AURORA CAVE and TE ANAU VALLEY, FIORDLAND, NEW ZEALAND

Paul Williams
University of Auckland

Te Anau Valley in Fiordland was once occupied by one of New Zealand's largest Pleistocene glaciers. It now contains Lake Te Anau, the largest lake in the South Island and the source of the Waiau River, the largest river draining eastern Fiordland. The lake is situated in a fault-aligned depression striking NNE-SSW and receives drainage from a mountainous catchment of 2998 km^2 that rises to 1500-2000 m above sea level. It is composed mainly of Paleozoic igneous and metasedimentary rocks (Turnbull et al. 2010). The lake has an area of 348 km^2 and has an average depth of 132 m. Its surface is at 203 m above sea level, but has a maximum depth of 417 m, so its floor descends well below sea level. It has been over-deepened by glacial scour, but is also slightly impounded by a moraine dam.

At the height of the global Last Glacial Maximum (LGM), the Te Anau Glacier above Aurora Cave was more than 20 km wide and, as it flowed south, was joined from the east by large glaciers from South Fiord and from the Lake Manapouri basin; their combined ice spreading across lowlands to the east and southeast as a piedmont lobe. The ice abutted against Mt Prospect (970 m) and neighbouring Danby Hill (724 m) to the southeast and against the Cheviot Hills, foothills of the Takatimu Mountains, to the south. Meltwaters escaped down the Waiau River valley.

The western side of the Te Anau glacial trough between two western arms of the lake (known as Middle Fiord and South Fiord) is covered by a series of lateral moraine benches that ascend the valley side to 975 m, almost to the tree-line at 1100 m. The lower part of this slope is underlain by Oligocene limestones of the Tunnel Burn Formation (Turnbull 1985), which is the host rock for Aurora – Te Ana-au Cave that lies beneath the slope and extends from near lake level to 469 m. The modern stream flowing through the cave comes from a hanging tributary of the main trough known as the Takahe valley (Fig. 1), and re-emerges at 204 m beside Lake Te Anau. The lowest part of the cave near the lake is a tourist cave, known as Te Ana-au Cave, and upstream part beyond a sump is a larger upstream section known as Aurora Cave (Fig. 2). The lake is the baselevel for the stream that flows through the system. High abandoned passages in the Aurora section of the cave are the equivalent of subterranean river terraces. These are 30-40 m above the modern stream passage and contain speleothems dating to 273 ka; so a maximum rate of stream incision of ~0.15 m/ka is implied.

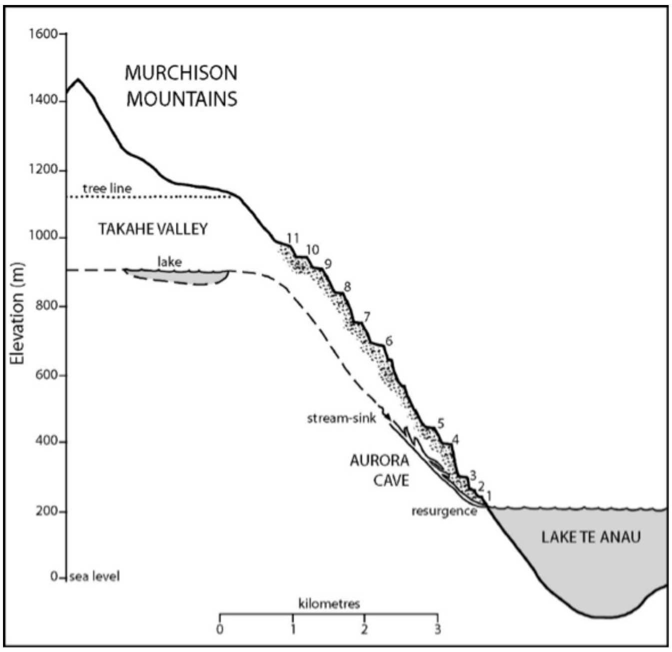

Fig. 1 Schematic profile of the slope above Aurora Cave. Numbers refer to lateral moraines.

ACKMA members at Aurora Cave entrance.
Photo: John Brush

A staircase of lateral moraines left by retreating glaciers runs up the valley side (Fig. 1), and these provide the opportunity to date glacial events in the valley by using cosmogenic exposure age dating of glacial erratics left of the surface of the moraines. By contrast, in the cave beneath the same slope, calcite deposition in the cave provides the opportunity to date mild unglaciated intervals, when speleothems accumulated, by using uranium series dating of calcite. The two independent

Jodie Anderson at the Twin Falls, Aurora Cave.
Photo: John Brush

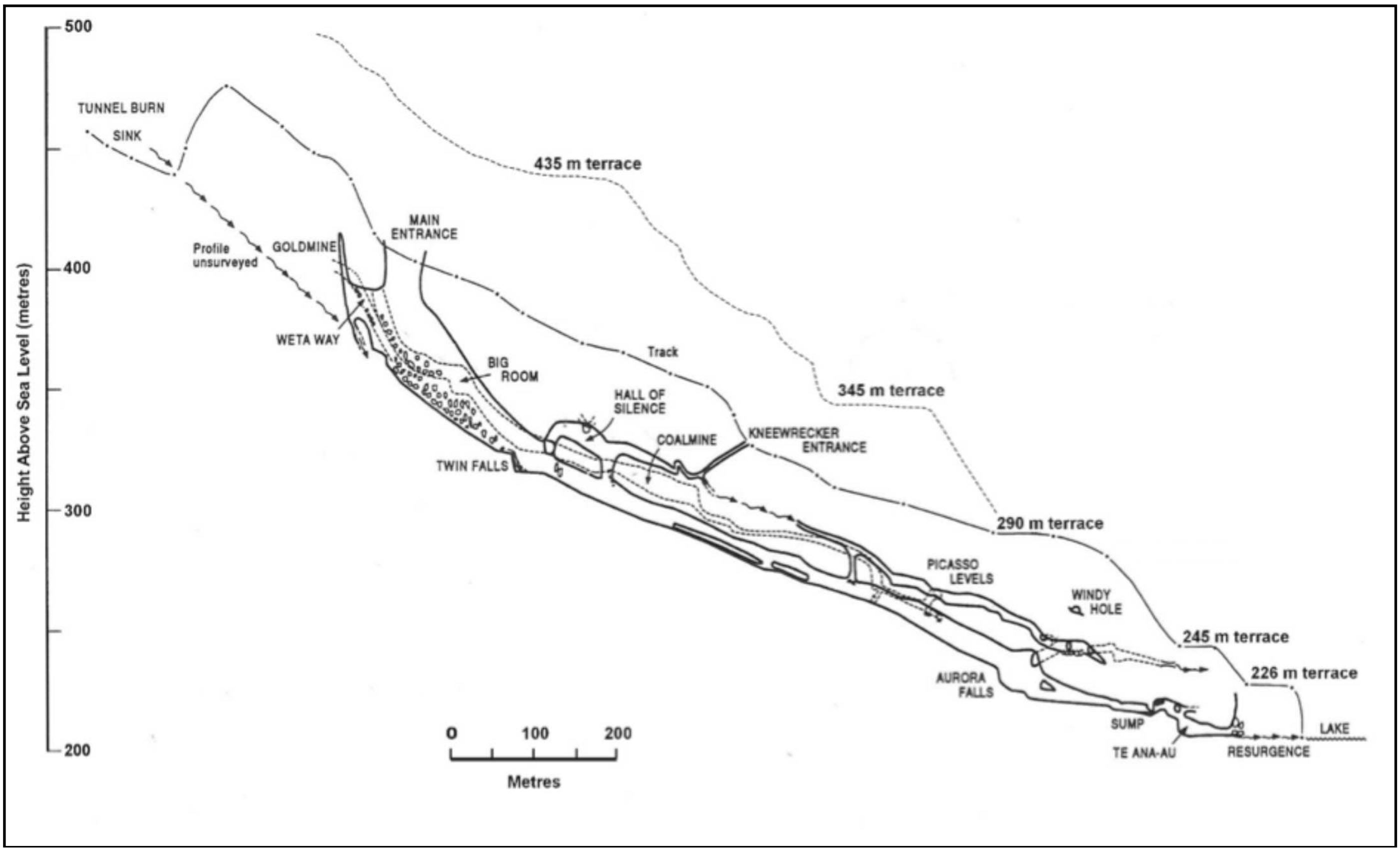

Fig. 2 Projected long profile of Aurora-Te Ana-au Cave showing moraine terrace levels overlying the cave. The Hall of Silence is illustrated in Fig. 3.

Paul Williams interpreting features of Aurora Cave. Photo: Steve Bourne

and complementary sources of dates offer a rare opportunity to learn much more about the Late Quaternary climatic history of the valley, specifically the timing of cold events (represented by moraines) and intervening warm intervals (represented by speleothems).

The cave acted as a sediment trap during glacial events (refer to Williams 1996 for more detail), but during mild intervals between glacial advances the cave stream re-excavated these sediments and, elsewhere, percolating water deposited speleothems on them. Stratigraphic sections in the cave reveal calcite speleothems interbedded with sands and gravels laid down by glacial meltwaters (glacifluvial deposits), and these provide the main source of dateable evidence within Aurora Cave. Thus speleothems provide evidence of when mild interstadial and interglacial conditions prevailed, and their ages yield bounding dates for glacifluvial events. Fig. 3 illustrates the dates on speleothem samples from the Hall of Silence. The main Te Anau valley glacier was the source of most meltwater and sediment in the cave, but the Takahe glacier, located in a hanging tributary that is the catchment of the modern cave stream (Fig. 1), would also have contributed glacifluvial sediments.

The ages of lateral moraines provide a chronology of glacial activity. Cosmogenic ages of erratic boulders on moraine surfaces provide minimum estimates of how long the boulders have been exposed. Samples from six lateral moraine terraces provided useable results, and showed terrace ages to become progressively younger as they descended in elevation towards the lake. The exposure ages indicated that an early Last Glaciation advance reached high up the valley-side above Aurora Cave and that the next lowest terrace at 830 m was deposited at the start of the global Last Glacial Maximum around 32,000 years ago (see Fink *et al* 2006 for details). At that time, the ice above Aurora Cave reached 627 m above modern lake level, and the glacier was about 1 km deep, but was not as large as the MIS 4 glacier (61-66 ka) that had preceded it. Lateral moraine terraces at 735 m, 435 m, 290 m and 226 m clearly define the level and date of the declining ice surface of the Te Anau Glacier through the LGM between about 30 ka and 18.5 ka.

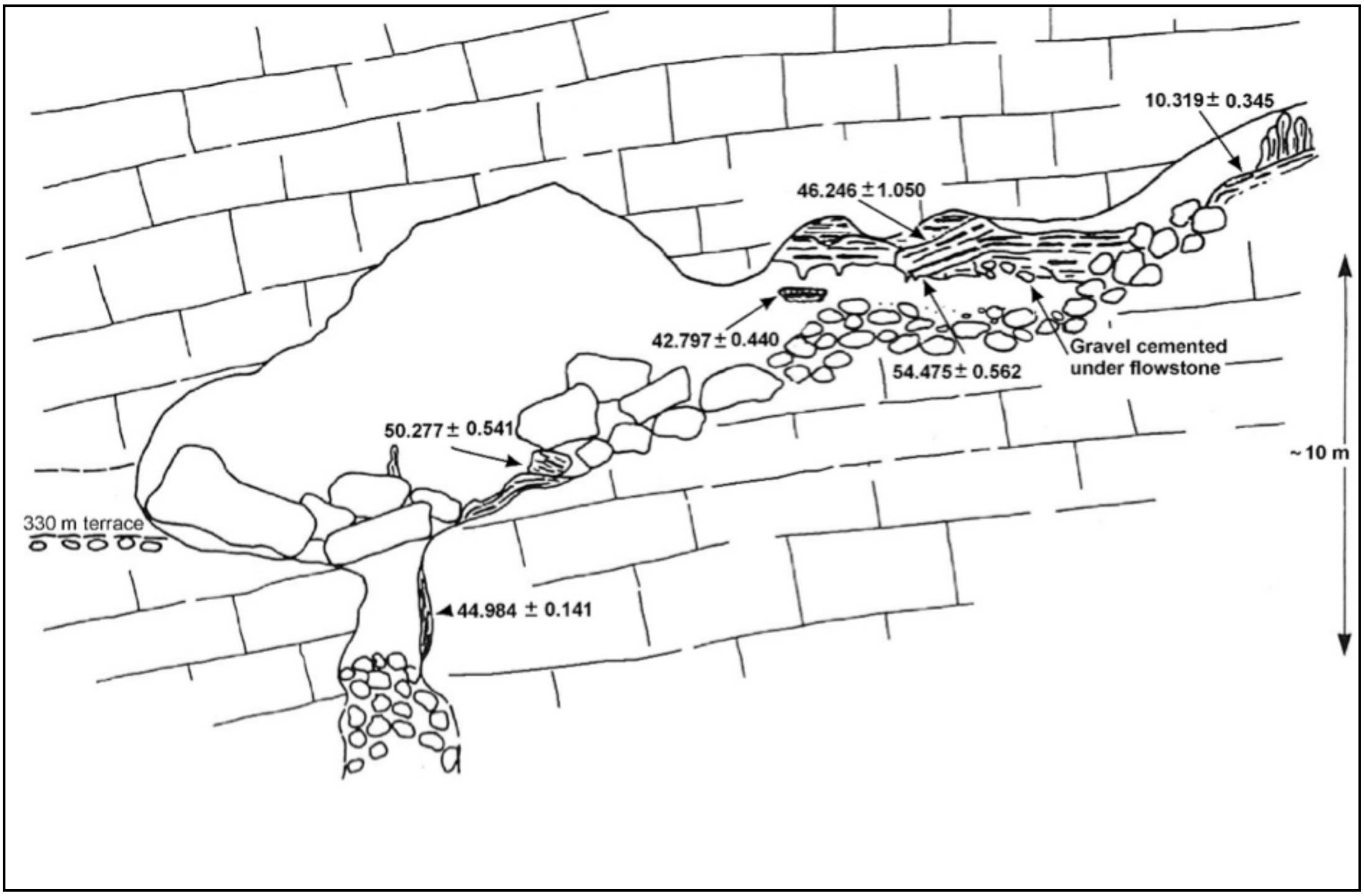

Fig. 3 Schematic cross-section through the Hall of Silence, with U/Th ages of dated speleothems. Access is via the passage with the 330 m terrace at left.

A passage formed by paragenesis in Aurora Cave. Paragenesis is when cave passage development is upwards due to the presence of sediment which prevents the erosion of the cave floor. Some of this sediment and large rocks are visible adhering to the wall partway up the right side of the cave passage. Photo: Steve Bourne

The Main Entrance of Aurora Cave at 406 m would have been exposed by glacial retreat during the mid-LGM interstadial around 22.5 ka. At that time the meltwater stream from the Takahe valley would have reinvaded the cave, and so would have recommenced the sluicing out some of the glacifuvial fill.

During the Late Glacial after 18 ka, it is probable that a glacier floated on the lake and calved icebergs as the ice margin retreated. By that date, the exit of the hanging Takahe valley at 890 m was ice-free, although a cirque glacier would have still remained further up-valley. The first recorded Late Glacial speleothems in Aurora Cave were growing around 16.5 ka in Weta Way Passage at 385 m and, thereafter, mild conditions sufficient for speleothem growth continued near lake level into the Holocene.

References

Fink, D., Williams, P.W., Augustinus, P., Shulmeister, J. 2006. Glacial chronologies across southern hemisphere latitudes during the past 30 ka and correlations to Antarctic ice cores. In: Burge, P.I., Shulmeister, J., Turney, C. (Eds) Australasian INTIMATE Meeting, University of Auckland, p. 14-16.

Turnbull, I.M., 1985. Te Anau Downs, Sheet D42AC & Part Sheet D43, Geological Map of New Zealand 1:50,000. Department of Scientific and Industrial Research, Wellington, New Zealand.

Turnbull, I.M., Allibone, A.H. and Jongens, R. (compilers) 2010. Geology of the Fiordland area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 17. 1 sheet + 97p. Lower Hutt, New Zealand, GNS Science.

Williams, P. W. 1996. A 230 ka record of glacial and interglacial events from Aurora Cave, Fiordland, New Zealand. NZ J. Geol. & Geophys. 39, 225-241.