Terraces of Tyrrhenian III age (= Ouljium or Monastirian II) are also known to exist on many coasts of all oceans (*14, 19*).

With further investigation by means of radiocarbon, more marine terraces now considered to be of last interglacial age might also turn out to be of postglacial age.

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References and Notes

1. "Oölite" is a rock, composed predominantly of "oöids," which are more or less spherical, sand-sized grains with a concentrically layered, mainly calcareous coating around a nucleus of various origin.
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11. If the oöids of sample KS 19, for example, were older than 40,000 years and 5 percent of cement were Recent, the apparent age would be 24,000 years B.P. (see also samples KS 58 and KS 59). In our samples, 5 percent of Recent calcitic cement can be responsible for an apparent age, which is about 1000 years too young.
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17. F. P. Shepard, *Ann. Geomorphol.* (N.S. suppl.) **3**, 30 (1961).
18. The measured C^{14} contents, after normalization to $\delta C^{13} = 0$ per mil deviation from the Chicago PDB (Pee Dee belemnite) standard, are expressed in percent of 0.95 NBS (National Bureau of Standards) oxalic acid. Allowance is also made for isotope fractioning between plants and ocean carbonates as well as for C^{14} pileup at the air-sea interface (*20*).
19. It is not the aim of this report to discuss the still pending problem of "Quaternary Sea Level Rise" (*13, 17*) from this local point of view. Recently, this question was critically reviewed by Guilcher (*14*).
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21. Nucleus (N)-ratio: the proportion of quartz nuclei to calcareous nuclei of oöids.
22. The field work was carried out in March 1967 by F.H.F. in cooperation with R. Hesse. His help and the financial support given by the Deutsche Forschungsgemeinschaft are gratefully acknowledged. We also thank P. Jutro for field assistance, and J. Sorauf and U. von Rad for criticism and help with the translation of the text.

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A Possible Bedrock Source for Obsidian Found in Archeological Sites in Northwestern Alaska

Abstract. *Recently discovered deposits of obsidian in the Koyukuk valley may be the long-sought-for source of obsidian found in archeological sites in northwestern Alaska. Obsidian from these deposits compares favorably in physical characteristics and sodium-manganese ratio with the archeological obsidian, and there is evidence that the deposits have been "mined" in the past.*

Artifacts and chippings of obsidian have been found at a number of archeological sites in northwestern Alaska, including the well-known excavations at Onion Portage and Cape Denbigh (*1–3*) (Fig. 1). These materials are commonly mixed with other cultural materials composed of chert and slate. However, although sources for the chert and slate are widely distributed in the bedrock terrane of northwestern Alaska, no natural occurrence of obsidian has been reported anywhere in the vast region that lies north and west of the Yukon River. Some archeologists have even suggested that the archeological obsidian was carried in from natural sources as far away as the Aleutian Islands or Wrangell Mountains.

Locating the source of the artifact obsidian clearly is of great importance to archeologists, as it would provide

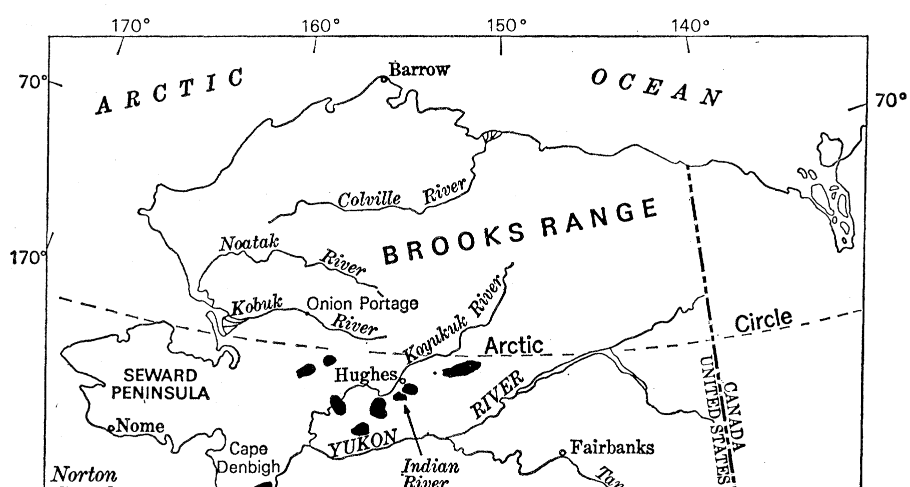

Fig. 1. Map of Alaska showing location of Indian River obsidian deposits and other Upper Cretaceous and Tertiary volcanic rock occurrences (shaded) along lower Yukon and Koyukuk rivers.

considerable insight into the pattern of ancient cultural ties and trading routes. Giddings, for example, has suggested that in the stratified Onion Portage site the abundance of obsidian in some levels and scarcity in others may reflect the ebb and flow of coastal-oriented and inland-oriented cultures along the Kobuk valley (*1*).

Our purpose is to describe newly discovered bedrock deposits of obsidian in the Koyukuk River valley and to review the available evidence that these deposits were a source for the obsidian materials found in the archeological sites of northwestern Alaska. We also wish to call attention to other areas of young volcanic rocks in the Koyukuk and Yukon valleys where additional obsidian deposits may occur.

The newly discovered obsidian deposits are situated 29 km southeast of the village of Hughes along a birch-forested drainage divide between the Indian and Little Indian rivers (Fig. 1) [see (*4*) for precise locations]. The obsidian occurs in a nearly horizontal tabular body of rhyolite flows and tuffs of probable mid-Tertiary age, which rests with angular discordance upon deformed sedimentary strata of Cretaceous age. Bedrock exposures of the obsidian have been completely reduced to rubble, and the obsidian is found as subround pelletal and globular fragments up to 10 cm in length strewn across a sandy surface of finely divided vitric and pumiceous debris. The size and shape of the obsidian fragments suggest that they formed as residual inclusions [sometimes called "marekanites" or "Apache tears" (*5*)] in a hydrated perlitic glass. Fresh surfaces of the obsidian are glossy black, but slivers up to 1 cm thick appear nearly transparent and commonly show fine fluidal banding. Exteriors of the residual fragments characteristically have a frosted and finely pitted hydration rind. In thin section the obsidian is seen as an unaltered, nonhydrated, and undevitrified glass free of visible microlites and rock fragments. The refractive indices measured for several samples range from 1.484 to 1.487, thus indicating a high silica content.

Most chips and artifacts that we have seen from the archeological sites in northwestern Alaska compare favorably with the Indian River obsidian in color, transparency, and the absence of devitrification and hydration. In addition, many of the archeological specimens show remnants of a pitted and frosted hydration rind along untrimmed edges, suggesting that they were chipped from residual fragments similar to those in the Indian River deposits.

Table 1. Sodium and manganese content of (*A*) bedrock obsidian samples from the Indian River deposits and (*B*) nonindigenous obsidian fragments from the Kokhila Hills (sample 10), Hochandochtla Mountain (sample 11), and the Big Creek hills (sample 12), northwestern Alaska (*9*).

Sample No.	Na (%)	Mn (% × 10^2)	Na-Mn Ratio
(*A*) *Bedrock obsidian samples**			
1	3.48	6.78	51.30
2	3.30	6.29	52.51
3	3.55	6.73	52.72
4	3.58	7.51	47.67
5	3.45	7.08	48.76
6	3.67	7.53	48.52
7	3.47	7.20	48.21
8	3.14	6.34	49.49
9	3.60	7.67	46.90
Average	3.47	7.01	49.56
Range	3.14–3.67	6.29–7.67	46.90–52.72
(*B*) *Nonindigenous obsidian fragments*			
10	3.61	7.04	51.29
11	3.57	7.16	46.93
12	3.59	7.40	48.46

* Results are the average of five short-term irradiation tests per sample.

Recent investigations (*6, 7*) of obsidian have focused on chemical composition as a means of matching archeological specimens with bedrock deposits. Of particular interest are ratios of Na to Mn. Gordus *et al.* (*6*) suggest that neutron activation analyses for Na and Mn provide useful data for geologic source identification, since the Na content may differ by a factor of 2 or more and the Mn content by a factor of 10 or more between different obsidian flows. Griffin *et al.* (*2*) recently analyzed 103 archeological specimens from northwestern Alaska (chiefly from the Onion Portage site) by neutron activation; and, according to their interpretation, the results suggest a fourfold grouping by Na-Mn ratios representing "at least four obsidian sources." Eighty-nine of their specimens, however, fall in a single group with a Na-Mn ratio of 53 to 60. The other three groups, which include only 14 specimens, have ranges of 45 to 51, 70 to 80, and 89 to 93.

In order to make comparisons with these results, we submitted nine samples from the Indian River deposits for neutron activation analyses to Griffin and his associates at the University of Michigan. Results of five short-term irradiation tests per sample (*8*) give Na-Mn ratios of 47 to 53, close to the ranges determined by Griffin and others for the bulk of archeological specimens from northwestern Alaska (Table 1).

Our brief examination of the Indian River deposits did not permit a thorough search for evidence of ancient "mining." However, in several places artificially chipped flakes were seen scattered among the residual fragments of obsidian. In addition, we found chipped fragments of obsidian on ridge-tops and hillslopes in the surrounding countryside. These fragments were undoubtedly carried there by humans, probably from the Indian River source. Three of these nonindigenous fragments were analyzed by neutron activation and gave Na-Mn ratios that closely match the Indian River bedrock samples (Table 1).

Possibilities of finding additional deposits of obsidian in the region north and west of the Yukon River appear limited to Late Cretaceous and Tertiary felsic flows scattered along a 650-km belt extending from the Yukon delta to the Arctic Circle (Fig. 1). Much of northern and western Alaska has been geologically mapped at reconnaissance scale during the past 20 years, and it appears that volcanic rocks of the type normally associated with obsidian deposits are confined to this belt. Volcanic glasses have been noted in several places along this belt, but except for the Indian River occurrence, no undevitrified non-hydrated glass comparable in quality to the archeological specimens has yet been reported.

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8. The neutron activation analysis technique is discussed in detail in (*6*) and (*7*); the short-term irradiation data presented here are of a preliminary nature and should be used only for grouping and tentative interpretation.
9. Coordinates for sample localities: sample 10, 66°28′N, 155°00′W; sample 11, 65°32′N, 154°59′W; sample 12, 65°50′N, 153°34′W. Coordinates from Hughes and Melozitna quadrangles, U.S. Geological Survey 1 : 250,000 series (topographic).
10. We thank J. B. Griffin, J. A. Walthall, and their colleagues at the University of Michigan, Museum of Anthropology, for the neutron activation analyses reported in this paper. We also thank D. M. Hopkins and G. D. Eberlein of the U.S. Geological Survey for their reviews and helpful criticisms of this report.

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