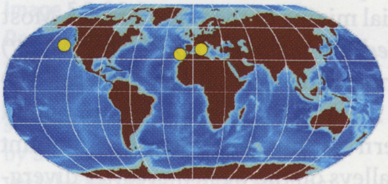
5.2.6
Volcanic Formations



A distinction of volcanic formations and seamounts (Sect. 5.2.7) may appear questionable since the nearly innumerable number of seamounts strewn over the sea floor are also of eruptive origin. They were created at the *mid-ocean ridges*, the origin and spreading zones of new sea floor (Sect. 5.2.3, 5.2.4) and migrated away as inactive formations, riding on the new sea floor towards the *subduction zones* (Sect. 5.2.1, 5.2.2). However, many of the still active volcanoes owe their origin to tectonic processes at and near subduction zones and *hot spots* (Sect. 5.2.8). The examples of volcano images shown in this context are not taken in far remote sites like the *Orca Seamount* of the *Antarctica* (Sect. 5.5.2) but they deal with active volcanism in the *Mediterranean*, and with two former active volcanoes, one with an exemplary, textbook-like crater, an unnamed volcano near *Juan de Fuca Ridge* and the other one in the *Atlantic* near the *Strait of Gibraltar* at the transition between the only subduction zone in *Europe* and the adjacent strike slip fault extending to the *Mid-Atlantic Ridge* (map of Sect. 5.2). This is the large *Ampère Seamount*, typical of a *guyot* type with its conspicuously flat summit from erosion during former times of exposure above sea level.

5.2.6.1
Ampère Seamount

The *Ampère Seamount*, 600 km west of *Gibraltar*, is one of nine inactive volcanoes along a bent chain, the so called *Horseshoe Seamounts*. All of them ascend from an abyssal plain of 4 000 to 4 800 m depth up to a few hundred meters below the sea surface, except two, which nearly reach the surface: the *Ampère Massif* on the southern flank of the group and the summit of the *Gorringe Bank* in the north. The horseshoe, serrated like a crown, opens towards Gibraltar and stands in the way of its outflow. These seamounts are part of the *Azores-Gibraltar* structure, which marks the boundary between two major tectonic plates: the *Eurasian*- and the *African Plate*.

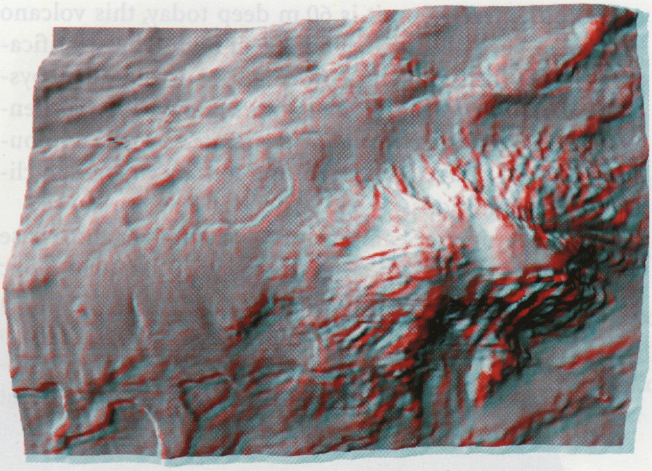


Image 5.2.6.1-1.
***Ampère Seamount, Horseshoe Seamount Chain* off *Gibraltar*. Multibeam echosounder image in red-green anaglyphic stereo-depiction.** The bird's view which is most appropriate for stereo depiction reveals the two level abrasive flattening of the Ampère summit more clearly than the slant view. This typical summit shape called guyot of a fully submerged seamount indicates its past with wind induced erosion when emerged above sea level. The simulated illumination from north shows deep going landslides in the foreground and traces of volcanic outflow in the west, covering the south west part of the declivity with sharply marked boundaries.

Project: Scientific Expeditions to Antarctica; cruise: ANT IX/4 (1991)
Research vessel: *RV Polarstern*, Germany
Multibeam echosounder: HYDROSWEEP DS-2; 15.5 kHz, beamwidth: 2.3 × 2.3°, fan width: 90°/8 km at 4 km depth
Height exaggeration factor: 6
Image ©: Jörn Hatzky, AWI, Germany ■

The submarine volcanism which formed the Horseshoe Seamounts belongs to the sea floor spread area of the *Mid-Atlantic Ridge*. The maximum activity was between 17 and 10 million years ago and terminated thereafter. The volcanoes consist of basalts and tuffs. Most of their flanks and the abyssal plain around are covered by sediments of micro-organic origin.

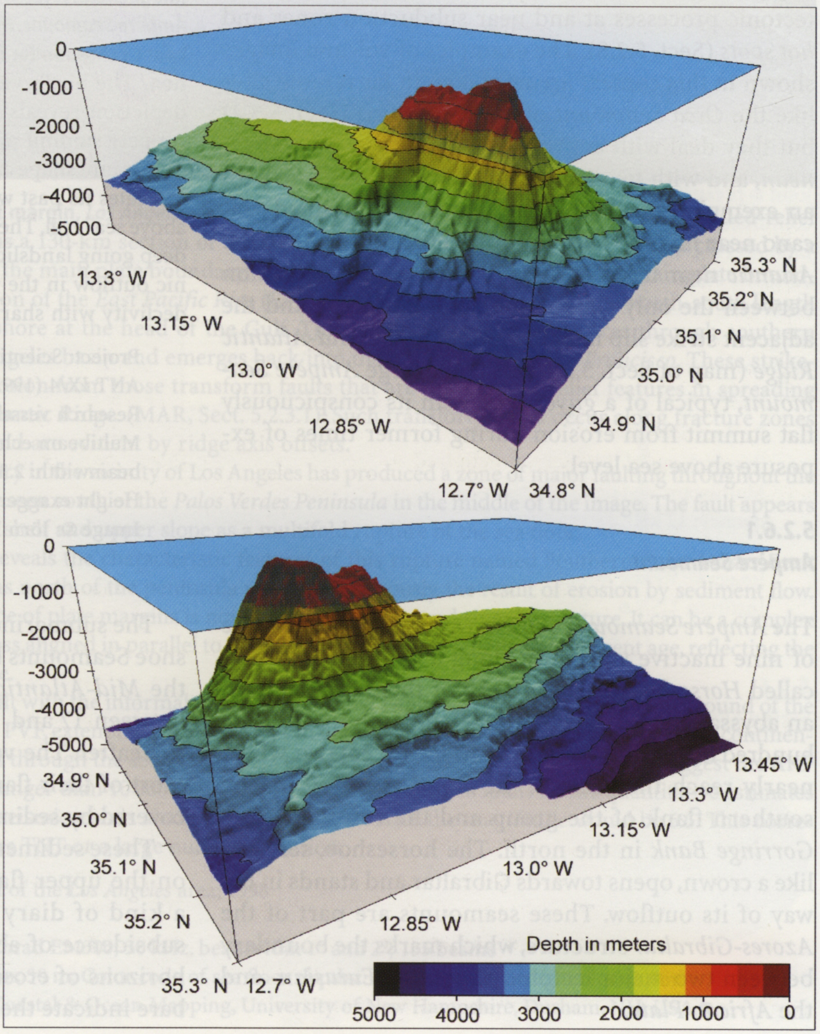
These sediments, in particular their partial absence on the upper flanks are a circumstantial proof and a kind of diary of the initial rise and subsequent subsidence of about 600 m of these seamounts. The horizons of erosion where the basalt substrate is laid bare indicate the rise above sea level in the past. Since the Ampère summit is 60 m deep today, this volcano must have been an island 500 m high. The stratification of the sediments covering the surrounding abyssal plain reveals discrete events of downslope suspension flows, called turbidites, separated by tens of thousands of years and perhaps induced by changes in climate conditions.

The Ampère Seamount of 4 800 m height and a base diameter of 50 km exceeds the size of the *Mont Blanc Massif.* Its southern and eastern flanks are steep with basalts cropping out, in parts with nearly vertical walls of some hundred meters. The west and north sides consist of terraces and plateaus covered with sediments at 140 m, 400 m, 2 000 m, and 3 500 m.

The Horseshoe Seamount area is also remarkable as a disturbed crossing of three major oceanic flow systems at different depths and directions with forced upwelling and partial mixing of the water masses. Most prominent is the *Mediterranean Outflow Water (MOW)* with its higher temperature and salinity between 900 and 1 500 m depth. It enters the horseshoe unimpaired from the open eastern side but penetrates the seamount chain through its valleys on the west, thereafter diverging and crossing the entire Atlantic Ocean. Below the MOW is the *North Atlantic Deep Water (NADW)* between 2 000 m and 3 000 m depth flowing *southward* and finally there is the *Antarctic Bottom Water (AABW)* flowing *northward* below the two other systems.

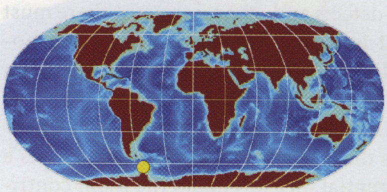
Image 5.2.6.1-2.
***Ampère Seamount*. Multibeam echosounder image in color coded 3D-depiction.** The pair images showing the Ampère Massif from two opposite sides quantifies the depth regime of more than 4 000 m, as well as the varying slope structure of the flanks ascending from a broad, inclined fundament.

Image documentation: same as for Image 5.2.6.1-1 ■



5.5.2

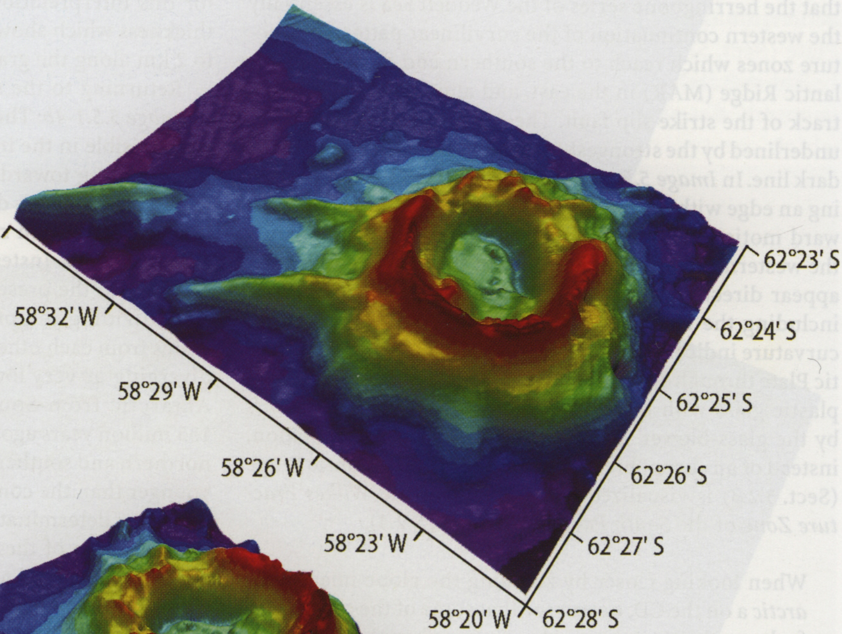
5.5.2 The *Orca Seamount* Region, *Antarctica*

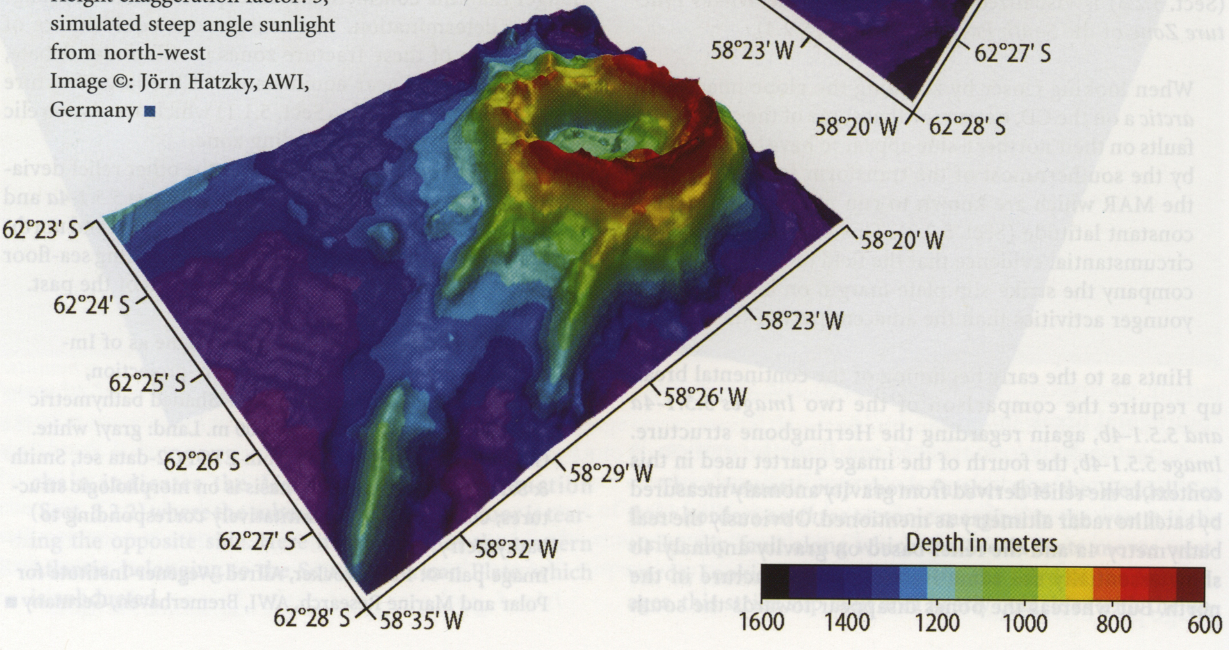


The *Orca Seamount* was discovered in the central basin of the *Bransfield Strait* around the position 62°26' S and 58°24' W on the west side of the *Antarctic Peninsula*, the most western area of the south polar continent. Though the discovery was made known in 1987, it was only during three bathymetric surveys with high resolution fan echosounders between 1993 and 1995 that the character and complete shape of a remarkable volcano seamount became evident. The data acquisition and processing revealed a spectacular crater of 350 m depth. The relative height of this 3 km wide "caldera" rim is 550 m with a basal diameter of the seamount cone of 11 km. Its flanks are about 15° steep but in some places the slope reaches up to 36°. The nearly circular shape of the Orca edifice spreads out with several pronounced spurs, trending parallel to the basin axis in a northeast-southwest direction.

Image 5.5.2-1.
***Orca Seamount, Antarctica*. Close up multibeam echosounder image.** The color coded 3D-image reveals details of the inner crater and the partially irregular rim of the Orca volcano, being one of the largest known in the Antarctica region.

Project: Scientific Expeditions to Antarctica; cruise: ANT XI/3, 1994
Research vessel: *RV Polarstern*, Germany
Multibeam echosounder: HYDROSWEEP DS-2; 15.5 kHz, beamwidth: 2.3 × 2.3°, fan width: 90°/8 km at 4 km depth
Height exaggeration factor: 3, simulated steep angle sunlight from north-west
Image ©: Jörn Hatzky, AWI, Germany ■





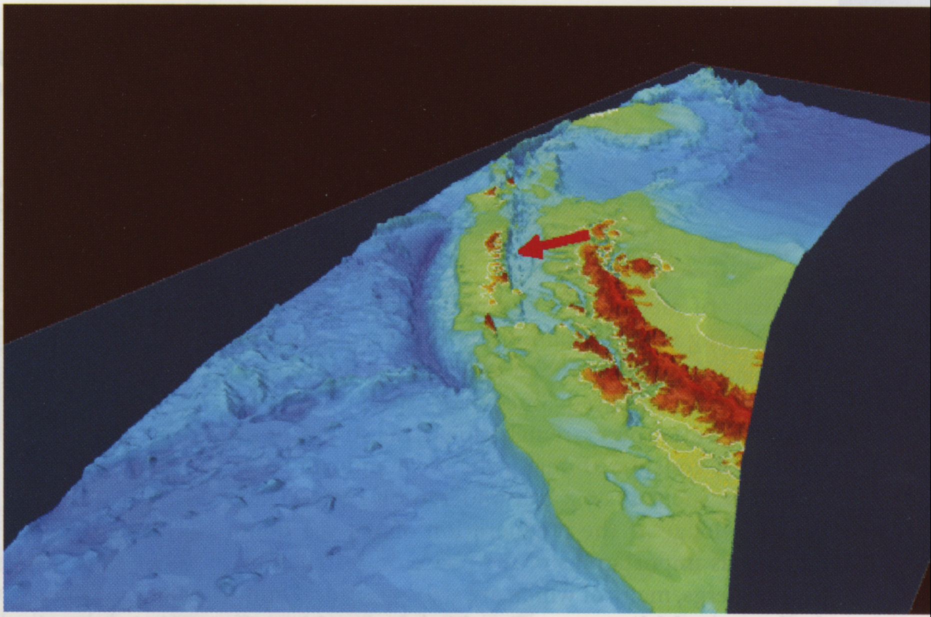


Image 5.5.2-2.
Environment of the *Orca Seamount*. Multibeam echosounder Image (overview). The arrow indicates the Orca position inside the *Bransfield Strait* along the Antarctic Peninsula. Despite the coarser resolution by the standard grid of 1 km the trench on the western side of 5 000 m depth is clearly visible.

Image documentation: same as for Image 5.5.2-1, except: image width at Orca: ca. 670 km; height exaggeration factor: 6 ■

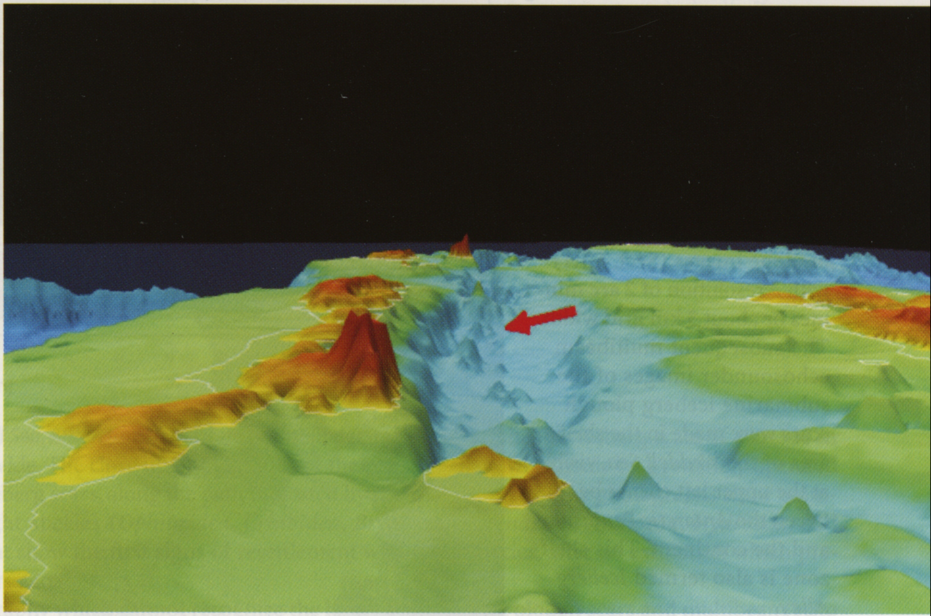


Image 5.5.2-3.
Environment of the *Orca Seamount*. Multibeam echosounder Image (semi close up). The arrow indicates the Orca as one of a chain of seamounts inside the *Bransfield Strait*. The standard grid of the depiction of 1 km, which cannot resolve the crater of the Orca volcano, demonstrates the peerless diagnostic capability of the best high resolution multibeam imaging shown in the close-up of Image 5.5.2-1.

Image documentation: same as for Image 5.5.2-1, except: image width at Orca: ca. 180 km; height exaggeration factor: 6 ■

The globe Image 5.1.1.6, Antarctica, shows the large scale overview of the topography of the Bransfield Strait area: The Strait is the trough-shaped basin of 400 km length and 2 km depth between the *South Shetland Island Arc* and the Antarctic Peninsula, formed by rifting behind the islands. The separation of the South Shetland island chain from the peninsula began possibly several million years ago. The active rifting is still going on however, and has caused recent earthquakes and volcanism along the Bransfield Strait. The Strait hosts a chain of submerged seamounts of volcanic origin (Images 5.5.2-2 and 5.5.2-3) with the presently inactive Orca Seamount as the most spectacular one. The South Shetland Islands owe their existence to a subduction related volcanism which is perhaps 5–10 times older than the age of Orca and the other seamounts along the central basin of the Bransfield Strait.

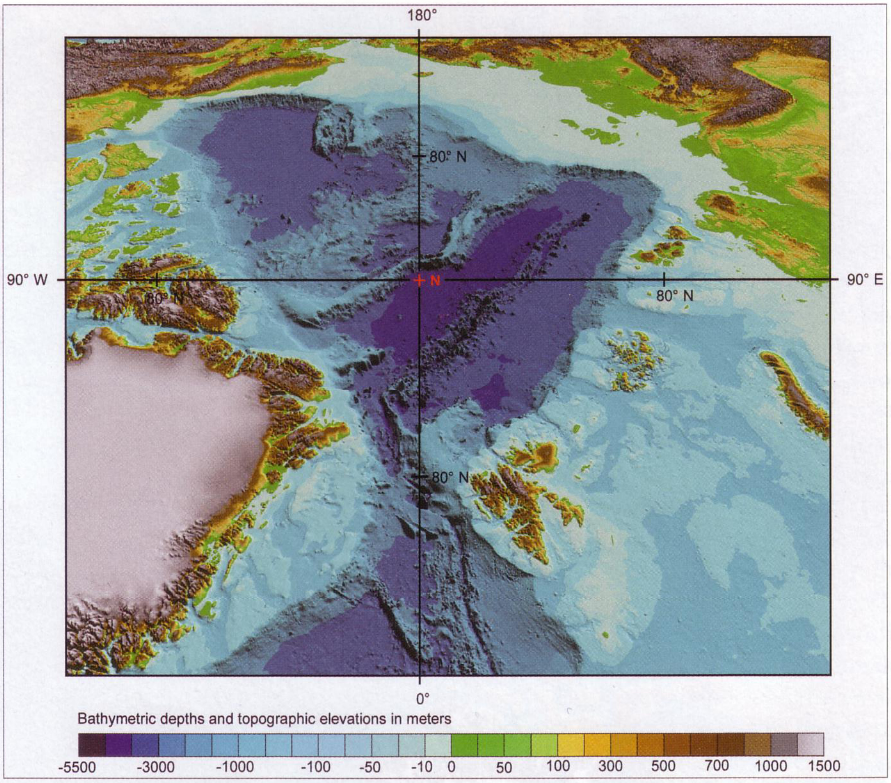


Image 5.4.1-1a.
Slant view of a cut-out of Image 5.4.1-1 with the axis cross through the *North Pole*

Image ©: Jörn Hatzky, AWI ■

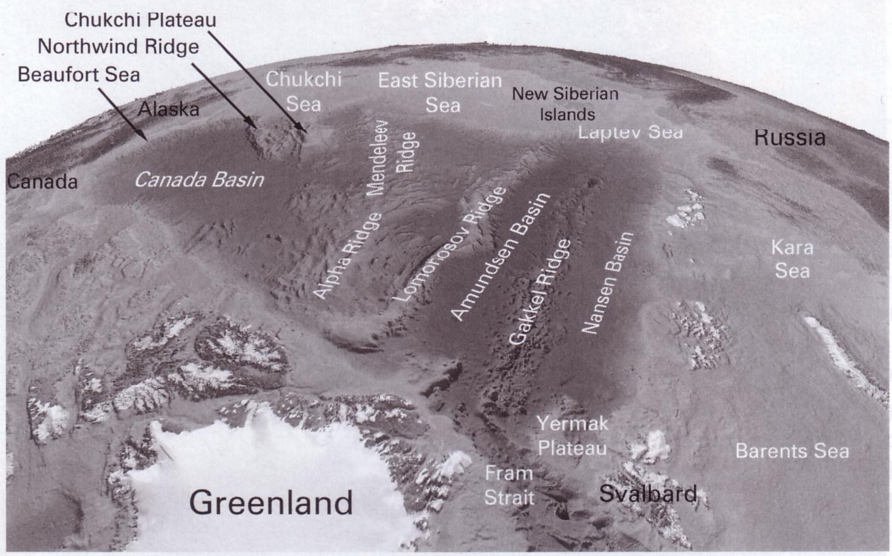


Image 5.4.1-2.
The names of the major formations, attached to the spherical depiction

Image ©: Martin Jakobssen, CCOM ■

used for the IBCAO compilation published bathymetric contour maps in areas where original depth measurements were sparse or not available. These include the recently published Russian 1 : 5 000 000 scale bathymetric contour map "Bottom Relief of the Arctic Ocean" (VNIIOkeangeologia 1999).

In summary, IBCAO has been constructed from all available data of the Arctic Ocean to the compilers, i.e.