GEOLOGIC NOTES

A Postulated New Source for the White River Ash, Alaska

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The White River Ash (Lerbekmo and others, 1968), product of two of the most voluminous pyroclastic eruptions in North America in the past 2,000 yr, blankets much of the Yukon Temtory, Canada, and a small part of adjoining eastern Alaska. Lerbekmo and Campbell (1969) narrowed the source of the ash to an area northeast of the Mt. Bona–Mt. Churchill massif in the St. Elias Mountains of southern Alaska. Based on indirect evidence, Lerbekmo and Campbell (1969) further suggested that the vent was beneath the Klutlan Glacier, adjacent to a mound of coarse pumice, 16 km northeast of Mt. Bona. Recently discovered pumice and ash deposits and a possible vent structure near the summit of Mt. Churchill suggest an alternate source area.

The White River Ash is a bilobate plinian fallout deposit covering more than 340,000 km^2 and containing an estimated 25–50 km^3 of tephra (Bostock, 1952; Berger, 1960; fig. 1). Radiocarbon ages indicate that the northern lobe was deposited about 1,887 yr B.P. and the eastern, and larger, lobe about 1,250 yr B.P. (Lerbekmo and others, 1975). The axes of the two lobes converge near Mt. Bona [16,420 ft (5,005 m)] and Mt. Churchill

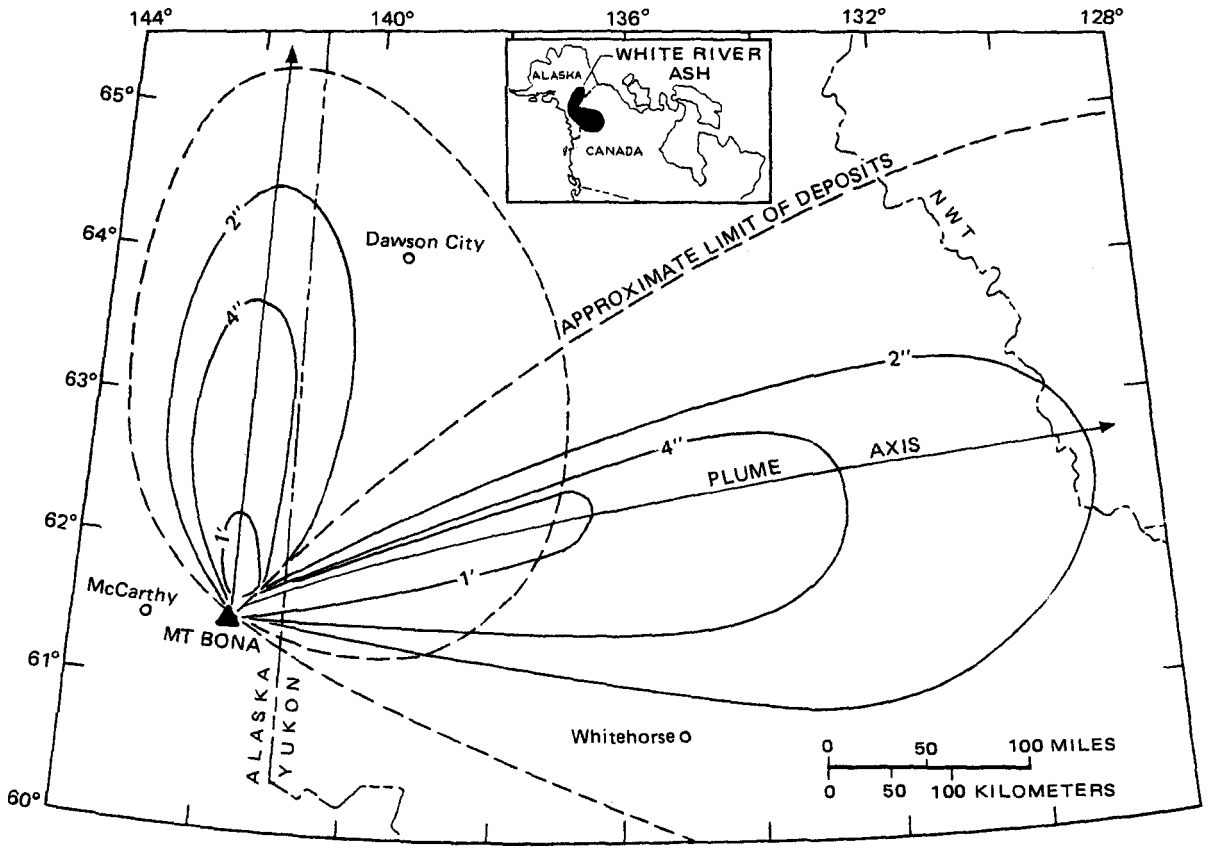


Figure 1. Isopach map of White River Ash (Lerbekmo and others, 1968) in Yukon Territory, Canada, and Alaska. Isopachs shown for 1 ft, 4 in., and 2 in. Axes of the two tephra lobes converge on area near Mt. Bona, Alaska. Modified from Lerbekmo and others (1975).

[15,638 ft (4,766 m)], which together form a prominent massif in the St. Elias Mountains. The Klutlan Glacier, a large valley glacier that flows eastward into Canada, has its principal source on the eastern flank of the massif.

Careful field studies by Lerbekmo and Campbell (1969) in search of the source of the White River Ash led to the discovery of a 90-m-high mound of White River pumice adjacent to the Klutlan Glacier at an elevation of about 8,000 ft (2,438 m) (fig. 2). Some of the pumice clasts are as much as 50 cm in diameter, but the modal size is less than 10 cm. Based on interpretation of the mound as a remnant pumice cone and a change in gradient of the glacier adjacent to the mound, Lerbekmo and Campbell (1969) concluded that the source vent of the White River Ash lies under the Klutlan Glacier, near the pumice mound, at about the 7,700 ft (2,347 m) level (fig. 2).

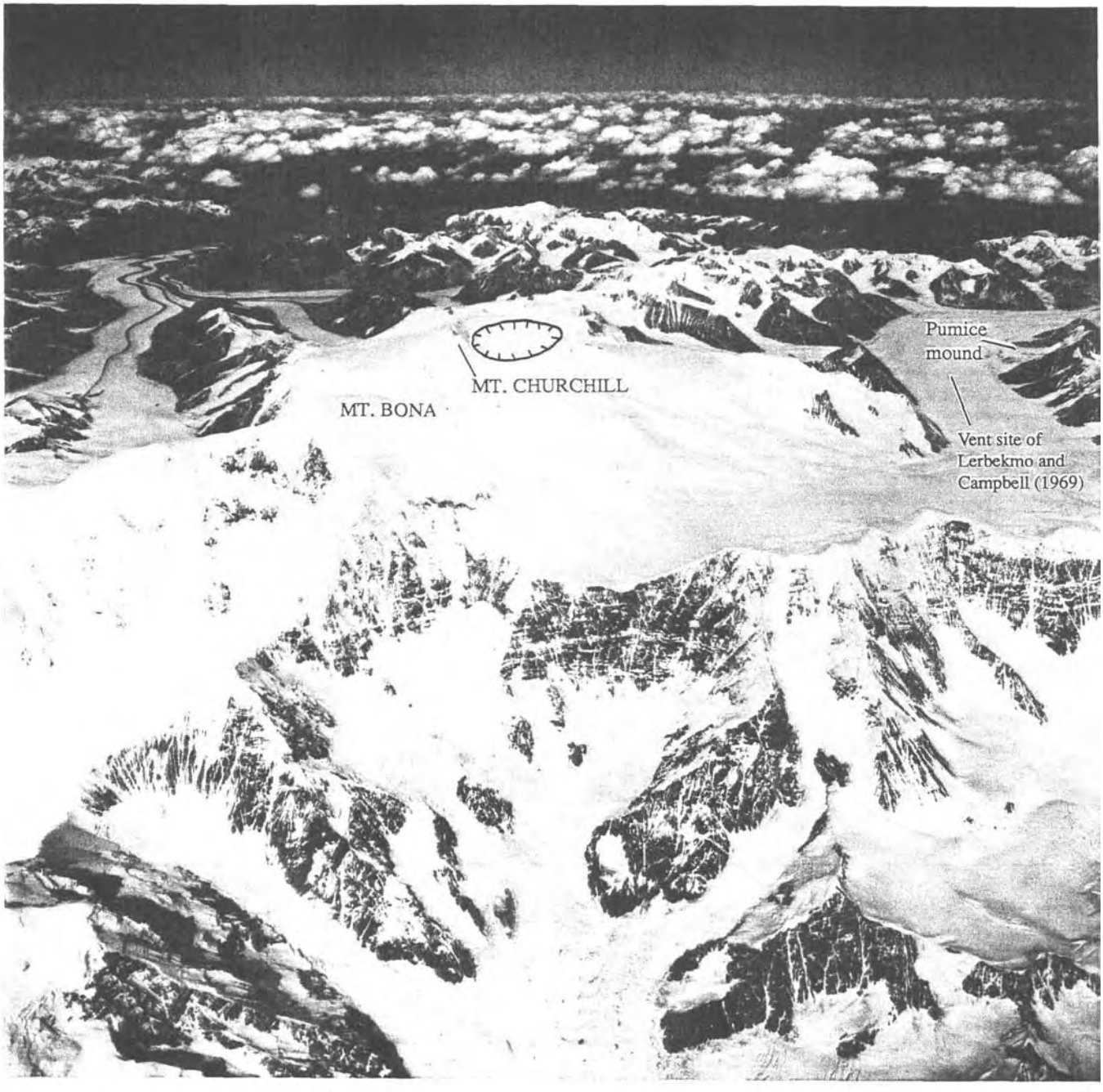
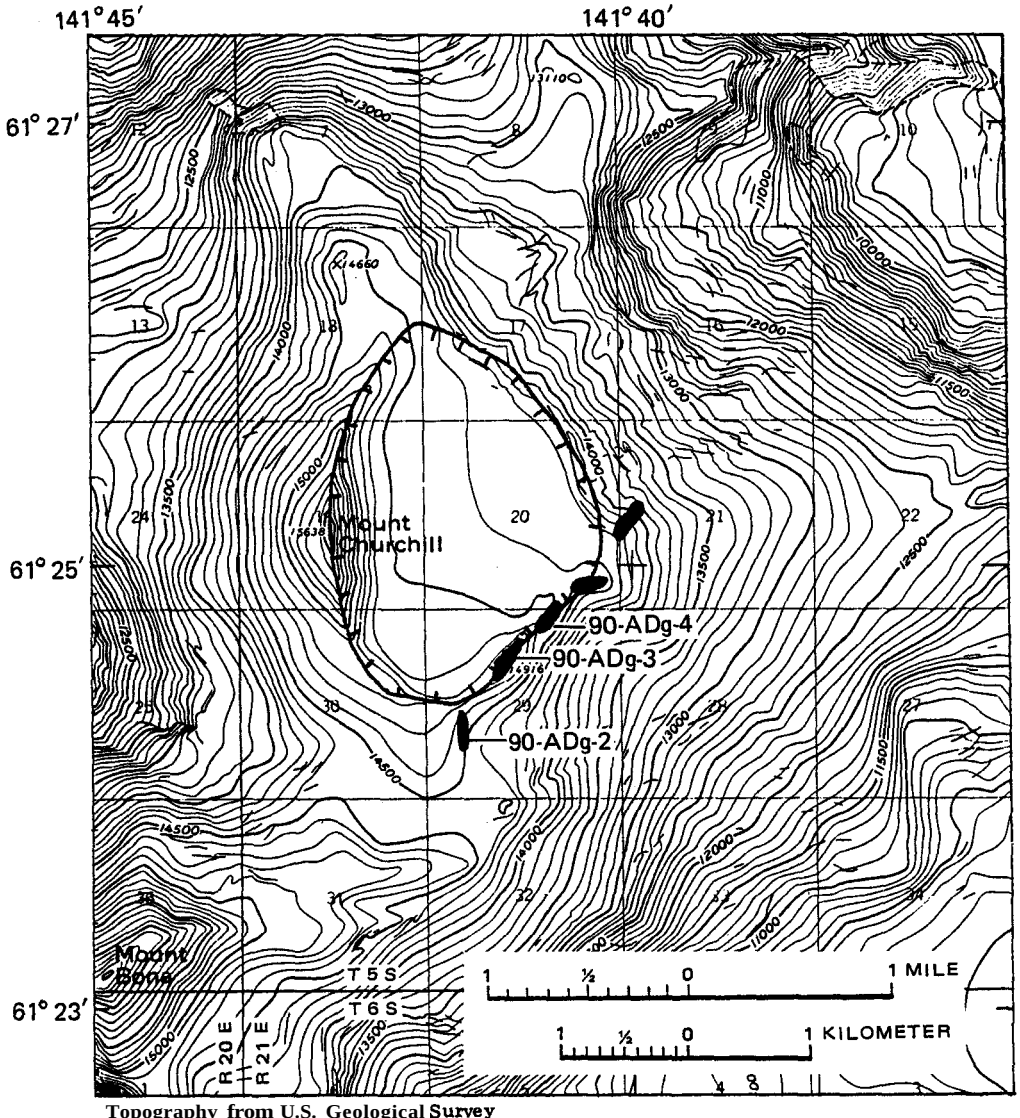


Figure 2. Oblique aerial photograph of Mt. Bona–Mt. Churchill area, view to the northwest, showing location of postulated caldera and source of White River Ash (Lerbekrno and others, 1968) on Mt. Churchill, and the pumice mound of Lerbekrno and Campbell (1969) adjacent to Klutlan Glacier. U.S. Army–Air Force trirnetrogon oblique photograph, June 16, 1948.

Aerial photographs and the modem topographic maps of the Mt. Bona–Mt. Churchill massif suggest an alternate source area 12 km southwest of the pumice mound. A 4.2 km x 2.7 km elliptical, gently sloping, ice-filled depression is located at about 14,500 ft (4,420 m) on the east side of Mt. Churchill (fig. 3). The high point of Mt. Churchill [15,638 ft (4,766 m)] forms the western margin of the depression, and a lower curved ridge forms most of the southeastern rim. Maximum relief from the floor of the depression to the highest point (Mt. Churchill) on its rim is over 300 m. The topographic map and aerial photographs show that ice not only fills the summit depression, but also covers almost the entire summit region of the massif. An apparent exception was a very small ice-free area, less than 400 m long, on the southeastern rim of the depression.

In May 1990, a U.S. Geological Survey field party ascended Mt. Churchill from the Klutlan Glacier to search for rock exposures in an attempt to ascertain the nature of the ice-filled depression. The four-member field party was landed by ski plane at the 8,200-ft level (2,500 m) of the Klutlan Glacier, where base camp was established. Gear and supplies were ferried to camps placed at 10,000 ft (3,048 m) and 12,500 ft (3,810 m) on the east flank of Mt. Churchill. From the high camp, the party climbed to the large depression adjacent to the summit of Mt. Churchill.

Five areas of bedrock, extending over a length of about 2.4 km, were discovered along the southeastern



Topography from U.S. Geological Survey McCarthy B-2 quadrangle, 1959

Figure 3. Topographic map of Mt. Churchill showing postulated caldera, outcrops examined (black), and locations of samples. From the U.S. Geological Survey McCarthy B-2 topographic map.

rim of the depression (figs. 3, 4). The exposures are predominantly of pumice, ranging from lapilli to blocks as much as 50 cm in diameter, but also contain similar-sized clasts of granite, andesitic lava, and crystal-rich felsic lava (figs. 5, 6). At one locality, a flow-banded dacite flow or dome is exposed through a cover of pumice and lithic clasts. Hydrothermally altered, yellow-orange clasts of pumice and lithic fragments are scattered throughout the tephra deposits. Underlying the surface accumulation of loose pumice is an ash-and-pumice zone consisting of pumice disseminated in an ash matrix. The ash was solidly frozen 15 cm below the surface. The absence of ash at the surface most likely is the result of eolian winnowing of the exposed ridge. During the ascent, pumice up to 15 cm in diameter was observed lying on top of the snow surface on gentle slopes 300 m below the ridge crest, apparently transported by high winds.

Although the Mt. Churchill pumice and the White River Ash pumice are megascopically similar, the available samples do show some differences in chemistry and mineralogy (table 1). All the pumices and associated volcanic rocks are calc-alkaline dacites. The Mt. Churchill samples (including the flow or dome) contain 64.1 to 67.0 percent SiO_2, whereas White River Ash pumice, from the mound on the Klutlan Glacier, contains 69.2 percent SiO_2. However, 66 analyzed samples of White River Ash (Lerbekmo and Campbell, 1969) indicate an average SiO_2 content of 67.4 percent, almost identical to the silica content of the Mt. Churchill pumice. In addition, the Mt. Churchill pumice contains minor biotite, a mineral phase that has not been reported from the White River Ash. If the Mt. Churchill and White River Ash pumices are products of the same eruption(s), these chemical and mineralogical differences may be due to an inadequate sample base, or an intrinsic inhomogeneity in the magma chamber (Downes, 1985), or both.

We believe that the ice-filled depression on Mt. Churchill is a small caldera and the source of the White River Ash. The abundance and size of the pumice together with the presence of large angular lithic blocks strongly suggest that the Churchill deposits are of near-

Figure 4. Outcrop of pumice and lithic blocks on southeast rim of postulated caldera on Mt. Churchill. View toward the east. Photograph by Tom Brigham.

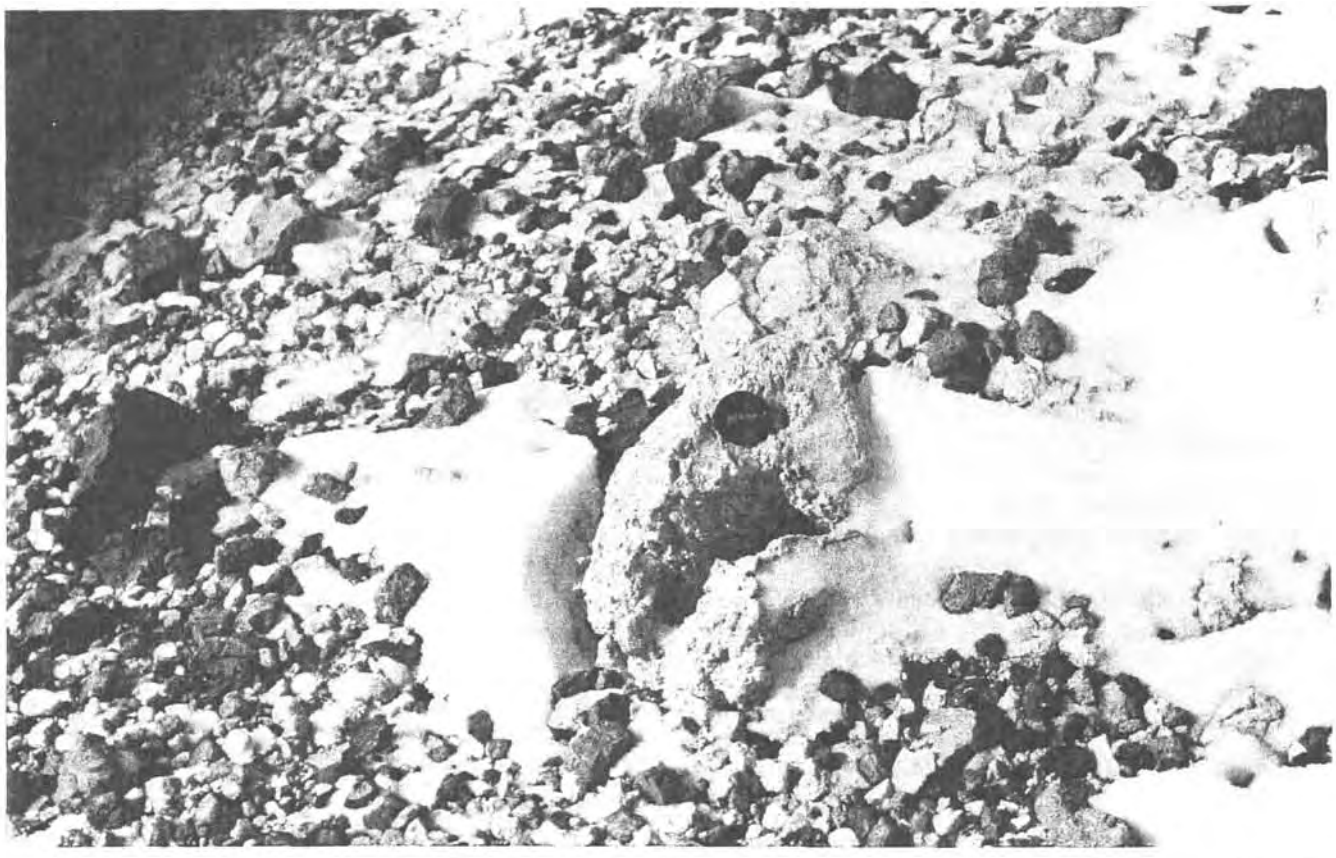


Figure 5. Large dacite pumice block along ridge at 14,700 ft (4,480 m). Dark angular clasts and blocks are lithic fragments. Camera lens cap, 6 cm in diameter.

Figure 6. Pumice and lithic lapilli and blocks on southeast rim of depression adjacent to Mt. Churchill. Note large lithic blocks (as large as 50 cm in diameter) on skyline and center foreground. View toward the north.

Table 1. Chemical and modal analyses, in weight percent, of White River Ash and Mt. Churchill volcanic rocks

[Analyses of samples 2, 3, and 4 by U.S. Geological Survey X-ray spectroscopy (analysts D.F. Siems and J.E. Taggart) and rapid-rock methods (Fe, H_2O^+, H_2O^-, CO_2) (analyst S.T. Pribble)]

	Sample (see footnotes for descriptions)				
	1	2	3	4	5
SiO_2	67.4	66.1	62.9	64.9	68.1
Al_2O_3	15.1	16.2	19.2	16.4	15.4
Fe_TO_3					2.89
Fe_2O_3	2.2	1.55	1.71	3.4	--
FeO	2.0	1.40	1.48	.27	--
MgO	2.0	1.36	1.51	1.70	1.16
CaO	4.1	4.18	4.39	4.78	3.36
Na_2O	4.1	4.16	4.04	4.36	4.23
K_2O	2.5	2.51	2.25	2.10	2.68
H_2O^+	--	.49	.52	.02	--
H_2O^-	--	.13	.13	.03	--
TiO_2	.5	.42	.48	.57	.37
P_2O_5	--	.14	.13	.22	.14
MnO	--	.05	.05	.05	.05
CO_2	--	.04	.05	.02	--
LOI(925 °C)					1.06
Total		98.73	98.76	98.84	99.44
SiO_2 normalized volatile-free		67.0	65.8	64.1	69.2
	Modes (volume percent)				
Plagioclase		9.1	--	25.1	8.2
Hornblende		2.9	--	4.6	2.7
Biotite		1.2	--	0	0
Clinopyroxene		0	--	1.2	0
Orthopyroxene		0	--	.6	0
Opaques		.4	--	.4	.6
Groundmass		86.4	--	68.1	88.5

1. Mean chemical composition of 66 whole-ash samples of White River Ash (Lerbekmo and Campbell, 1969)
2. Dacite pumice lapillus, Mt. Churchill. Sample 90-ADg-2
3. Dacite ash. Mt. Churchill. Sample 90-ADg-4
4. Flow-banded dacite, Mt. Churchill. Sample 90-ADg-3
5. Dacite pumice, White River Ash, Klutlan Glacier. Sample 84-ARh-66

vent origin. If the Churchill deposits are the White River Ash, as this preliminary evidence suggests, it is untenable to consider that the Churchill deposits may have come from a vent 12 km to the east and 2,135 m lower, near the pumice mound along the Klutlan Glacier. Moreover, the pumice mound contains no lithic debris or hydrothermally altered pumice that would likely occur on a cone proximal to a vent. The flat-floored depression on Mt. Churchill, on whose rim the volcanic deposits are located, is a striking feature viewed at ground level and easily discernible on the oblique photograph (fig. *2*). It has neither the morphology nor the location of a typical glacial cirque, but it does have a form suggestive of a caldera. The pumice mound alongside the Klutlan Glacier can be reasonably accounted for by glacier transport, debris avalanche, or pumice flow.

Acknowledgments.—Climbers Tom Brigham and John Kress, serving as U.S. Geological Survey volunteers, ably assisted with the technical aspects of the ascent. Ken Bunch of Gulkana Air Service transported the field party to and from base camp on the Klutlan Glacier. Wrangell–St. Elias National Park personnel provided an overflight to check on the party's progress and safety.

REFERENCES CITED

Berger, A.R.. **1960,** On a recent volcanic ash deposit. Yukon Temtory: Proceedings of the Geological Association of Canada, v. **12,** p. **117–118..**

Bostock, H.S., **1952,** Geology of the northwest Shakwak Valley, Yukon Temtory: Geological Survey of Canada Memoir **267,** 54 p.

Downes, Hilary, **1985,** Evidence for magma heterogeneity in the White River Ash (Yukon Temtory): Canadian Journal of Earth Science, v. **22.** p. **929–934.**

Lerbekmo, J.F., and Campbell, F.A., **1969,** Distribution, composition. and source of the White River Ash. Yukon Territory: Canadian Journal of Earth Sciences. v. **6,** p. **109–116.**

Lerbekmo, J.F., Hanson, L.W., and Campbell, F.A., **1968,** Application of particle size distribution to determination of source of a volcanic ash deposit: International Geological Congress, **23rd,** Prague, Proceedings, **sec. 2,** p. **283–295.**

Lerbekmo. J.F., Westgate, J.A., Smith. D.G.W.. and Denton, G.H., **1975,** New data on the character and history of the White River volcanic eruption. Alaska, in Suggate. R.P. and Cresswell, M.M., **eds., Quaternary** studies: Wellington. Royal Society of New Zealand, p. **203–209.**

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