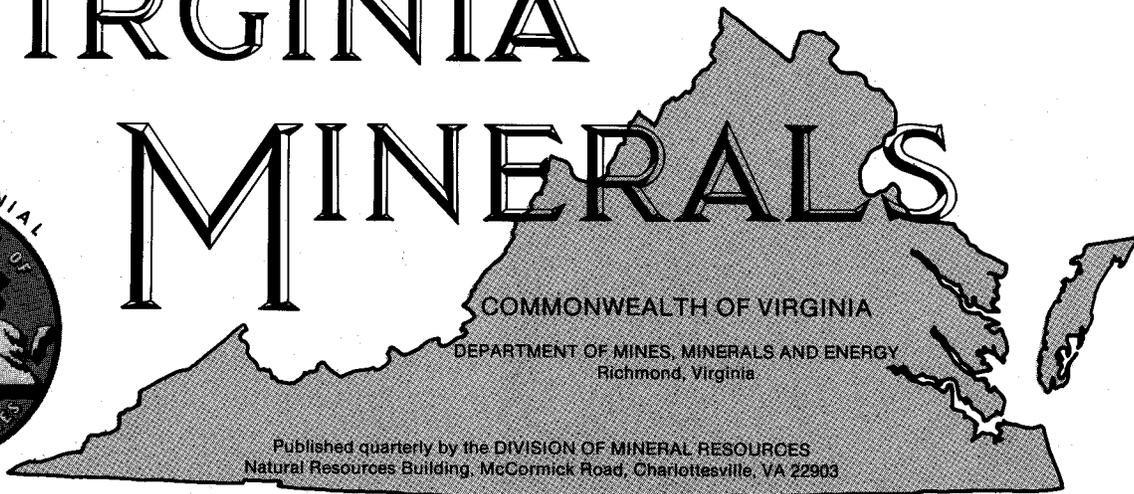
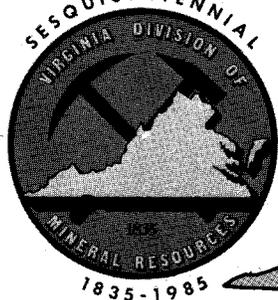


VIRGINIA

MINERALS



Published quarterly by the DIVISION OF MINERAL RESOURCES
Natural Resources Building, McCormick Road, Charlottesville, VA 22903

Vol. 31

February 1985

No. 1

TRAVERTINE-MARL DEPOSITS OF THE VALLEY AND RIDGE PROVINCE OF VIRGINIA - A PRELIMINARY REPORT

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The travertine and marl deposits of Virginia's Valley and Ridge province are the result of precipitation of calcium carbonate from fresh water streams and springs. Travertine is white to light yellowish brown and has a massive or concretionary structure. Buildups of this material tend to form cascades or waterfalls along streams (Figure 1). Marl refers to white to dark yellowish brown, loose, earthy deposits of calcium carbonate (Figure 2). Deposits of these carbonate materials are related and have formed during the Quaternary period. This preliminary report is a compilation of some literature and observations of these materials. A depositional model is proposed.

These deposits have long been visited by man. Projectile points, pottery fragments, and firepits record the visitation of American Indians to Frederick and Augusta county sites. Thomas Jefferson (1825) wrote an account of the Falling Spring Falls from a visit prior to 1781. Aesthetic and economic considerations continue to attract interest in these deposits.

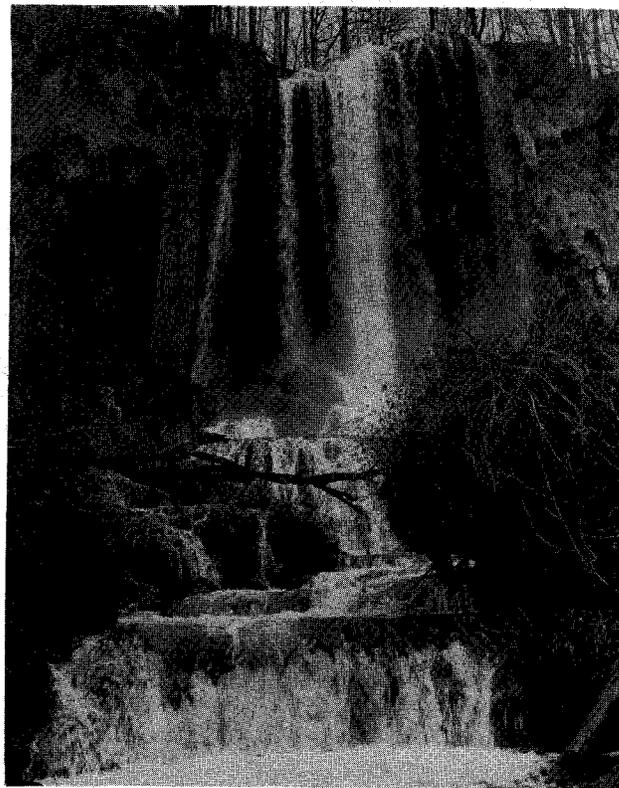


Figure 1. Travertine waterfall and cascade series on Falling Springs Creek, Alleghany County, Virginia. Note man standing in center of left margin.

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Figure 2. An extensive marl deposit located in Frederick County, Virginia. Stream, in foreground, has incised and drained the deposit. A soil profile, removed by producer, had developed on the marl. (Photograph by S. O. Bird)

The authors have observed travertine and marl along streams and springs in seventeen counties of western Virginia. Calcium carbonate deposition assumes a variety of forms: rimstone dams (Figure 3), terrace cascades, drapery-like features, encrustation of organic materials, and oncolites. Encrusted materials and associated fossils include leaf impressions, twigs, seeds, stem and trunk casts, land and water snails and crustacean fragments.

Distinctive well-drained dark-colored soils (Mollisols) have developed over a number of travertine-marl deposits. These characteristic soils may be used with topographic signatures to aid in identification of potentially economic deposits.

RANGE AND SCOPE OF DEPOSITS

Travertine and marl deposits were located along 57 streams and springs in the Valley and Ridge province of western Virginia (Figure 4). Further examination is expected to reveal additional deposits.

Deposits are generally found downstream from faulted carbonate rocks (Thornton, 1953; Mathews, 1962 and 1962a; McFarland, 1981; McFarland and Sherwood, 1981). Over fifty percent of the sites examined are associated with mapped faults. The remaining sites are in highly fractured and folded rocks and are commonly associated with springs. Falling Springs, as well as other thermal springs on the Warm Springs anticline, is associated with lineaments observable on LANDSAT imagery (Gathright, 1981). Gathright (1981) suggested that



Figure 3. Rimstone dam form resulting from precipitation of calcium carbonate in Mill Creek, Page County, Virginia.

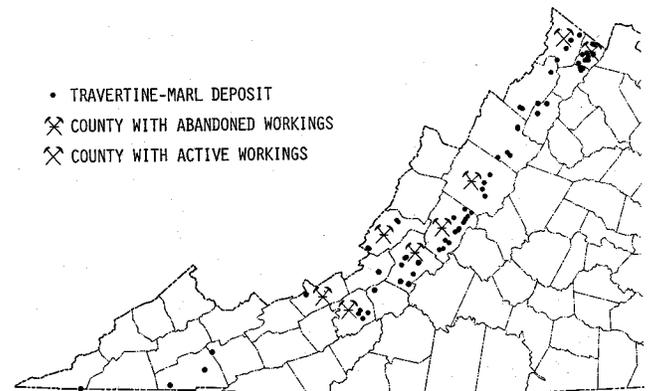


Figure 4. Travertine-marl deposits found in Alleghany, Augusta, Botetourt, Clarke, Craig, Frederick, Giles, Lee, Montgomery, Page, Roanoke, Rockbridge, Rockingham, Shenandoah, Smith, Warren and Washington counties.

the thermal springs are a result of deep groundwater circulation in vertical fracture zones that are expressed as lineaments.

The term, travertine, refers to a white (10YR 8/1), very pale brown (10YR 8/3) or light yellowish brown (10YR 6/4), massive or concretionary limestone with a radiating or concentric structure. Spongy or less compact varieties are commonly referred to as calcareous tufas. Julia (1983) notes the present trend is to term encrusting varieties of calcium carbonate, related to plants, as travertine, regardless of pore volume or density. Travertine commonly forms rimstones, terraces,

cascades and dams. A series of cascades and falls may total over one hundred and fifty feet in height. Travertine features are intimately associated with less spectacular deposits of marl.

The term, marl, applies to white (10YR 8/1), light gray (10YR 7/1), light yellowish brown (10YR 6/2) or dark yellowish brown (10YR 4/4), loose, earthy deposits of calcium carbonate and insoluble clays, silts or sands. Marl is defined as containing 35 to 65 percent calcium carbonate (Pettijohn, 1957). However, some marls reported in the literature and materials considered marls in this report, contain up to 98 percent calcium carbonate (see Economic Development). Deposited as valley fills, some Virginia marls extend to widths of 500 feet across terraced flood plains and have thicknesses up to 60 feet.

Buildups of travertine and/or calcareous tufa result from precipitation from stream and spring waters supersaturated with calcium carbonate (Emig, 1917; Woodward, 1936; Thornton, 1953). Accumulations are usually found where streams cross bedrock ledges or boulder lags. Marls aggrade behind travertine and tufa structures. Travertine-marl deposits often consist of a series of travertine-dam and marl-terrace sequences which may extend for several miles along a stream. Marl materials can be fine to coarse textured. Coarse textured marls are associated with the larger dam sequences and higher stream flow regimes.

Precipitating calcium carbonate encrusts organic as well as inorganic materials. Concretions and concentrically layered oncolites are common features in stream beds and banks (Roddy, 1915; Thornton, 1953). Green and blue-green algae and mosses identified in streams as having encrustations of calcium carbonate include *Philononotis calcarea* (Steidtmann, 1934b); *Oocardium stratum*, *Chara vulgaris* and *Calothrix viguieri* (Mathews, 1962 and 1962a); *Cladophora glomerata*, *Phormidium incrustatum*, *Oscillatoria agardii*, *Vancheria* spp., *Spirogyra* spp. and *Oscillatoria* cf. *splendid* (Gillespie and Clendening, 1964). Encrustations of calcium carbonate have been observed on plant stems and roots and result in hollow tube fragments of various sizes (Gillespie and Clendening, 1964; Dean, 1981). Leaf impressions are commonly observed in travertine masses and include angiosperm varieties: black gum, black walnut, sycamore, pine and oak (Trainer, 1948; Thornton, 1953; Gillespie and Clendening, 1964).

Fragments of encrustations may act as nuclei for further concentric encrustation, forming pisolites. Pisolites, oncolites and other loose calcium

carbonate materials including fragments of travertine can make up a large portion of the carbonate materials in marls.

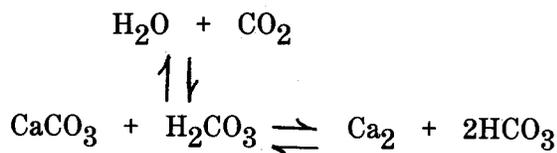
Erosion of travertine dams and other buildup forms result from periodic floods (Emig, 1917; Steidtmann, 1936; Chafetz and Folk, 1984). During Hurricane Camille, in 1969, rainfall exceeded 30 inches for eight hours in local areas of Virginia. Reports and observations indicate this storm had a catastrophic affect on travertine buildups in Moores Creek and Gibbs Falls in Rockbridge County, Virginia. Both falls were nearly stripped of travertine, exposing the underlying bedrock. One observer (Phillip Lucas, 1984, personal communication) estimated only 20 percent of the travertine still remains at the Moores Creek Falls.

DEPOSITIONAL FACTORS

Travertine-marl deposits form downstream from sites where groundwater emerges from carbonate rocks. These emergent waters generally mix with surface water prior to calcium carbonate deposition. Faults and fractures in carbonate rocks are important in providing conduits for migration of groundwater to the surface. Where faults are transected by surface streams, groundwater can emerge, either directly at the surface as discrete discharge (spring) or as a diffuse discharge. Diffuse discharge may extend a considerable distance downstream from an incised fault through unconsolidated surficial materials.

The emerging groundwater differs in chemical composition and seasonally in temperature from surface stream waters. The content of CO₂ in surface waters is generally near equilibrium with atmospheric CO₂, which is 0.03 percent by volume or 10^{-3.5} atmospheres. The CO₂ content in groundwater can be much higher because rainwater infiltrating through soil may dissolve additional CO₂ from the soil air. Soil air can contain several percent CO₂ because of plant root respiration and the decomposition of organic material by microorganisms (Holland and others, 1964). Diffusion of CO₂ from overlying soils can add more CO₂ to the groundwater (Jacobson and Langmuir, 1970). A study of 14 carbonate springs in the Central Appalachians showed that all waters contained about an order of magnitude more CO₂ than they would if they were in equilibrium with the atmosphere (Shuster and White, 1971). The high CO₂ content of groundwater greatly increases the amount of the calcium carbonate groundwater can dissolve relative to surface waters. The equation for the dissolution of calcium carbonate by a

solution of water and CO₂ (carbonic acid) can be written:



The solubility of calcite depends on the amount of CO₂ available. Any process that increases the amount of CO₂ in the solution causes more calcium carbonate to dissolve, whereas processes that decrease the amount of CO₂ can cause calcium carbonate to precipitate.

Waters from springs in Virginia are usually at about the mean annual temperature of their respective areas. During summer and early fall, surface waters are warmer than spring waters. At this time atmospheric precipitation is also at a low for the year; thus, stream levels are down, and groundwater flow can be significant relative to surface flow. When groundwater joins a low-flow summer stream, dissolved calcium carbonate and CO₂ content of the stream can increase dramatically.

The main factor controlling deposition of calcite to form travertine-marl deposits appears to be the loss of CO₂ from the mixed stream waters. As the CO₂ enriched groundwater issues to the surface and mixes with a stream, the water loses CO₂ as it approaches equilibrium with the atmosphere (Jacobson and Langmuir, 1970). The equilibrium solubility of calcite decreases substantially as CO₂ degasses, and the water becomes supersaturated with respect to calcite (Jacobson and Langmuir, 1970). The degree of calcite supersaturation increases downstream as the CO₂ content of the water decreases (Jacobson and Uzdowski, 1975; Dandurand and others, 1982). When groundwater joins a warm summer stream, CO₂ degasses more readily from the water because CO₂ is less soluble at higher temperatures. Agitation of the stream water also results in more rapid outgassing of CO₂; thus, calcite precipitation tends to be most rapid in turbulent zones of the stream.

Metabolic interaction of biologic agents such as algae, fungi and bacteria can result in further loss of CO₂ and a corresponding increase in supersaturation with respect to calcite (Dean, 1981; Chafetz and Folk, 1984). Osmotic uptake of H₂O could result in the exclusion and subsequent deposition of calcium carbonate on plants (Emig, 1917). A number of researchers have reported calcium carbonate encrustation on algae and

mosses (Emig, 1917; Steidtmann, 1934, 1934a, 1935, 1935a, 1936; Mathews, 1962 and 1962a; Gillespie and Clendening, 1964). In addition, osmotic uptake of H₂O could result in the exclusion and subsequent deposition of calcium carbonate on these plants (Emig, 1917). Fungal influence on calcium carbonate deposition in streams is implied by Emig (1917) and Dennen and Diecchio (1984). Bacterially-constructed travertine is reported by Chafetz and Folk (1984), and evidence suggests that bacteria may be partly responsible for travertine deposition at Falling Spring Falls in Virginia (Dennen and Diecchio, 1984).

DEPOSITIONAL MODEL

Based on the depositional factors previously discussed, a depositional model for Virginia travertine-marl is proposed. Travertine-marl deposits form downstream from where a significant flow of carbonate-rich groundwater joins a surface stream (Figure 5, B and/or C) and are commonly associated with fractures or faults. The deposits form in summer or early fall during periods of the warmest water temperature and lowest surface flow. Precipitation of calcium carbonate proceeds downstream from the zone of mixing of the warm low calcium surface water and cool higher calcium groundwater (Figure 5, D). Deposition occurs only after the mixed waters reach supersaturation with respect to calcium carbonate, a result of CO₂ outgassing. CO₂ evolves from the stream by diffusion into the atmosphere which is enhanced by agitation. Buildups of travertine on ledges can cause pools to develop. Environmental warming of pooled waters, agitation of plunging and cascading waters, and the metabolic activity of biologic agents further increase the saturation index of calcium carbonate. Precipitation includes carbonate encrustation on plants, cobbles and bedrock exposures along the stream. As the travertine structures grow, loose calcium carbonate materials accumulate behind them. The aggrading stream migrates across the valley in such a way that the dams and fill deposits of travertine and marl may become extensive. Large dams can form in a few hundred years (Emig, 1917).

Clastic sediments derived from mass wasting may be locally interbedded in travertine-marl deposits. Burial of some travertine-marl deposits by alluviation and incision of travertine structures have increased as a result of agricultural practices over the last two hundred years. Many deposits have undergone enrichment of calcium carbonate along the banks of incising streams. At most deposits seasonal deposition is not keeping pace with erosion.

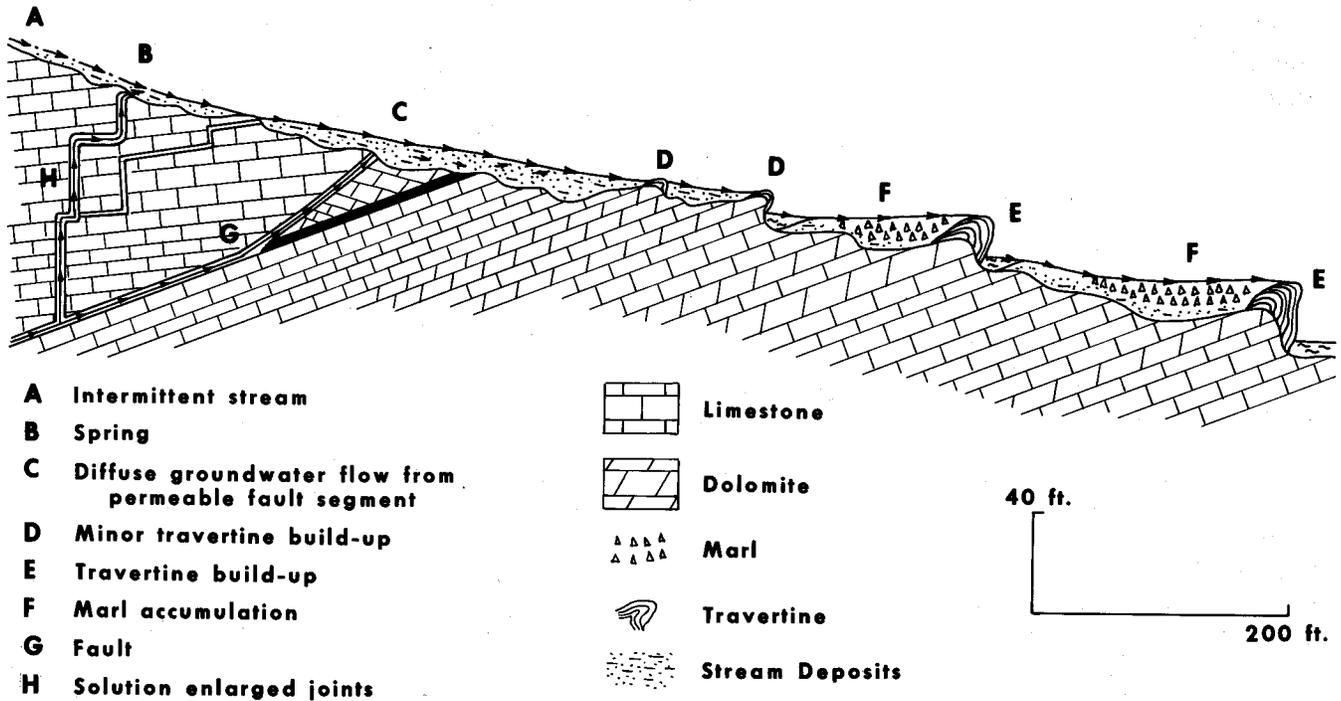


Figure 5. Generalized stream profile illustrating deposition of travertine-marl.

SOIL DEVELOPMENT

The continued incising and resulting drainage of travertine-marl deposits often results in a distinctive soil development. Mollisols are dark basic soils (Soil Conservation Service, 1975); at least two of these soil types have been identified in association with travertine-marl deposits in Virginia.

The Weaver soil is associated with marl deposits in Clarke County. This is a brown to dark brown soil which contains up to 10 percent lime concretions and effervesces with dilute hydrochloric acid. The subsoil contains layers of marl (Edmonds, Circa 1970). A Weaver soil that contains two buried soil profiles is described in a recent soil survey of Clark County (Edmonds and Stiegler, 1982). Interlayered and basal marls can be recognized from this description. A second important Mollisol, the Massanetta Series, is found in Rockingham County. The Massanetta Series soils contain anomalously high percentages of solid calcium carbonate material (McFarland, 1981).

ARCHAEOLOGICAL ASSOCIATIONS

Fragments of indian pottery and charcoal were reported by Collins (1924) at a travertine-marl

deposit in Augusta County. These materials were found at a depth of several feet, apparently in a terrace marl. The owner of the property noted that there were "several rings of fire discolored stones with charcoal in their midst" beneath the overburden overlying a travertine bluff.

A number of projectile points and pottery fragments were found at a commercial marl deposit in Frederick County. These artifacts were found beneath the soil layer near the top of the marl, in association with a number of stones believed to have outlined a fire pit.

Artifacts from Frederick County are identified as having been made by late middle to early late Woodland Indians of about 750 AD to 1000 AD (W. Boyer, 1984, personal communication). These were horticultural indians and their campsites are frequently found associated with the range of flora and fauna found in the swampy depositional environment of an aggrading marl.

PALEONTOLOGICAL ASSOCIATIONS

In addition to the leaf impressions mentioned previously, a number of other fossils and sub-fossils have been found in association with travertine-marl deposits. Downstream from Natural Bridge, Rockbridge County, *Helix alternata* and *Physa*

mollusk shells were identified (Britton, 1886). *Bythinella nickliniana* Lea, *Planorbis bicarinatus* Say, *Planorbis parvus* Say and *Pisidium* sp. were identified by Dr. Paul Bartsch from an Augusta County deposit (Kindle, 1911). Molluscs collected from a second Augusta County deposit were identified by Dr. H. A. Pilsbry as: *Circinaria concava* (Say), *Polygyra tridentata* (Say), *Polygyra frandulenta* (Pilsbry), *Gonyodiscus alternatus carinatus* (Beck), *Gastrodonta ligera* (Say), *Polygyra thyroidus* (Say), *Physa heterostropia* (Say), *Planorbis bicarinatus* Say, (or *P. antrosus* of Conrad), *Campeloma decisum* (Say), *Sphaerium sulvatum* (Lamarck), and *Unio* sp. (Collins, 1924). Five species of land snails and two of freshwater snails were found at the Falling Springs deposit (Trainer, 1948). Gillespie and Clendening (1964) reported gastropods and pelecypods in the stream traversing a West Virginia deposit.

A number of gastropods and two clams were found in 1983 associated with a marl deposit in Frederick County, Virginia. Specimens from this site on Red Bud Run were identified by J. J. Murray as: *Triodopsis rugosa*, *T. fallax*, *T. albolabris*, *Lymnaea palustris* (?), *Heliosoma trivolvis* (?), *Gastrocopta* cf *G. armifera*, *Strobilops aenea*, *Physagyryna*, *Pisidium casertanum* and *Elliptio* sp. Specimens of gastropods collected surficially from the Falling Springs deposit in 1984 were identified by S. O. Bird as *Triodopsis* spp., *Lymnaea* sp. and *Heliosoma* cf *H. anceps*.

ECONOMIC DEVELOPMENT

Marl from Valley and Ridge areas was marketed for many years. Rogers (1884) noted values for "carbonate of lime" (CaCO_3) ranging from 76 to 91 "grains in the 100" for ten Virginia marl localities. Some Virginia marls were used as a flux in iron-making (Watson, 1907). He cited four analyses of "lime" ranging from 48 to 53 percent for Alleghany, Frederick and Rockbridge counties. Analyses of four Virginia freshwater marls were presented by Shubert (circa 1921):

	Montgomery County (in %)	Rockbridge County (in %)	Rockingham County (in %)	Washington County (in %)
Calcium carbonate	94.35	96.70	97.75	93.00
Magnesium carbonate	4.20	1.39	0.73	1.34

A marl deposit northwest of Daleville, Botetourt County, was worked for fertilizer prior to 1920 (Woodward, 1932). A deposit on Spreading Spring Branch at Springwood, (apparently mislabeled Springfield in production records reported in Table

1 - Botetourt 2) was worked with a two horse scraper (George L. Hayth, 1984, personal communication). Travertine-marl was put through a drier and then a crusher before being screened. Mr. Hayth reported his wages as a laborer in 1919 or 1920 as ninety cents a day, the scraper operator made two dollars and fifty cents a day. U. S. Bureau of Mines data indicates that agriculture lime from this deposit sold for about \$3.00 a ton. Travertine or calcareous tufa material from Falling Spring Falls, Alleghany County was marketed as Barbers "Fallingsprings" Lime in the early to mid 1920's (Ohio C. Barber Fertilizer Company, circa 1926). In 1944 the Falling Springs Lime Company was quarrying travertine just west of the falls. Raw material was hauled two miles by narrow gauge railroad to the town of Falling Springs where it was ground for agricultural use. A travertine sample from the locality contained 97.85 percent calcium carbonate, 0.90 percent magnesium carbonate, and 0.48 percent silica (Edmundson, 1958).

Marl was recovered commercially for over 20 years in Augusta County at Quicks Mill. Collins (1924) noted that this Falling Spring Run site was being worked when he visited the area (Table 1, Augusta 5a). Mrs. Avis La Port recalled that marl for agricultural use was produced from the site by J. S. Jordan from the early 1900's until the 1940's (personal communication, 22 July 1984).

Agricultural lime was produced for more than forty years from loose marl deposits in Clarke County. Producers included J. C. Digges and Sons, located west of Calmes Neck on the Shenandoah River (Edmundson, 1945; Edmundson and Nunan, 1973).

Records from the U. S. Bureau of Mines reveal that travertine-marl production was carried out in eight Valley and Ridge Province counties (Figure 4) during the interval from 1913 to 1956 (Table 1). Thirty-two producers were responsible for a reported 1,297,239 tons of travertine marl during these forty-three years (Table 2). Additional U. S. Bureau of Mines data indicate 140,102 tons of travertine-marl production from 1957 thru 1969 for a total figure of 1,437,341 tons for the period 1913 through 1969 for the Valley and Ridge province of Virginia.

Travertine-marl deposits in at least three other counties may have been utilized. Schubert (circa 1921) reports analyses from Rockingham and Washington counties in a Norfolk and Western Railway brochure on *Fresh Water Marl in the Virginias*. A manufacturer along the railway is listed as located in Abingdon (Washington County),

Table 1. Travertine-marl production for the Valley and Ridge province.

County	Producer	Deposit Location or Name	Years of Production ^a	Tonnage Sold ^a	Total Yield of Deposit
Alleghany	1a. Ohio C. Barber Fert. Co.	Barber, VA	1914-1926	201,570	387,760
	b. Falling Springs Lime Co.	Barber, VA	1927-1941	186,190	
Augusta	1a. A.S. Bailey	Mount Sidney, VA	1929	30	42
	b. G.S. Bailey	Mount Sidney, VA	1940	12	
	2. James L. Coffey	Staunton, VA	1941-1944	285	285
	3. Farmers Marl Lime Co.		1921-1922	2,250	2,250
	4. Bennett W. Huff	Fort Defiance, VA.	1921-1929	865	865
	5a. J.S. Jordan	Staunton, VA. Verona	1921-1945 (excl. 1932, '33, '36, '42)	70,502	70,502
	b. leased to Carver F. Marshall		1942	13,394	13,394
	6a. Arthur B. Kerr		1940-1941	205	1,205
	b. Wilson & Taylor	Staunton, VA. Kerr Pit	1942-1945	1,000	
	c. leased to Verona Marl Co.		1946-1947		
	7. Verona Marl Co. Inc.	Alexandria, VA. Kerr Pit & Verona Marl Pit	1945-1947	24,328	24,328
Botetourt	1a. Daleville Lime Marl Co.	Roanoke, VA. Daleville	1919-1921	4,170	12,072
	b. Botetourt Lime Marl Co.	Roanoke, VA. Daleville	1922-1930	7,902	
	2. Roanoke Lime Co.	Roanoke, VA. Springfield	1919-1920	4,189	4,189
	3. Robinson Lime Marl Co.	Fincastle, VA.	1947	No production reported	
Clarke	1. Clarke Farmers Coop, Inc.	Berryville, VA. Millwood	1940 ^b -1950 (excl. 1942)	137,497	137,497
	2a. W. R. Thompson	White Post, VA. Old Chapel Marl Pit	1946	18,545	118,429
b. J. C. Digges & Sons	White Post, VA. Old Chapel Marl Pit	1947-1956 (excl. 1951-1955)	99,884		
	3. Fincham Marl Plant	Berryville, VA. Old Chapel Marl Pit	1947-1949	26,272	26,272
	4. A. Golightly & Burkner		1950	13,000	13,000
	5. Elmer Kinney	Berryville, VA.	1958-1962 ^c		
	6. Aimee Strother & Bro.	Berryville, VA.	1952-1957 ^c 1956	500	500
Frederick	1. Cornwall Lime Marl	Winchester, VA.	1923	1,942	1,942
Giles	1. Blankenship		1950	No production reported	
	2. Gatewood & Talbott Co.	Huntington, WV. Narrows	1945-1948 (sold to Langhorne & Langhorne-1948)	84,242	84,242
	3. Rufus C. Hale	Narrows, VA	1941-1947	2,650	2,650
	4. Langhorne & Langhorne	Huntington, WV. Narrows	1942-1947	141,056	141,056
	5a. Wolf Creek Marl	Narrows, VA. Narrows	1945-1946	42,640	84,571
	b. leased to Narrows Contracting Company	Narrows, VA. Narrows	1947-1950 (1952 ^c)	41,931	
Montgomery	1a. J.N. Lantz	Salem, VA	1930-1938 (excl. 1932, '33 & '35-'37)	911	911
	b. J. Gilbert Cox	Ellison, VA	1948-1949	No production reported	
Rockbridge	1a. Calcium-Phosphate & Fertilizer Company	Roanoke, VA. Riverside	1918-1923	16,540	29,121
	b. Farmers Marl Lime Co. (name change)		1918-1923	12,581	
	2. Dupont Chemical	Wilmington, Del. Riverside	1918	6,000	6,000
	3. F.M. Hughson	Roanoke, VA. Riverside	1922-1923	No production reported	
	4. Marlbrook Lime Co.	Marlbrook, VA. Marlbrook	1913-1931 (excl. 1916-1917)	109,205	109,205
	5. United Chemical Products Company	Buena Vista, VA	1923-1931	24,951	24,951

a. U.S. Bureau of Mines Mineral Production Data

b. On file with the Virginia Division of Mineral Resources file data

c. From U.S. Bureau of Mines "Minerals Yearbook"

Table 2. Travertine-marl production by year for the Valley and Ridge province for 1913-1956^a.

Year	Tonnage Sold	No. of Producers	Year	Tonnage Sold	No. of Producers
1913	3,750	1	1936	8,190	1
1914	10,400	2	1937	6,173	1
1915	22,500	2	1938	17,169	3
1916	25,000	1	1939	19,603	2
1917	12,500	1	1940	37,500 ^b	5
1918	37,720	4	1941	32,735	6
1919	37,790	5	1942	13,541	5
1920	36,276	5	1943	61,659	6
1921	27,248	7	1944	68,617	6
1922	28,346	7	1945	88,831	8
1923	36,562	8	1946	137,122	7
1924	28,742	6	1947	98,932	8
1925	30,964	7	1948	53,477	5
1926	23,927	7	1949	62,428	4
1927	23,525	7	1950	52,131	4
1928	29,468	7	1951	no data	4
1929	36,882	8	1952	no data	
1930	36,742	7	1953	no data	
1931	17,442	5	1954	no data	
1932	5,541	1	1955	no data	
1933	5,678	1	1956	10,500	2
1934	8,363	3			
1935	3,265	1	Total	1,297,239	

a. U.S. Bureau of Mines Mineral Production Data

b. Includes production figure from correspondence not reported by U.S. Bureau of mines

Virginia. Bath and Rockingham counties are noted as having preparations underway in 1912 for utilization of marls for agricultural purposes (Watson, 1913).

One deposit continues to yield lime in Frederick County, Virginia. This working initially contained an estimated 100,000-ton reserve of marl containing in excess of 90 percent calcium carbonate.

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ANNOTATED BIBLIOGRAPHY OF THE VALLEY AND RIDGE TRAVERTINE-MARL DEPOSITS OF VIRGINIA

David A. Hubbard, Jr.

ALLEN, R. M., JR., 1967, Geology and mineral resources of Page County: Virginia Division of Mineral Resources Bull. 81, 78 p.

Quaternary (Recent) tufa terraces or dams have been observed in several Shenandoah Valley streams. Tufa or travertine is chemically deposited from streams having high concentrations of calcium carbonate. Precipitation results from the loss of carbon dioxide at riffles and small waterfalls. The tufas observed were brown to buff, porous, and punky. The greatest accumulations were observed downstream from Hamburg on Mill Creek.

BARTLETT, C. S., JR. and Webb, H. W., 1971, Geology of the Bristol and Wallace quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 25, 93 p.

Travertine is found in some parts of the stream beds in and near Bristol. One deposit occurs along Beaver Creek in Monroe Park northwest of the intersection of Valley Drive and Old Abingdon Place.

BASSLER, R. S., 1905, Portland cement resources of Virginia: U.S. Geol. Survey Bull 243, p. 312-323, Map.

Calcareous tufa, if favorably located in sufficient quantities, would be of value in cement manufacture. Calcareous fresh water marls are of more importance, but surface indications are so meager that no estimate can be made of their quantity. Deposits 10 to 12 feet thick were located in Staunton a by Mr. Catlett.

BASSLER, R. S., 1909, Cement resources of Virginia: Virginia Geol. Survey Bull. 2-A, 309 p.

Numerous springs in western Virginia are depositing quantities of calcareous tufa or travertine. Analysis of a Staunton deposit containing "a calcareous marl or travertine 10 or 12 feet deep" yielded 90.4 percent CaCO_3 . Ellett and Eskridge, and Roger's works were acknowledged.

BRENT, W. B., 1960, Geology and mineral resources of Rockingham County: Virginia Division of Mineral Resources Bull. 76, 174 p.

"Travertine" is found in old and present stream beds in Rockingham County. Travertine is defined as a precipitation product from hot springs. Therefore, most of the deposits of calcium carbonate in stream beds of the county would not commercially be classed as travertine. They are classed commercially with the marbles.

BRITTON, N. L., 1886, Geological notes on western Virginia, North Carolina, and Tennessee: New York Acad. Sci., Trans., vol. 5, p. 215-223.

Quantities of calcareous tufa occur along the banks of a small stream entering Cedar Creek below Natural Bridge. Mollusk shells of *Helix alternata* and *Physa* and twigs of *Arbor Vitae* are found in the deposit. Deposition is recent and may still be occurring.

COLLINS, R. E. L., 1924, Travertine deposits in Virginia: Pan-American Geol., vol. 41, p. 103-106.

Travertine and marl occur along Falling Springs Run, near Staunton, Virginia. The run is fed by springs in the upper valley. Three distinct terraces with small water-falls at their abrupt lower slopes extend over 40 acres. The deposits occur in two distinct forms, one a massive hardened variety forming the retaining walls of the terraces, the second type a fine, unconsolidated, sandy granular calcium carbonate of cream color, commonly known as marl. The second type is often used by farmers for liming the soil. The third terrace has been worked and fragments of Indian pottery and rings of fire blackened

stones and charcoal were found. Tree limb and trunk casts, leaf impressions, fragments of bone and teeth, and molluscan shells were found. Molluscs identified include:

Circinaria concava (Say)

Polygyra tridentata (Say)

Polygyra fraudulenta (Pilsbry)

Gonyodiscus alternatus carinatus (Beck)

Gastrodonta ligera (Say)

Polygyra thyroidus (Say)

Physa heterostropha (Say)

Planorbis bicarinatus Say, (or *P. antrosus* of Conrad)

Campeloma decisum (Say)

Sphaerium sulvatum (Lamarck)

Unio sp? fragments

Leaf impressions were of common chestnut oak and sycamore. The deposit may be of late Pleistocene age, but in all probability is recent.

DENNEN, K. O. and Diecchio, R. J., 1984, The Falling Springs, Alleghany County, Virginia, in Rader, E. K. and Gathright, T. M., II, Stratigraphy and structure in the thermal springs area of the western anticlines: Sixteenth Annual Virginia Geologic Field Conference, Oct. 13-14, p. 17-19.

Precipitation of calcium carbonate occurs along Falling Springs Creek, below the falls, in late summer and fall. Deposition is the result of degassing of CO_2 , evaporation and biologic factors including: algae, fungi, and bacteria. Ancient travertine at an elevation higher than the spring indicates that the travertine started to form when the valley floor was higher than it is today.

DENNEN, K. O. and Diecchio, R. J., 1984, Chemical observations of Falling Spring, Alleghany County, Virginia (abs): Virginia Jour. Sci., vol. 35, no. 2, p. 119.

Travertine precipitates downstream from Falling Spring Creek waterfall. Seasonal changes in surface runoff and the activity of algae and bacteria are important to the formation of travertine. Ancient travertine consisting of waterfall/cascade deposits formed under conditions similar to those today, but at higher elevations.

EDMONDS, W. J. and Stiegler, J., 1982, Soil Survey of Clarke County, Virginia: U. S. Department of Agriculture, Soil Conservation Service, 211 p.

Weaver series soils form on calcareous alluvial sediments and massive deposits of travertine. A soil section is recorded from approximately 660 feet west-northwest of where Virginia Highway 621 crosses Spout Run. Carbonate concretions, mollusk* shells, and soft marly material make up 5 to 10 percent of the A and B horizons noted. The C horizons contain 40 to 50 percent calcareous materials. This soil profile contains two buried A and B horizon sequences. The deepest C horizon contains lime concretions with leaf imprints.

* refers to gastropod and pelecypod (misidentified as brachiopod by Edmonds and Stiegler)

EDMUNDSON, R. S., 1945, Industrial limestones and dolomites in Virginia: Northern and central parts of Shenandoah Valley: Virginia Geol. Survey Bull. 65, 195 p.

A calcareous marl deposit at Calmes Neck, about two miles east of Millwood in Clarke County, is being operated for agricultural lime.

EDMUNDSON, R. S., 1958, Industrial limestones and dolomites in Virginia: James River district west of the Blue Ridge: Virginia Division of Mineral Resources. Bull. 73, 137 p.
The travertine deposit on Falling Springs Creek was

actively quarried when visited in 1944, but is not now. Analysis of a sample shows 97.85 percent calcium carbonate, 0.90 percent magnesium carbonate, and 0.48 percent silica.

EDMUNDSON, R. S. and Nunan, W. E., 1973, Geology of the Berryville, Stephenson, and Boyce quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 34, 112 p.

Marls occupying the flood plains of Clarke County streams are intermixed with variable amounts of sand and clay. Calcium carbonate content ranges from 65 to 94 percent with a magnesium carbonate content of less than one percent. Where free from other sediments, marls contain more than 97 percent CaCO_3 . Commercial operations for agricultural lime were conducted along Dry Marsh Creek, Calmes Neck and are active along Chapel Run. Massive travertine, coated pebbles and mollusk shells were observed in many streams. Some floodplains mapped as alluvium may contain marl deposits of commercial importance.

ELLETT, W. B. and Eskridge, A. T., 1897, Virginia marls: Virginia Agric. Exp. Station Bull. 78, vol. 6, no. 7, p. 65-70.

Marl is a earthy material of variable composition with a considerable percent of carbonate of lime. Analyses of five Valley and Ridge marls are listed with twenty or more percent lime: Allegheny Co. - 50.58 percent, Frederick Co. - 52.19 percent and 52.62 percent and Rockbridge Co. - 47.87 percent and 88.79 percent.

GATHRIGHT, T. M., II, 1974, Geology of the Ashby Gap quadrangle, Virginia: Virginia Division of Mineral Resources Rept. Inv. 36, 55 p.

Tufa deposits are common along spring-fed streams incised in flood-plain alluvium. These impure deposits contain organic debris and fine grained siliceous sediment.

GATHRIGHT, T. M., II, 1976, Roadlog to several thermal springs of western Virginia in Near-normal geothermal gradient workshop: ERDA, Los Alamos Scientific Laboratory, University of California, ERDA 76-11, CONF-750366, p.265-292.

Calcareous tufa extends along Falling Springs Creek from the 60- to 70-foot falls upstream to the spring. The tufa forms a broad floodplain and was deposited by the thermal waters from the spring.

HELZ, G. R. and Sinex, S. A., 1974, Chemical equilibria in the thermal spring waters of Virginia: Geochim. Cosmochim. Acta., vol. 38, p.1807-1820.

Massive travertine deposits were found downstream from Falling Spring. The deposit was extensively quarried during the 1940's. Travertine has been found 60 feet higher than the present stream level. The spring system is estimated to be at least 3×10^9 years old based on average rates of erosion in the region.

HINKLE, J. H., 1934, Chemical studies of travertine and travertine-depositing waters (abs): Proc. Virginia Acad. Sci., p. 57 (abs.).

Travertine and travertine depositing waters along Marl Creek in Rockbridge County were observed. Summer travertine layers have only half as much quartz, feldspar and clay as winter layers. Calcium content of the winter stream was two times saturation.

KINDLE, E. M., 1911, The collapse of recent beds at Staunton, Va.: Proc. Washington Acad. Sci., vol. 13, No. 2, p. 35-49.

Marl occurs along a minor tributary of Lewis Creek. Accumulations of clay and marl range from twenty to sixty feet. Great numbers of fresh water shells in the marls afford indisputable evidence of pond conditions of accumulation. A well at the ice plant reportedly passed through 12 feet of marl. Shells collected from marl beds represented:

Bythinella nickliniana Lea
Planorbis bicorinatus Say
Planorbis parvus Say
Pisidium sp.?

These species indicate a post-Pleistocene age of the beds.

MATHEWS, H. L., 1962, Marl deposition by the algae *Oocardium stratum* and *Chara vulgaris* in Montgomery County, Virginia (abs): Proc. Virginia Acad. Sci., p. 250

Calcium carbonate dissolved from highly fractured and faulted carbonates was found to be precipitated by the algae *Oocardium stratum* in swift streams, and in smaller amounts by *Chara vulgaris* in still and eddy waters. *Calothris viguieri* was observed, but thought to play a very minor role in the deposits.

MATHEWS, H. L., 1962, The formation of calcareous tufa deposits in Montgomery County, Virginia (abs): Proc. Virginia Acad. Sci., p. 283.

Groundwater rising from highly fractured and faulted dolomitic limestone is responsible for precipitation of CaCO_3 in Montgomery County. The presence of *Oocardium stratum* is of major importance to the deposition of CaCO_3 downstream from these springs. Inorganic factors affecting deposition include increasing temperature and loss of CO_2 to the atmosphere. *Chara vulgaris* and *Calothris viguieri* are other algae influencing deposition.

MCDONALD, J. V., 1984, The Saltville, Virginia, locality: A summary of research and field trip guide: Symposium on the Quaternary of Virginia, Charlottesville, Virginia, 45 p.

A tufa/travertine fan lies just beneath the surface between the parking lot and Palmer Spring.

MCFARLAND, E. R., 1981, Geochemistry of an unusual carbonate-rich soil in Rockingham County, Virginia: Unpublished Senior Thesis, James Madison University 25 p.

Massanetta Series soils contain a large percentage of solid carbonate material. This soil type typically occurs along small streams downstream from the point at which a fault or fault zone in carbonate rock crosses the stream. Carbonate layers and deposits in the soil are attributed to soil forming processes. Travertine was observed to be forming in the stream channel.

MCFARLAND, E. R. and Sherwood, W. C., 1981, Geochemistry of an unusual carbonate-rich soil in Rockingham County, Virginia (abs): Virginia Jour. Sci., vol. 32, no. 3, p. 128.

Massanetta Series soils were mapped along streams draining faulted carbonate rocks. Carbonate content in these soils increased with depth to 65 percent in the C horizon. The deposition of calcite in these soils is attributed to surface evaporation.

MCGUIRE, O. S., 1976, Geology of the Daleville quadrangle, Virginia: Virginia Division of Mineral Resources, Rept. Inv. 42, 43 p.

The commercial marl deposit 0.5 mile northwest of Daleville is cited from Woodward (1932). No commercial operation involving marl deposits is known to have occurred since the 1930's.

OHIO C. BARBER FERTILIZER COMPANY, circa 1926, Facts concerning Barbers "Fallingsprings" lime: Barber, Virginia, 16 p.

An analysis of precipitated lime: 97.84 percent CaCO_3 , 0.13 percent MgCO_3 , and a table of comparison values of CaCO_3 and "Percentage Soluble in Rain Water or Soil Moisture" for "Precipitate lime", Murate (sic), Helderburg, Shenandoah and Lewiston Limestones are presented. A number of letters from satisfied customers indicate production has been carried out since the early 1920's.

RADER, E. K., 1967, Geology of the Staunton, Churchville, Greenville, and Stuarts Draft quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 12, 43 p.

Travertine along Folly Mills Creek may be greater than fifteen feet thick. Plant fragments and leaves are a common feature in this travertine.

REEVES, Frank, 1932, Thermal springs of Virginia: Virginia Geol. Survey Bull. 36, 56 p.

Some warm springs are currently forming marl, and some are cutting away earlier deposits. Other springs have not formed

such deposits. Deposits are a few feet wide and possibly several hundred feet long in the valleys fed by warm springs. Deposits are not limited to warm springs, marls occur below cold springs, as along Falling Springs Creek.

ROGERS, W. B., 1884, A reprint of the geology of the Virginias: D. Appleton and Company, New York, 832 p.

Analyses of "carbonate of limes" are given for eleven Virginia marl locations, ten of which are within the current state boundaries. Analyses ranged from 76 to 91 "grains in the 100".

SCHUBERT, F. A., circa 1921, Fresh water marl in the Virginias: Norfolk and Western Railway, 6 p.

Fresh water marls are found throughout the Shenandoah Valley and southwest Virginia from the Potomac River to the Tennessee line. Spring waters highly charged with acids act on limestones. As the stream comes in contact with waters of a different chemical composition or the waters of the streams become supersaturated with lime, precipitation takes place down the stream to where it empties into another stream, where the precipitation is the most active.

Analyses of Virginia samples include: Montgomery County - 94.35 percent calcium carbonate and 4.20 percent magnesium carbonate, Rockbridge County - 96.70 percent calcium carbonate and 1.39 percent magnesium carbonate; Rockingham County - 97.75 percent calcium carbonate and 0.73 percent magnesium carbonate; and Washington County - 93.00 percent calcium carbonate and 1.34 percent magnesium carbonate.

The principal use for fresh water marl is for agricultural purposes. Fresh water marl deposits collectively contain "a number of" million tons. Fresh water marls can be transported to any rail station in Virginia at a price ranging from \$2.00 to \$3.00 a ton depending on distance. Virginia manufactures along the Norfolk and Western Railway include: R. C. Copenhaver, Abingdon, Va.; Daleville Marl Company, Cloverdale, Va.; Marlbrook Lime Company, Roanoke, Va.; and F. M. Hughson, Roanoke, Va.

SPENCER, E. W., 1968, Geology of the Natural Bridge, Sugarloaf Mountain, Buchanan, and Arnold Valley quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 13, 55 p.

Massive porous deposits of tufa or travertine have formed along a number of streams draining areas underlain by carbonate rocks. These materials are formed generally at waterfalls, rapids, or cascades where agitation has resulted in a loss of carbon-dioxide and promoted precipitation of calcium carbonate.

STEIDTMANN, Edward, 1934, Travertine deposits near Lexington, Virginia (abs): Proc. Virginia Acad. Sci., p. 56.

Mosses and algae furnished a framework for travertine deposition on rapids and falls near Lexington, Virginia. Travertine was classified into cascade, pool and fan deposits. Winter layers were thin compact and relatively clastic compared to summer layers. The present destructive erosion of the deposits is a consequence of land cultivation. Increases in water temperatures result in the deposition of travertine.

STEIDTMANN, Edward, 1934, Travertine deposits near Lexington, Virginia: Science, vol. 80, no. 2068, p. 162-163.

The moss *Philonotis calcarea* is the most important travertine builder. Calcite gathers on the dead tissues of these mosses. Decay is believed to be a factor in deposition. Travertine may have imprints of leaves, tree trunks and other plant structures, all species are living today. Travertine deposits are found only associated with rapids and falls. Falls grow vertically as well as downstream. Some falls were raised 25 feet and extended 100 feet downstream. The amount of insoluble materials in winter layers averages two times that found in summer layers. Increased temperatures of stream waters are the cause of inorganic precipitation. Summer streams are warmer than the springs which feed them. The present muddiness of streams after rains is the reason mosses have been greatly reduced and erosion is outstripping retention.

STEIDTMANN, Edward, 1935, Travertine near Lexington, Virginia (abs): American Min., vol. 20, no. 3, p. 206. Geol.

Soc. America Proc. (for 1934, 1935) p. 49 (Title), p. 111-112.

Cascade deposits are tough and mossy or algal, and plainly show summer and winter layers. Travertine is forming on mosses and algae on cascades and as encrustations in pools. Muddy waters are now causing erosion to exceed retention. Waters downstream from the feeder spring show progressive loss of CaCO_3 but are still supersaturated.

STEIDTMANN, Edward, 1935, Travertine depositing waters near Lexington (abs): Proc. Virginia Acad. Sci., p. 70.

Monthly testing of Wilson Creek in Rockbridge County revealed CaCO_3 content of two or three times saturation. CaCO_3 content decreased downstream from the feeder spring except during the coldest months, a period of maximum stream flow, when a weaker uniform content was found along the profile. Physical factors of deposition were ascribed to a rise in temperature, aeration, and close contact with calcite.

STEIDTMANN, Edward, 1936, Travertine-depositing waters near Lexington, Virginia: Jour. Geol., vol. 44, no. 2, p. 193-200.

A feeder spring was more supersaturated with CaCO_3 than Wilson Creek. When the stream was cold (below 8°C) sampling showed that little or no CaCO_3 was deposited. At higher temperatures, the stream showed a progressive loss of CaCO_3 downstream. The supersaturation of the spring with respect to both CO_2 and CaCO_3 results from the high CO_2 content of soil gas, reported as ranging from 1 to 8 percent by volume. Cultivation has resulted in a decline in the CaCO_3 content of the springs, as a result of reduced levels of CO_2 in the soils. Floods have resulted in the entrenchment of travertine deposits to depths of 25 feet. Where deposition occurs on cascades, calcite is deposited at the base of *Philonotis calcarea*. Concentrations of these plants result in a framework for the calcite deposit.

THORNTON, C. P., 1953, The geology of the Mount Jackson quadrangle, Virginia: Unpublished Ph.D. Thesis, Yale University, 211 p.

Tufa deposits were found in three locations along Smith Creek, Holman Creek, and a tributary of Passage Creek. The deposits were of two types: 1) dams, and 2) concretionary masses and pellets. A number of dams were observed to be partially buried under alluvium. Some of these dams were growing where exposed by the stream. "In all three areas of tufa deposition the material is deposited from a stream at points downstream from where the stream crosses a fault... The calcium carbonate is brought to the surface by underground water circulating in the fault plane or fault zone; the crushed condition of the limestone makes its solution easy." A reduction in the solubility of calcium carbonate in streams is the result of outgassing of carbon dioxide by agitation and solar heating. The presence of algae is noted but their responsibility for deposition of CaCO_3 is uncertain. Dams were formed under drier conditions, perhaps during the Post-Glacial Thermal Maximum from 6000 to 4000 years ago.

TRAINER, F. W., 1948, Notes on the flora and fauna of the Falling Springs travertine, Alleghany County, Virginia (abs): Proc. Virginia Acad. Sci., p. 117-118.

Organic and inorganic agencies appear to be responsible for deposition of travertine. Fossils found in the deposit include leaf impressions from elm, black walnut, sycamore, and black gum trees and freshwater as well as land snails. Part of the deposit may be of Pleistocene age.

VAN HORN, F. B., 1910, A cave-in caused by an underground stream at Staunton, Va.: Engineering News, vol. 64, p.238-239.

An old stream valley has been filled to some depth with marl and alluvial wash. Springs are numerous along the valley borders.

VIA, E. K., 1962, Geology of the Wolf Creek-Piney Ridge area: Unpublished M. S. thesis, Virginia Polytech. Inst., 89 p.

Quaternary calcareous tufa is locally associated with limestones and dolomites. Deposits are small and occur surficially or as fillings in parts of a fault zone. Thickest accumulation occurs on Cambrian carbonates near Wolf Creek

in the vicinity of Shumate.

WATSON, T. L., 1907, Mineral resources of Virginia: J. P. Bell Company, Lynchburg, Virginia, 618 p.

Analyses from Ellett and Eskridge are quoted. Uses of marl as a fertilizer and limited use as a fluxing material in some iron furnaces are cited.

WATSON, T. L., 1909, Annual report on the mineral production of Virginia during the calendar year 1908: Virginia Geol. Survey Bull. 1-A, 141 p.

Calcareous marls are found in the Valley region west of the Blue Ridge. Their only development in Virginia has been for local use.

WATSON, T. L., 1913, Biennial report on the mineral production of Virginia during the calendar years 1911 and 1912: Virginia Geol. Survey Bull. 8, 76 p.

Fresh water calcareous marls of excellent grade and in quantity are found in several counties of the Valley region west of the Blue Ridge. Preparations were under way in 1912 in Bath and Rockingham counties to utilize these marls for agricultural purposes.

WOODWARD, H. P., 1932, Geology and mineral resources of the Roanoke area, Virginia: Virginia Geol. Survey Bull. 34, 172 p.

The largest of several small scattered marl deposits occurs about half a mile northwest of Daleville in Botetourt County. The marl was irregularly deposited on the floor of an old lake less than one acre in extent and had a maximum thickness of twenty feet. Abundant fossil leaves, stems of plants and gastropod shells were found in the deposit. Owned by Messrs. Ikenberry and Thomas, this occurrence was worked until 1920. A small crusher was used to process the material for use as fertilizer. Other marl beds are located west of Blue Ridge Springs near the Lynchburg or Grubb iron mines and along Catawba Creek on the old McCormick farm approximately 6 miles southwest of Catawba Sanatorium.

WOODWARD, H. P., 1936, Geology and mineral resources of the Natural Bridge region, Virginia: Virginia Division of Mineral Resources Open File Rept. 12, 350 p.

Calcareous fluvial deposits of travertine are precipitated from solution by ground and surface waters. Cellular or frothy, in structure, these deposits are common in stream channels at, or near, small waterfalls, where they tend to increase the size of the falls. Deposits were observed along Lipsley Run, Cascade Creek and in the area south and southwest of Springwood. The deposits are extremely local and of no economic value. An analysis is reported for Rockbridge County.

SINKHOLE STUDY

The Virginia Division of Mineral Resources is collecting current and historic reports of sinkhole collapse. Newspaper accounts (including name of newspaper and date) or other written reports are being sought. Reports should include date of formation of the sinkhole, location — including road directions from nearest town, shape and dimensions, extent of property damage, name and address of landowner, and any information related to possible cause of the sinkhole (eg. new well tested 100 feet away, water main leaking, or heavy equipment had been working over the site, etc.).

Please report sinkhole collapses to:

D. A. Hubbard
Virginia Division of Mineral Resources
P.O. Box 3667
Charlottesville, Virginia 22903

JERRYGIBBSITE DISCOVERED

A violet-pink mineral discovered in Franklin, New Jersey has been named jerrygibbsite in honor of G. V. Gibbs, professor of mineralogy at Virginia Polytechnic Institute and State University, Blacksburg.

The mineral was discovered by a group of scientists doing a survey of the chemical composition of specimens of leucophoenicite, a non-commercial humite mineral. They found a second, closely related, mineral and named it for Gibbs "in recognition of his outstanding contributions to the science of mineralogy and the society of mineralogists."

Jerrygibbsite is made up of the same elements as leucophoenicite but put together differently and is probably a member of the leucophoenicite group. Both minerals have a Mohs hardness of approximately 5.5, but jerrygibbsite is denser at 4.0 than leucophoenicite at 3.8. Jerrygibbsite is more brown and violet colored than most leucophoenicite but is not easily recognized without X-ray or chemical data, according to the scientists who discovered it (Pete J. Dunn, Donald R. Peacor, William B. Simmons and Eric J. Essene, in *American Mineralogist*, 1984). Gibbs is the second Virginia Tech professor with a mineral named after him; in 1981, wonosite, a mica mineral, was named for David R. Wones.

MINERAL RESOURCE NEWS

Texasgulf Chemicals Company is presently renovating the old Greer Lime Company high-calcium lime plant in Saltville, Smyth County. There will also be some new phases of construction on the site. The company plans the ship phosphate rock from its active operation on Lee's Creek, North Carolina by railroad to Saltville. In Saltville, the raw material will be defluorinated by heating the material in coal-fired rotary kilns. The product will be marketed as an animal and poultry feed supplement. It will be shipped in bulk by truck. Plant and kiln renovation and new construction work should be complete by late summer, 1985.

United Fiberglass, Inc. is operating a home insulation plant in northern Virginia, in Prince William County at Woodbridge. The company utilizes a ground dolomite from Virginia and feldspar and glass-grade sand from out-of-state sources. A borate mineral is also imported from out of state, prepared in Virginia, and utilized in their batch process. The ingredients are heated in an electric furnace to produce a mineral wool for home insulation.

REFRACTORY GRADE DOLOMITE IN VIRGINIA

Palmer C. Sweet and William F. Giannini

Dolomite is a rock-forming mineral ($\text{CaMg}(\text{CO}_3)_2$); the term is also applied to rocks that approximate the mineral in composition. The rock is composed of calcium-magnesium carbonate with varying amounts of silica, iron, and other impurities. A variety of applications include crushed stone for use as polishing roadstone, concrete aggregate, agriculture stone, asphalt stone, filler, and extender and for refractory uses.

Refractory-grade dolomite is used in open-hearth steel furnaces to cover and increase the life of the refractory brick and maintain the hearths. The lime (CaO) component helps to resist the erosive effect of high-acid slag. Presently, seawater periclase (stable form of MgO), which is expensive, and imported chromite are more widely used for various refractory processes in the United States. In 1982, the U. S. Bureau of Mines reported refractory dolomite production of just over 450,000 short tons. The Bureau is conducting studies on potential refractory dolomite resources in order to decrease domestic dependence on imported chromite and the more expensive seawater-derived periclase.

In early 1983, the Virginia Division of Mineral Resources, during the course of its long-term

carbonate evaluation project, sampled several dolomites units between Clarke County in the northeastern part of the Valley and Ridge province and Lee County in the extreme southwestern part of the State. Samples were taken at six different locations (Figure) from three different rock units, and tests were made as a preliminary reconnaissance study of materials potentially suitable for refractory grade dolomite. Differential Thermal Analysis (DTA) (Table 1) was run on six samples by heating the material at a definite rate to produce a particular curve or pattern to identify the mineral under examination. Chemical analyses (Table 2) and physical tests (Table 3) were also performed on the six samples.

Table 1. Differential Thermal Analysis (DTA).

Sample	Formation	CaCO_3	MgCO_3	Al_2O_3	Fe_2O_3	Si_2O_3
31-C	Mayn.	53.44	42.31	0.40	0.32	4.07
53-D	Shady	53.94	43.70	0.27	0.27	1.52
87-C	Honaker	53.19	43.01	0.61	0.42	2.01
135-C	Shady	54.94	45.09	0.02	0.23	0.09
135-D	Shady	54.94	44.05	0.05	0.33	0.28
216-B	Shady	54.44	44.05	0.10	0.27	1.97

U.S. Bureau of Mines, Albany Research Center, Albany, Oregon.

No.	County	Unit
216-B	Clarke Co.	Shady Dol.
135-D	Rockbridge Co.	Shady Dol.
135-C	Botetourt Co.	Shady Dol.
87-C	Russell Co.	Honaker Dol.
53-D	Wythe Co.	Shady Dol.
31-C	Lee Co.	Maynardville Dol.

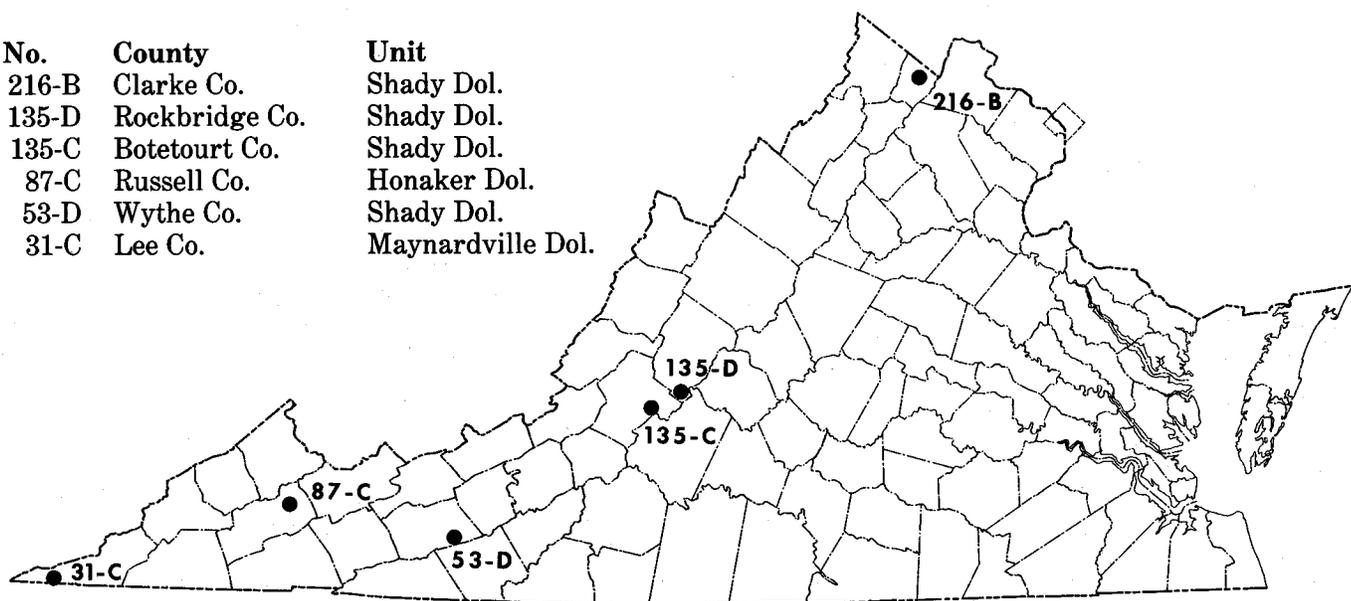


Figure. Dolomite sample locations.

Table 2: Chemical Analyses (percent).

Sample	Formation	Endothermic peak temperatures,	
		°C	
31-C	Maynardville	809	977
53-D	Shady	805	984
87-C	Honaker	826	988
135-C	Shady	808	973
135-D	Shady	797	982
216-B	Shady	796	980
Standard (1st)		812	957
Standard (2nd)		815	955

U.S. Bureau of Mines, Albany Research Center, Albany, Oregon.

Table 3. Physical tests performed at Dept. of Geophysical Sciences laboratory, Old Dominion University, Norfolk, Virginia.

Sample	Bulk Volume	Porosity	Grain Density
31-C	2.32	0.04	2.56
53-D	2.08	0.02	2.76
87-C*	2.32	0.04	3.07
135-C	2.21	0.03	2.64
135-D	2.03	0.04	2.65
216-B	2.08	0.04	2.65

*Although the grain density of this sample appears anomalously high, an X-ray analysis indicated only dolomite, calcite, and quartz. No barite or celestite was noted. Visible pyrite appears in the sample and may account for the difference in weight. Another sample from the same formation in the vicinity was also evaluated; density of sample No. 2 was 2.91.

ROCK UNIT LITHOLOGIES

Honaker Dolomite -- thin to medium-bedded, light gray to medium-dark gray, micro- to fine-grained dolomite. Thickness of the unit ranges up to 2000 feet.

Maynardville Formation -- medium to dark gray micrograined limestone with dolomitic laminations (ribbon-banding), and fine-to-medium grained, very light to light gray dolomite intervals (Chances Branch Member). Thickness of the unit is approximately 100 feet.

Shady Dolomite -- massive, white to pinkish gray and light to dark gray, fine-to medium-grained high-magnesium dolomite. In Clarke County, thickness of this unit is estimated at 1000-1500 feet.

SAMPLE LOCATIONS

31-C, Lee County, Coleman Gap 7.5-minute quadrangle (N4,053,450 E287,380, Zone 17) Maynardville Formation (Chances Branch

Member), 10-foot section, west side of State Road 683 and 2700 feet north of Virginia-Tennessee line.

53-D, Wythe County, Sylvatus 7.5-minute quadrangle (N4,078,350 E512,770, Zone 17) Shady Dolomite, grab sample from quarry of H. D. Crowder and Sons.

87-C, Russell County, Honaker 7.5-minute quadrangle (N4,097,730 E417,450, Zone 17) Honaker Dolomite, 4-foot section from southwest quarry wall of E. Dillon and Co.

135-C, Botetourt County, Buchanan 7.5-minute quadrangle (N4,153,620 E617,900, Zone 17) Shady Dolomite, 8-foot section from south-southeast quarry wall of James River Limestone Co., Inc.

135-D, Rockbridge County, Arnold Valley 7.5-minute quadrangle (N4,164,480 E631,450, Zone 17) Shady Dolomite, 10-foot section in roadcut on the northwest side of State Road 708, 0.25 mile by road southwest of its intersection with Virginia Highway 130 at Natural Bridge Station.

216-B, Clarke County, Berryville 7.5-minute quadrangle (N4,334,580 E247,940, Zone 18) Shady Dolomite, 8-foot section from north quarry wall of Stuart M. Perry, Inc.

CONCLUSIONS

Each sample gave DTA curves typical of dolomite, showing a deep endothermic peak at about 800°C representing decomposition of the $MgCO_3$ component and another deep endothermic peak at about 980°C representing decomposition of the $CaCO_3$ component. Chemical analyses indicate that two of the samples (135-C, 135-D) fall within the generally accepted range of refractory dolomite specifications of a maximum of 0.75% SiO_2 , 0.4% Fe_2O_3 and 0.3% Al_2O_3 in the raw material.

Besides chemical composition requirements, physical properties of dolomite such as porosity and density values are also important in determining suitability. Bulk volume, porosity and density values were determined for this study.

These data can be used with data for refractory properties of actual calcined grain prepared in the kiln to determine which materials may be suitable for producing refractory-grade dolomite. Raw materials with variances in hydration, microstructure and thermal behavior may have different grain densities when calcined, some of which may not be suitable for lining steel furnaces.

ABINGDON OFFICE

The Virginia Division of Mineral Resources has opened a Southwest Regional Office in Abingdon, Virginia. It is located in Room No. 100, Johnson Center, 468 East Main Street (Phone 703-628-3940). Geologists in the office are conducting field investigations in the Appalachian Plateau, Valley and Ridge, and Blue Ridge provinces of southwest Virginia. In addition, the staff will provide information to individuals, companies and governmental agencies. A complete set of Virginia Division of Mineral Resources publications and selected U.S. Geological Survey publications are available for use in the office. Because of the field duties of the personnel, an appointment should be made before visiting to ensure the office is open.

MINERAL UPDATE

Wm. F. Giannini¹ and Richard S. Mitchell²

Anglesite (lead sulfate), sphalerite (zinc, iron sulfide), and brochantite (hydrous copper sulfate) were recently discovered in the Albemarle-Nelson county soapstone belt (W.F. Giannini). X-ray analyses were used to confirm the identification of the three specimens (R.S. Mitchell). All minerals were found in a dump adjacent to an abandoned soapstone quarry (Figure). This is the first known occurrence of these minerals from the soapstone belt.

Anglesite occurs as gray, prismatic, tabular crystals associated with sphalerite, brochantite, chalcopyrite, and millerite. All five minerals were found in cavities occurring in a ferroan dolomite vein cutting soapstone. The sphalerite exhibits a tetrahedral crystal form and is amber colored, whereas the brochantite occurs as a dark green crust on chalcopyrite.

Anglesite is an ore of lead, sphalerite a zinc ore, and brochantite an ore of copper. The scarcity of these minerals in the soapstone near the surface renders them of interest only to mineralogists and collectors, however, this occurrence may be a reflection of larger deposits elsewhere.

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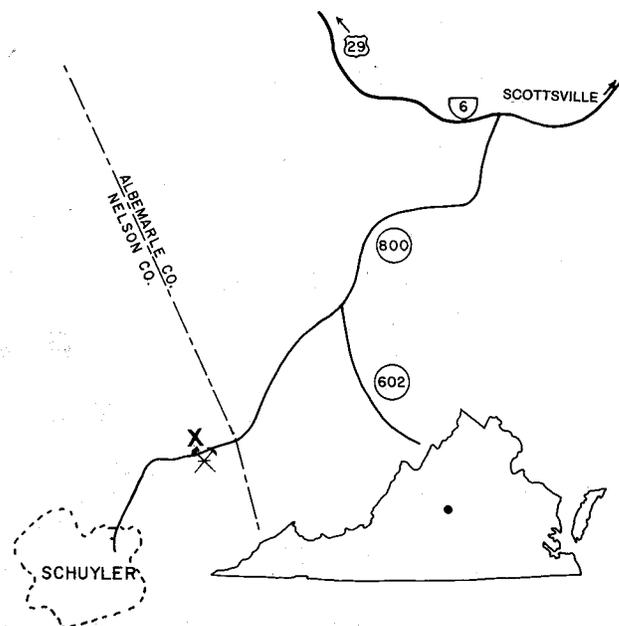


Figure. Location (X) of three newly discovered minerals from the Albemarle-Nelson county soapstone belt.

OIL AND GAS NEWS

Thirty-nine thousand acres in seven eastern states including more than 1400 acres in Virginia National forests may contain oil and natural gas potential according to the Bureau of Land Management. In Virginia the lands are 729 acres in George Washington National Forest in Highland County and 693 acres in Jefferson National Forest in Dickenson County.

The revised version of State Minerals Management Plan of Virginia is available from Virginia Division of Mineral Resources and the Department of General Services, Division of Engineering and Buildings. This Plan outlines the regulations regarding mineral surveys, exploration, leasing, and extraction of State-owned lands.

Over 20 million acres off the coasts of New Jersey, Maryland, Delaware, Virginia, North Carolina, New York, and Rhode Island are tentatively scheduled for competitive oil and gas leasing in 1985 by the Department of Interior. Blocks offered for leasing are located from 50 miles (25 miles off North Carolina) to 140 miles offshore. The water depths are between 132 feet and 10,560 feet.

ANR Production Company expects 20 million dollars in sales this year from 63 gas wells in Wise County. ANR expects to drill 35 wells in 1985.

Postmaster:
 Send address corrections to —
 Virginia Division of Mineral Resources
 Box 3667
 Charlottesville, VA 22903

Virginia Minerals
 Second-class postage paid at
 Charlottesville, Virginia
 ISSN 0042-6652

TOPOGRAPHIC COUNTY MAPS

Multicolor county topographic maps, scale 1:50,000, are now available for 13 Virginia counties (map). These maps show by color and symbols cultural and natural features of the county and sell for \$4.16 each.

Information for these maps was obtained from the interpretation of recent aerial-mapping photography, from review by planning district commissions, and from compositions of detailed 1:24,000 scale maps. They were prepared by the U. S. Geological Survey within a jointly funded program with the Division of Mineral Resources and the Appalachian Regional Commission.

The county maps are useful for planning, governmental land-use programs, and personal recreational activities such as hunting, fishing, and camping. They are also valuable as route locators for emergency response to fires and accidents.

Ozalid one-color paper copies are available for Dickenson, Russell, Scott, and Wise counties at \$4.16 each (map).

