Meteorite Impact Crater in Central Alaska

Study of Landsat imagery prompted Cannon (*1*) to suggest that Sithylemenkat Lake in central Alaska occupies a meteorite impact crater. In support of his thesis, he cites physiographic, structural, geochemical, and aeromagnetic evidence from various published sources. We believe, on the basis of our previous work in the area (*2–4*), that Cannon has largely misinterpreted these published data, which, when viewed in the context of the regional geology, provide little or no support for his thesis. We continue to favor a glacial origin for Sithylemenkat Lake, as first suggested by Herreid (*5*), and believe that Cannon has completely overlooked the evidence for glaciation in the area.

In his argument, Cannon rules out a glacial origin for Sithylemenkat Lake because there are "no glacial features of any sort" in the Sithylemenkat Lake area. This is a surprising statement in view of Herreid's report of glacial drift on the east side of Sithylemenkat Lake and earlier reports and maps by Eakin (*6*), Karlstrom (*7*), and Coulter *et al.* (*8*) of drift and other glacial features in and around the margin of the Kanuti Flats. Part of Cannon's confusion about the glacial history of this area may stem from his apparent misconception that Sithylemenkat Lake is situated in the Ray Mountains, when, in fact, it lies 35 to 50 km north of the Ray Mountains in the Kokrines-Hodzana Highlands at the margin of the Kanuti Flats [see for example, Wahrhaftig (*9*) and Orth (*10*)]. In the Ray Mountains, Pleistocene glaciation was confined to small valley glaciers that terminated more than 30 km south of the Sithylemenkat Lake area (*11*). The Kanuti Flats and adjoining parts of the Kokrines-Hodzana Highlands, on the other hand, were covered by a vast piedmont glacier fed from collection areas far to the north in the Brooks Range. Evidence for this piedmont glacier was cited first by Eakin (*6*). Later Karlstrom (*7*) and Coulter *et al.* (*8*) identified and mapped remnants of drift around the margin of the Kanuti Flats. Our investigations indicate that drift from this piedmont glacier extends as far south as the Kanuti River–Melozitna River drainage divide, or about 20 km south of the latitude of Sithylemenkat Lake. We found gravels of probable glacial origin in the Kokrines-Hodzana Highlands at an elevation of 700 m, or nearly 500 m above the present level of Sithylemenkat Lake.

The surficial geology of the Sithylemenkat Lake area has not been systematically mapped; hence, it is not possible to state unequivocally that the lake had a glacial origin. However, the position of the lake close to the margin of the Kanuti Flats and the presence of glacial drift in its drainage basin certainly are highly suggestive.

Cannon suggests that the high nickel values in stream-sediment and soil samples collected by Herreid (*5*) in the Sithylemenkat Lake area may have been derived from meteorite fragments because "no collaborating evidence could be found for the existence of a parent ore body for the nickel." This is a puzzling statement, inasmuch as Herreid clearly points out that these high values are directly related to the occurrence of ultramafic rocks. The ultramafic rocks in the Sithylemenkat Lake area are part of a 100-km-long belt that has been mapped along the northwest flank of the Kokrines-Hodzana Highlands from Caribou Mountain to the upper Melozitna River (*2*). Samples of the ultramafic rocks give nickel values as high as 2600 parts per million (ppm), and streams draining the ultramafic rocks yield sediment samples with values as high as 5000 ppm (*2, 3, 5*). The high values obtained around Sithylemenkat Lake are in no way unique to that area but characterize the entire ultramafic belt.

Cannon also finds support for his meteorite impact crater thesis in the aeromagnetic survey of the Sithylemenkat area (*12*). Specifically, he notes the occurrence of a magnetic low "discretely associated with the [Sithylemenkat Lake] depression" which he suggests is an indicator of intense fracturing of the bedrock immediately below the impact zone. His interpretation is unconvincing, however, because the low, when viewed on the regional (1:250,000 scale) aeromagnetic maps of eastern Bettles (*12*) and Tanana (*13*) quadrangles, is seen not as a unique feature confined to the Sithylemenkat Lake area but one of a series of lows aligned along the northwest flank of the Kokrines-Hodzana Highlands. These are steep-gradient negative anomalies and are clearly related to a northeast-trending belt of mafic and ultramafic rocks that extends along the flank of the Kokrines-Hodzana Highlands for more than 300 km. The lows, which are situated along the southeastern margin of this belt, are a reflection of the northwesterly dip of the slab-like body of mafic-ultramafic rocks.

From his study of aerial photographs, Cannon characterizes the bedrock in the Sithylemenkat "impact zone" as intensely fractured. The bedrock in this area includes pelitic schist and phyllite of Paleozoic and possibly Precambrian age, mafic and ultramafic rocks of late Paleozoic and Mesozoic age, and granitic intrusive rocks of Cretaceous age. We have mapped these rock units along a broad northeast-trending belt for more than 300 km from the Yukon River to the Brooks Range (*4, 14*). Although these rocks are folded and faulted everywhere along this belt, our ground observations do not suggest any markedly greater deformation in the Sithylemenkat Lake area. Impact features such as shatter cones, which are common at such impact craters as the Wells Creek structure in Tennessee, were not observed in the area. In addition, we are not able to corroborate either from ground observation or from aerial photograph inspection the radial and concentric fracture patterns described by Cannon in the "impact zone."

In summary, there is little or no field evidence to suggest that Sithylemenkat Lake is a meteorite impact crater. It should be emphasized that while Landsat imagery is a valuable tool for interpreting many geologic features, it is best used in conjunction with on-the-ground inspection.

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Patton and Miller provide no evidence that supports glaciation as a mechanism for the origin of the Sithylemenkat Lake

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basin. They incorrectly cite three published sources (*1–3*) as an intended appeal to add validity to Herreid's observations (*4*). Eakin (*1*) makes no reference to drift in or around the Sithylemenkat Lake basin. Also, the basin is not indicated on either of his maps. The Sithylemenkat Lake basin is shown on the map by Karlstrom (*2*) to be located in an undifferentiated unit (*5*) containing mostly alluvium with possible deposits of eolian, colluvial, fluvial, marine, and glacial origin. As to Patton and Miller's appeal to the map by Coulter *et al.* (*3*), Sithylemenkat Lake is shown on that map (*3, 6*) as being more than 20 km from any glaciated area. Wahrhaftig has published a map (*7*) showing the areas in Alaska covered by Pleistocene glaciers, and it does not support Herreid's work (*4*) in any manner. Moreover, Pewe (*8*) in a 1975 publication shows a map (*8*, p. 16) indicating the extent of Quaternary glaciations in Alaska, and it does not provide any support for glaciation in the area. Perhaps Patton and Miller are not aware of Pewe's work (*8*).

I do not think that my inclusion of the Sithylemenkat Lake basin in the northern Ray Mountains is unreasonable. The center of Sithylemenkat Lake is 44 km north of the drainage divide in the center of the Ray Mountains, and of course mountains do have width. The reference to the Ray Mountains as a geographic area was to help my readers, and interestingly this is supported by Eakin (*1*, p. 15). Eakin (*1*, p. 14) indicated that the Ray Mountains were located on the headwaters of the Ray, Tozitna, and Kanuti rivers. Sithylemenkat Lake is in the upland part of the Kanuti drainage basin, and the center of the lake is 27 km northwest of the drainage divide in the headwaters of the Ray River. Locate Sithylemenkat Lake and the Ray Mountains on the color composite of Landsat scene 1341-21130 and one will see easily the continuity of terrain which could warrant the inclusion of the lake area in the northern Ray Mountains.

Herreid's description of drift (*4*) in the basin is moot when taken in consideration of his preceding discussion of altiplanation terraces (*9*), nivation effects, and solifluction of materials situated physically above the deposit of so-called drift.

Since Patton and Miller do not indicate in their comments a direction for the flow of glacial ice which they favor forming the lake basin but indicate some relation to a piedmont glacier to the northwest, I assume that their glacial ice moved toward the southeast when it scooped out the basin (*10*). I find incredible an attempt to account for the creation of a basin which exhibits the morphology of the Sithylemenkat Lake basin with ice flowing from the northwest toward the southeast. Regardless of the direction of the flow of the assumed glacial ice, the creation of the lake basin by glacial ice would make it one of the most unusual glacial landforms on Earth or Mars. Most lakes created by piedmont glaciers are similar to those created by large ice sheets (*11*) and are elongate and unlike the Sithylemenkat Lake basin.

If one were to assume that the basin was formed by glacial ice, it would seem more reasonable to consider that a cirque glacier created the basinform. However, this consideration is also difficult to support. One factor is the wall height to diameter ratio, which is unlike that for cirques (*11*, p. 133) but similar to that of meteorite impact craters (*12*). Another factor is that the snowline must be at or slightly above the cirque floor (*11*, p. 136) for the creation of a cirque glacier. The floor of the Sithylemenkat Lake basin is less than 200 m above sea level, and work by Pewe (*8*, pp. 21–23) indicates that the snowline in this area was probably no lower than 900 m in Illinoian or Wisconsinan time. All of the Sithylemenkat Lake basin is below 900 m.

In my report I qualified the statements about the relationships of the nickel concentrations and the magnetic low to the lake basin. The statements by Patton and Miller about these items are repetitious.

Patton and Miller make no comment about what they can or cannot see on the Landsat imagery, but this is immaterial as they indicate difficulties with the aerial photographs of the area. I have closely studied stereo aerial photographs of the area in an effort to find landforms which would provide a clue as to the creation of the basinform. There are no elongated ice-scoured features to be seen. In order to enhance the microtopography for better interpretation purposes SLAR (*13*) imagery of the area was acquired. There are no indications of glacially related features in or around the basinform on the SLAR imagery. The SLAR imagery of the area also enhances some of the major fracturing to a certain degree. Owing to this enhancement the SLAR imagery indicated subtle radial fractures which cannot be easily recognized on the aerial photographs.

A possible shatter cone has been found in the area. Although it strongly resembles a shatter cone resulting from meteorite impact, it has not been verified as such, and the collection locality has yet to be precisely determined. At present I do not consider it as having any relationship to the Sithylemenkat Lake basin. It is most probable that any shatter cones associated with Sithylemenkat Lake basin would be in the bedrock beneath the lake.

I have done recent fieldwork in the basin which has produced evidence strongly supporting a meteorite impact origin. The fracture systems noted on the remote sensing data have been confirmed on the ground. A search was also made on the ground for glacial evidence and none was found.

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References and Notes

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4. G. Herreid, *Alaska Div. Mines Geol. Geol. Rep. 35* (1969), pp. 2–3.
5. This unit is denoted with the symbol Qu, and is labeled as "Undifferentiated upland valley and lowland alluvium."
6. On the map by Coulter *et al.* (*3*) Sithylemenkat Lake is shown as a rough circle under the first "m" in the word "Old Dummy."
7. C. Wahrhaftig, *U.S. Geol. Surv. Prof. Pap. 482* (1965), p. 12.
8. T. L. Pewe, *U.S. Geol. Surv. Prof. Pap. 835* (1975), p. 1.
9. Altiplanation is incorrectly spelled antiplanation in Herreid's report (*4*).
10. Herreid apparently assumed an eastward or southeastward direction of flow for the glacial ice (*4*, p. 10).
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12. N. M. Short, *Planetary Geology* (Prentice-Hall, Englewood Cliffs, N.J., 1975), p. 83.
13. Acronym for side-looking airborne radar.

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Rape Among Mallards

Barash (*1*) has assumed that the pairs of mallards (*Anas platyrhynchos*) he saw in Seattle, Washington, from January through May were permanent mates and that the rapist was attempting to fertilize the female. He has reported two behavioral strategies of the female's mate: (i) to intervene aggressively, in which case "this behavior was apparently successful in preventing sperm transfer by the rapist (that is, neither 'bridling' nor 'nod-swimming' occurred)"; or (ii) to force a copulation with the "just-raped female [which] conveys the benefit of intro-