Permian and Triassic driftwood from the Allan Hills, Antarctica

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The fossil forests of Antarctica are a reminder that conditions on the ice continent were very different in the distant geological past. Paleoclimate was evidently warm enough to support forests during the early Cretaceous (Jefferson 1982), Triassic (Taylor and Taylor 1993), and Permian (Taylor, Taylor, and Cúneo 1992). These well-known assemblages of permineralized fossil wood are called "fossil forests" because they are in place of growth within paleosols. Their spacing and growth rings preserve a record of the anomalously productive growth of forests at high latitudes under low summer Sun and dark winters (Creber 1990). Even drifted logs entombed in fluvial paleochannels can yield useful information about stature of past ecosystems, in addition to paleocurrent data. Drifted fossil logs of the Allan Hills have been known for some time (Plumstead 1962; Francis et al. 1993; Woolfe et al. in press), but work reported here is the first detailed mapping of these impressive accumulations of fossil wood.

One of the most extensive accumulations of fossil wood in the Allan Hills is at the head of Trudge Valley, on the broad sandstone bench that forms a col separating it from a valley to the west (figure 1, 76°42.5'S 159°48.6'E). Fossil wood is common throughout this 11-meter (m) thick sandstone for about 1 kilometer (km) in the col. The sandstone is within the mid-Permian Weller Coal Measures (Kyle and Schopf 1982, pp. 649–659), some 30 m stratigraphically below the top of the formation as mapped by Woolfe et al. (in press). All the fossil wood is gymnospermous and similar to *Dadoxylon allani* Kräusel (Plumstead 1962), a fossil species based on specimens collected by B.M. Gunn and G. Warren from this same sandstone bed some 2 km to the east. Shales within the sandstone and associated with the coal seam below the sandstone have yielded fossil leaves of *Glossopteris* 2 km to the east (Plumstead 1962; Townrow 1967; Cúneo et al. 1993). Both leaves and wood are remains of glossopterid swamp forests. Two accumulations of logs were chosen for detailed mapping: one stratigraphically 5 m above the underlying coal bed along the western margin of the ridge to the south side of the col (figure 2*B*) and a second one stratigraphically 9 m above the underlying coal near the eastern margin of the narrowest part of the col platform (figure 2*A*). In both cases, the accumulations include a few erect stumps, but no indication of roots extending down into a paleosol is evident. Some large roots of the stumps are rounded as if water-worn and transported. The enclosing sandstone shows abundant trough-cross bedding and scour-and-fill structures and is interpreted as the deposit of braided streams (by Ballance 1977; Cúneo et al. 1993; Woolfe et al. in press).

A second extensive area of fossil wood crops out over some 2 km in an arc 600 m inland of the ice margin 4 km to the north of Trudge Valley (figure 3; 76°48.3'S 159°48.4'E). These fossil logs are stratigraphically 135 m above the base and 43 m below the top of the Feather Conglomerate, 15 m above a zone of conspicuous clayey paleosols near the point where the trace fossil *Skolithus* becomes much scarcer than lower in the formation. Although the geological age of the Feather Conglomerate is a matter of some debate, this stratigraphic level is regarded as early-middle Triassic (Collinson 1990), by correlation with sediments yielding fossil pollen and spores elsewhere in southern Victoria Land (Helby and McElroy 1969; Kyle 1977; Kyle and Schopf 1982). Again the wood is gymnospermous, but its growth rings are narrower and its cellular structure more compact than for *Dadoxylon allani*. These Triassic logs from the Allan Hills are superficially comparable to podocarp conifer woods from Antarctica referred to *Antarcticoxylon priestleyi* and *Nothophytum krauselii* (Meyer-Berthaud and Taylor 1991) and corystosperm seed fern wood

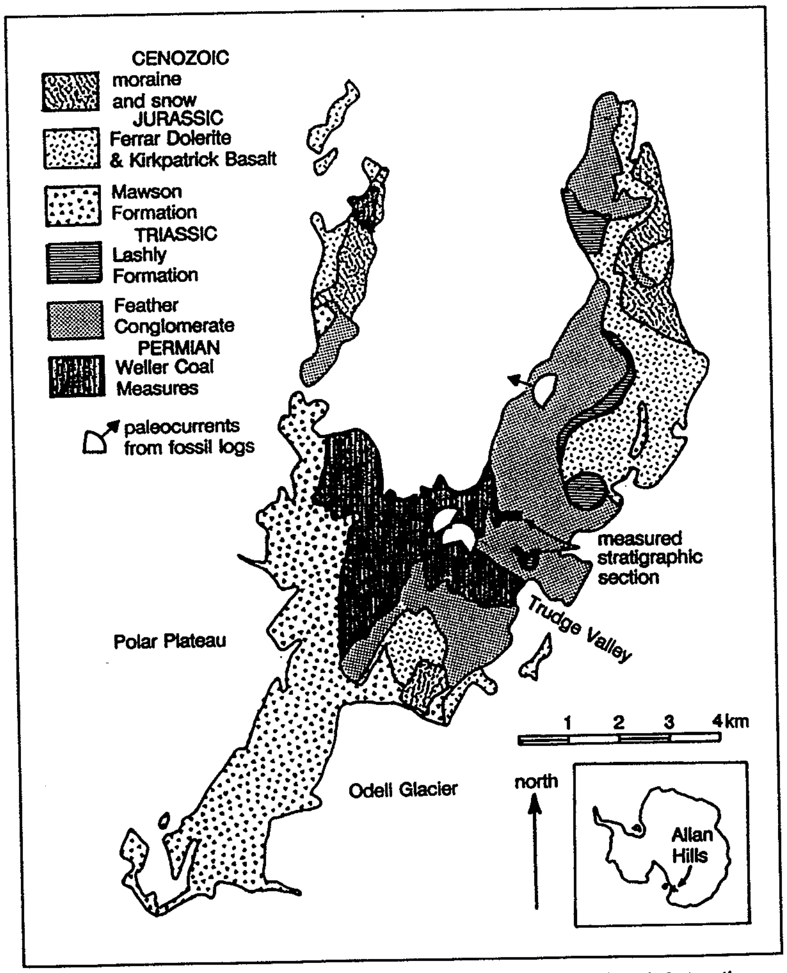

Figure 1. Location of fossil wood in the Allan Hills, South Victoria Land, Antarctica.

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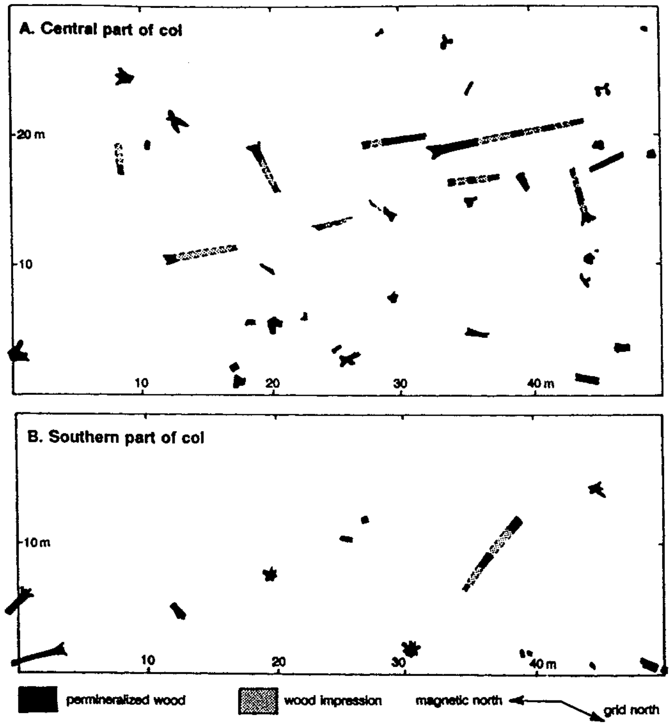

Figure 2. Fossil logs in the mid-Permian, Weller Coal Measures at the head of Trudge Valley, Allan Hills; *A*, in the central part of the col to the valley to the northeast; *B*, in the southern part of the col.

of *Kykloxylon fremouwense* (Meyer-Berthaud, Taylor, and Taylor 1993). The logs are associated with angular blocks of permineralized peat within a matrix of trough cross-bedded sandstone that has been interpreted as the deposit of braided streams (Collinson 1990). No fossil root traces or laterally continuous permineralized peats that could be interpreted as paleosols in place were found.

Orientations of the fossil logs were measured looking from the direction of the stump toward the top of the tree, assuming that the heavy and irregular stump grounded in the stream, then the bole swung around in the current. Flume studies have shown that asymmetric-elongate wood fragments tend to adopt such current-parallel orientation (MacDonald and Jefferson 1985). Log orientation shows great variation, perhaps in part because of mutual interference in a log jam. Both Permian and Triassic logs were oriented with flow to the north or northwest (figure 1, table), consistent with paleocurrent directions measured from cross-bedding in the Weller Coal Measures and Feather Conglomerate (Ballance 1977; Woolfe et al. in press).

Some of the fossil logs are big. The longest log seen in the Feather Conglomerate was 19 m long (Woolfe et al. in press), and in the Weller Coal Measures, the longest was 12 m. These figures mean little considering the incompleteness of even the largest logs. Given the maximum diameters observed and linear regressions between diameter and height for a variety of living cool-temperate trees (Whittaker and Woodwell 1968), these probably were trees up to 50 m high. Although this is impressive, the diameters and growth ring counts are not those of old-growth forests. These Permian and Triassic streams sampled forests only 50–100 years old, probably because they were within the channelway of the 100-year flood. Old-growth forests were also present, not represented by fossil logs but by thick clayey paleosols (Woolfe et al. in press).

The Triassic logs are smaller than the Permian logs, but this could reflect a change in flooding regimen and preservational biases, rather than past ecological conditions. The Triassic logs also are botanically distinct from the Permian logs. Despite massive extinctions of plants at the Permian-Triassic boundary (Retallack 1995), forests flourished in Antarctica during Permian and Triassic time in a much warmer and more humid climate than in the Allan Hills today. Drift logs of the Allan Hills are impressive monuments to those vanished forests.

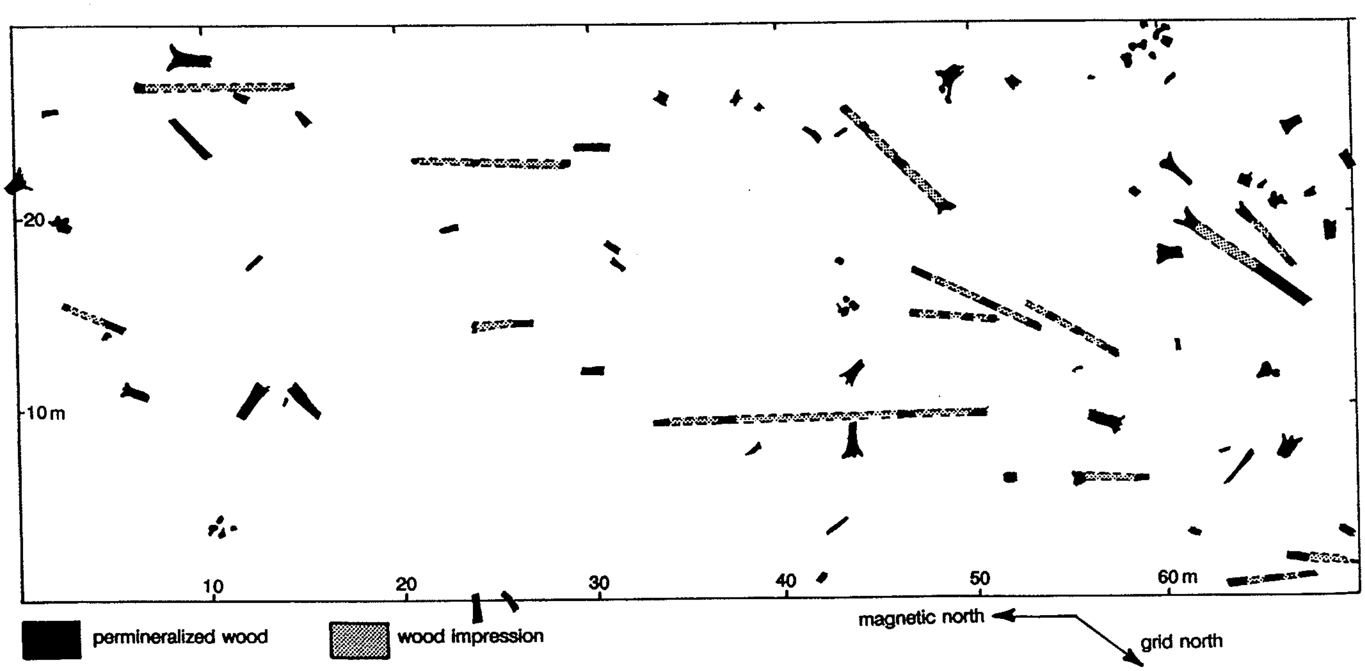

Figure 3. Accumulation of fossil logs in the early Triassic Feather Sandstone, Allan Hills.

Measurements of fossil logs from Allan Hills. (Mag. denotes magnetic. Std. dev. denotes standard deviation.* n *denotes number. Max denotes maximum. Min. denotes minimum.)

Fossil forest	Orientation				Diameter					Growth rings (no.)				
	True mean	Mag. mean	Std. dev.	*n*	Mean	Max.	Min.	Std. dev.	*n*	Mean	Max.	Min.	Std. dev.	*n*
Trudge Valley South (Permian)	023	236	123	6	43	59	24	9	13	71	116	32	35	5
Trudge Valley North (Permian)	323	176	74	17	47	114	9	30	32	60	110	51	26	6
Northeast Allan Hills (Triassic)	290	143	85	28	24	94	5	16	72	58	67	36	13	4

Shaun M. Norman helped in the field with tape and compass, and U.S. Navy squadron VXE6 helicopters delivered us to the field. Research was funded by National Science Foundation grant OPP 93-15228.

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