Antarctic Science 9 (2): 168–180 (1997)

Central and eastern Bransfield basins (Antarctica) from high-resolution swath-bathymetry data

EULÀLIA GRÀCIA[1], MIQUEL CANALS[1]*, MARCEL·LÍ FARRÀN[2], JORDI SORRIBAS[1] and RAIMON PALLÀS[1]

[1]U.A. Geociències Marines CSIC-UB, GRQ Geociències Marines, Departament de Geologia Dinàmica, Geofísica i Paleontologia, Facultat de Geologia, Universitat de Barcelona, 08028 Barcelona, Spain

[2]U.A. Geociències Marines CSIC-UB, Grup Geologia Marina, Institut de Ciències del Mar (C.S.I.C.), Passeig Joan de Borbó s/n, 08039 Barcelona, Spain

*corresponding author. e-mail: miquel@natura.geo.ub.es

Abstract: For the first time complete swath bathymetric maps of central and eastern Bransfield basins are presented at a medium scale and detailed morphological descriptions are provided. Bathymetry reveals morphological structures which provide important information about the structure, volcanism, and kinematics of these basins. The central basin is dominated by two roughly orthogonal sets of extensional faults (N065° the main set and N145° the secondary set), displays several discontinuous along-axis large volcanic cones and ridges trending about N059°, and undergoes extension roughly normal to the basin. The structure of the eastern basin has a roughly rhomboidal pattern (fault sets along N053° and N103°), displays four deep troughs and a much smaller amount of volcanism than the central basin, and is affected by extension with a significant sinistral strike-slip component.

Received 15 August 1996, accepted 15 March 1997

Key words: backarc, Bransfield Basin, morphostructure, swath-bathymetry, volcanism

Introduction

Bransfield Basin is the narrow and elongated basin separating the South Shetland Islands from the northern tip of the Antarctic Peninsula, located at the south-western end of the Scotia Arc (Fig. 1). It extends for more than 400 km from Low Island to Clarence Island, and is up to 80 km in width, between longitudes 62°–54°W, and latitudes 61°–64°S. The Bransfield Basin/northern Antarctic Peninsula area is one of the most accessible parts of Antarctica. Since the first geophysical investigations carried out in the 1970s (e.g. Ashcroft 1972), the crustal structure of this area has been extensively studied by scientists from different countries of Europe, Asia, and North and South America. Morphologically, Bransfield Basin is composed of three sub-basins, western, central and eastern, separated by the highs of Deception and Bridgeman islands (Jeffers & Anderson 1991) (Fig. 2). Bransfield Basin had not previously been mapped in detail using modern swath bathymetry systems, and only a digital compilation of pre-existing data has been published so far (Klepeis & Lawver 1994, 1996). Gràcia *et al.* (1996) described the morphostructure of the central and eastern Bransfield basins and discussed several aspects of the basin evolution based on the newly acquired, full coverage swath bathymetric data, magnetic and seismic profiles. We present for the first time the detailed bathymetric maps of the central and eastern Bransfield basins at a medium scale, showing details of the basin floor structure and volcanism which are fundamental to better understand the recent evolution of the basin.

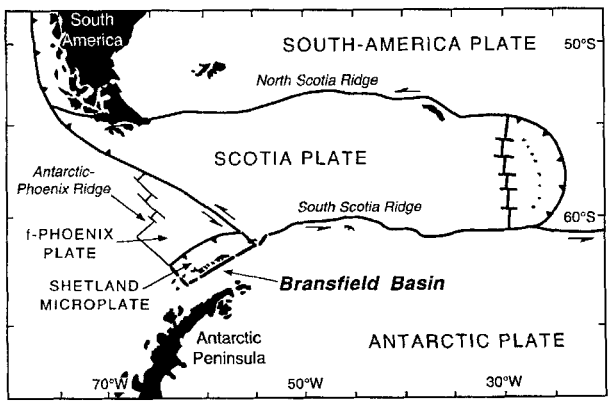


Fig. 1. Plate tectonic setting of the Scotia arc and north-west Antarctic Peninsula region. Bold lines indicate plate boundaries and triangles denote subduction zones, indicated with triangles pointing to the overriding plate. Thin lines show former plate boundaries.

Geological background

The South Shetland Islands and the northern tip of the Antarctic Peninsula (Trinity Peninsula) are part of a large Mesozoic to Cenozoic magmatic arc lying on a pre-Mesozoic continental basement (e.g. Moyes & Hamer 1983). This magmatic arc resulted from long-lived subduction of oceanic lithosphere all along the Pacific margin of Gondwana and is represented both by calc–alkaline plutonic rocks (Middle

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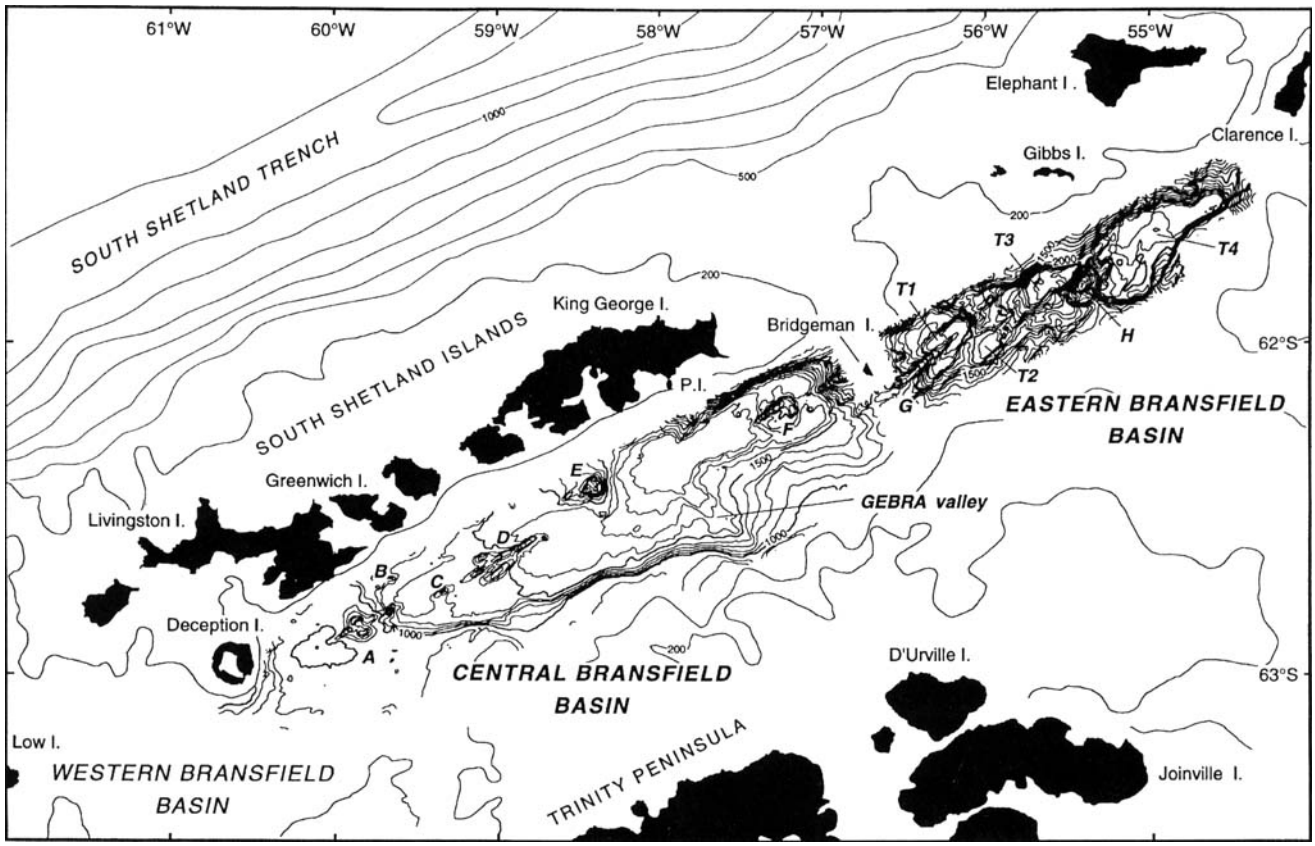


Fig. 2. Simplified bathymetric map of central and eastern Bransfield Basin to show the main features and place names. Isobath contour interval is 100 m. Edifices A to H, and troughs T1 to T4 are described in the text. P.I.= Penguin Island.

Triassic–Cenozoic, Rex 1976, Pankhurst 1982, Gledhill *et al.* 1982, Hole *et al.* 1991) and volcanic rocks (the early Jurassic–early Cenozoic Antarctic Peninsula Volcanic Group, Rex 1976, Thomson & Pankhurst 1983). Highly deformed flysh-like sedimentary successions (?Permian–Triassic, Adie 1957, Thomson 1975, Pankhurst 1983, Dalziel 1984) crop out extensively on Trinity Peninsula and locally on Livingston Island, and have generally been interpreted as deposited and/or deformed in a forearc setting (Smellie 1979, Hyden & Tanner 1981, Dalziel 1982, Smellie 1991), although deposition on a passive margin has also been suggested (Dalziel & Elliot 1973, Smellie 1987, Trouw & Pankhurst 1995). These sediments seem to have their metamorphic counterparts in Elephant and Clarence islands, where rocks have widely variable metamorphic ages (early Jurassic–Paleogene) and are considered to be deformed in an accretionary prism setting (Trouw & Pankhurst 1995). A number of sedimentary units (late Jurassic–Paleogene) crop out east and west of the Antarctic Peninsula and correspond to lateral equivalents of the Antarctic Peninsula Volcanic Group, which were deposited both in back- and fore-arc basins (Crame *et al.* 1993, Hathway & Lomas 1995, Rees & Smellie 1989, Macdonald *et al.* 1988).

Bransfield Basin is a young and active rift basin (Saunders & Tarney 1984, Fisk 1990, Grad *et al.* 1992, Lawver *et al.* 1995) that isolates the Shetland Microplate from the Antarctic Plate (Fig. 1). According to Barker (1982), Barker & Dalziel (1983), Barker *et al.* (1988), and Lawver *et al.* (1995) the opening of Bransfield Basin may be related to passive subduction of the former-Phoenix plate and rollback of the South Shetland Trench (the only remnant of the long trench that flanked the Gondwana margin of Antarctica during the Mesozoic). The timing of the initial rifting is still a point of debate. Barker (1982) and others considered that Bransfield Strait extension started about 4 m.y. ago, when accretion at the Antarctic–Phoenix spreading centre as recorded by the marine magnetic anomalies, stopped. In contrast, according to radiometric ages of extensional dykes on King George Island, Birkenmajer (1992) suggested that incipient rifting could have begun between 26 and 22 m.y. ago.

Quaternary volcanic rocks form the islands of Deception, Bridgeman and Penguin (Weaver *et al.* 1979), crop out on Livingston, Greenwich and King George islands (Smellie *et al.* 1984, Smellie 1990, Smellie *et al.* 1995), and constitute all of the dredged seamounts located between Deception and Bridgeman islands (Fisk 1990, Keller *et al.* 1994). The volcano of Deception Island has experienced several eruptions during the present century (Smellie 1990), whereas the rocks of Penguin Island are probably no older than 300 years (Birkenmajer 1980). The sampled seamounts in the basin

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yielded fresh glassy basalts which are no older than 300 Ka (Fisk 1990, Keller *et al.* 1994). The Quaternary volcanic rocks of the South Shetland Islands and Bransfield Basin, having alkaline affinities and transitional compositions between IAB and MORB, are in clear geochemical contrast with the older arc-related successions and are considered to record the transition from a subduction-driven regime to an intra-plate extensional or initial seafloor spreading regime (Smellie *et al.* 1984, Lawver *et al.* 1995).

Data

The field data described in this chapter were obtained during the GEBRA 93 cruise (Geological Evolution of the BRAnsfield), which took place between 2–24 December, 1993 aboard the Spanish RV *Hespérides*. They consist of full swath-bathymetry coverage of the central and eastern Bransfield Basin (Canals *et al.* 1994).

The bathymetric data were acquired using SIMRAD multibeam echosounders, EM-12, with 81 beams covering twice the water-depth in deep areas, and the EM-1000, with 48–60 beams covering up to seven times the water-depth in shallow areas. A full coverage of the central (10 366 km^2) and eastern Bransfield basins (3816 km^2), covering a surface of about 14 200 km^2 was produced. The bathymetric survey covers the floors of both basins with 25 and 10 shiptracks, respectively, running NE–SW with a spacing of 2.7–3.7 km. Horizontal resolution varies from *c.* 5 m for near-vertical beams to *c.* 50 m for echoes 60° from vertical and water depths of 2–6 km (Renard *et al.* 1991).

The raw bathymetric data were processed using the multibeam echosounder processing programs *Neptune* developed by SIMRAD Systems (Norway) and *TRISMUS*, developed by IFREMER (France) (Bourillet *et al.* 1996).

Description of the swath-bathymetry maps

A longitudinal bathymetric section along the axial part of central and eastern Bransfield basins shows a progressive deepening towards the north-east, with Bridgeman Island marking the boundary between the two basins (Fig. 3). Central Bransfield Basin is characterized by a smooth, step-like topography whereas the eastern basin shows both greater topographic roughness and depth. Detailed swath bathymetric maps of the central and eastern Bransfield Basin are presented in Figs 4 & 5 respectively. Both sub-basins differ greatly in size, morphology, and structure and are described separately below. Note that the following descriptions have been prepared by using maps at 1:250.000 scale, contoured at every 25 m, which give greater detail than is possible in those presented in Figs 4 & 5.

Central Bransfield Basin

The central Bransfield Basin is located between longitudes 60°30'–56°50'W, and its along-basin extent is defined by the highs of Deception Island and Bridgeman Island (Fig. 2). The basin is *c.* 30–38 km in width (areas located within the margins), *c.* 230 km long and has a maximum depth of 1950 m (Fig. 4). Three morphological domains are considered in the following description: the basin margins, the basin floor and the seamounts.

The *margins* (including the continental shelves and slopes) of central Bransfield Basin are highly asymmetric. The South Shetland margin (only partially surveyed) is narrow (from less than 6 to up to 15 km wide) and rectilinear, as is suggested by the south-eastern coast of the South Shetland Islands, and trends approximately N065° (Figs 2 & 4). The swath-band surveyed along the north-eastern edge of the bathymetric map shows that the slope is steep, up to 24° (Figs 4, 6a & 7a). In contrast, the Antarctic Peninsula shelf is wide (from *c.* 70–85 km) and the shelf break is sinuous in plan view. The slope of this margin has gentle dips, generally less than 10° and only locally up to 20° (Figs 3, 6a & 7a). To the north-east, the margin is especially wide and is rarely steeper than 10° (Fig. 7a).

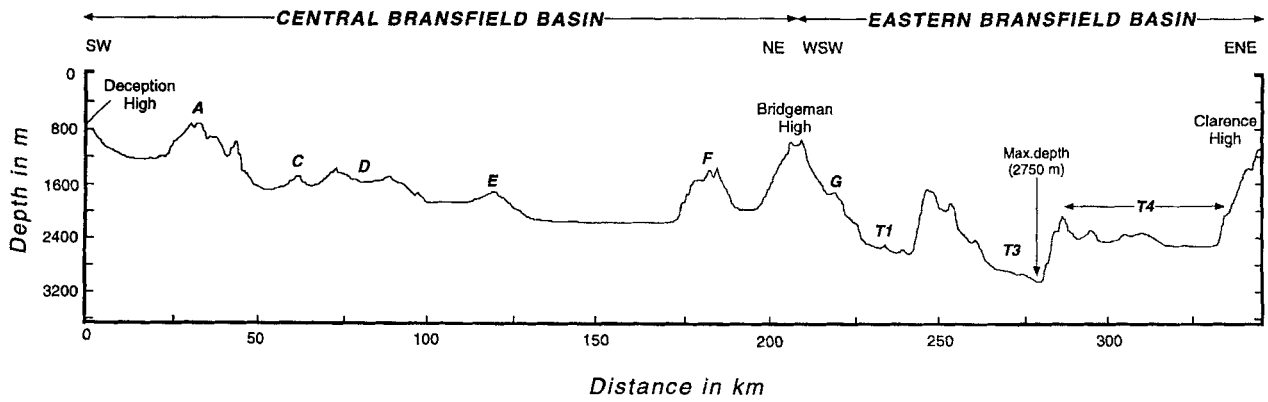


Fig. 3. Axial depth profile along the central and eastern Bransfield Basin. Edifices A, D, E, F, and G, and troughs T1, T3 and T4 are depicted. Note the rough axial topography of the eastern basin in comparison with the central Bransfield Basin. Vertical exaggeration = x20.

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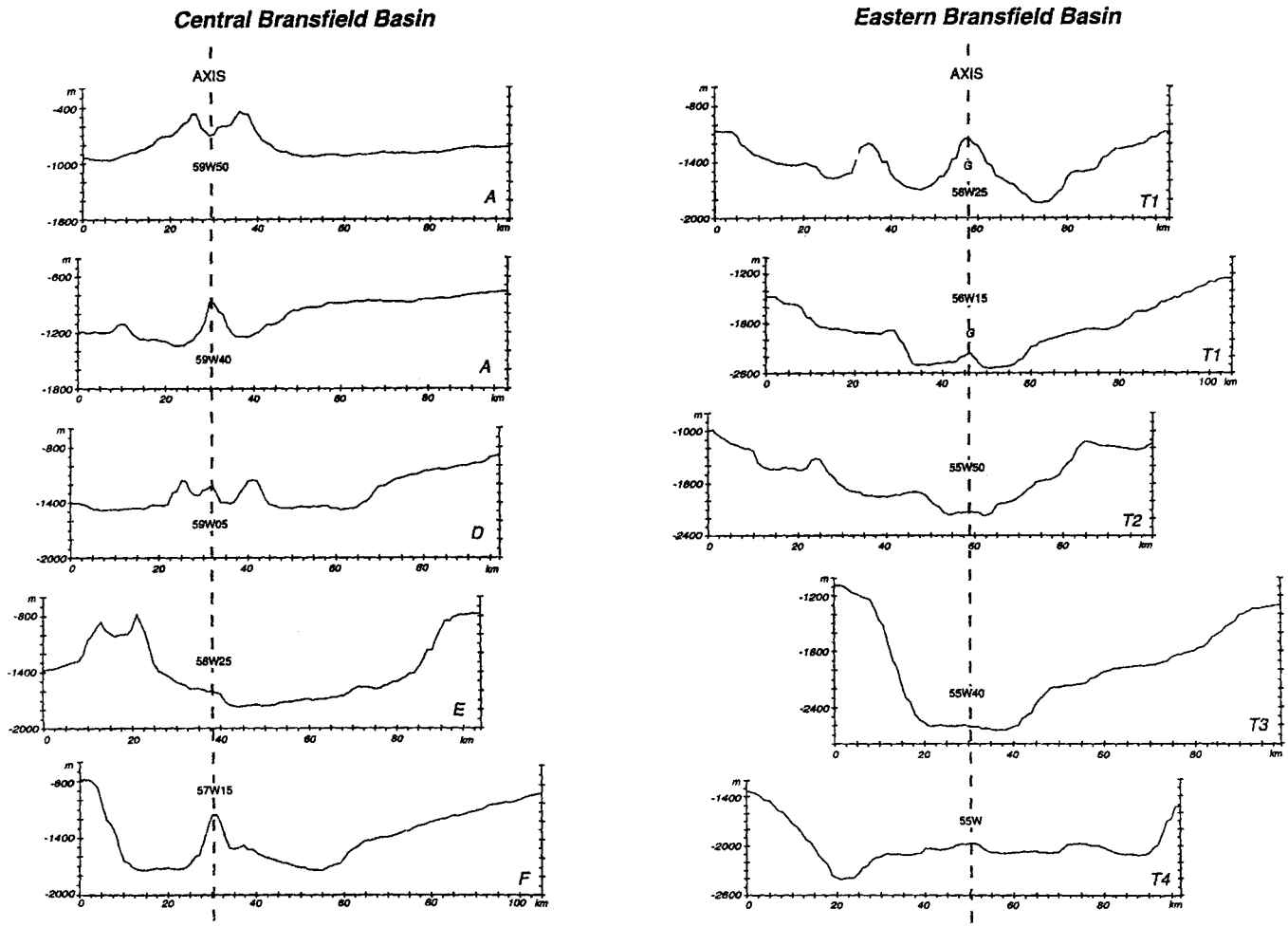


Fig. 6. Bathymetric sections across Bransfield Basin. **a.** Central Bransfield Basin; all sections are drawn along a N150° trend orthogonal to the axis. A, D, E and F correspond to volcanic edifices located on Fig. 2. **b.** Eastern Bransfield Basin; all sections are drawn following a N135-140° trend, orthogonal to the axis. T1 to T4 correspond to the troughs located on Fig. 2. Vertical exaggeration = x5.

The *floor* of the central Bransfield Basin corresponds to the area located between the foot of the South Shetland and the Antarctic Peninsula margins; it has slopes generally less than 2° and only locally up to 6° (Figs 3, 6a & 7a). There is a general deepening and widening of the basin towards the north-east. Four almost horizontal levels are distinguished on the bathymetric map (Figs 4 & 7a). They are separated by wide steps or gentle slopes transverse to the basin that trend approximately N145°. The deepest level occurs south-east of King George Island, next to the South Shetland margin, and has a maximum depth of 1950 m (Fig. 4). This portion of the basin shows almost horizontal seafloor extending over an area *c.* 10–18 km wide and 45 km long. To the south of this flat and low-lying area the basin floor rises gently (for 20–32 km) by *c.* 400–800 m to meet the base of the Antarctic Peninsula slope. Between 57°50'–57°20'W, this wide and gentle slope is cut by a rectilinear 30 km long, 4.5–6.2 km wide valley (named GEBRA valley by Canals *et al.* 1994). The flanks of this flat bottomed valley are narrow, rise up to 175 m and slope up to 12° (Figs 4 & 7a). The head of the valley is marked by a steep (up to 16°) linear scar showing a clear semicircular composite morphology. Farther upslope, towards the south-east, there is an additional but less well-defined semicircular and composite scar affecting the upper and steeper portion of the continental slope which also drains towards GEBRA valley (Figs 4 & 7a).

The most spectacular feature of central Bransfield Basin is the existence of several volcanic edifices that rise out of the seafloor (Figs 3 & 4). We have labelled six large *seamounts* A to F for ease of reference (see Fig. 2).

Seamount A is centred at 62°51'S, 60°10'W, is 550 m high (above the surrounding basin floor) and its summit lies at a depth of 350 m (Fig. 8a). It is a composite edifice with a central, 28 km long by about 2 km wide, discontinuous ridge and two flanking half cones. The central ridge is slightly curved and trends N055° to N065°. The ridge flanks and the inward slopes of the half cones are steep, up to 20°, while the outward flanks of the cones have gentler slopes, generally

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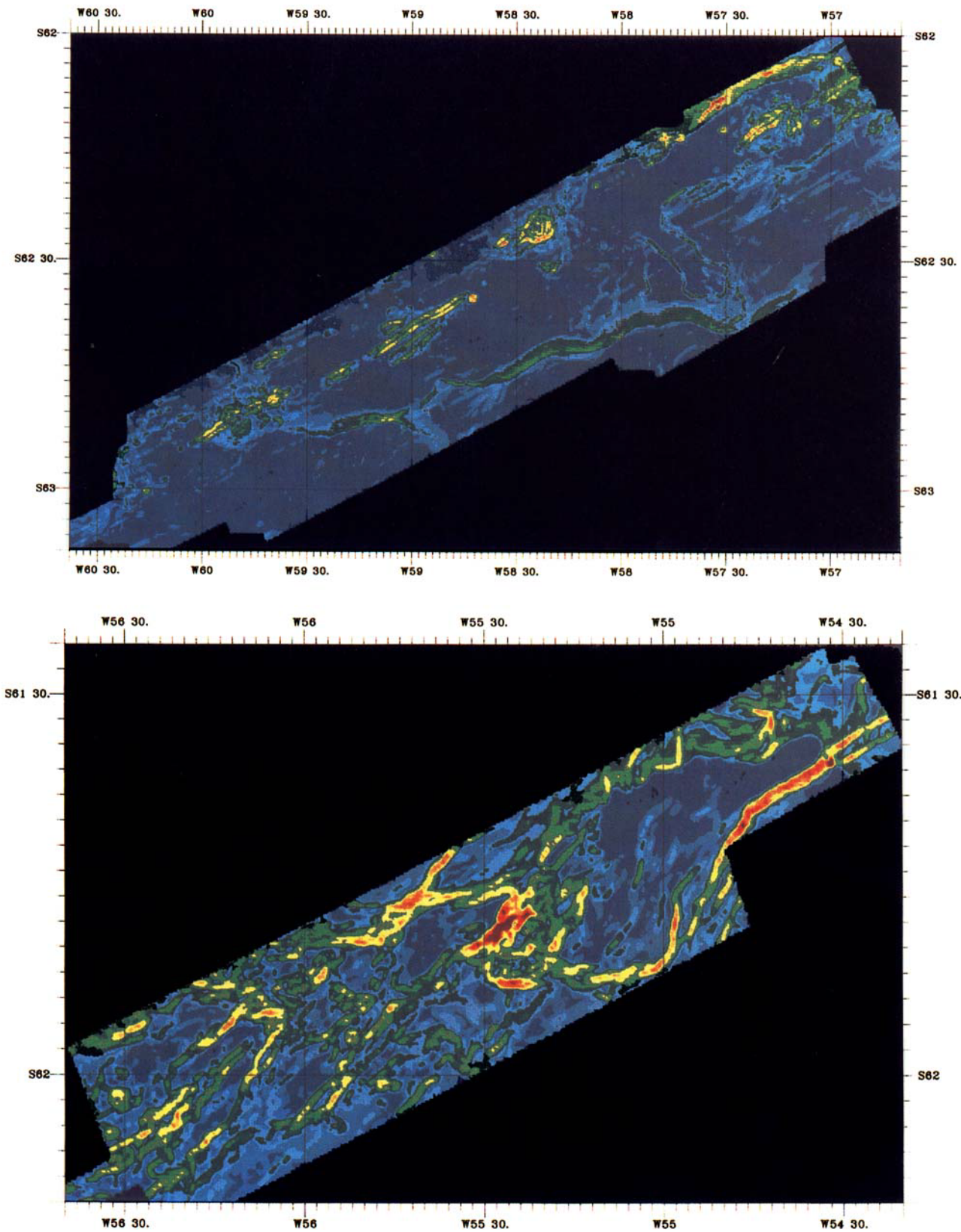


Fig. 7. Slope map of **a.** central Bransfield Basin and **b.** eastern Bransfield Basin. Same colour scale is applied to both maps. Blue colours correspond to gently slopping areas (less than 8°) whereas reds correspond to the steepest areas (more than 24° and up to 32°).

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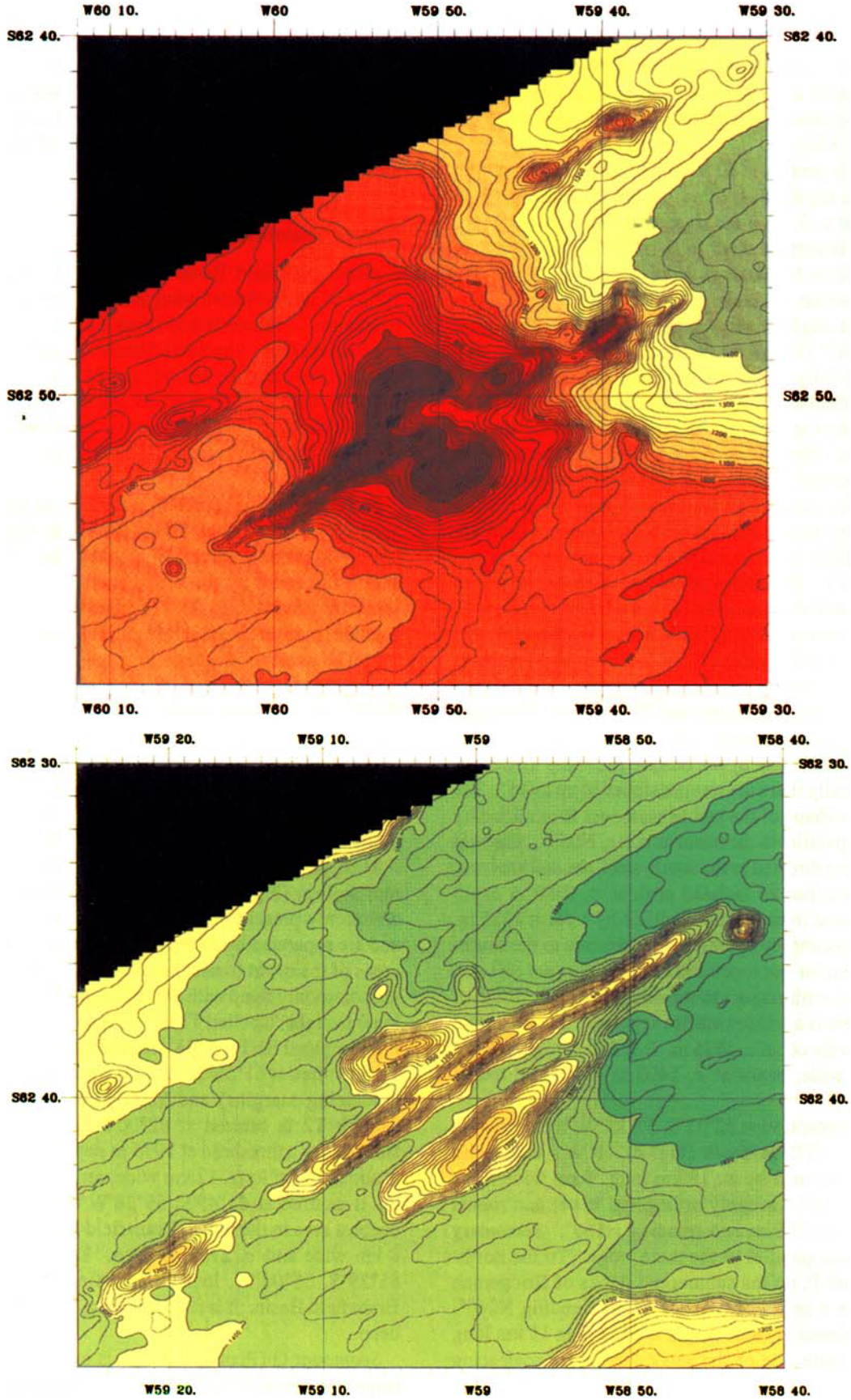


Fig. 8. Detailed bathymetric maps (25 m contour) of **a.** seamount A and **b.** seamount D (central Bransfield Basin). The same colour interval (100 m) and scale is applied to both figures. Dark green is more than 1600 m deep and brown is less than 600 m.

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less than 12°.

Seamount B is centred at 62°42'S, 59°42'W, is 325 m high and has its summit at a depth of 1050 m (Fig. 8a). It is an elongated two-peaked ridge trending N058°, and *c.* 10 km long and 3 km wide.

Seamount C is centred at 62°44'S, 59°20'W, is 250 m high with a peak at a depth of 1150 m (Fig. 8b). It is formed by a 10 km long and *c.* 3 km wide ridge that trends N059°.

Seamount D is centred at 62°38'S, 59°00'W (Fig. 8b). It is a composite edifice formed by a 31 km long and *c.* 3 km wide central ridge which is flanked by two other ridges. The central ridge is slightly curved, trends N054° (the central portion) to N061° (the eastern end). The northern flanking ridge is 7.8 km long and *c.* 3.1 km wide and trends N067°. The southern flanking ridge is 15.6 km long, 4 km wide, trends N052° and at its south-eastern end slightly divides into two ridges. The central ridge is closer to the northern than to the southern flanking ridge. The col separating the northern flanking ridge from the central ridge lies at a depth of *c.* 1300 m whereas the col separating the southern flanking ridge is at *c.* 1400 m. The flanks of the central ridge are steeper, up to 24°, than those of the northern and southern ridges. The central ridge is directly aligned withseamount C.

Seamount E is centred at 62°25'S, 58°23'W (Fig. 9a), it is approximately circular in plan view, is 550 m high, peaks at a depth of 700 m, and has a basal diameter of *c.* 11 km. It has a central crater, 3 km in diameter and 325 m deep. The crater rim is lower in the north-west, where it lies at a depth of *c.* 900 m. The outer flanks of the edifice generally slope less than 15° but locally there are steeper slopes of up to 36°. The general circular shape of the whole seamount is modified by spurs trending parallel to the basin axis at *c.* N057°. The best developed spur is directed to the south-west, about 9 km long, 2.2 km wide and has an isolated peak at *c.* 1050 m depth which is separated from the main edifice by a col at 1225 m. Other parallel secondary spurs are also directed to the south-east whereas similar but much smother features are directed to the north-east with respect to the central edifice. South of seamount E there is a smaller edifice separated from the main semount by a wide col at *c.* 1575 m. It is 300 m high, 5.5 km long, *c.* 2 km wide, peaks at *c.* 1400 m depth and trends N085°.

Seamount F is centred at 62°11'S, 57°15'W, is 550 m high and peaks at *c.* 1075 m depth (Fig. 4). It is a composite edifice, mainly formed by an 18 km long, 4 km wide ridge oriented N059° and a roughly orthogonal lower and robust ridge, peaking at 1200 m and trending N160°. Secondary spurs are present, parallel to the main ridge. To the north-east of seamount F, on the submerged flanks of Bridgeman Island there are a series of parallel ridges trending N060°. The most prominent of these ridges is more than 15 km long and is aligned with one of the secondary spurs coalescing with edifice F.

In addition, apart from the large edifices, small isolated cones occur over the basin floor (Fig. 4). They typically have highly regular rounded shapes in plan view. Their basal diameters are 2.5 km in average and their maximum heights over the surrounding seafloor are up to 400 m (e.g. the small cone south-west of seamount A, aligned with the main ridge, or the cone east of the north-eastern tip of seamount D (Figs 8a & 8b, respectively)).

Eastern Bransfield Basin

Eastern Bransfield Basin lies between longitudes 56°40'–54°20'W, and is limited along basin by the highs of Bridgeman Island and Clarence Island (Figs 2 & 5). The area enclosed between the foot of the South Shetland and Antarctic Peninsula margins has a maximum width of 24 km, is 120 km long and is deeper than 2500 m in its central part (61°47'S, 55°28'W). In the following description we consider three different domains: the basin margins, the basin floor and troughs, and the seamounts.

Eastern Bransfield Basin is limited to the north by the *margins* of the Gibbs Island-Elephant Island block, the north-easternmost extension of the South Shetland Islands, and to the south by the broad shelf north of d'Urville and Joinville islands (Fig 2). In plan view, the northern and southern margins have an irregular zig-zag pattern (Figs 5 & 7b). The trends of the lineations present along both margins are highly coincident and all of them approximate to N053°, N103° or, less commonly, N003°. The South Shetland margin slope is steep (locally up to 32°) and narrow but less linear and more irregular than its homologue in central Bransfield Basin. The Antarctic margin slope is locally much steeper (up to 34°) than in the central basin and has a much more irregular trend (Figs 5 & 7b).

Most of eastern Bransfield Basin *floor* shows stepped morphology (Fig. 6b). Gently dipping flats (less than 2°) are commonly present between the 1700 and 1900 m isobaths, and are separated by a step from the inner troughs or deepest areas of the basin (more than 2000 m). These steps or walls are commonly steep with dips of up to 70° (Figs 6b & 7b). The inner troughs, labelled T1 to T4 for ease of reference (Fig. 2), are elongated ENE–WSW and arranged *en echelon*. Trough T1 is centred at 61°59'S, 56°14'W, is 20 km long, 10 km wide (excluding margins) and 2300 m deep (Figs 6b and 9b). Trough T2 is centred at 62°00'S, 55°59'W and separated from T1 by a threshold at 1975 m depth (Fig. 5). The trough is about 24 km long, 12 km wide, and 2175 m deep. Trough T3 is centred at 61°49'S, 55°38'W and corresponds to the deepest area in the whole Bransfield Basin. It is 18 km long, 8 km wide and *c.* 2750 m deep. Trough T4 is centred at 61°39'S, 55°00'W, located at the northern end of eastern Bransfield Basin. It is *c.* 45 km long, 16 km wide and 2400 m deep.

Seamount G (Figs 2, 5 & 9b) is a more than 30 km long ridge that trends N048° and bisects trough T1. To the south-west it rises towards the submerged southern flank of Bridgeman Island and widens from less than 1.2 km to more

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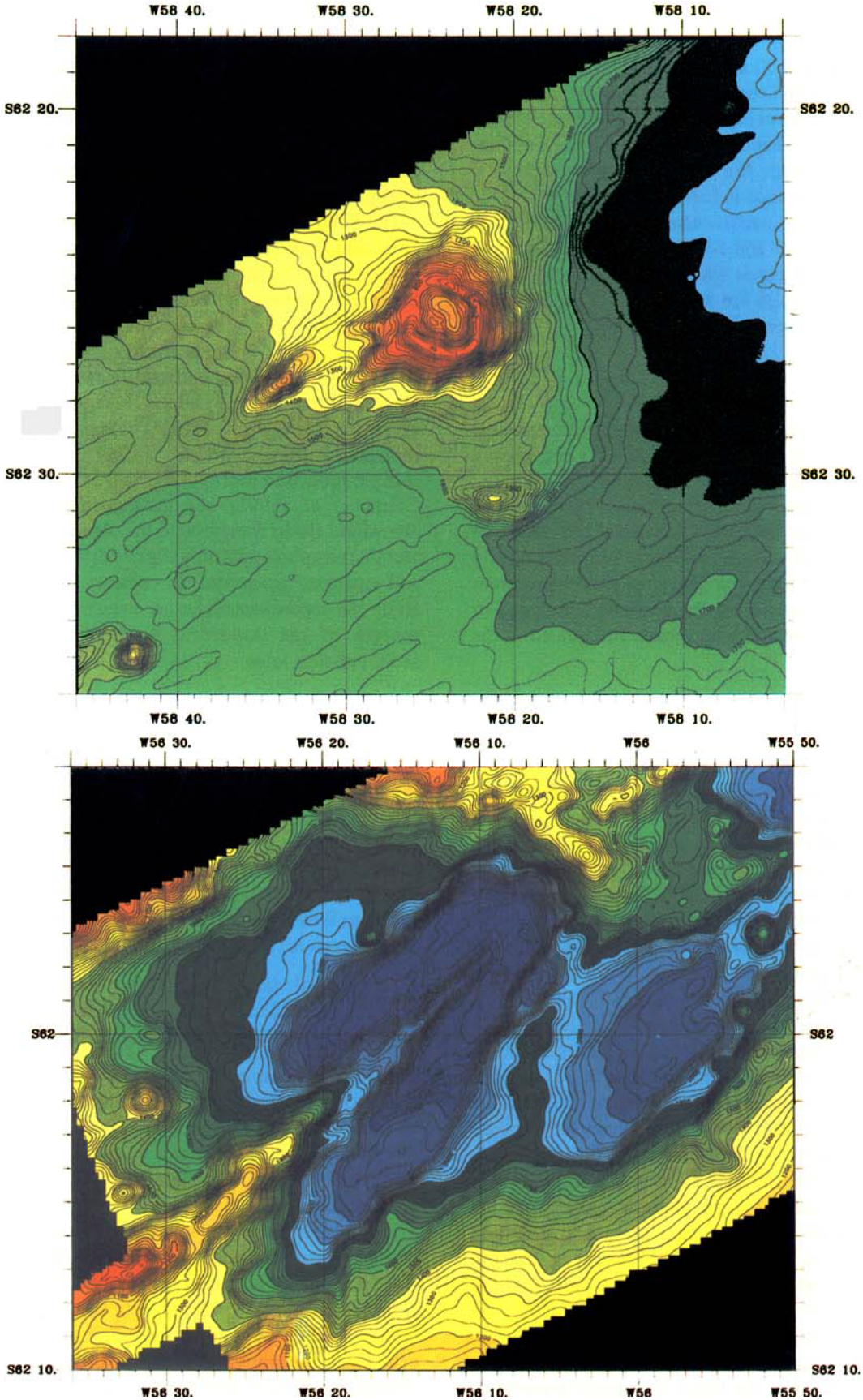


Fig. 9. Detailed bathymetric maps (25 m contour) of **a.** seamount E and **b.** trough T1 and ridge G (central and eastern Bransfield basins, respectively). Same colour interval and scale as in Fig. 8; deep blue is more that 2200 m deep.

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than 4 km (Figs 5 & 9b).

Seamount H (Figs 2 & 5) is centred at 61°45'S, 55°24'W, separates T3 from T4 and constitutes the shallowest point of the area surveyed in eastern Bransfield Basin. It has an approximately circular shape and, peaking at around 650 m, contrasts markedly with the neighbouring trough, T3, involving a sharp difference in bathymetry of 2000 m.

Predominantly on the south-western half of the eastern basin (between 56°30'W and 55°30'W) there are multiple scattered round shaped cones with basal diameters ranging from at least 0.5 km to 1.8 km and heights of up to 300 m above the surrounding seafloor (Figs 5 & 9b).

Discussion

High resolution bathymetric techniques are of fundamental importance in revealing the shape and structures of the ocean floor. The relatively small rates of erosion and deposition in large areas of the deep ocean floor imply that detailed bathymetric maps can be partly translated into maps of structure and volcanism. Thus, rectilinear slopes are mostly interpreted here as the morphologic effect of faults whereas positive reliefs that rise above the seafloor (elongated or conical and of limited extent) are mostly interpreted as the effect of volcanism.

Structure versus sedimentary cover

The rectilinear and strongly dipping slope of the South Shetland margin adjacent to central Bransfield Basin has generally been interpreted as the result of normal faults dipping to the south-east (e.g. Ashcroft 1972). Those faults are observed in seismic reflection profiles (Gamboa & Maldonado 1990, Henriet *et al.* 1992, Jeffers & Anderson 1990, Prieto *et al.* 1995, 1996) and correspond to the north-western boundary of the Bransfield rift. The Antarctic Peninsula margin of the central basin is less regular and shows gentler slopes (Fig. 4); the sinuosity and general morphology of that margin is more consistent with depositional rather than structural control. Faults bounding the Bransfield rift to the south-east are likely to be buried or to have their morphology smoothed by thick glaciomarine sequences prograding from the Antarctic Peninsula, as seen in the seismic reflection profiles (Jeffers & Anderson 1990, Prieto *et al.* 1996). Nevertheless, some portions of the slope are rectilinear and parallel to the general alignment of the basin for more than 10 km. This suggests that the distribution of depositional sequences and the resulting margin morphology may be controlled by faulting to some extent and may reflect the underlying basement structure (Fig. 10). As seen in the longitudinal seismic reflection lines of Prieto *et al.* (1995) thick sedimentary sections are cut at depth by transverse faults. We consider that the broad and gentle transversal steps that separate the basin floor into four different levels can best be explained by the effect of these normal faults which, according to the bathymetric map, would trend roughly N145° with downthrows to the north-east (Fig. 10). The same two sets of approximately orthogonal faults that define the overall structure of central Bransfield Basin also seem to be present on Livingston Island (Smellie *et al.* 1995, Pallàs 1996), King George Island (Birkenmajer 1992) and on Deception Island (Martí *et al.* 1996).

The South Shetland and the Antarctic Peninsula margins of eastern Bransfield Basin are not as asymmetrical as those of the central basin. The straight lineations, strong slopes, transverse stepped morphology and the highly coincident trends of both margins indicate that the morphology of eastern Bransfield Basin is directly determined by structure. We interpret the steep and rectilinear walls bounding the troughs as the result of faults. There are two main families of faults (N053° and N103°) which determine a rough rhomboidal shape of the troughs (Fig. 10). As shown by the seismic reflection profiles of Prieto *et al.* (1995, 1996) and Gràcia *et al.* (1996), the greater ruggedness of eastern Bransfield Basin compared to the central basin is due to the fact that morphology is only slightly modified by depositional and erosional processes. In contrast to central Bransfield Basin, the eastern basin is farther away from the progradational margin of the Antarctic Peninsula, implying lower sedimentation rates.

Volcanism versus structure

All seamounts in the central Bransfield Basin (A to F in Fig. 2) may be considered as volcanic edifices. This is supported by:

1) the morphology of some seamounts,
2) the nature of all samples that have been dredged in the area (Weaver *et al.* 1979, Fisk 1990, Keller & Fisk 1992, Keller *et al.* 1992, 1994), and
3) the acoustic facies recorded in seismic reflection profiles (Gamboa & Maldonado 1990, Jeffers & Anderson 1990, Acosta *et al.* 1992, Prieto *et al.* 1995, 1996).

The edifices sampled so far are C, D, E, F, all of which correspond to fresh, glassy basalts (Keller *et al.* 1994). Edifice E shows a clear conical and caldera-shaped morphology typical of many volcanoes (Figs 2, 4 & 9a). Edifice A is formed by a split caldera the two halves of which preserve their original shape. Between both halves there is a ridge formed by several round shaped highs which can only be interpreted as coalescing point-sourced volcanoes. The ridge is probably propagating along-basin as suggested by a detached small cone aligned with the ridge (to the south-west). Edifice D would correspond to a further stage of extension and propagation of volcanism, where the initial volcano would have lost its original shape. Thus, edifices E, A and D illustrate how volcanism and tectonics interplay at the axis of an extensional basin (Gràcia *et al.* 1996).

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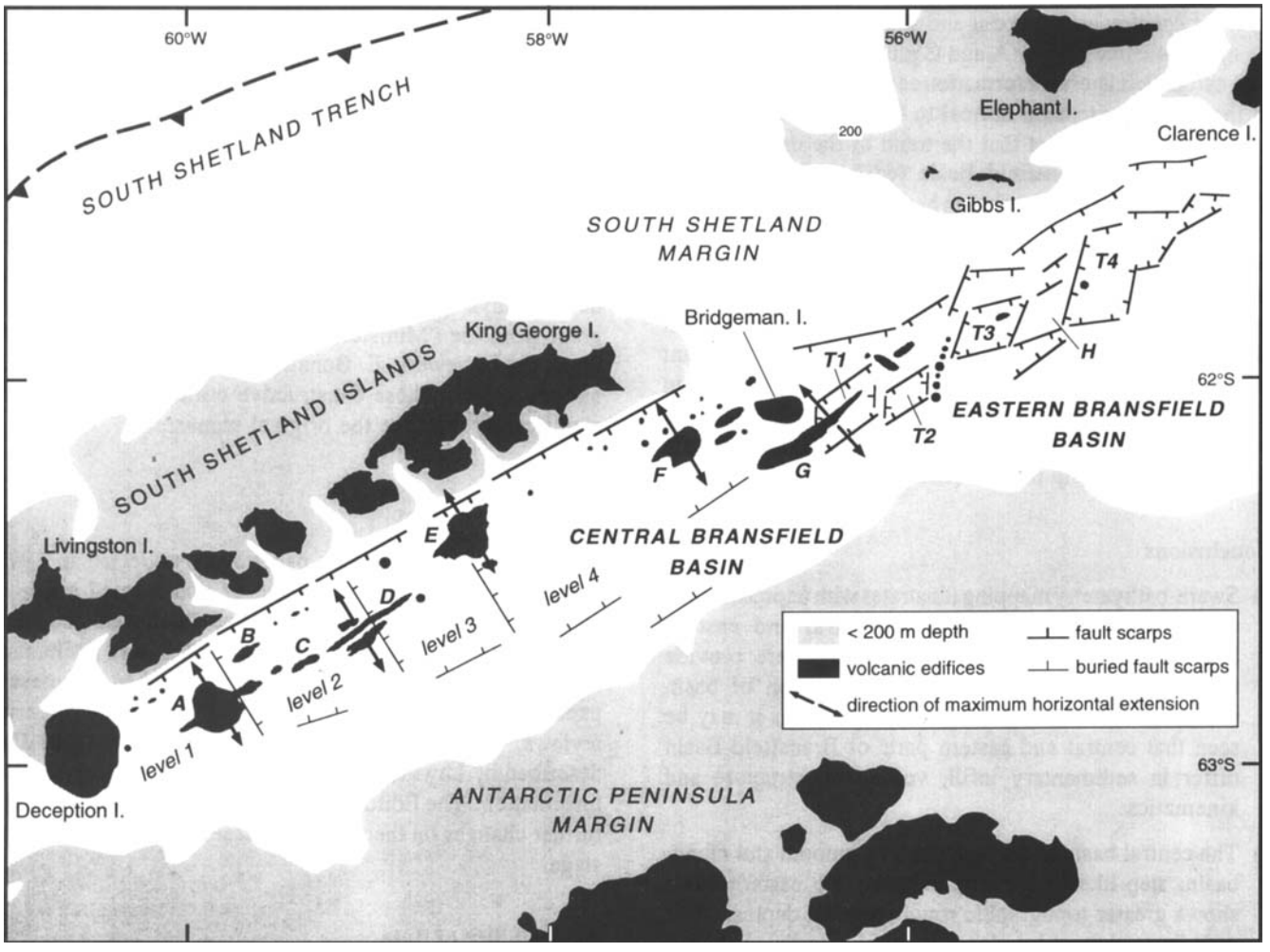


Fig. 10. Interpretative structural sketch map of central and eastern Bransfield Basin (modified from Gràcia *et al* 1996).

Most of the seamounts consist of volcanic ridges or spurs arranged parallel to the basin axis. All these features show strikingly consistent trends around N059° with deviations of generally less than 2° and always less than 8°. The larger edifices (A, C, D and E) are all located above the transverse-trending steps separating the four different levels of the basin. This indicates that volcanism is mainly concentrated at the intersection between longitudinal and transversal structures. These large edifices are located on the basin axis and aligned approximately N062° so that their ridges are arranged slightly *en echelon* with respect to the general alignment of the basin. Some of these *en echelon* ridges are also curved in plan view and are weakly sigmoidal (as seamount A, and C and D together).

In eastern Bransfield Basin, only edifice G is similar to the volcanic ridges found in the central basin. The narrowing of this ridge within trough T1 suggests that this volcanic structure may be propagating towards the north-east. Its N048° trend is in clear contrast with the coherent N059° trend encountered in the central basin. On morphological grounds, it is not possible to decide if the wide seamount H is a volcanic edifice or a horst. Apart from edifice G the remaining volcanic structures in eastern Bransfield Basin are limited to scattered small volcanic cones, showing no obvious relationship with any structural lineation. The total extent of volcanic edifices in the eastern Basin is less than a third of that found in central Bransfield Basin (Gràcia *et al.* 1996).

Kinematics

Assuming that the volcanic ridges are formed perpendicular to the direction of maximum extension, their trend in central Bransfield Basin permits us to suggest that the basin is undergoing extension along a maximum horizontal axis oriented N149°. This direction of extension is approximately perpendicular to the basin margins (N065°). Under N149°-directed extension, the marginal and longitudinal structures have to move as normal faults, and probably have a very slight sinistral strike-slip component. We consider that this strike-slip component is also reflected in the bathymetric maps; the

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weak *en echelon* arrangement and slight sigmoidal shape of the main volcanic ridges (A and C plus D) is also consistent with a slight left lateral deformation component superimposed on the general extension normal to the basin (Fig 10).

Similarly, we suggest that the trend of the only volcanic ridge in eastern Bransfield Basin (edifice G) indicates a N138°-directed axis of maximum horizontal extension, which is not perpendicular to the basin axis. Under this N138° - directed extension, structures trending N053° would move essentially as normal faults, while structures trending N103° would be normal-sinistral faults. All these structural observations are consistent with extension under a significant left lateral strike-slip regime in eastern Bransfield Basin (Fig. 10). The proximity of the left-lateral plate boundary of the South Scotia Ridge (Pelayo & Wiens, 1989) may explain part of this strike-slip motion (Gràcia *et al.* 1996).

Conclusions

1) Swath-bathymetry mapping illustrates with unprecedented clarity the submarine relief of central and eastern Bransfield Basin. The maps presented here provide important information for the interpretation of basin evolution. From morphological observations it may be seen that central and eastern parts of Bransfield Basin differ in sedimentary infill, volcanism, structure and kinematics.

2) The central basin is characterized by smooth and along-basin, step-like bathymetry whereas the eastern basin shows greater topographic roughness and depths. This may be explained by closer proximity to the Antarctic Peninsula margin and hence a thicker sedimentary cover in the west than in the east.

3) The central basin contains several large ridged edifices, aligned discontinuously along-axis, which show a consistent N059° trend along the basin. The total extent of volcanic edifices in the eastern basin is much smaller and, apart from a N048°-oriented ridge, evidence of volcanic activity is limited to small cones scattered on the seafloor.

4) The structure of central Bransfield Basin is determined by two families of roughly orthogonal structures trending about N065° (main set) and about N145° (secondary set). The structure of eastern Bransfield Basin is dominated by two sets of faults trending approximately N053° and N103°, giving rise to a roughly rhomboidal pattern.

5) The direction of volcanic ridges permits us to infer that the central basin is undergoing extension along a direction approximately normal to the basin, whereas the eastern basin shows extension with a significant sinistral strike-slip component.

Acknowledgements

We would like to thank the captain of the RV *Hespérides*, Commandant V. Quiroga, and the crew members and our colleagues who participated in the GEBRA 93 cruise. This work was supported by the Spanish "Programa Nacional de Investigación en la Antártida", projectANT-93-1008-C03-01, funded by the "Comisión Interministerial de Ciencia y Tecnología". The GRQ "Geociències Marines" at the University of Barcelona has been supported by "Generalitat de Catalunya" grant GRQ94/95-1026. E. Gràcia received a grant from the "Ministerio de Educación y Ciencia". We thank the reviewers, E. Bonatti, Y. Lagabrielle, A. Cooper and the editor, whose constructive criticism enabled us to significantly improve the original manuscript.

Editorial comment

The data described in this paper were collected in 1993. During 1995 an overlapping survey was carried out by a group of US scientists, some details of which were published by Lawver *et al.* as a lead article in GSA Today (Reference here). That paper came to our attention when the present paper was already under revision from three international reviews. The present paper covers a larger area than that described by Lawver *et al.* 1996 and contains more detailed information. The Editors considered it unnecessary to inflict further changes on the ms of the present paper at such a late stage.

Accessibility of data

Both rough and filtered digital x, y, z data used to construct the bathymetric maps presented here are available by request to Miquel Canals (miquel@natura.geo.ub.es).

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