Fluorine in a Closed Drainage Basin, Saguache and Alamosa Counties, Colorado

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By RALPH E. VAN ALSTINE *and* FREDERICK O. SIMON

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Fluorine content of samples from the vast quantities of lacustrine clay in the San Luis Valley ranged from 170 to 970 ppm

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FLUORINE IN A CLOSED DRAINAGE BASIN, SAGUACHE AND ALAMOSA COUNTIES, COLORADO

By RALPH E. VAN ALSTINE[1] and FREDERICK O. SIMON

ABSTRACT

Chemical analyses of 63 samples of lacustrine clay from a closed basin in the San Luis Valley, Saguache and Alamosa Counties, south-central Colorado, showed that fluorine content ranged from 170 to 970 ppm. The sump area of the basin covers about 140 mi^2 (362 km^2). The closed basin is dotted with alkaline playa lakes fed by San Luis Creek and other streams draining the San Juan Mountains and the Sangre de Cristo Range. The San Luis Valley is the northern extension of the Rio Grande trough. The area has an arid climate and a shallow water table; evaporation and evapotranspiration are rapid.

The increase in fluorine concentration toward the ephemeral sump area is largely due to evapotranspiration. The fluorine has been derived from five fluorspar deposits in the surrounding mountains, from six hot springs, from weathering of volcanic and crystalline rocks, and from the artesian water of the trough sediments. The sampled clay was from the Alamosa Formation of Pliocene or Pleistocene age; the formation is 1,000 ft (305 m) thick. Although the fluorine content of the lake clay is low, the vast quantity of the clay makes it a fluorine resource.

INTRODUCTION

The San Luis Valley of south-central Colorado is within a fluorine-rich province noted for its abundance of fluorspar deposits and fluoride-bearing hot springs (Van Alstine and Tooker, 1979). In July 1975, 63 auger samples (lab. Nos. W-190400 through W-190462, table 1) of lacustrine clay were collected in the sump area, Alamosa and Saguache Counties, San Luis Valley (fig. 1) for fluorine determinations. The auger samples were 2 ft (0.61 m) deep and came from Colorado's only basin of interior drainage; fluorine content was 170-970 ppm (table 1). Fluorine was determined by means of a specific-ion electrode.

[1]Deceased.

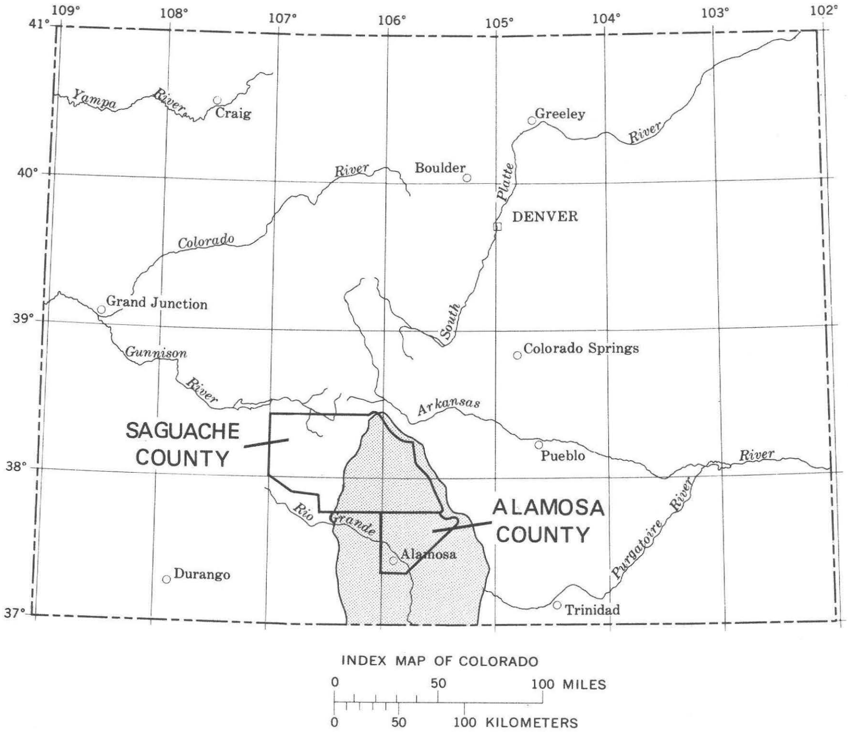

FIGURE 1.—Location of San Luis Valley, south-central Colorado.

TABLE 1.—*Fluorine in 63 auger samples of clay from the San Luis Valley, Colorado*

Lab. No.	Field No.	Fluorine (ppm)
W-190400	1	440
W-190401	2	740
W-190402	3	860
W-190403	4	290
W-190404	5	600
W-190405	6	760
W-190406	7	660
W-190407	8	640
W-190408	9	600
W-190409	10	340
W-190410	11	580
W-190411	12	340
W-190412	13	500
W-190413	14	440
W-190414	15	470
W-190415	16	860
W-190416	17	440

TABLE 1.—*Fluorine in 63 auger samples of clay from the San Luis Valley, Colorado* Continued

Lab. No.	Field No.	Fluorine (ppm)
W-190417	18	320
W-190418	19	170
W-190419	20	740
W-190420	21	670
W-190421	22	510
W-190422	23	610
W-190423	24	570
W-190424	25	530
W-190425	26	710
W-190426	27	750
W-190427	28	510
W-190428	29	390
W-190429	30	410
W-190430	31	670
W-190431	32	390
W-190432	33	570
W-190433	34	390
W-190434	35	600
W-190435	36	610
W-190436	37	890
W-190437	38	310
W-190438	39	890
W-190439	40	970
W-190440	41	950
W-190441	42	370
W-190442	43	790
W-190443	44	510
W-190444	45	550
W-190445	46	390
W-190446	47	410
W-190447	48	310
W-190448	49	550
W-190449	49a	630
W-190450	50	570
W-190451	51	600
W-190452	52	850
W-190453	53	830
W-190454	54	950
W-190455	55	600
W-190456	56	850
W-190457	57a	890
W-190458	57b	950
W-190459	58	830
W-190460	59	560
W-190461	60	610
W-190462	61	400

The sump area, between Alamosa and the Great Sand Dunes National Monument, is outlined by the 7,535-ft contour and covers about 140 mi^2 (362 km^2); the closed basin is about 20 mi (32 km) long north-south and about 7 mi (11.2 km) wide east-west (pl. 1). The closed basin is dotted with alkaline playa lakes, San Luis being the largest. Soda brine was shipped to Denver before 1916 from this lake; the brine contained 4.49 percent K (Gale, 1919). These shallow lakes are fed by San Luis Creek and many other streams draining the adjacent mountains. The alluvial fan from the Rio Grande forms a low divide and the south limit of the closed basin.

The San Luis Valley is the northern extension of the Rio Grande trough or depression (Van Alstine, 1969), which extends from Mexico through Colorado (Van Alstine, 1976). The rift consists of a series of horsts and grabens bordered on the east by the Sangre de Cristo fault, the most active fault in Colorado (Kirkham and Rogers, 1978, p. 40). The graben at the east side of the valley is more than 3.6 mi (5.8 km) deep (Davis and Keller, 1978) and contains upper Tertiary, Pleistocene, and Holocene sediments. The San Luis Valley, between the Sangre de Cristo Range and the San Juan Mountains, is larger than the State of Connecticut. The area has an arid climate; evaporation from the soil in areas having a shallow water table, and evapotranspiration from the rabbitbrush, greasewood, and saltgrass plants are very rapid. The water table is within 5 ft (1.5 m) of the surface in the sump area, and much of the water is tinted brown from decayed vegetation (Siebenthal, 1910, p. 114–115). The sump is an area of deflation by the westerly winds (Johnson, 1969) and receives only 7–8 in. (18–30 cm) of precipitation annually (Emery and others, 1971).

Hydrothermal alteration and weathering of fluorine-rich rocks, especially during the pluvial periods of the Pleistocene and Holocene Epochs, leached fluorine from the rocks bordering the closed basin. Upper Tertiary ash-flow tuffs of the San Juan Mountains contain as much as 1,000 ppm F (Ratte and Steven, 1967). Chemical analyses have shown that the Precambrian metamorphic and igneous rocks bordering the basin contain 1,200–1,500 ppm F (Van Alstine and R.T. Russell, unpub. data, 1981).

The increase in fluorine concentration toward the ephemeral sump area of the closed basin is largely the result of evapotranspiration. The fluorine was derived from fluorspar deposits in the surrounding mountains, from alkaline hot springs, from weathering of volcanic and other crystalline rocks high in fluorine, and from the artesian water of the trough sediments.

Major deposits of fluorite have been found in tuffaceous lake sediments of Tertiary age in Rome, Ore.; Eastgate, Nev.; and

Buckhorn, N. Mex. (Sheppard and Gude, 1969, 1980). The fluorine-bearing tuffaceous lake sediments investigated in the San Luis Valley are of Pleistocene or Holocene age.

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Thanks are due Peter W. Van Alstine for doing most of the auger work during sampling.

ALAMOSA FORMATION

Lacustrine sandy clays underlie the area. They are dark gray and contain tiny pebbles of gray silicified and magnetic volcanic rock; elsewhere, fine sand predominates. The beds have been mapped as the Alamosa Formation of late Pliocene or early Pleistocene age. The formation is about 1,000 ft (305 m) thick. Freshwater shells of gastropods were found in clay at Hansen Bluff about 8 mi (13 km) southeast of Alamosa (Siebenthal, 1910, p. 47). A gastropod identified as *Stagnicola reflexa* (Say) of Pleistocene or Holocene age was collected from a limestone layer 2 in. (5 cm) thick at the northwest corner of sec. 14, T. 40 N., R. 11 E. (J. H. Hanley, written commun., 1977). X-ray study of the clay in sample No. 41 (lab. No. W–190440, table 1), which contained 950 ppm F, revealed montmorillonite, illite, calcite, sodium feldspar, and a trace of fluorite (Sallie Whitlow, written commun., 1980).

FLUORSPAR DEPOSITS

At the north end of the San Luis Valley, the Poncha Pass fluorspar district (A, pl. 1) contains veins of white botryoidal fluorite that formed from hot springs localized along faults. Although the drainage has been captured by Rock Creek, which flows west and north, its first direction was south by way of San Luis Creek. Also to the north is the southern part of the Bonanza base- and precious-metals district (B, pl. 1), where light-green and purple fluorite occurs as a gangue mineral with quartz and rhodochrosite in Tertiary volcanic rocks (Burbank, 1932). Northeast of the basin is the Beryl fluorspar prospect (C, pl. 1) on the north slope of Rito Alto Creek (D.C. Cox, unpub. data, 1943). A vein of coarse green fluorite, quartz, chalcedony, and psilomelane cuts quartzite. To the south, along Pole Creek at the Liberty fluorspar prospect (D, pl. 1), white and green fluorite is associated with calcite and chalcedony in two veins in fractured quartzite (Brady, 1975, p. 15). To the west is the Wagon Wheel

Gap fluorspar district (E, pl. 1) near Creede. A vein of white to varicolored fluorite cuts upper Tertiary pyroclastic rocks (Steven and Lipman, 1973) and is associated with a hot spring depositing fluorite (Emmons and Larsen, 1913). In the gold and base-metal mines at Creede, white fluorite also occurs as a gangue mineral.

HOT SPRINGS

Six alkaline hot springs (Barrett and Pearl, 1978) that issued water containing fluoride border the San Luis Valley. Near Poncha Pass (1, pl. 1), fluorite was deposited in a hot-spring environment. At the Fullenwider Warm Spring (2, pl. 1) in Saguache County, the water contains 4.4 ppm F (Barrett and Pearl, 1976). The Valley View Hot Springs (3, pl. 1) 10 mi (16 km) southeast of Villa Grove contain 0.3–0.7 ppm F. The Mineral Hot Springs (4, pl. 1) 6 mi (9.7 km) south of Villa Grove, contain 3.6–4.6 ppm F. The Shaws Warm Springs (5, pl. 1) in Saguache County contain 2.9–4.2 ppm F. The above springs ultimately discharged their fluoride-bearing water into the closed drainage basin.

FLUORINE ANALYSES

Plate 1 shows in red the parts per million of fluorine in lacustrine clays at the auger-sample sites in and near the closed basin. The parts per million of fluorine in high sodium bicarbonate water from artesian wells is shown in blue. Many of the highest fluorine values are near the San Luis, Head, and other playa lakes and their alkaline flats. Fluorine values for water wells were taken from Powell (1958).

The high fluorine content in the waters constitutes hazards to the teeth of children and to the teeth and bones of cattle that drink the water. Drinking water containing much more than 1 ppm F will cause mottled enamel in at least 90 percent of the native children (McClure, 1970, p. 67). Saguache County is one of those counties in the United States whose ground water contains more than 1.5 ppm F (Fleischer, 1962).

Although the fluorine content of the lake clay is low, the vast quantity of the clay makes it a fluorine resource.

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