Scale 1:100,000

0 1 2 3 4 Miles

Mercator Projection 1927 North American Datum
Standard parallel 46° 15 Central meridian 100° 30
Shaded Relief - Vertical Exaggeration 9x

Linton 100K Sheet, North Dakota

Areas of Volcanic Ash
Linton 100K Sheet, North Dakota

Adjoining 100K Maps

North Dakota Geological Survey
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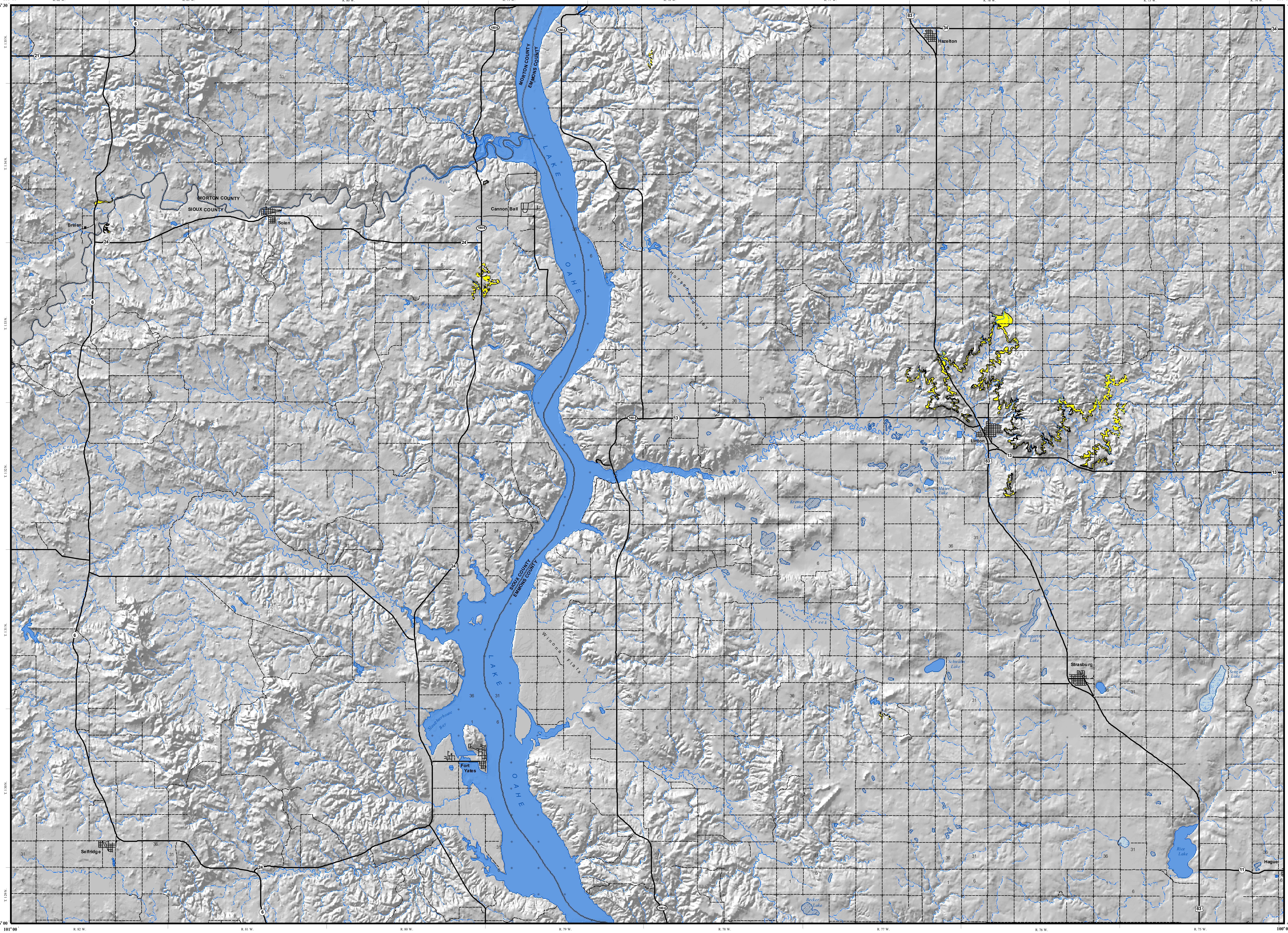

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Introduction

Tuffaceous sandstone and siltstone are present in northwestern, southwestern, and central Emmons County, as well as northern Sioux and southern Morton counties in south-central North Dakota. Approximately 70 ash exposures were investigated in the area. Typically, only a few feet of ash is visible at the surface in these localities, but up to 27 feet of ash was measured in a handful of larger exposures. As a result of this fieldwork, it was determined that more than 1 billion tons of volcanic ash is present in five deposits scattered throughout the Linton 100k sheet

Previous Work

Linton Ash

Volcanic ash deposits were first identified in the Linton area in 1917 by T.W. Stanton. This deposit has been informally referred to as the Linton ash. Stanton noted the ash was 26 feet thick and occurred in the lower part of the Fox Hills Formation. In 1952, S.P. Fisher greatly expanded the known extent of the ash identifying it in several localities in both central and southern Emmons County. Unfortunately, later workers have been unable to find many of the outcrops he identified in the southern part of the county. Manz (1962) investigated the pozzolanic properties of 22 samples within a 35 square-mile area around Linton and estimated the deposit contained 500 million tons of volcanic ash. Artzner (1974) determined the Linton ash is 80% volcanic glass, 10% quartz, 7% feldspar, 1% hornblende, and 2% minor constituents. Forsman (1992) reported less volcanic glass and more clay; 67% volcanic glass, 9% phenocrysts and/or admixed detrital grains, and 24% secondary clay. Forsman noted his samples came from a weathered outcrop which might explain the decrease in glass grains and the increase in clay. He determined the glass is rhyolitic and the glass grains, except where coated by montmorillonite, appear unaltered and reveal no birefringence. Bluemle plotted the locations of a dozen ash outcrops near Linton on topographic maps (unpublished) and included several photographs of ash outcrops in his geologic report of Emmons County (1984). Erickson (1992) constructed an isopach of the Linton ash. He suggested the shape of the ash body was the result of having been deposited in a distributary channel and portions of an estuarine embayment of the Western Interior Seaway.

Other Ash Locailities

Laird and Mitchell (1942) were first to note the presence of volcanic ash in northern Sioux County, east of the town of Breien. They reported a layer of ash was present in the basal portion of the Hell Creek Formation, the stratigraphic position of this ash was later confirmed by Frye (1967) and Murphy and others (1995). Frye noted the ash had a rhyolitic composition and that 98% of the deposit was silt-sized glass shards.

In 1972, Feldmann identified an ash in the upper portion of the Fox Hills Formation near the town of Cannon Ball in northern Sioux County. Feldmann speculated that the Cannon Ball, Linton, and Breien ashes might be the result of one ash fall. He theorized that the ash gets progressively lower stratigraphically from west to east because it is reflecting the paleo-surface at the time of the ash fall event. In other words, when the ash was blown in from Montana or Wyoming (likely source areas) the edge or near-shore portions of the Interior Seaway (Hell Creek and Fox Hills Formations) were in the Breien area and the deeper, offshore portion of the seaway (Pierre Formation) was east of Linton. Feldmann supported this theory by noting the Breien, Cannon Ball, and Linton ashes are lithologically similar and are progressively finer-grained from west to east.

This Study

Linton Ash

This field investigation identified more than 60 outcrops of volcanic ash within a six-mile radius of Linton. The outcrops were plotted on USGS topographic maps at a scale of 1:24,000. The ash deposit appears to extend over an area of about 70 square miles and contains approximately 1 billion tons of ash. Approximately 380 million tons of this ash are under less than 50 feet of overburden. More than two dozen ash samples were collected in the Linton area, three were submitted for analysis (Table 1). On average, the ash contains 60% silica and 12.8 % aluminum oxide. A PIXE analysis of two Linton ash samples detected 21 elements including titanium (0.16 %), copper (7.4 ppm), gallium (13.4 ppm), rubidium (136 ppm), strontium (183 ppm), and barium (628 ppm).

Additional Ash Localities

As first noted by Feldmann (1972), the ash in the Breien area appears coarser-grained than ash near Linton. The Breien ash is 20 to 25 feet thick in a cut on the north side of the Cannonball River (T.134N., R.81W., senw section 30). This ash contains 72% silica and 13.5% aluminum oxide. The Breien ash deposit extends over an area of at least 160 acres and contains approximately 9 million tons of ash.

The basal contact of the Cannon Ball ash is exposed in several outcrops but it was not possible to gain access to land where the upper contact may be exposed. Fifteen feet of ash is exposed at a couple of these outcrops, this must be viewed as a minimum thickness in the absence of an upper contact (T.133N., R.79W., sec. 9). This deposit contains approximately 14 million tons of ash. The Cannon Ball ash was found to contain 64% silica and 14% aluminum oxide (Table 1).

As first noted by Fisher (1952), an isolated outcrop of ash, tuffaceous sandstone, is present along two adjacent drainages leading into Little Beaver Creek (T.130N., R.77W., secs. 3 and 4). The ash layer is less than 10 feet thick and cannot be correlated through the area even though outcrops are present throughout the area at this same elevation.

An additional ash was discovered at the top of the Fox Hills Formation near Coal Butte in northwestern Emmons County (Murphy and others, 2002). This ash is only exposed in one isolated outcrop (T.135N., R.78W., secs. 28 and 33). In the absence of drilling or trenching, it is not possible to determine if this ash extends much beyond an area of about 20 acres (roughly 1 million tons). The Coal Butte ash contains 61% silica and 13% aluminum oxide (Table 1). The ash is of equal thickness to the Breien and Linton ashes (27 feet) but occurs much higher stratigraphically than Feldmann's model would suggest for this area. There are at least two possible explanations: 1) the Breien and Coal Butte ashes occur at the same approximate stratigraphic horizon suggesting they are equivalents and that the Linton is a second, older ash or 2) Feldmann's model of a single ash fall may still be accurate. An irregular shoreline of the Interior Seaway in this area would explain why the ash at Coal Butte is an anomaly in the otherwise progressively decreasing stratigraphic position of the ash layer from west to east.

Commercial Uses of Volcanic Ash

Manz (1962) listed many commercial uses of volcanic glass including as: abrasives; cleansers; scouring or polishing compounds; concrete admixtures; glazes for pottery, brick and tile; glass wool; enamels; lightweight products; fertilizer; asphalt constituents; acoustical tile; sweeping compounds; paint filler; insecticide carrier; a catalyst carrier in the chemical industry; absorptive packing material; and in purification of lard and tallow. Most of the ash mined in the United States is used in the manufacture of lightweight concrete. Some toothpastes and powders, as well as soaps, contain volcanic ash. Volcanic ash has also been promoted as a surfacing material to create a comfortable, non-slip, minimum-maintenance cow race.

Table 1. Chemical Composition of Ashes in the Linton 100K Sheet.

	Linton 1	Linton 2	Linton 3	Breien	Cannon Ball	Coal Butte
As Received (wt. %)						
Total Moisture	24.19	19.68	5.06	4.07	24.81	19.72
Ash	71.88	75.52	89.67	91.16	71.61	75.82
Carbon	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Hydrogen	< 0.5	1.24	< 0.5	< 0.5	2.04	1.6
Nitrogen	0.15	0.18	0.2	0.16	< 0.1	0.18
Total Sulfur	< 0.01	< 0.01	< 0.01	< 0.01	<0.01	< 0.01
Oxygen by Difference	26.96	22.55	9.12	7.67	25.74	21.89
Dry Basis (wt. %)						
Ash	94.82	94.02	94.45	95.03	95.24	94.44
Carbon	< 0.66	< 0.62	< 0.53	< 0.52	< 0.66	< 0.62
Hydrogen	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Nitrogen	0.2	0.22	0.21	0.17	< 0.13	0.22
Total Sulfur	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Oxygen by Difference	7.22	6.31	4.87	4.23	4.93	5.45
Silicon Dioxide in Ash	55.77	54.84	70.35	72.32	63.81	61.58
Aluminum Oxide in Ash	12.76	12.26	13.27	13.46	14.11	13.13
Titanium Dioxide in Ash	0.25	0.24	0.23	0.31	0.32	0.23
Iron Oxide in Ash	2.58	2.46	2.3	2.32	3.25	2.52
Calcium Oxide in Ash	1.89	1.94	1.71	1.59	1.84	1.26
Magnesium Oxide in Ash	2.14	1.81	1.47	1.88	2.24	1.74
Potassium Oxide in Ash	2.38	2.66	3.17	2.09	1.95	2.08
Sodium Oxide in Ash	2.53	2.59	2.9	3.38	2.79	2.84
So_3 in Ash	< 0.02	< 0.02	< 0.02	< 0.02	0.05	< 0.02
Phosphorus Pentoxide	0.09	0.08	0.08	0.11	0.1	0.08
Strontium Oxide in Ash	0.02	0.02	0.02	0.03	0.03	0.02
Barium Oxide in Ash	0.1	0.1	0.11	0.1	0.09	0.1
Manganese Dioxide in Ash	0.05	0.05	0.05	0.05	0.04	0.04

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The ash outcrops were initially plotted on 1:24,000 scale quadrangle maps and then transferred onto the 100K Linton sheet. Individual quadrangles that contain volcanic ash deposits: Linton, Temvik, Rohrich Dam, Strasburg, Grassna, Hazelton NW, Cannon Ball NW, Cannon Ball SE, Cannon Ball SW, and Breien, are available from the North Dakota Geological Survey.

UNIT DESCRIPTIONS

GEOLOGY UNDIFFERENTIATED

Includes geologic units that are both younger and older than the Linton Ash.

CRETACEOUS

Volcanic Ash

Light gray to bright white sandstone and siltstone. The ash is poorly cemented, moderately indurated, and blocky. The ash deposit(s) range stratigraphically from the base of the Hell Creek Formation to the base of the Fox Hills Formation.

Geologic Symbols/Other Features

Known contact between two geologic units
Approximate contact between two geologic units
Water
River/Stream
County Border
State Highway
Water - Intermittent
Stream - Intermittent
County/Tribal Border
Paved Road
Marsh
Section Corner
U. S. Highway
Unpaved Road

Cartographic Compilation: Elroy L. Kadrmas