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Sedimentology of the Polarstar Formation (Permian), Ellsworth Mountains

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Sedimentologic studies of the Polarstar Formation were conducted by the authors from 11 to 29 December 1979. Most locations were reached by motor toboggan from a tent camp in the northern Sentinel Range (figure 1). Helicopter support from the Ellsworth Mountains base camp aided in setting up the tent camp and in visiting the less accessible sites.

The Polarstar Formation consists mostly of argillite and sandstone. Craddock (1969) described the following stratigraphic sequence: (1) argillite at the base; (2) argillite and fine-grained sandstone in the middle; and (3) coal measures at the top. His estimate of the thickness, 1,700 meters, is greater than our more conservative estimate of 800 to 1,000 meters. An accurate determination of the thickness is not possible because of the lack of a complete sequence at any one locality, the intense deformation of these rocks, and the lack of distinct marker beds. Disharmonic folds and thrust faults in argillite units inflate the apparent thicknesses of sections.

The base of the formation is well exposed on the north flank of Whiteout Nunatak, where a 50-meter-thick sequence of black argillite conformably overlies the Whiteout Conglomerate, an Upper Carboniferous–Lower Permian diamictite. The basal contact of the argillite is sharp, but dispersed pebbles occur within the lower 5 meters. A 2.5-meter-thick, poorly sorted, fine-grained sandstone occurs 7.5 meters above the base. The lower argillite unit is exposed on the lower slopes of Mt. Ulmer and along a ridge extending eastward from Mt. Ulmer toward Mt. Wyatt Earp.

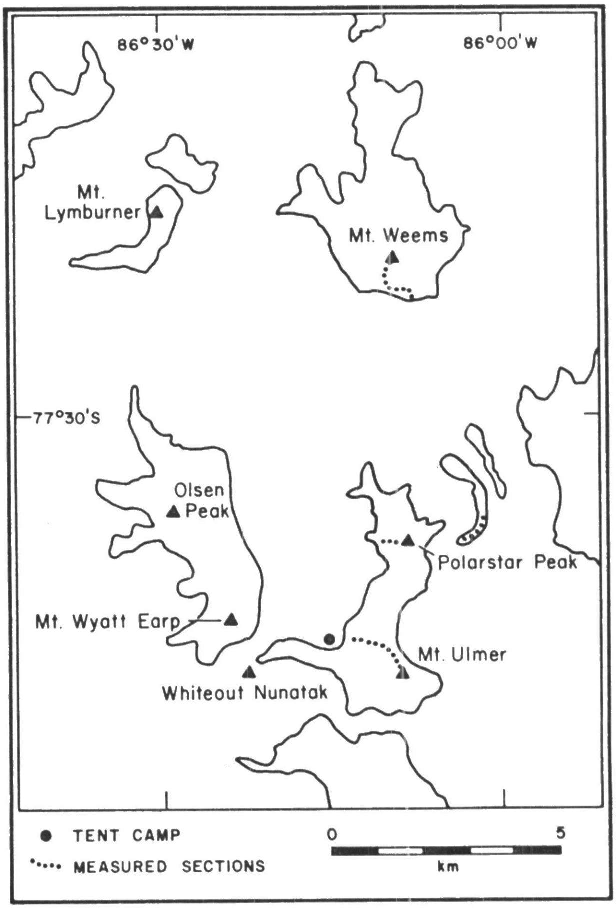

Figure 1. Location of measured sections in northern Sentinel Range.

The middle Polarstar Formation is well exposed on Polarstar Peak, Mt. Ulmer, and Mt. Weems. The formation consists of sequences, 10 to 100 meters thick, that become coarser gradually toward the top and range from argillite to sandstone. The transitions from argillite to sandstone are characterized by lenticular bedding overlain by wavy bedding and flaser bedding in sequences similar to those described by Reineck and Singh (1975). Sandstone sequences grade upward from ripple-laminated, fine-grained sandstone into large-scale, trough crossbedded, medium-grained sandstone. Coalified plant fragments occur sparsely in the lower part, but are increasingly abundant in the upper part.

The upper part of the Polarstar Formation, which is well exposed on high ridges directly east of Polarstar Peak, is composed of sequences that begin with medium-grained sandstone at the base and gradually become finer, ending with carbonaceous argillite at the top. Sandstone units commonly have channeled bases and are characterized by large-scale, trough crossbeds. Argillite units locally contain mudcracks; coalified plant fossils, including *Glossopteris* leaves and calamitid stems, are abundant on bedding planes. Specimens of *Glossopteris* from the Ellsworth Mountains were first reported by Craddock, Bastien, Rutford, and Anderson (1965), and the flora was listed by Rigby and Schopf (1969).

Paleocurrent directions, determined on the basis of 119 readings from six localities, are broadly dispersed from northwest to northeast with a mean direction of due north (figure 2). Readings are based mainly on ripple laminae in the middle part of the formation.

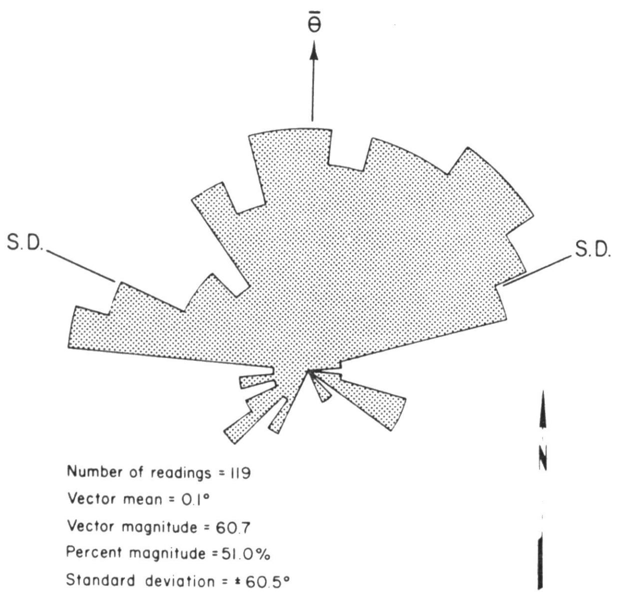

Figure 2. Rose diagram showing distribution of paleocurrent measurements from the Polarstar Formation.

The vertical distribution of facies in Polarstar sequences indicates a depositional setting in which deltaic terrigenous material slowly prograded into a large standing body of water. The lower part of the formation represents prodeltaic deposition; the middle part records the transition from a prodeltaic to deltaic front environment; and the upper part contains the transition to deltaic plain or coastal plain environments characterized by meandering streams. The absence of marine fossils in the Polarstar Formation suggests that this body of water was not marine in the Ellsworth Mountains. The uniformity of paleocurrent directions and the types of sedimentary structures (e.g., lenticular bedding, figure 3) in the middle part of the formation suggest episodic transport of fine-grained sand down the gentle slope of a delta front.

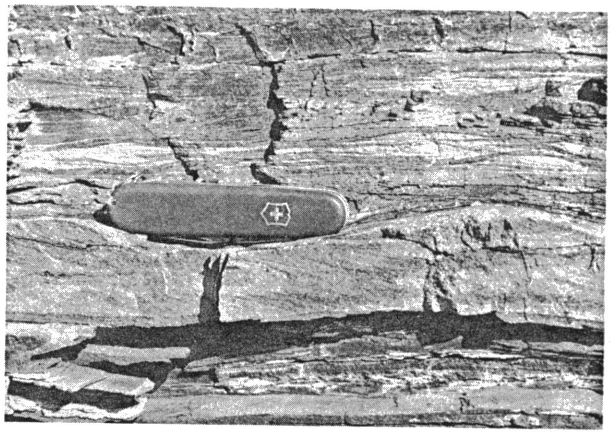

Figure 3. Sandstone with small-scale crossbedding and current ripples overlain by argillite with lenticular bedding. Current direction from left to right.

The similarity of the Polarstar Formation to Permian postglacial sequences as far away as the Beardmore Glacier area in the Central Transantarctic Mountains suggests deposition in a very large body of water. The black shales that immediately overlie diamictites can be traced for more than 1,000 kilometers along the Transantarctic Mountains. If the Ellsworth Mountains have been rotated from a former position north of the Pensacola Mountains in the structural trend of the Transantarctic Mountains, as suggested by Schopf (1969), this distance is even greater. In this case paleocurrent directions in the Ellsworth Mountains, although rotated approximately 90°, remain north, a direction consistent with those obtained from equivalent sequences in the Central Transantarctic Mountains (Elliot 1975).

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Resource and radioactivity survey in the Ellsworth Mountains

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During the 1979–80 field season, radiometric survey operations were mostly limited to the Ellsworth Mountain area. The only exception was a brief attempt to detect radioactive fallout on the sea ice at McMurdo Station. The fallout measurements were made in an effort to detect a supposed nuclear bomb test off the South African coast. No fission products were found. The gamma-ray spectrometer used for the survey was a Geometrics GR–800 with a total sodium iodide (NaI (Tl)) detector volume of 8,390 cubic centimeters (512 cubic inches) (Zeller and Dreschhoff 1979). The equipment had not been modified since the previous year and it functioned without interruption throughout the survey flights.

Actual field measurements were begun on 14 December 1979 from the Ellsworth Mountains Camp and were completed on 19 December 1979. The field area was located in the Ellsworth Mountains and included both the Sentinel and Heritage Ranges. It encompassed an area roughly 300 kilometers in length and 80 kilometers in width. Outcrops were limited in the region, which receives over 50 centimeters of snow each year; generally they were confined to steep slopes, ridge crests, and a few areas where high winds tend to sweep rock surfaces free of snow. A few small dry valleys exist in the Heritage Range, but they are of very limited aerial extent.

Most of the rocks surveyed were sediments, but several limited outcrops of basic igneous rocks were also examined. The sediments range in age from Precambrian to Permian. The airborne survey track was flown mainly over Precambrian and Lower Paleozoic sediments because these outcrops were most readily accessible from the camp location. Two flights did go over Upper Paleozoic sediments, but in both cases the outcrops were near the limit of the helicopter range from the camp. The Precambrian and Cambrian sediments consist of marbles, contorted argillites, phyllites, sandstones, and shales, with a few breccia bodies associated with the marbles at the south end of the Heritage Range. The Devonian rocks also show low-grade metamorphism and are tightly folded in many areas. Quartzite is by far the most common rock type, but some localities have fairly extensive interbedding of phyllites and a few areas show nearly unmetamorphosed sandstones and shales. Sedimentary structures showing evidence of shallow water deposition are common. The Permian rocks are mainly dark conglomerates, siltstones, and graywackes; they also appear to have been deposited under shallow water conditions in many portions of the sedimentary sequence. Some thin coal beds are also present.

No significant concentrations of radioactive elements were found in any of the rocks covered by the flight path. A number of landings were made for ground checking at outcrops that appeared to have some geologic interest, but no significant radioactive anomalies were detected. Computer evaluation of all of the radiometric survey data from flights in the Ellsworth Mountains is in progress.

Almost all of the rocks exposed in the Ellsworth Mountains show evidence of low-grade metamorphism. It appears that this metamorphism proceeded under relatively dry conditions and that the uranium remained essentially immobile during the metamorphic process. For this reason, the entire area apparently has a higher than average uranium:thorium ratio. This condition probably reflects the fact that the uranium in the sediments is primary and has remained in refractory accessory minerals that are almost completely insoluble.

The project is a continuing joint research effort of the University of Kansas and the West German Federal Institute of Geosciences and Resources represented by Volker Thoste and Klaus Bulla. This research was supported in part by National Science Foundation grant DPP 77–21504.

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