Antarctic Science 18 (2), 261–264 (2006) © Antarctic Science Ltd Printed in the UK DOI: 10.1017/S0954102006000290

Latest Jurassic–earliest Cretaceous age for a fossil flora from the Latady Basin, Antarctic Peninsula

MORAG A. HUNTER[1], DAVID J. CANTRILL[2] and MICHAEL J. FLOWERDEW[1]

[1]*British Antarctic Survey, NERC, Madingley Road, High Cross, Cambridge CB3 0ET, UK*
[2]*Swedish Museum of Natural History, Department of Palaeobotany, Box 50007, Stockholm, 104 05, Sweden*

Abstract: Dating Jurassic terrestrial floras in the Antarctic Peninsula has proved problematic and controversial. Here U–Pb series dating on detrital zircons from a conglomerate interbedded with fossil plant material provide a maximal depositional age of 144 ± 3 Ma for a presumed Jurassic flora. This is the first confirmed latest Jurassic-earliest Cretaceous flora from the Latady Basin, and represents some of the youngest sedimentation in this basin. The presence of terrestrial sedimentation at Cantrill Nunataks suggests emergence of the arc closer to the Latady Basin margin in the south compared to Larsen Basin in the north, probably as a result of the failure of the southern Weddell Sea to undergo rifting.

Received 15 March 2005, accepted 4 October 2005

Key words: absolute age, Antarctica, biostratigraphy, palaeobotany

Introduction

Terrestrial Jurassic and Early Cretaceous floras in the Southern Hemisphere have been hard to date accurately largely due to the difficulty of correlating nonmarine sequences with well dated marine sequences, but also due to the lack of a terrestrial biostratigraphic framework for floras in the Southern Hemisphere. Consequently this has lead to considerable debate about the ages of floras, which in turn has had a significant impact on geological interpretations. This is particularly so in the Antarctic Peninsula where floras such as those of the Botany Bay Group (Larsen Basin; Fig. 1) have been variously interpreted as Early Jurassic (e.g. Rees & Cleal 2004); Middle Jurassic (e.g. Halle 1913) or even latest Jurassic to earliest Cretaceous (e.g. Gee 1989a). More importantly, Jurassic floras to the south of the Larsen Basin have been thought to be more or less coeval with those of the Botany Bay Group (e.g. Gee 1989b). The Botany Bay Group floras occur in the initial pre-rift break-up sequences and so provide evidence for the initial timing of continental fragmentation. Recent geochronological investigations have established an absolute age for the Botany Bay Group flora as Middle Jurassic (167 Ma; Hunter *et al.* 2005). To the south, volcanism and sedimentation in the Latady Basin associated with initial break up started during the Early Jurassic (Fanning & Laudon 1999) implying that the deposition along the Weddell Sea basin margin was not synchronous with the opening of the Weddell Sea embayment occurring earlier in the south (Hunter *et al.* 2005). This also implies that floras to the south, which were thought to be coeval with the Botany Bay Group, may not be. For this reason we dated a newly discovered flora from the Cantrill Nunataks region (Fig. 1) of the Latady Basin (Cantrill & Hunter 2005) using U–Pb zircon ion-microprobe ages.

Geological background and setting

The Latady Basin on the eastern side of the Antarctic Peninsula contains a thick sequence of Jurassic sedimentary and volcanic strata assigned to the Latady (Williams *et al.* 1972) and Mount Poster (Rowley *et al*. 1982) formations. A lack of precise age constraints within the formations, coupled with tectonic deformation and low levels of exposure have hampered attempts to generate a regional lithostratigraphy and hence a model for basin evolution. The oldest strata recognised within the Latady Basin are the volcanics of the Mount Poster Formation (Fig. 1). These contain thick intra- and extra-caldera sequences of silicic and basaltic volcanics, with rare interbedded lacustrine sediments. Cantrill Nunataks, ~10 km north of the main exposure of the Mount Poster Formation, comprise sequences of deltaic sandstones that contain a small palaeoflora (Cantrill & Hunter 2005). This flora is similar to that found in the Botany Bay Group in the northern Antarctic Peninsula (Rees & Cleal 2004), where the plants were buried during the earliest phase of terrestrial deposition in the Larsen Basin (Farquharson 1984).

The 120 m of sedimentary strata exposed in the Cantrill Nunataks region is dominated by repeated, 2 m thick, fining upwards cycles of fine-grained sandstone to mudstone that often terminate in thin silicified coals or palaeosols. Sandstone beds can display fine scale normally graded bedding, flaser bedding, or contain entrained mudstone flakes. Thicker (3–5 m) cross-bedded medium- to coarse-grained sandstone units often cut into the finer-grained sediments and occur every 10–15 m in the section. These sandstones are sometimes channelized (tens of metres wide and 3–4 m thick) and may contain a basal conglomerate, otherwise they form more continuous beds. Plant remains are most abundant in the mudstone units. Where present,

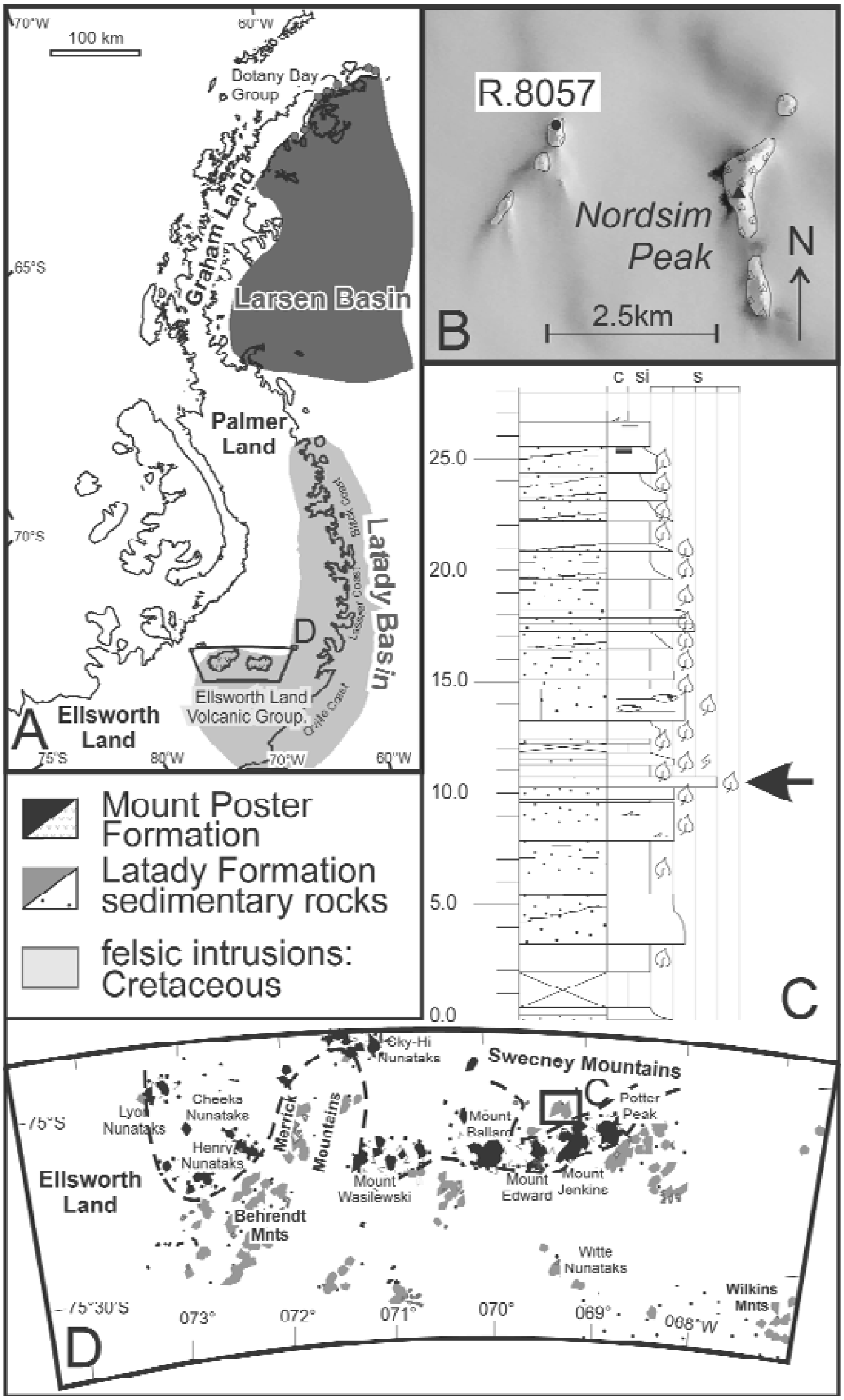

Fig. 1. Map showing the location of **a.** Larsen and Latady basins, **b.** location of the sample at Cantrill Nunataks, **c.** lithological log from the locality showing the sample location interbedded with the plant bearing horizons, and **d.** outcrop pattern of the Mount Poster Formation and Latady Formation.

fossil roots extend from palaeosols through to sandier units below. The fining upwards cycles, thin coals, rooted horizons and abundant plant material are all consistent with a terrestrial, fluvial to deltaic setting. Sheeted sandstones represent overbank crevasse splay deposits. Between these predominantly mudstone facies are channelized sandstones representing waterways meandering through the delta system.

Materials and methods

Zircons were extracted from a granule grade conglomerate (R.8057.1) interbedded with plant bearing mudstones, 3 km west of Nordsim Peak (Fig. 1c). The sediment is poorly- to moderately-sorted, with sub-angular to well-rounded grains dominated by silicic volcanic and alkali feldspar clasts. Quartz granules are common and include vein quartz and quartzite. Zircons are mostly clear and colourless prisms,

https://doi.org/10.1017/S0954102006000290 Published online by Cambridge University Press

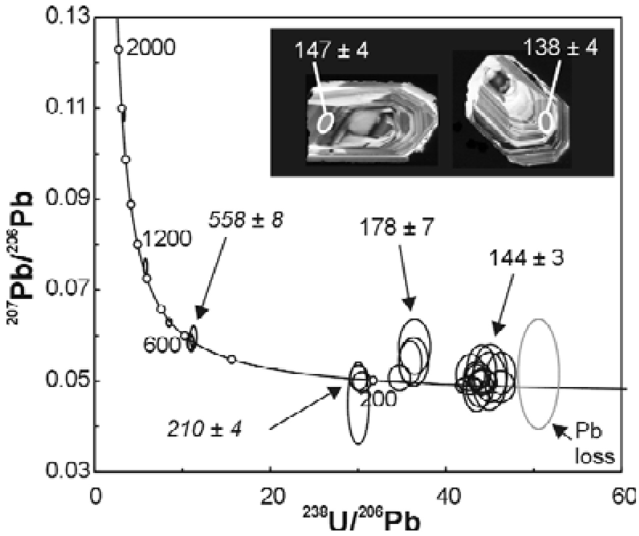

Fig. 2. Cathodo-luminescence images and Concordia diagram. For the CL images, ellipses show the location of analysis spots; ages refer to the $^{206}Pb/^{238}U$ age (± 2σ) of the analysis. For the Concordia diagram, ages (± 2σ) relate to distinct detrital zircon populations. Ages are calculated from a weighted average of the $^{206}Pb/^{238}U$ age for each population; ages in italics are Concordia ages. Ellipse in grey, labelled Pb loss, is interpreted to have suffered Pb loss and so does not yield a meaningful result.

100–250 µm in length, with aspect ratios between 1:1 and 3:1 and have well-developed crystal facets.

The separated zircons were mounted in epoxy and imaged under cathodo-luminescence (CL) prior to analysis. Under CL the grains range in florescence, and exhibit clear growth zoning (Fig. 2). U–Pb zircon analyses were performed by the Cameca 1270 ion-microprobe at the NORDSIM facility, Swedish Natural History Museum, Stockholm. The analytical procedure adopted closely followed that outlined by Whitehouse *et al.* (1997). In this report only the results are presented; the data and a more detailed analytical method will be published elsewhere. Concordia diagrams and concordia average ages (Ludwig 1998) have been calculated using ISOPLOT version 3.1 (Ludwig 1999), using the decay constants recommended by Steiger & Jäger (1977). Age ellipses and results are shown and quoted at the 2σ level throughout. Results are presented in Fig. 2.

Age and implications

Our initial thesis was that floras in the Latady Basin should predate those in the Botany Bay Group based on recent geochronological studies (Laudon & Fanning 2003, Hunter *et al.* 2005). In particular the occurrence of terrestrial deposition at Cantrill Nunataks, in close proximity to the terrestrial volcanic break up sequence of the late Early Jurassic Mount Poster Formation (Fanning & Laudon 1999) was thought to suggest that these floras were part of the initial break up sequence. Our results (Fig. 2) have yielded a youngest U–Pb detrital zircon population age of 144 ± 3 Ma, suggesting a maximum depositional age in the latest Jurassic to earliest Cretaceous, making these some of the youngest strata in the Latady Basin.

The only previously described Late Jurassic deposits in the Latady Basin are deep marine mudstones at Cape Zumberge, which contain a Tithonian ammonite fauna (Thomson 1983). Late Jurassic deposition in the northern Antarctic Peninsula (Larsen Basin, Fig. 1) is also deep marine and current models of basin evolution along the eastern Antarctic margin suggest deposition of a Late Jurassic post rift transgressive megasequence as a result of thermal sag following late Early to Middle Jurassic rifting (e.g. Hathway 2000). Subduction under the Pacific (or western) margin of the Antarctic Peninsula during the Late Jurassic resulted in the production of arc material. The arc was initially submerged but was progressively uplifted as arc construction proceeded in the latest Jurassic and Early Cretaceous (Pirrie & Crame 1995). Deposition continued to be marine, consistent with a distal arc somewhere to the west in the northern Antarctic Peninsula. However, identification of terrestrial sedimentation in the latest Jurassic/Early Cretaceous at Cantrill Nunataks suggests emergence of the volcanic arc closer to the basin margin in the south, rapid erosion and progradation of deltaic sediments over the shallow marine Latady Basin. Failure of the southern Weddell Sea to undergo sea floor spreading plus continued uplift of the arc could have led to further progradation of the terrestrial environment, and would explain the absence of younger deposits in the Latady Basin compared to the Larsen Basin, which extends into the Tertiary (Macdonald *et al*. 1988).

Acknowledgements

Support for the analytical work was provided to Morag Hunter through the European Framework 5 major research infrastructure grant HIGHLATS to the Swedish Museum of Natural History. Martin Whitehouse and the NORDSIM staff are thanked for their analytical assistance. We thank Dan Hikuroa and an anonymous referee for their helpful comments. This is NORDSIM contribution number 130.

References

Cantrill, D.J. & Hunter, M.A. 2005. Macrofossil floras from the Latady Basin. *New Zealand Journal of Geology and Geophysics,* **48**, 745–748.

Farquharson, G.W. 1984. Late Mesozoic, non-marine conglomeratic sequences of northern Antarctic Peninsula (the Botany Bay Group). *British Antarctic Survey Bulletin*, No. 65, 1–32.

Fanning, C.M. & Laudon, T.S. 1999. Mesozoic volcanism, plutonism and sedimentation in eastern Ellsworth land, West Antarctic. *In* Skinner, D.N.B., *ed. 8th International Symposium on Antarctic Earth Sciences, programme and abstracts.* Victoria: University of Wellington, Wellington, New Zealand, 102.

Gee, C.T. 1989a. Revision of the Late Jurassic/Early Cretaceous flora from Hope Bay, Antarctica. *Palaeontographica B,* **213**, 149–214.

GEE, C.T. 1989b. Permian *Glossopteris* and (Jurassic) *Elatocladus* megafossil floras from the English Coast, eastern Ellsworth Land, Antarctica. *Antarctic Science*, **1**, 35–44.

HALLE, T.G. 1913. The Meoszoic flora of Graham Land. *Wissenschaftliche ergebnisse Der Schwedischen Südpolar expedition 1901–1903*, **3**(14), 1–123.

HATHWAY, B. 2000. Continental rift to back-arc basin: Jurassic–Cretaceous stratigraphical and structural evolution of the Larsen basin, Antarctic Peninsula. *Journal of the Geological Society, London,* **157**, 417–432.

HUNTER, M.A., CANTRILL, D.J., FLOWERDEW, M.J. & MILLAR, I.L. 2005. Middle Jurassic age for the Botany Bay Group: implications for Weddell Sea Basin creation and Southern Hemisphere biostratigraphy. *Journal of the Geological Society, London*, **162**, 745–748.

LAUDON, T.S. & FANNING, C.M. 2003. SHRIMP U–Pb characteristics of detrital zircons, eastern Ellsworth Land. *9th International Symposium on Antarctic Earth Sciences, Potsdam, Germany*. Programme and Abstracts, 200–202.

LUDWIG, K.R. 1998. On the treatment of concordant U–Pb ages. *Geochimica et Cosmochimica Acta,* **62**, 665–676.

LUDWIG, K.R. 1999. Using Isoplot/Ex version 2, a geochronological toolkit for Microsoft excel. *Berkley Geochronological Special Publications,* **1a**, 1–47.

MACDONALD, D.I.M., BARKER, P.F., GARRETT, S.W., INESON, J.R., PIRRIE, D., STOREY, B.C., WHITHAM, A.G., KINGHORN, R.R.F. & MARSHALL, J.E.A. 1988. A preliminary assessment of the hydrocarbon potential of the Larsen Basin, Antarctica. *Marine and Petroleum Geology*, **5**, 34–53.

PIRRIE, D. & CRAME, J.A. 1995. Late Jurassic palaeogeography and anaerobic-dysaerobic sedimentation in the northern Antarctic Peninsula region. *Journal of the Geological Society, London*, **152**, 469–480.

REES, P.M. & CLEAL, C.J. 2004. Early Jurassic floras from Hope Bay and Botany Bay, Antarctica. *Special Papers in Palaeontology*, **72**, 1–90.

ROWLEY, P.D., SCHMIDT, D.L. & WILLIAMS, P.L. 1982. Mount Poster Formation, southern Antarctic Peninsula. Mount Poster Formation, southern Antarctic Peninsula and eastern Ellsworth Land. *Antarctic Journal of the United States*, **17**, 38–39.

STEIGER, R.H. & JÄGER, E. 1977. Subcommission on geochronology; convention on the use of decay constants in geo- and cosmochronology. *Earth and Planetary Science Letters,* **36**, 359–362.

THOMSON, M.R.A. 1983. Late Jurassic ammonites from the Orville Coast, Antarctica. *In* OLIVER, R.L., JAMES, P.R. & JAGO, J.B., *eds*. *Antarctic earth science*. Canberra: Australian Academy of Science, 315–319.

WHITEHOUSE, M.J., CLAESSON, S., SUNDE, T. & VESTIN, J. 1997. Ion microprobe geochronology and correlation of Archaean gneisses from the Lewisian Complex of Gruinard Bay, northwestern Scotland. *Geochimica et Cosmochimica Acta,* **61**, 4429–4438.

WILLIAMS, P.L., SCHMIDT, D.L., PLUMMER, C.C. & BROWN, L.E. 1972. Geology of the Lassiter Coast area, Antarctic Peninsula: preliminary report. *In* ADIE, R.J., *ed*. *Antarctic geology and geophysics*. Oslo: Universitetsforlaget, 143–153.