British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Instituto Geológico y Minero de España

Bathymetry and Geological Setting of the Drake Passage

BAS GEOMAP 2 Series, Sheet 7, Edition 1 - Journal of Maps edition

scale: 1 : 1,600,000

Preferred reference for this map: Bohoyo, F., Larter, R.D., Galindo-Zaldívar, J., Leat, P.T., Maldonado, A., Tate, A.J., Gowland, E.J.M., Arndt, J.E., Dorschel, B., Kim, Y.D., Hong J.K., Flexas M.M., López-Martínez, J., Maestro, A., Bermudez, O., Nitsche, F.O., Livermore, R. A., Riley, T.R. (2016). *Bathymetry and Geological Setting of the Drake Passage (1:1 500 000)*. BAS GEOMAP 2 series, Sheet 7, British Antarctic Survey,

Bathymetric and geophysical interpretation: Bohoyo, F., Larter, R.D., Galindo-Zaldívar, J., Leat, P.T., Maldonado, A., Tate, A.J., Gowland, E.J.M., Arndt, J.E., Dorschel, B., Kim, Y.D., Hong J.K., Flexas M.M., López-Martínez, J.,

Projection: Mercator; Spheroid: WGS84; Central meridian: 60ºW; True scale latitude: 57.5ºS.

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Bathymetry and topography

2500 2000 1000 0 -1000 -2000 -3000 -4000 -5000 -6000

Height (m)

Earthquakes and other symbols

Depth (km)
- below 30
- 30 to 60

Seismicity from USGS Catalog

Magnitude (Mw)
- 5.1—5.5
- 5.5—6.0
- 6.0—6.5
- 6.5—7.0
- 7.0—7.6

Plate Motion
7.1 Scotia Plate fixed mm per year (Thomas et al., 2003)

Grid spacing 200 m
Hillshade illumination from azimuth 315° and elevation 45°

Tectonics
- Convergence
- Divergence
- Strike-slip (sinistral)

Bathymetric contours at 1000 m interval
- Coastline
- 1000 m interval

Kilometres
0 20 40 60 80 100

Nautical miles
0 20 40 60 80 100

Magnetics

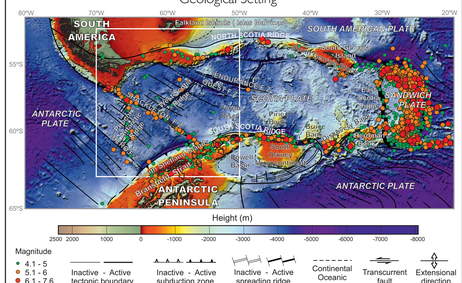
Positive magnetic lineations are shown on the map as red lines. Similarly aged pairs of lineations propagate away from the spreading ridges, with older pairs further from the ridge and younger near the centre. Each pair is numbered corresponding to the Geomagnetic Polarity Timescale "chron" notation (from Cande & Kent 1995)

3A

0 5 10 15 20 25 30 35

Magnetic reversal timescale (Millions of years)

Geological Setting



Magnitude
- 4.1 - 5
- 5.1 - 6
- 6.1 - 7.6

Inactive - Active tectonic boundary

Inactive - Active subduction zone

Inactive - Active spreading ridge

Continental Oceanic boundary

Transcurrent fault

Extensional direction

The **Drake Passage** is an oceanic gateway of about 850 km width located between South America and the Antarctic Peninsula that connects the southeastern Pacific and the southwestern Atlantic oceans and influences deep mantle flow, oceanographic water mass exchanges, and migrations of biota. This gateway developed within the framework of geological evolution of the **Scotia Arc**. The Scotia Arc includes the Scotia and Sandwich plates, which are bounded to the north by the North Scotia Ridge, to the south by the South Scotia Ridge, to the west by the Shackleton Fracture Zone, and to the east by the South Sandwich Trench. The Scotia Sea contains several active and extinct spreading ridges that led to the opening of the Drake Passage. Several continental banks and oceanic basins are located in Scotia Sea, notably its southern part.

The **Shackleton Fracture Zone (SFZ)** occupies a central position in the Drake Passage and is an intra-oceanic ridge which rises several hundreds to thousands of metres above the surrounding seafloor. The SFZ separates the Scotia Plate of the Scotia Sea to the east and the former Phoenix Plate and the Antarctic Plate to the west, part of the Pacific Ocean. The SFZ is an active transpressional and left-lateral transcurrent fault that accommodates, in conjunction with the North Scotia Ridge and South Scotia Ridge, the relative motion between the Scotia Plate and the South-American and Antarctic plates and connects the Chile Trench with the South Shetland Trench. The SFZ is underthrusted below Elephant Island. The SFZ intersects two extinct spreading centers – the **West Scotia Ridge** and the **Phoenix–Antarctic Ridge** – between which the SFZ acted as an oceanic ridge-to-ridge transform fault when both spreading centres were active. The geodynamic evolution of the region, seismic activity and tectonic data suggest a complex evolution of the Drake Passage such that the SFZ began as an oceanic transform fault with strike-slip motion along most of its length and then formed a transpressive transcurrent fault zone as at present day. Uplift of the SFZ in the last 8 Myr has formed a barrier for oceanic bottom currents.

The Phoenix-Antarctic spreading axis was extinct by chron C2A (2.6-3.6 Ma), when the Phoenix Plate became part of the Antarctic Plate, and following a long period of late Mesozoic and Cenozoic subduction of the Phoenix Plate below the Pacific Margin of the Antarctic Peninsula. Subduction continued at the **South Shetland Trench** due to rollback of the hinge of subduction and active spreading in the Bransfield Strait.

The West Scotia Ridge formed most of the oceanic crust of the Scotia Sea from early Oligocene to its extinction after chron C3A (6.4 Ma) during a period of regional Scotia Sea compression after 17 Ma due to the migration of the pole of rotation. The West Scotia Ridge spreading segments are separated by former transform faults. On its eastern part, the **Endurance** and **Quest** fracture zones are clearly recognisable. Recent studies of the Drake Passage geodynamics suggest opening of oceanic basins that developed in the southwestern Scotia Arc during Eocene time.

The opening of the main southern oceanic gateways, Drake Passage and the Tasmanian gateway separating South America and Australia from Antarctica respectively, permitted the modern pattern of global ocean circulation to be established. This allowed extensive exchange of water between the main ocean basins and led to the development of the Antarctic Circumpolar Current, which contributed to the thermal isolation of Antarctica, was partially responsible for global cooling at the Eocene-Oligocene boundary and played an important role in middle Miocene cooling.

Barker, P.F., 2001. Scotia Sea regional tectonic evolution: implications for mantle flow and palaeocirculation. Earth-Science Reviews, 55, 1-39.

Cande, S.C., and Kent D.V., 1995. Revised calibration of the geomagnetic polarity timescale for the Late Cretaceous and Cenozoic, Journal of Geophysical Research,100,(B4), 6093–6095.

Dalziel, I.W.D, Lawver, L.A., Norton, I. O., Gahagan, L. M., 2013 "The Scotia Arc: genesis, evolution, global significance." Annual Review of Earth and Planetary Sciences. 41, 767-793.

Eagles, G., Jokat, W., 2014. Tectonic reconstructions for paleobathymetry in Drake Passage. Tectonophysics, 611, 28-50.

Geletti, R., Lodolo, E., Schreider, A.A., Polonia, A., 2005. Seismic structure and tectonics of the Shackleton fracture zone (Drake Passage, Scotia Sea) Marine Geophysical Researches, 26: 17-28.

Larter, R.D., Barker, P.F., 1991., Effects of ridge crest-trench interaction on Antarctic–Phoenix spreading: forces on a young subducting plate. Journal of Geophysical Research, 96:(B12), 19586-19607.

Livermore, R., Eagles, G., Morris, P., Maldonado, A., 2004. Shackleton Fracture Zone: no barrier to early circumpolar ocean circulation. Geology, 32 (9), 797-800.

Maldonado, A., Balanyá, J.C., Barnolas, A., Galindo-Zaldívar, J., Hernández, J., Jabaloy, A., Livermore, R., Martínez-Martínez, J.M., Rodríguez-Fernández, J., De Galdeano, C.S., Somoza, L., Surinach, E., Viseras, C. 2000., Tectonics of an extinct ridge-transform intersection, Drake Passage (Antarctica). Marine Geophysical Researches, 21:(1-2), 43-67.

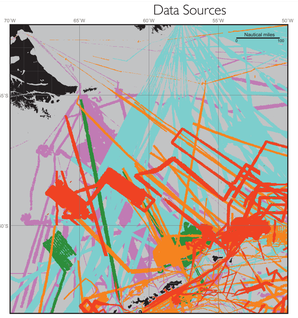
Maldonado, A., Bohoyo, F., Galindo-Zaldívar, J., Hernández-Molina, F.J., Lobo, F.J., Lodolo, E., Martos, Y.M., Pérez, L.F., Schreider, A.A., Somoza, L., 2014. A model of oceanic development by ridge jumping: Opening of the Scotia Sea. Global and Planetary Change, (123(B):152-173.

Maldonado, A., Dalziel, I.W.D. and Leat, P.T., 2015. The global relevance of the Scotia Arc: An introduction. Global and Planetary Change, 125:A1-A8

Maldonado, A., Larter, R.D., Aldaya, F., 1994. Forearc tectonic evolution of the South Shetland margin, Antarctic Peninsula. Tectonics, 13:(5), 1345-1370.

Tectonic map of the Scotia arc, 1:3 000 000, BAS (Misc) 3. Cambridge, British Antarctic Survey, 1985.

Data Sources



- BAS Multibeam
- SPAIN Multibeam
- KOPRI Multibeam
- AWI Multibeam
- USA Multibeam
- GEBCO (IBCSO)
- Land area

This bathymetric map has been compiled from a variety of data sources. The primary data is multibeam swath bathymetry collected from scientific cruises undertaken by British Antarctic Survey (BAS), Spanish Antarctic Program, Korean Polar Research Institute (KORPI), Alfred Wegener Institute (AWI) and United States Antarctic Program. Where no data exist, global compilations from the General Bathymetric Chart of the Oceans (GEBCO) including the International Bathymetric Chart of the Southern Ocean (IBCSO) have been used; this data set uses

Arndt, J.E., Schenke, H.W., Jakobsson, M., Nitsche, F., Buys, G., Goleby, B., Rebesco, M., Bohoyo, F., Hong, J.K., Black, J., Greku, R., Udintsev, G., Barrios, F, Reynoso-Peralta, W., Morishita, T., Wigley, R., 2013. The International Bathymetric Chart of the Southern Ocean (IBCSO) Version 1.0 – A new bathymetric compilation covering circum-Antarctic waters. Geophysical Research Letters , 40, 3111-3117.

Weatherall, P., Marks, K.M., Jakobsson, M., Schmitt, T., Tani, S., Arndt, J.E. Rovere, M., Chayes, D., Ferrini, V., Wigley R., 2015. A new digital bathymetric model of the world's oceans. Earth and Space Science, 2, 331–345.

THIS MAP IS FOR SCIENTIFIC RESEARCH ONLY AND IS NOT TO BE USED FOR NAVIGATION OR OTHER PURPOSES

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