processes along the whole GEBRA-MAGIA complex.

Key words: Antarctic Peninsula; morphosedimentary features; submarine mass movements

Resumen: *El complejo GEBRA-MAGIA es un significativo ejemplo de procesos de inestabilidad sedimentaria submarina que se localiza en el talud continental inferior de la Península Antártica, en la Cuenca de Bransfield central (CBB). La identificación de sus principales características morfosedimentarias, permite inferir que el complejo GEBRA-MAGIA ha sido configurado por la combinación de diferentes depósitos de transporte en masa que se han repetido a través del tiempo contribuyendo a la evolución del talud continental.*

El valle GEBRA se ha definido como un valle Cuaternario formado como resultado de repetidos procesos de inestabilidad a gran escala. Esta evolución ha determinado su marcada morfología así como la arquitectura sedimentaria de esta parte del talud continental. Aunque las inestabilidades sedimentarias son también los principales procesos, en la zona adyacente de MAGIA, la arquitectura y la morfología resultantes son completamente diferentes. Nuevos datos registrados en la escasamente conocida zona de MAGIA han permitido definir que los principales procesos recientes a lo largo de todo el complejo GEBRA-MAGIA son la ocurrencia de flujos gravitativos intercalados con procesos de transporte de masa de diversa magnitud.

Palabras clave: *Península Antártica; Característica morfosedimentarias; Inestabilidades submarinas*

INTRODUCTION

Submarine mass-movement is characteristic process described on high latitude margins. The interplay of repeated advance and retreat of grounded ice, oceanographic, glacigenic and tectonic processes make gravitational instability a common process. In the particular case of Antarctica continental margins, there are some important examples, some of them well-documented like the case of the GEBRA Debris Valley, located in the lower continental slope of the Antarctica Peninsula in the Central Bransfield Basin-CBB. The GEBRA valley has been defined as a Quaternary Debris valley formed as a result of repeated large-scale mass transport processes (Imbo et al., 2003;

Casas et al., 2013). This feature is included in the so-called GEBRA-MAGIA complex formed by the GEBRA valley itself and another valley–shaped feature, MAGIA, defined as well as a large area of mass wasting deposits (Garcia et al., 2008; Figure1). New data recorded around the MAGIA area allow the characterization of the main recent sedimentary processes affecting this area of the continental margin of the Antarctic Peninsula.

METHODS

This work is based on high-resolution bathymetry (Simrad EM12 multibeam echosounder) and seismic records (TOPAS-Topographic PArametric Sonar). The main data were collected during the R/V Hesperides MAGIA and SCAN-2013 Cruises.

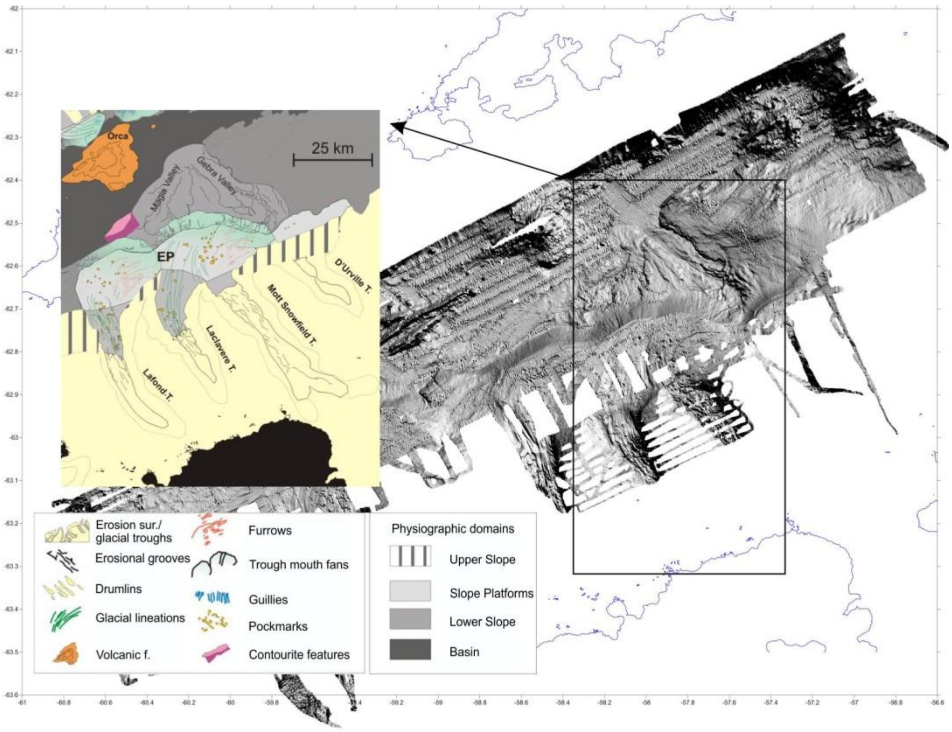

FIGURE 1. General bathymetry of Bransfield Basin and morphological map of the study area (modified from Garcia et al. 2008).

MORPHOSEDIMENTARY CHARACTERIZATION

The GEBRA-MAGIA complex can be defined as sedimentary instability complex that includes first order features (scars, mass transport deposits and channel) and second-order features (secondary scars, minor channels and escarpments).

The Gebra Valley displays a NW-SE trend, is about 31 km long and 7 to 10 km wide, and extends from 750 to 1930 m water depth, disappearing sharply when it goes into the King George Basin. The valley covers an area of about 230 km^2 (Imbo et al. 2003). It comprises three main morphosedimentary domains: the *headwall*, the *sidewall* and the *valley floor*. The headwall domain is characterized by a complex amphitheatre-shaped geometry formed by two main subparallel systems: the upper and lower headwalls, which are connected by an eastern sidewall (Figure 2). The sidewall domain is 27 km long, with an average slope gradient of 16° for the western side and 20° for the eastern side. Both sides have a relief of about 150 m and a terrace-like topographic profile. The valley floor domain can be divided into the proximal course (1600 - 1650 mwd), the middle (to 1750 mwd) and the distal course (to 1930 mwd). The floor of the proximal course is highly irregular and displays laterally variable cross-section profiles. In contrast, the middle course is characterized by a less irregular convex-up floor that becomes smoother towards the distal course.

The MAGIA area is defined as a landslide features composite covering an area of about 348 km^2. The system displays a SW-NE trend, is about 27 km long and 18 km wide, and extends from 900 to 1915 m water depth. A set of individual seaward-concave scars, with a SW/W-NE/E trend, are affecting the lower continental slope of the Antarctica Peninsula at different depths, between 900 and 1700 m (Figure 2). These scars have lengths of 3 to 10 km, a relief of 37 to 150 m and slope gradients up to 24°. The seafloor area surrounding the scars is irregular, being characterized by a combination of linear to slightly sinuous positive and negative features of hundred metres in scale. These features are interpreted as minor-scale scars and gullies.

Downslope from the scars the seafloor is highly irregular and displays laterally variable cross-section profiles, shaping terraced and mounded bulge geometries. A linear to slightly sinuous negative relief feature (25 km long and 1 to 4 km wide) with oblique trend to the slope is also observed in this area. This feature has an asymmetric cross section and is interpreted as a channel, named hereafter MAGIA channel (Figure 2).

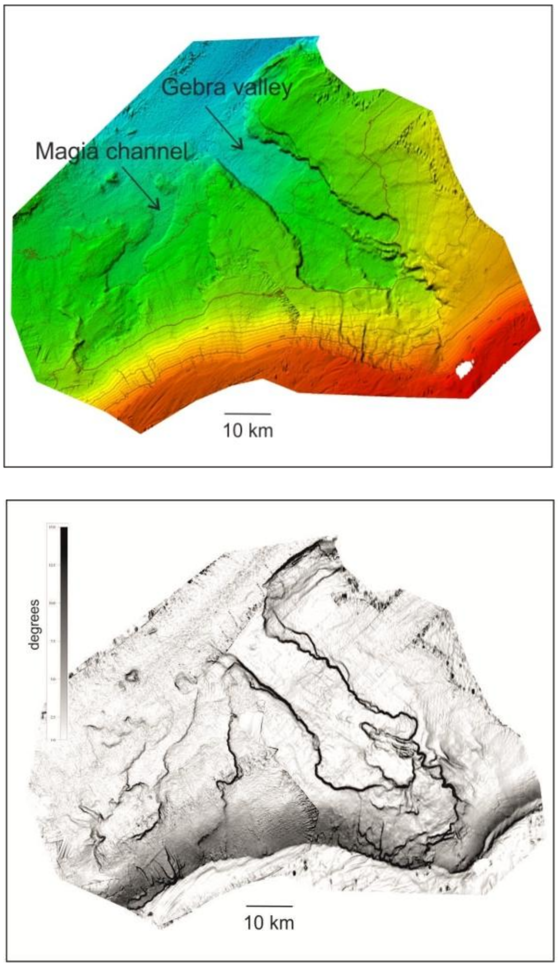

FIGURE 2. *Maps showing the main Gebra-Magia complex features. Its plan-view morphology is clearly defined by NW-SE trend valley of Gebra and by the landslide features composite* of MAGIA.

The near-surface sediments of the upper and middle courses of GEBRA comprise irregular/lenticular bodies that are 10 to 55 ms thick and 2 to 10 km long, internally defined by transparent facies with hyperbolic echoes which can be associated with mass-transport deposits. Locally, the bodies are draped by irregular stratified deposits (25 ms thickness) that may be interpreted as turbidites (Figure 3). These turbidites are locally disrupted and contorted, forming seafloor irregularities that mimic the underlying irregular topography. Toward the distal course, near-surface sediments are defined by parallel/subparallel stratified facies alternating with laterally continuous beds with transparent facies (i.e., mass-flow deposits).

The MAGIA channel seafloor is acoustically characterized by sub-bottom parallel reflections (7 to 11 ms thickness) that can be interpreted also as turbidites (Figure 4). The near-surface sediments for the rest of area comprise irregular/lenticular bodies that are 25 to 36 ms thick and 2 to 8 km long, internally defined by semi-transparent facies which can be associated with mass-transport deposits. These deposits are draped by irregular stratified deposits (7 ms thickness) interpreted as turbidites.

Gebra valley and Magia channel features are flanked by asymmetric, open-slope margins (Figure 2 & 3). The margin that separates them is characterised by sub-bottom parallel reflections of high lateral continuity and high amplitude, interstratified with extensive/lenticular levels (<25 ms thickness) of semi-transparent sediments.

DISCUSSION AND CONCLUSIONS

The Gebra Valley was defined by Casas et al., 2013 as the result of repeated large-scale slope failures during the Plio-Quaternary. Large-scale landslides that have determined the morphology (striking relief of the valley) and governed the architecture of this part of the continental slope.

Evolution of the adjacent area of MAGIA results in a different sedimentary architecture and morphology although sedimentary instabilities are also the main processes. The first-order scars affecting the lower continental slope configure a domain acting as source area for the observed mass-movement deposits. This means that near-surface sediments in this domain are unstable and several mass-movements have been triggered during different periods of time. Mounded geometries and sediment ridges below the headwall area, which are visible on both seismic and bathymetry data, are failured sediments from further upslope that contribute to the highly irregular relief observed.

Contrary to the Gebra valley, the irregular to slightly sinuous relief of MAGIA channel points out to its origin as a product of the highly irregular/chaotic seafloor geometry. The deposition of different mass-transport deposits along the area, with different run out distances favoured the negative relief defining the channel. This relief is used by flows as an evacuation pathway evolving to a channel structure.

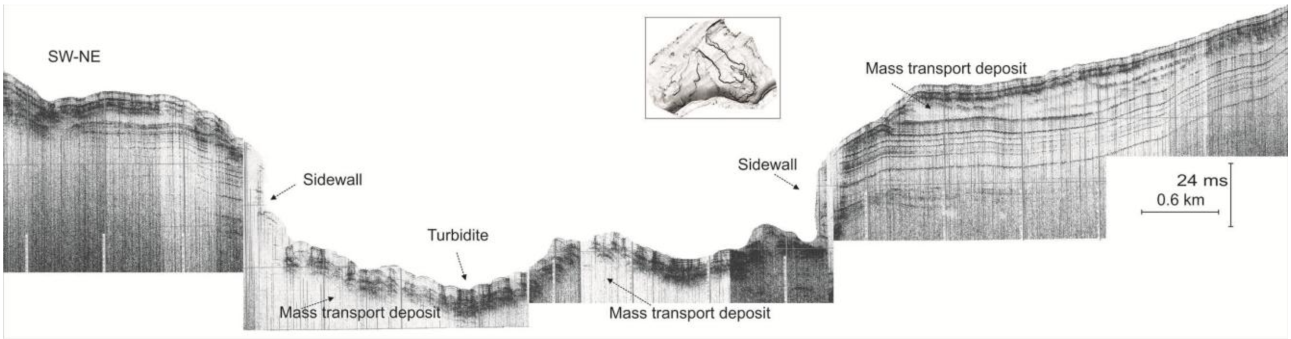

FIGURE 3. *TOPAS seismic record displaying the open slope margins truncated by de sidewalls of Gebra. The nearsurface sediments comprise several bodies which can be associated to mass-transport deposits that locally are draped by turbidites. Modified from Casas et al. 2013.*

The near-surface sediments defining the GEBRA-MAGIA complex, including the open slope margins, indicate the general and continuous occurrence of recent mass movements, also evidenced by flows transported downslope as unchannelized or as channelized flows (through Gebra or Magia channel).

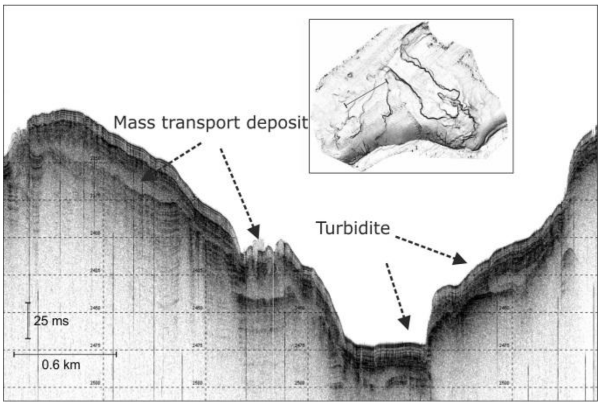

FIGURE 4. *TOPAS seismic record displaying the mass-transport deposits defining the MAGIA complex.*

The presence of stratified facies overlying or intercalated with mass transport deposits (e.g. mounds and ridges) may represent turbidity currents coming from mass-wasting processes affecting the slope but it may also represent primary deposition. Mass flows coming from the source area, may evolve to diluted mass flows or to turbidity flows running basinward, contributing to the deposition of a level of stratified turbidites that drape the near-surface floor. Turbidity flows of low and high density from glaciomarine proglacial or the continuous sediment transfer derived from large meltwater discharges over time may also contribute to the stratified deposits.

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