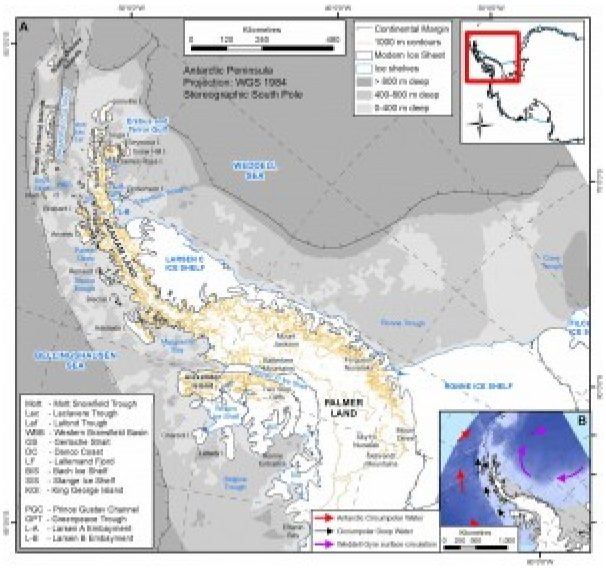
Antarctic Peninsula Ice Sheet

Introduction | Oceanography and climate | Modern Glaciology | Geological history | References | Comments |

Introduction

This section largely taken from Davies et al., 2012 (*Quaternary Science Reviews*)[1].



Map of the Antarctic Peninsula, after Davies et al., 2012 (Quaternary Science Reviews)

The Antarctic Peninsula Ice Sheet (sometimes written as APIS) is widely regarded as sensitive to climate change due to its small size and northerly location, and because this region is one of the most rapidly warming places in the world[2-5].

This sensitivity has been manifest through the collapse of numerous ice shelves, increased ice velocities, and the retreat and thinning of glaciers and ice caps[6-10].

The Antarctic Peninsula is a relatively long, thin spine Alpine-style mountain chain[1]. These mountains extend north towards the Drake Passage, reaching 63°S. The Antarctic Peninsula is 70 km wide, with an average height of ~1500 m[11]. It is 522,000 km^2 in area and 80% ice-covered[12].

You can explore the Antarctic Peninsula Ice Sheet through the Google Map below. Note the flat ice shelves, the islands on the western and eastern Peninsula, and the flowline structures of the glaciers as they flow into the sea. You can also see the rifts in the Larsen Ice Shelf and the few mountain summits that poke through the ice.

View Larger Map

Oceanography and climate


Sea ice in Antarctic Sound

These mountains form a significant barrier to the persistent westerly, moisture-laden winds. The climatic regime either side of the Antarctic Peninsula is therefore quite different.

In the Bellingshausen Sea, there is a polar maritime climate, and in the Weddell Sea, a cold, dry, polar continental climate[1, 3, 11, 13, 14].

The Weddell Sea is further cooled by the Weddell Sea Gyre, which circulates sea ice, icebergs and cold water clockwise towards the northern Antarctic Peninsula[15]. Sea ice also modulates sea surface temperatures in the Weddell Sea[3, 16].

Modern Glaciology

The modern Antarctic Peninsula Ice Sheet is approximately 500 m thick, with outlet glaciers flowing out east and west[17]. Summer air temperatures are greater than 0°C at sea level, and the mass balance of Antarctic Peninsula glaciers is largely controlled by surface melting and glacier calving.

Many of these tidewater glaciers are grounded, particularly on the north-western Peninsula[18]. However , there are large ice shelves fringing the Antarctic Peninsula south of 68°S in the east and 70°S in the west[1, 8].


Whisky Glacier, James Ross Island; a tidewater glacier

The Antarctic Peninsula Ice Sheet contains enough water to raise sea level by 0.24m on full melting[9], and currently contributes 0.22 ± 0.16 mm per year to sea level rise[19].

The Antarctic Peninsula is particularly important because several large ice free areas, for example, on James Ross Island, Alexander Island and South Shetland Islands preserve important palaeoenvironmental archives [e.g., 20, 21-29].

In addition to these, the Bransfield Strait (and its topographic expression, Bransfield Basin) is an 1800 m deep marginal basin separating the South Shetland Islands from the Antarctic Peninsula. It is infilled with thick sequences of marine and glaciomarine sediments, which provide detailed information on Antarctic Peninsula Ice Sheet fluctuations throughout the Quaternary [30-35].

Bathymetry of the northern Antarctic Peninsula. Note the deep Bransfield Basin.

The Palmer Deep, south of Anvers Island, is 1000 m deep and 200 km^2 in area, and also contains a long record of glacial activity and Holocene environmental variability [36, 37].

Geological history

ERA	PERIOD		EPOCH (and Ma)		
CENOZOIC	QUATERNARY		Holocene	0.01	
			Pleistocene		Late
					Middle
				2.54	Early
	TERTIARY	Neogene	Pliocene		Late
				5.33	Early
			Miocene		Late
					Middle
				23.03	Early
		Palaeogene	Oligocene		Late
				33.09	Early
			Eocene		Late
					Middle
				55.8	Early
			Palaeocene		Late
					Middle
				65.5	Early
MESOZOIC	CRETACEOUS		Late	99.0	
			Early	144	
	JURASSIC		Late	159	
			Middle	180	
			Early	206	
	TRIASSIC		Late	227	
			Middle	242	
			Early	248	

Table 1. Geological timescale

The Antarctic Peninsula was once part of the now fragmented Gondwana continent, that extended from South America through the Antarctic Peninsula and New Zealand until the Late Cretaceous[38].

Arc magnetism (resulting in volcanoes around the Antarctic Peninsula) was active throughout the Cenozoic, formed in response to subduction of the proto-Pacific ocean floor along the western margin of the Antarctic Peninsula. The Antarctic Peninsula basement rocks are the Trinity Peninsula Group; these intermediate grade rocks were metamorphosed during this subduction.

The Antarctic Peninsula is bordered to the east (for example, James Ross Island) by a back-arc basin stratigraphy of thick Jurassic and Cretaceous marine shales and siltstone[39]. Deposits began to accumulate in James Ross Basin, providing evidence of the earliest glaciation.

The Drake Passage between South America and the Antarctic Peninsula began to open following fragmentation and brittle response of the crust from compressive to extensional forces[39]. During this time (Palaeogene and Neogene; cf. Table 1), the Mesozoic rocks that now form the Antarctic Peninsula mountains were uplifted.

This uplift aided the accumulation of ice masses across the Peninsula and resulted in glacial and glacially-related erosion and deposition on the continental shelf. During this period, the Antarctic landmass also moved southwards, towards its present position. See Past Behaviour for information on the earliest glacierisation of the Antarctic Peninsula.

Go to top or jump to Climate Change.

Further reading

- Antarctic Peninsula photographs
- Evolution of the Antarctic Peninsula Ice Sheet
- West Antarctic Ice Sheet
- East Antarctic Ice Sheet
- Antarctic Peninsula glacier recession

References

1. Davies, B.J., et al., *Antarctic Peninsula Ice Sheet evolution during the Cenozoic Era.* Quaternary Science Reviews, 2012. **31**(0): p. 30-66.

2. Vaughan, D.G., et al., *Devil in the detail.* Science, 2001. **293**(5536): p. 1777-1779.

3. Vaughan, D.G., et al., *Recent rapid regional climate warming on the Antarctic Peninsula.* Climatic Change, 2003. **60**: p. 243-274.

4. Smith, T.R. and J.B. Anderson, *Ice-sheet evolution in James Ross Basin, Weddell Sea margin of the Antarctic Peninsula: The seismic stratigraphic record.* GSA Bulletin, 2010. **122**(5/6): p. 830-842.

5. Turner, J., et al., *Antarctic climate change during the last 50 years.* International Journal of Climatology, 2005. **25**: p. 279-294.

6. De Angelis, H. and P. Skvarca, *Glacier surge after ice shelf collapse.* Science, 2003. **299**: p. 1560-1562.

7. Scambos, T.A., et al., *Glacier acceleration and thinning after ice shelf collapse in the Larsen B embayment, Antarctica.* Geophysical Research Letters, 2004. **31**: p. L18402.

8. Cook, A.J. and D.G. Vaughan, *Overview of areal changes of the ice shelves on the Antarctic Peninsula over the past 50 years.* The Cryosphere, 2010. **4**(1): p. 77-98.

9. Pritchard, H.D. and D.G. Vaughan, *Widespread acceleration of tidewater glaciers on the Antarctic Peninsula.* Journal of Geophysical Research-Earth Surface, 2007. **112**(F3): p. F03S29, 1-10.

10. Cook, A.J., et al., *Retreating glacier fronts on the Antarctic Peninsula over the past half-century.* Science, 2005. **308**(5721): p. 541-544.

11. Summerhayes, C.P., et al., *The Antarctic Environment in the Global System*, in *Antarctic Climate Change and the Environment*, J. Turner, et al., Editors. 2009, Scientific Committee on Antarctic Research: Cambridge. p. 1-32.

12. Bindschadler, R., *The environment and evolution of the West Antarctic ice sheet: setting the stage.* Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 2006. **364**(1844): p. 1583-1605.

13. Reynolds, J.M., *The distribution of mean annual temperatures in the Antarctic Peninsula.* British Antarctic Survey Bulletin, 1981. **54**: p. 123-133.

14. Morris, E.M. and A.P.M. Vaughan, *Spatial and temporal variation of surface temperature on the Antarctic Peninsula and the limit of viability of ice shelves*, in *Antarctic Peninsula climate variability: historical and palaeoenvironmental perspectives*, E.W. Domack, et al., Editors. 2003, American Geophysical Union, Antarctic Research Series, Volume 79: Washington, D.C. p. 61-68.

15. Barker, P.F., *The history of Antarctic Peninsula glaciation.* USGS Short Research Paper, 2002. **42**: p. 1-5.

16. King, J.C., *Recent climate variability in the vicinity of the Antarctic Peninsula.* International Journal of Climatology, 1994. **14**: p. 357-369.

17. Turner, J., et al., *Antarctic Climate Change and the Environment*. 2009, Cambridge: Scientific Committee on Antarctic Research. 555.

18. Heroy, D.C. and J.B. Anderson, *Ice-sheet extent of the Antarctic Peninsula region during the Last Glacial Maximum (LGM) – Insights from glacial geomorphology.* GSA Bulletin, 2005. **117**(11/12): p. 1497-1512.

19. Hock, R., et al., *Mountain glaciers and ice caps around Antarctica make a large sea-level rise contribution.* Geophysical Research Letters, 2009. **36**: p. L07501.

20. Björck, S., et al., *Late Holocene palaeoclimatic records from lake sediments on James Ross Island, Antarctica.* Palaeogeography, Palaeoclimatology, Palaeoecology, 1996. **121**(3-4): p. 195-220.

21. Ingólfsson, Ó., et al., *Late Pleistocene and Holocene glacial history of James Ross Island, Antarctic Peninsula.* Boreas, 1992. **21**(3): p. 209-222.

22. Clapperton, C.M. and D.E. Sugden, *Late Quaternary glacial history of George VI Sound area, West Antarctica.* Quaternary Research, 1982. **18**(3): p. 243-267.

23. Clapperton, C.M. and D.E. Sugden, *Geomorphology of the Ablation Point massif, Alexander Island, Antarctica.* Boreas, 1983. **12**(2): p. 125-135.

24. Sugden, D.E. and C.M. Clapperton, *West Antarctic Ice Sheet fluctuations in the Antarctic Peninsula area.* Nature, 1980. **286**: p. 378-381.

25. Sugden, D.E. and C.M. Clapperton, *An ice-shelf moraine, George VI Sound, Antarctica.* Annals of Glaciology, 1981. **2**(1): p. 135-141.

26. Troedson, A.L. and J.B. Riding, *Upper Oligocene to lowermost Miocene strata of King George Island, South Shetland Islands, Antarctica: Stratigraphy, facies analysis, and implications for the glacial history of the Antarctic Peninsula.* Journal of Sedimentary Research, 2002. **72**(4): p. 510-523.

27. Nelson, A.E., et al., *Neogene glacigenic debris flows on James Ross Island, northern Antarctic Peninsula, and their implications for regional climate history.* Quaternary Science Reviews, 2009. **28**(27-28): p. 3138-3160.

28. Smellie, J.L., et al., *Six million years of glacial history recorded in volcanic lithofacies of the James Ross Island Volcanic Group, Antarctic Peninsula.* Palaeogeography, Palaeoclimatology, Palaeoecology, 2008. **260**(1-2): p. 122-148.

29. Smellie, J.L., et al., *Late Neogene interglacial events in the James Ross Island region, northern Antarctic Peninsula, dated by Ar/Ar and Sr-isotope stratigraphy.* Palaeogeography, Palaeoclimatology, Palaeoecology, 2006. **242**(3-4): p. 169-187.

30. Heroy, D.C., C. Sjunneskog, and J.B. Anderson, *Holocene climate change in the Bransfield Basin, Antarctic Peninsula: evidence from sediment and diatom analysis.* Antarctic Science, 2008. **20**(1): p. 69-87.

31. Banfield, L.A. and J.B. Anderson, *Seismic facies investigation of the Late Quaternary glacial history of Bransfield Basin, Antarctica.* Anarctic Research Series, 1995. **68**: p. 123-140.

32. Gracia, E., et al., *Morphostructure and evolution of the central and eastern Bransfield Basins (NW Antarctic Peninsula).* Marine Geophysical Researches, 1996. **18**(2-4): p. 429-448.

33. Gracia, E., et al., *Central and eastern Bransfield basins (Antarctica) from high-resolutian swath-bathymetry data.* Antarctic Science, 1997. **9**(2): p. 168-180.

34. Khim, B.K., et al., *Unstable climate oscillations during the late Holocene in the eastern Bransfield Basin, Antarctic Peninsula.* Quaternary Research, 2002. **58**(3): p. 234-245.

35. Prieto, M.J., et al., *Seismic stratigraphy of the Central Bransfield Basin (NW Antarctic Peninsula): interpretation of deposits and sedimentary processes in a glacio-marine environment.* Marine Geology, 1999. **157**(1-2): p. 47-68.

36. Domack, E.W., et al., *Chronology of the Palmer Deep site, Antarctic Peninsula: A Holocene palaeoenvironmental reference for the circum-Antarctic.* The Holocene, 2001. **11**(1): p. 1-9.

37. Leventer, A., et al., *Laminations from the Palmer Deep: A diatom-based interpretation.* Paleoceanography, 2002. **17**(2).

38. McCarron, J.J. and R.D. Larter, *Late Cretaceous to early Tertiary subduction history of the Antarctic Peninsula.* Journal of the Geological Society, 1998. **155**: p. 255-268.

39. Domack, E.W., A. Burnett, and A. Leventer, *Environmental setting of the Antarctic Peninsula*, in *Antarctic Peninsula Climate Variability: Historical and Paleoenvironmental Perspectives*, E. Domack, et al., Editors. 2003. p. 1-13.

40. Siegert, M.J. and F. Florindo, *Antarctic climate evolution*, in *Antarctic Climate Evolution*, F. Florindo and M.J. Siegert, Editors. 2009, Elsevier: Rotterdam. p. 2-11.

Go to top or jump to Climate Change.