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Permian coprolites from Graphite Peak, Antarctica

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We report here the first known evidence for Permian vertebrates in Antarctica in the form of coprolites. Numerous coprolites were collected (Condon Collection, University of Oregon specimens F35111–35123) from a sandstone of the lower Buckley Formation [270 meters (m) below contact with Fremouw Formation in measured section of Barrett, Elliot, and Lindsay (1986)] of mid-Permian age (Farabee, Taylor, and Taylor 1991) in the slopes just above the moraine wall of the Falkenhof Glacier below Graphite Peak, central Transantarctic Mountains (85°2.9'S 172°21.3'E, elevation 2,600 m; figure 1). The sandstone matrix has large trough crossbeds similar to those found in paleochannels. It also contains large blocks of paleosol claystone and numerous permineralized logs in its basal 3 m. The coprolites are most common within a 2-m interval, 6 m above the base of the paleochannel. Our measurements of the long axis of 56 specimens showed a surprising uniformity of orientation (figure 2), aligned with paleocurrents for the Buckley Formation at Graphite Peak (Isbell 1991).

The coprolites are helical, pupiform, and discoidal in shape (figure 3). The helical coprolites have internal seams of carbonaceous sandstone marking the internally juxtaposed coils (figure 3*D*). They lack internal lumen or mucosal folds. They also are variable in degree of unravelling and in size, so were probably not fossilized intestinal contents [enterospirae or cololites of McAllister (1985)]. Pupiform coprolites show a terminal segment helically wrapped and probably were also pinched off from a helically valvate anus before full extrusion.

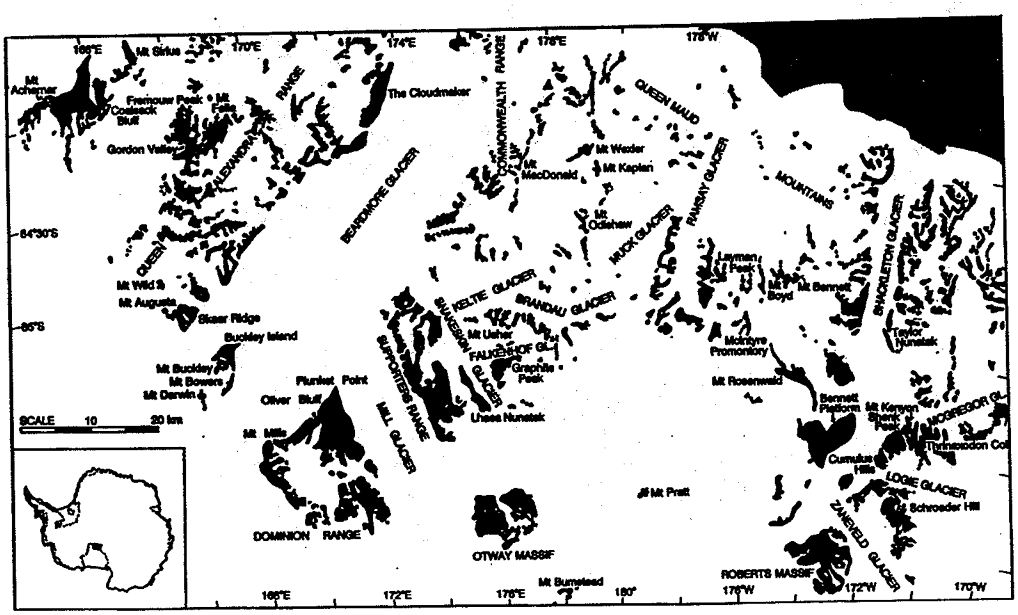

Figure 1. Location of Graphite Peak in the central Transantarctic Mountains.

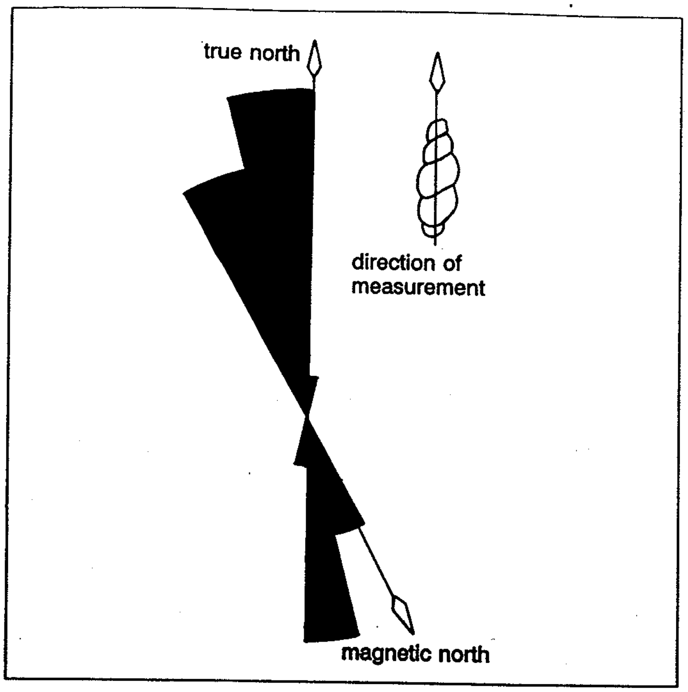

Figure 2. Orientation of 56 coprolites from the Permian Buckley Formation at Graphite Peak, Transantarctic Mountains, with sketch showing the direction measured.

Some of the discoidal masses with radiating cracks and ridges are preserved in the same manner as the associated helical and pupiform coprolites, and appear to be unravelled helices (figure 3*E* and *F*).

The coprolites consist of sandstone. Their matrix is 22.8 volume percent calcite and 9.0 percent clay by point counting 500 points in petrographic thin section. Most of the grains are sand-size and consist of quartz (23 percent), feldspar (12.4 percent), and metamorphic rock fragments (22.4 percent), with traces of hornblende (3.0 percent), mica (2.4 percent), coal fragments (0.2 percent), and other dark brown grains (3.8 percent). Many of the dark brown grains had an internal structure like that of ganoin (figure 3*G*) and are probably scales of paleoniscid fish. The scales are 0.5–1 millimeters (mm) long and 0.2–0.4 mm thick. From observations of complete Permian paleoniscid fish fossils from Germany and Texas, these scales would have come from animals 10–30 centimeters (cm) long. The elongate helical coprolites average 173 mm long (n=10, σ_n=41 mm, r=99–240 mm), 75 mm wide (n=10, σ_n=14 mm, r=50–100) but only 44 mm thick (n=10, σ_n=8 mm, r=34–64) due to postdepositional compaction. They are comparable in size and shape to a specimen of Triassic age from Graphite Peak (misidentified as a large snail by Barrett et al. 1986). They are much larger than Jurassic helical coprolites previously

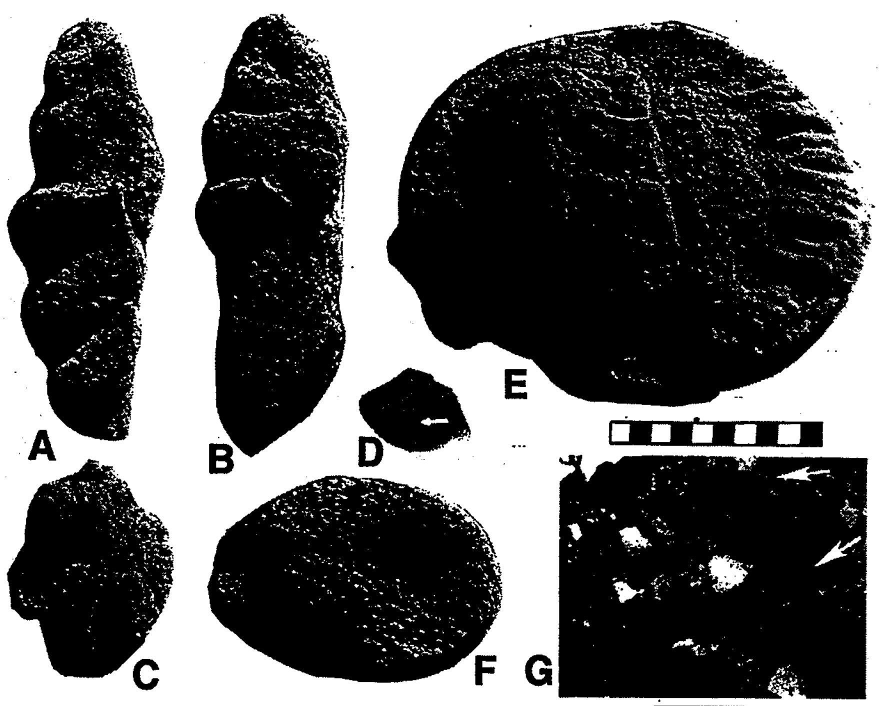

Figure 3. Permian coprolites from the Buckley Formation at Graphite Peak (*A–F*), with a sawn cross section (*D*) and photomicrograph under crossed nicols (*G*), from the Buckley Formation at Graphite Peak, central Transantarctic Mountains. White arrow in *D* indicates internal carbonaceous seam of helix. White arrows upper right in *G* show tabular near-opaque grains interpreted as paleoniscid fish scales. Scale bar for fossils: 10 cm graduated in cm and for photomicrograph 1 mm. Condon Collection, University of Oregon specimen numbers are F35111A (*A*), F35111B (*B*), F35112D (*C*), F35118C (*D*), F35119 (*E*), F35122 (*F*), and F35118C (*G*).

recorded from Antarctica (Tasch 1976; Doyle and Witham 1991).

Helical coprolites are formed by the helical intestine of many kinds of fish, including cyclostomes, placoderms, acanthodians, bowfin (*Amia*), garpike (*Lepisosteus*), chimaeras, sharks, and lungfish (Jain 1983; Coy 1995). Freshwater sharks and lungfish have a fossil record in the Middle Devonian of Antarctica and Australia (Long 1991; Young 1993) and sharks in the Permian of Australia (Long 1991). A loose helix and unravelling after sitting on the bottom for a few hours are characteristics of lungfish feces (Jain 1983), which are very similar to the fossils. A dipnoan bottom-feeding behavior would also be compatible with the sediment-rich nature of the coprolites, as argued for comparable scroll coprolites (Gilmore 1992). Coprolites of this size would be produced by living lungfish (*Neoceratodus forsteri*) some 2–6 m long (Jain 1983).

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