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Reinterpretation of Pingos in Antarctica

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In 1983 pingos were reported in the Vestfold Hills, Antarctica. The features form dome-shaped hills up to 4 m high and 12 m in diameter and occur on an ice-cored moraine. Their form, structure, and sedimentary processes observed on the surface of the moraine, together with a consideration of the environmental requirements for pingo growth preclude their origin as pingos. They appear to be residual landforms that have formed on the surface of the moraine as the ice core has been destroyed by ablation and thermal erosion. The previous interpretation of the features has relied on the shape of the hills and their occurrence in a similar geologic setting to pingos in the Northern Hemisphere. The interpretation appears to have misinterpreted tension cracks and coherent slumping of sediment as dilation cracks and as evidence for the extrusion of a central sediment plug. Pingos on supraglacial debris have not been described from any other locations and it seems that their formation is inconsistent with the ablation of the ice core of moraines.

Pingos are ice-cored hills that only persist and grow in a permafrost environment (Mackay, 1987). Pickard (1983) describes pingos on an ice-cored moraine in the Vestfold Hills, Antarctica (68°40′S 78°00′E). He proposed a mechanism of formation that was identical to that suggested for closed-system pingos in the arctic by Mackay (1979). Most arctic closed-system pingos develop in shallow residual ponds left by drained lakes (Mackay, 1979). Before the lakes are drained they maintain an unfrozen basin (talik) beneath them. When the lake-bottom sediments are exposed and become frozen, permafrost aggrades downward from the surface and upward from the base of the talik. The aggradation of the permafrost drives porewater upward where a core of ice forms (Mackay, 1987). Pickard's interpretation of the hills in Antarctica was based on the occurrence of a pingo-like form in "the proper geologic setting to produce pingos" (Pickard, 1983, p. 106).

The form, structure, and surface sedimentary processes on the features described by Pickard in Antarctica, and a consideration of the environmental conditions necessary for pingo growth, preclude their origin as pingos.

The pingos that Pickard describes occur on a 2-km^2 body of stagnant or slowly moving ice-cored moraine at the northern edge of the Sørsdal Glacier. The moraine has an irregular surface that consists of numerous flat surfaces that represent former stream and lake beds, with intervening small ice-floored lakes and stream channels. The thickness of supraglacial debris ranges from 0.2 m near the ice edge to a maximum of about 2 m on the western edge of the moraine. The small ice-cored hills that Pickard describes occur in the central part of the moraine where the thickness of supraglacial debris seldom exceeds 1.5 m. The hills range from 1 to 4 m in height and from 4 to 12 m in width. They are closely grouped with as little as 6 m separating the centers of some. Several of the larger hills are not in fact dome-shaped but have flat tops which are surrounded by a small scarp and debris slopes of around 25° (Fig. 1a). The flat tops are at the same altitude as larger surround-

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FIG. 1. Features described by Pickard (1983) as pingos. (a) A flat-topped ice-cored hill. (b) Tension cracks on the surface of a melting ice-cored hill.

ing terrace remnants. Pingos have not previously been described on ice-cored moraine and therefore it cannot be considered the proper geological setting for their development as described by Pickard.

The sediments exposed on the surface of the ice-cored hills and in the surrounding terrace edges are silty diamictons and are often interbedded with laminated lake silts. Although the hills occur in a former lake bed the thickness of laminated silts does not exceed 0.4 m and was commonly around 0.2 m. Excavation of the hills showed that they had an ice core that consisted of foliated glacier ice that dipped toward the glacier at 35° (Fig. 2). The dip of the ice is consistent with nearby exposures of the buried glacier ice. Over a period of 10 days meltwater was observed seeping from several of the hills and blocks of diamicton toppled from the scarps (Fig. 1). Cracks in the tops of the hills were produced as the coherent diamicton blocks slumped and rolled down the sides of the hills. The ice cores of the alleged pingos are clearly melting as is the ice core of the entire moraine.

Current understanding of closed-system pingos requires the formation of a talik in which pore water is increased by aggrading permafrost. The lakes on the ice-cored moraine either rest directly on glacier ice or on a very thin diamicton. The maximum thickness of a talik on the ice-cored moraine is 1.5 m, which is insufficient to hold sufficient pore water to produce a pingo. Even if the debris was substantially thicker, because the ice core of the moraine is degrading, much of the thickness of the supraglacial debris is thawed at some time during the summer. Observations suggest that the thickness of perennially frozen debris below the active layer on this part of the moraine ranges from 0 to 1 m depth. Most of the debris is within the active layer and cannot be considered to be permafrost.

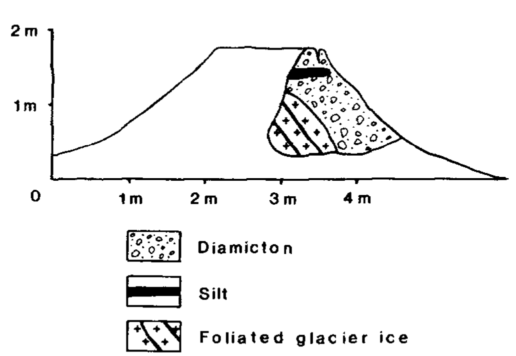

FIG. 2. Cross section showing the structure of an ice-cored hill.

The morphology of many of the hills are unlike pingos and their structure and surface sedimentary processes appear to preclude their origin as pingos. Rather, the evidence strongly suggests that the hills are residual landforms that have resulted from the melting and preferential thermal erosion of the ice core of the moraine. Flat-topped, dome, and mound-shaped hills are common in ice-cored moraines (Clayton, 1964; McKenzie, 1969; Hooke, 1970). The hills on the ice-cored moraine appear to have been formed from the disintegration of former surfaces which can be seen from the flat tops of the larger hills (Fig. 1a).

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