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## The Morefield Pegmatite, Amelia, Virginia. Mineral Update

by

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Six additional mineral species have been identified from the Morefield Pegmatite near Amelia, Virginia. Fluellite,  $Al(PO)_2F(OH) \cdot 7H_2O$ ; bismutite,  $Bi(CO)_3O$ ; hollandite,  $Ba(Mn^{4+}Mn^{2+})_2O$ ; cerussite  $PbCO_3$ ; gearksutite,  $CaAl(OH)F \cdot 8H_2O$  and brockite  $(Ca, Th, Ce)(PO)_4 \cdot H_2O$  have been identified by X-ray diffraction and further verified by semi-quantitative Energy Dispersive Analysis (EDAX). Euhedral crystals of prosopite have been found and photographed for the first time from the Morefield Mine. Light blue, cobalt blue, and purple apatite crystals are abundantly present in southwest workings of the mine.

***Fluellite:***  $Al(PO)_2F(OH) \cdot 7H_2O$

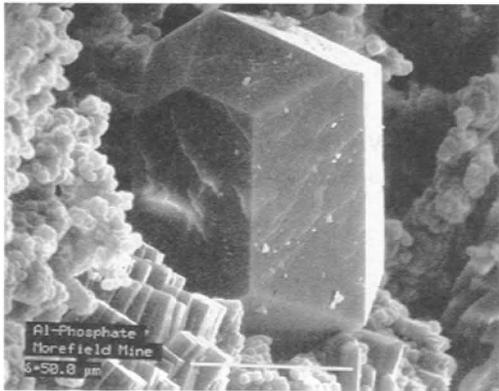
Fluellite is a rare, secondary aluminum phosphate, which forms as an alteration product of triplite  $(Mn^{2+}, Fe^{2+}, Mg, Ca)(PO)_4(F, OH)$ . It occurs in small vugs with triplite, bermanite, strengite, and spherules of opal-like material. Crystals are small (0.5 mm), colorless and transparent, with

orthorhombic forms  $\{111\}$ ,  $\{110\}$ , and are modified by a well developed  $\{010\}$  pinacoid (Figure 1). The Morefield occurrence represents the third U.S. locality along with the Carolina Pyrophyllite Mine, Randolph County, North Carolina (Dunn, 1977), and the Gold Quarry Mine, Eureka County, Nevada (Jensen et al., 1995).

Fluellite was originally discovered at Stenna Gwyn, Cornwall, England, and later at Kreuzberg, Bavaria, Germany. The German material was named kreuzbergite. Fluellite and kreuzbergite were proven to be the same mineral, and the name kreuzbergite was dropped. The original composition was not accurately determined; it was originally believed to be a hydrated aluminum fluoride (Palache et al., 1951). Guy and Jeffrey (1966) found the presence of essential phosphate during the structural determination.

***Bismutite:***  $Bi(CO)_3O$

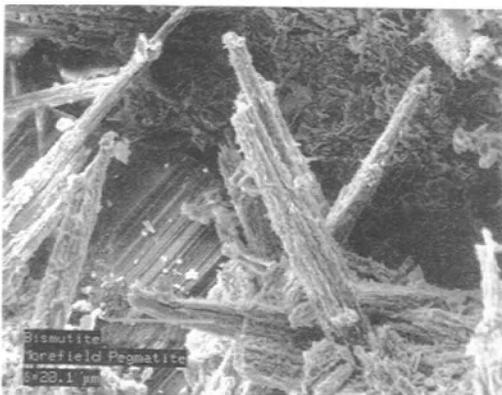
Bismutite occurs as masses, smooth crusts, and aggregates of opaque, rough needles up to 0.1 mm (Figure 2). Individual crystals are light yellow-



**Figure 1:** Fluellite crystal with bermanite (prismatic), and spheres of opaline material. SEM Photo.

ish-tan while masses and crusts run from tan to an intense yellow with a waxy, dull, or resinous luster. Crusts and crystals are associated with cassiterite, albite, tantalite, zircon, hollandite, microlite, and monazite.

Bismutite is a secondary bismuth carbonate which generally forms from alteration of bismuthinite or other primary bismuth minerals. Findings suggest that bismutite is widespread throughout the mine as a late stage alteration product. Other bismuth bearing minerals have not been identified from the Morefield Pegmatite.



**Figure 2:** Bismutite crystals. SEM photo.



Hollandite is found as small, black, botryoidal masses (up to 10 mm), and bright, silvery-black,

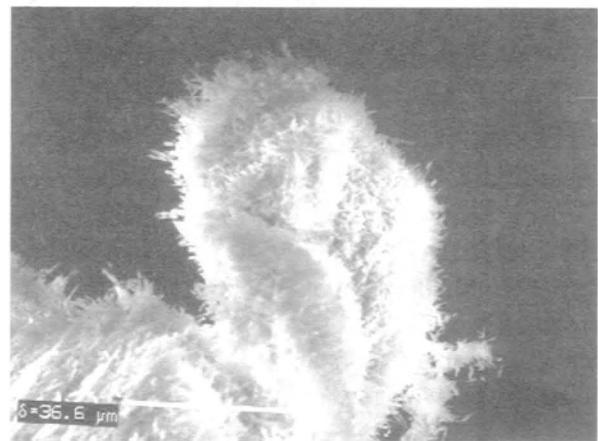
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broken pieces. Solid masses often show textured, flat surfaces which develop when formed between plates of cleavelandite albite. These flat surfaces are often iridescent. Botryoidal surfaces form in open cavities, and stalactitic forms are observed bridging vugs.

Hollandite is found with albite (cleavelandite), quartz, microcline (amazonite), and bismutite. Apatite masses frequently coat the hollandite. Pyromorphite and apatite crystals occur in vugs.



Gearsutite is the eighth alumino-fluoride mineral species to be recognized from the Morefield Pegmatite. It is found as chalk white masses and mats composed of very fine needle-like crystals. Mats of gearsutite are generally found in and around prosopite masses and crystals. The presence of gearsutite at the Morefield Pegmatite has been anticipated. It is characteristically associated with similar alumino-fluoride assemblages found at other cryolite bearing pegmatites like, Ivigtut, Greenland; St. Peter's Dome, Colorado; and the Zapot Pegmatite in Mineral County, Nevada.



**Figure 3:** Gearsutite. SEM photo.



One of the authors (B.S.M.) has recently collected numerous samples of cerussite from the heavy mineral fraction of the northeast adit floor.

The crystals (up to 2 mm) are adamantine, transparent, and twinned. Most specimens with matrix are associated with pyromorphite and, less commonly, with small clear apatite crystals. One specimen shows cerussite crystals on galena with yellowish green pyromorphite crystals. Specimens from the aluminofluoride area show cerussite with galena. Cerussite has also been noted in the southwest adit.

Glass (1935) previously reported the occurrence of cerussite from the nearby Rutherford pegmatite, but did not credit or reference the identification. Sinkankas (1968), did not include cerussite in his discussion of minerals from the Rutherford Pegmatite. This is the first known verification of cerussite from the Morefield Pegmatite.



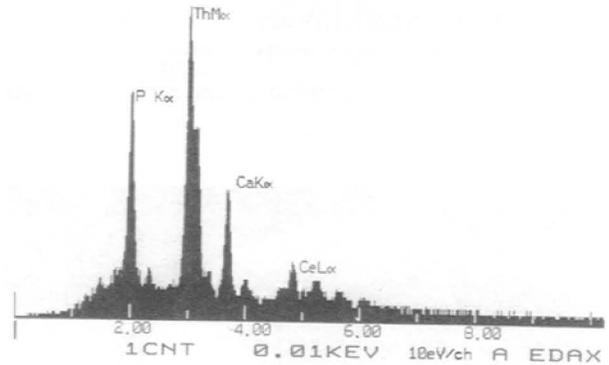
Brockite is an uncommon member of the rhabdophane group. The type material was originally described from the Bassick Mine, Wet Mountains, Custer County, Colorado in a similar mineral assemblage of quartz, albite, apatite, and hematite. The species was named in 1962 in honor of Maurice Brock of the U.S. Geological Survey.

The Morefield Mine material occurs as fragments and intact masses up to approximately 1 cm. in size. It is very fine grained, with a greasy to resinous luster, and conchoidal fracture. The color ranges from mottled reddish-brown to a solid yellowish-orange, the latter being translucent. Brockite is highly radioactive due to its high thorium content.

EDAX analysis of the darker, reddish-brown material shows a significant Fe content (hematite inclusions) that is absent from the translucent, yellowish orange material. The analysis of a yellowish orange sample (Figure 4) shows Ce as the major rare earth element. Concentrations of other rare earth elements were not great enough to be detected by EDAX analysis. Analyses show that some material has minor amounts of Si substituting for P.

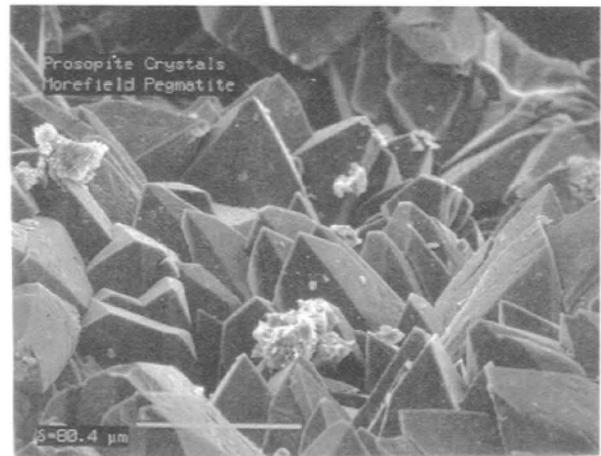


Prosopite,  $CaAl_2(F,OH)_8$ , was previously iden-

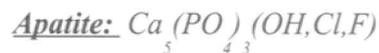


**Figure 4:** Energy Dispersive X-ray Analysis of yellowish-orange brockite.

tified from the Morefield Pegmatite (Kearns, 1992) as a lavender-gray, massive material. The first euhedral crystals have recently been identified as shown in Figure 5. The crystal habit is similar to those reported from St. Peters Dome, Colorado and illustrated in Palache *et al.* (1951)

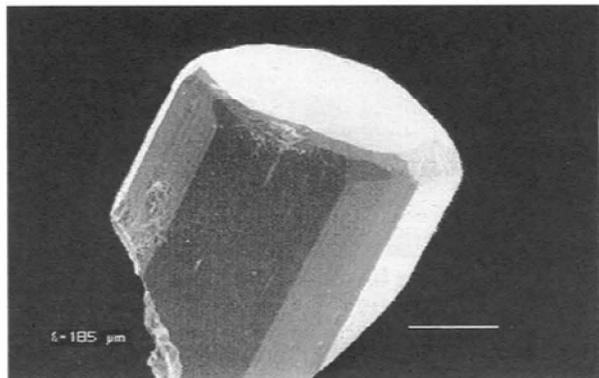


**Figure 5:** Prosopite Crystals. SEM Photo.



A number of small, well formed, purple, and light blue to cobalt blue apatite crystals have been recovered from the southwest end of the mine. These crystals have complex terminations (Figure 6). They are also striated and color zoned. Individual crystals have been reported up to 1 cm. in size but

are more commonly 1 to 3 mm. They fluoresce golden yellow in both LW and SW ultraviolet light. Mitchell and McGavock (1960) suggest the fluorescent activator is manganese, and is present from 2 to 3 percent by weight.



**Figure 6.** Apatite crystal showing complex termination. SEM photo.

### PROGRESS OF RECENT MINING ACTIVITIES

Sam Dunaway, owner and operator of the Morefield Mine, has been actively mining toward the southwest end of the pegmatite. Presently (Dec., 1999) the southwest mine face at the 45 foot level is 160 feet southwest of the original Morefield shaft. During 1998 and most of 1999, very little high quality amazonite was encountered in this area, but good cleavelandite, monazite, tantalite, and muscovite were found. In July of 1999, the adit passed through the site of a diamond drill hole, drilled by Martin Marrietta Corp. for the former owner of the mine, the late William "Bill" Baltzley. Water was flowing from the old drill hole at a rate of 3.75 gallons/minute. The core from this hole did not show the mineralization that was hoped for. It missed rich masses of amazonite, cleavelandite, and apatite crystals by only a few inches. In August, 1999, the southwest adit encountered an apparent shift (fault?) in the pegmatite. Beyond this point a new area rich in high quality amazonite, mica crystals, and heavy minerals was encountered.

During the spring of 1999, the Morefield shaft  
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was pumped down to 87 feet below the shaft collar (42 feet below the floor of the 45-foot adit). This is the first time this area has been exposed since the U.S. Bureau of Mines terminated its activities in 1948. Mud and iron stains on the shaft walls prevented detailed observation of mineralization. There appears to be about 18 to 19 feet of debris accumulated at the bottom of the shaft. Mr. Dunaway hopes to remove this material in late fall 1999 or spring 2000. Minor excavation for the northeast end is in the plans for the year 2000.

Extensive mine production and refurbishing have also been completed. The underground lighting system has been upgraded with disconnect boxes and in-use covers for shock protection. Large 18-inch air circulation ducts have been installed for more efficient removal of smoke and radon. A two-inch steel compressed air line has been installed down the shaft to get more air to the drills.

### ACKNOWLEDGEMENTS

We are, as always, indebted to Sam and Sharon Dunaway, owners and operators of the Morefield Mine, and to its previous owner, the late Wm. "Bill" Baltzley, who provided these samples for analysis. Without their trust and enthusiasm, this work and previous mineralogical discoveries at the Morefield Pegmatite would never have been possible. We also wish to thank Stan Rudis of Richmond and Dennis McClevey of Fredricksburg, Virginia for their hard work in screening the samples used by the authors.

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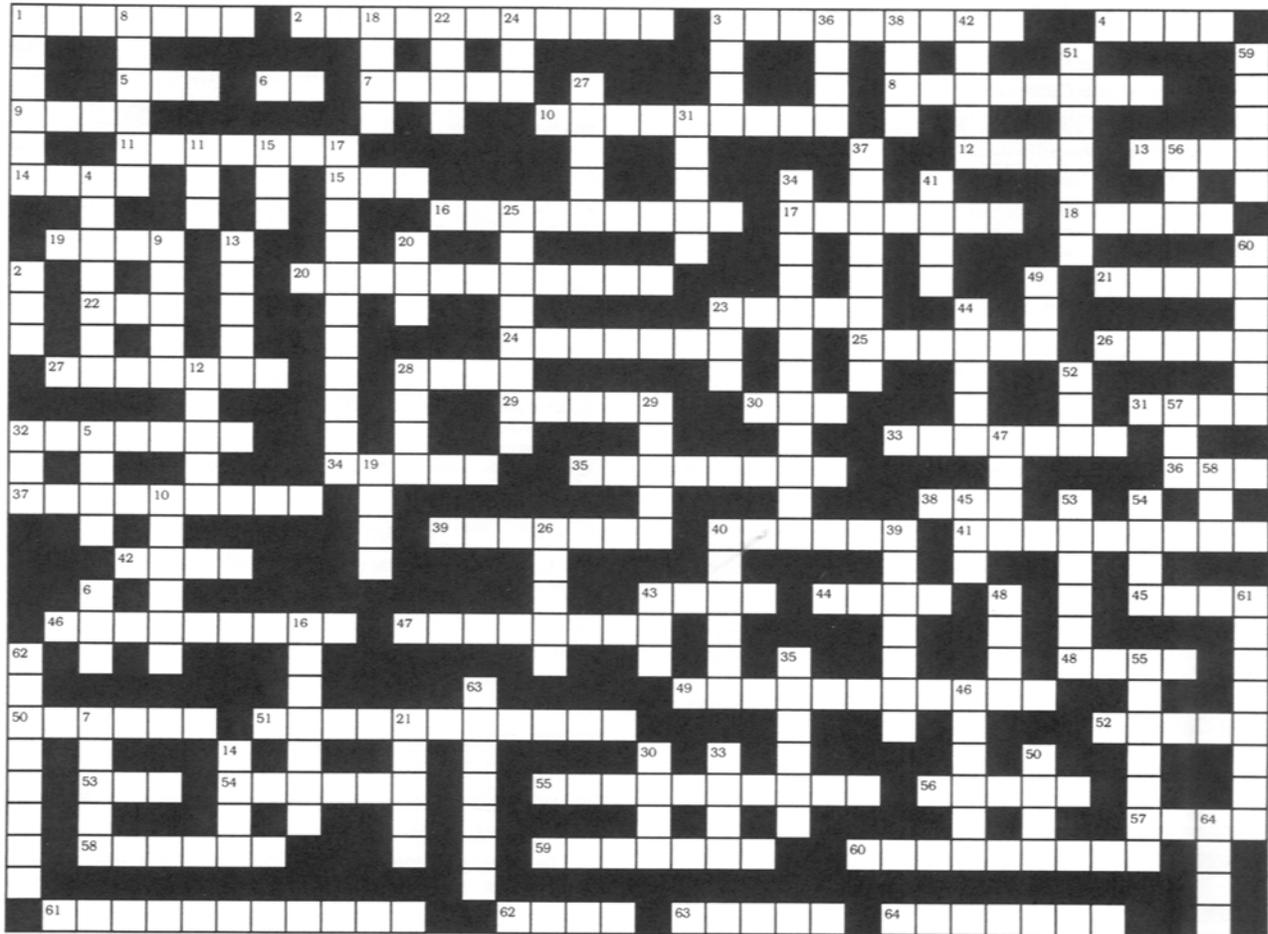
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**VIRGINIA GEOLOGIC CROSSWORD PUZZLE**

by  
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**ACROSS**

1. Virginia's best known salmon-pink and green gemrock.
2. A type of rock generally formed from other rocks being transported and deposited in water.
3. A coarse grained rock containing many rare minerals occurring in the Morefield Mine of Amelia County and simulated in the Smithsonian Rocks and Mineral exhibit.
4. The long narrow mountain chain trending northeast-southwest through the State is famously known as the \_\_\_\_\_ Ridge.
5. The liquid hydrocarbon being pumped from wells drilled principally in Lee County is called \_\_\_\_\_.

6. Millions of years ago (abbr.).
7. The type of terrain characterized by sinks and sinkholes occurring throughout the western portion of the State.
8. Many Virginians indulge in this hobby utilizing the many rocks, minerals, and gemstones found throughout the State.
9. Virginia's most valuable mineral resource, occurring principally throughout southwestern Virginia's Plateaus Province.
10. The type of rock capping Massanutten Mountain in Rockingham County. Formally called the Massanutten \_\_\_\_\_.
11. Rocks formed by the solidification from a molten state; these rocks are common throughout the Blue Ridge and Piedmont portions of the State.

12. Mining of this soft metal became predominate near Austinville, in Wythe County, after the Civil War and continued until 1981.
13. Mining of this metal was begun in the 18<sup>th</sup> Century within Virginia and was particularly coveted by the South throughout the Civil War. Mining occurred in districts such as Faber, in Albemarle County.
14. Large stone furnaces are still seen throughout the State as remnants of this, once flourishing, valuable metal industry.
15. A natural or artificial cavity or hole in the ground; generally in reference to the extraction of minerals.
16. This generally gray rock is prevalent throughout Virginia's Shenandoah Valley.
17. The area at the mouths of Virginia's principal rivers are subject to ebb and flow tides adjacent the Atlantic, and each such area is called an \_\_\_\_\_.
18. A collection of fallen rock, subject to slow movement, along generally steep mountainside slopes throughout the Blue Ridge and the western portion of the State is known as \_\_\_\_\_.
19. Virginia was one of the leading producers of this precious metal prior to the discovery at Sutters Mill in California.
20. Throughout Virginia's Piedmont and Blue Ridge there are pre-existing rocks that have been altered or changed by the effects of high temperatures and pressures, and/or by chemically active fluids. What type are these changed rocks?
21. Throughout Virginia's Piedmont and Blue Ridge there are found twinned staurolite crystals. They are exemplified in a State Park within Patrick County, where they are more commonly, and famously, called \_\_\_\_\_ stones.
22. The second highest order of division of geologic time; i.e. much of Virginia's geologic record represents the Paleozoic \_\_\_\_\_.
23. Virginia's Shenandoah Valley is actually a subdivision, historic more or less, of the much more extensive \_\_\_\_\_ Valley of the Central Appalachians.
24. An extensive plutonic rock that occurs around the Richmond area and is formally referred to as the Petersburg \_\_\_\_\_.
25. An elliptical area of older rocks surrounded by younger rocks, such as Burkes Garden in Tazewell County, is referred to as an \_\_\_\_\_.
26. The largest diamond found in North America was found along Rich Creek, Peterstown, W. Va., less than one mile from the Virginia State line, and is known as the famous "Punch" \_\_\_\_\_ Diamond. Its source is believed to be from Virginia.
27. This mineral is being mined from Willis Mountain in Buckingham County and is the only production mining of this mineral in North America. It is used for high-temperature refractories and other ceramic products, such as spark plugs.
28. Any extraction of minerals; most generally applied to any subsurface or underground workings.
29. Any aggregate or mass composed of one or more minerals. We see them everywhere.
30. During the early 17<sup>th</sup> Century, the Jamestown settlers attempted production of iron by using local sources of \_\_\_\_\_ ore.
31. The Virginia State fossil is a rather large, common fossil \_\_\_\_\_.
32. That science which studies the Earth and its rocks thereon.
33. Virginia's Eastern Shore and its environs are sediment dispersal systems referred to as offshore \_\_\_\_\_ islands.
34. This metamorphic rock is extensively mined in Buckingham County and has, for generations, been primarily used as roofing material.
35. Within the Mesozoic Culpeper basin of Culpeper County, extensive dinosaur tracks have been uncovered in \_\_\_\_\_-age rocks.
36. Greek word meaning "earth".
37. Within Albemarle County, near Schulyer, this massive metamorphic rock composed of talc, has been extensively mined in deep pit-quarries.
38. The geographic center of those earthquakes occurring in Virginia is referred to as an \_\_\_\_\_-center.
39. The remains or traces of animals or plants which have been preserved within Virginia Minerals, Vol. 46, No. 2, May 2000
- the rock layers; particularly predominate in the western and eastern portion of Virginia.
40. Term used to designate rocks formed during a fundamental chronologic time unit; the third order hierarchy unit designated to the rock record, such as the Devonian \_\_\_\_\_. Sometimes referred to as a Period.
41. Critzers Gap, south of Millboro Springs and Nimrod Hall in Bath County, shows a large bend in the rock formations, which reflects a well known geologic structure called an \_\_\_\_\_.
42. During the War of 1812 and the Civil War, Smyth County became a source for this valuable mineral commodity, even to a town dubbed for its namesake.
43. Within the Piedmont of Virginia, there is a narrow, defined area from the Potomac River to the Appomattox River, wherein many of Virginia's precious metals have been found and mined, called the Gold-Pyrite \_\_\_\_\_.
44. This material is mined in various scattered counties to provide raw material for making bricks.
45. A coarse grained sand or, as in the past, a sandstone with grains of varying size to produce a rough surface suitable for grindstones.
46. A pass through a mountain or a ridge, generally through which a river flows and thus further promoted early transportation routes, generally within the mountains of western Virginia, are known as \_\_\_\_\_; i.e. the Cumberland Gap.
47. The principal mineral within the greenstones, prevalent along the Blue Ridge, that provides the color namesake.
48. A prominent sinuous gap within Rockbridge County through which the Maury River flows is well known as Goshen \_\_\_\_\_.
49. Virginia's most valuable natural resource, vital to all residents within the Commonwealth, and is principally controlled by the underlying bedrock.
50. A recent discovery from geologic studies promotes the area surrounding the mouth of the Chesapeake to reflect an \_\_\_\_\_ crater caused by an extraterrestrial body.
51. Coverage of the entire Commonwealth by a series of maps showing all drainage, landforms, surface structures, and elevation contour lines, are called \_\_\_\_\_ maps.
52. The individual particles or discrete crystals that comprise a rock or sediment.
53. Any period of time in the history of the Earth marked by special events or physical conditions, such as the \_\_\_\_\_ of Reptiles.
54. An accumulation of rounded, waterworn pebble-size rock or mineral pieces, many, of which, are extracted from different parts of the State.
55. The most famous and extensively mined coal in Virginia is the \_\_\_\_\_ No. 3 coalbed.
56. Prominent along Virginia's eastern shoreline, there are mounds, ridges, and hills of wind-blown sand called \_\_\_\_\_.
57. Used primarily in the scientific fields, the basic unit of metric weight is the \_\_\_\_\_.
58. Found throughout Virginia's Piedmont and Blue Ridge, a medium to coarse grained rock in which subparallel platy minerals appear to predominate is called a \_\_\_\_\_.
59. A significant contribution to Virginia's production of hydrocarbons from Southwest Virginia, is the drilling of wells for coalbed \_\_\_\_\_.
60. Within Smyth and Russell Counties there have been found many fossil bones of mammals which roamed that area during the Pleistocene Epoch. Among "dem bones" excavated are those of large Pachyderm-like mammals called \_\_\_\_\_.
61. Virginia is one of only two states that mine this platy mineral, near Boswells Tavern in Louisa County. This product is used in insulation and potting soil.
62. A low depression or notch, where a stream formerly flowed across a ridge or mountain, such as Fancy Gap in Carroll County where U.S. Highway 52 crosses the Blue Ridge, is called a \_\_\_\_\_ gap.
63. Blocks of silica-cemented sandstone from \_\_\_\_\_ Creek in Stafford County were used (1791 - 1840) for construction of the White House, Capitol, and

other buildings in the District of Columbia.

64. The gap in Giles County through which flows a river, runs U.S. Highway 460, and a railroad track, is commonly known as the \_\_\_\_\_ of New River.

#### DOWN

1. Within the central and southern portion of the Blue Ridge, the basal Paleozoic unit of rocks, representing some of the oldest Paleozoic rocks in Virginia, resting upon "basement" rocks, is formally recognized as the \_\_\_\_\_ Formation.

2. Even though there is no production of this metal in the coterminous United States, Virginia had production of this metal from two mines located in Rockbridge County, and is still referred to today as the Irish Creek \_\_\_\_\_ District.

3. The Dismal Swamp in Chesapeake hosts a National Wildlife Refuge, Virginia's largest natural lake, and is underlain by Quaternary \_\_\_\_\_; destined to become a coal someday.

4. Virginia's geologic record of the rocks show several episodes of mountain building, generally involving plate tectonics, in a process referred to as an \_\_\_\_\_.

5. Having been found in several Virginia counties, this amorphous pale silica mineral generally displays a "play of colors" and is regarded as a gemrock.

6. Located in the Shenandoah National Park, this mountain is a favorite hiking spot, contains the oldest dated rock in Virginia, is comprised of a reddish granite (with the same namesake as the mountain) with occasional blue quartz veins, and is locally known as Old \_\_\_\_\_.

7. Located along the Blue Ridge Parkway in Bedford County, these two mountains are composed of granitic and gneissic rock complexes, and are well known as the \_\_\_\_\_ of Otter.

8. Located along the western flanks of the Blue Ridge, visible from I-81, in Augusta County, this soft "white clay" was mined for use in porcelain pottery to paint and paper filler. This locale is known as the Cold Spring \_\_\_\_\_ Mine or deposit.

9. Considering a river, i.e. the Roanoke River, and all of its contributing tributaries, that river is considered to \_\_\_\_\_ its watershed.

10. Most of the valleys within Virginia's Valley and Ridge province are topographic low areas because of the generally underlying \_\_\_\_\_, which are less resistant to weathering than other rock layers.

11. Probably the oldest river in Virginia that flows north-northwestward from the Blue Ridge and then essentially westward toward the Ohio River and thence onward to the Mississippi, is named the \_\_\_\_\_ River.

12. It was common for Virginia's mined metals to be cast as a mass into a bar or other convenient shape called an \_\_\_\_\_.

13. A plane of movement between two layers of rock formations that have been juxtaposed against one another, such as Virginia's North Mountain \_\_\_\_\_.

14. It is normal for geologists to be interested in the \_\_\_\_\_ of Rocks.

15. A mineral or aggregate of minerals occurring within the earth that have the potential to be economically exploitable and extracted.

16. The western boundary of the Coastal Plain in northern Virginia, marking the transition from more resistant rocks to the west to the less resistant rocks and sediments of the Coastal Plain is well defined as the Falls of the \_\_\_\_\_ River.

17. A more general scientific collective term applied to all the secondary mineral deposits found within caves, such as Virginia's numerous caverns.

18. Throughout Virginia's Piedmont and sparsely scattered within the Valley and Ridge are relatively thin tabular bodies of igneous rock that cut across the structure of adjacent rocks, or cuts other massive rock bodies. Each of these tabular rock bodies, with generally limited extent, is called a \_\_\_\_\_.

19. A soil composed of a mixture of clay, sand, silt, and organic matter, and considered good Virginia "bottom land".

20. The now drowned, ancient valley of the southward flowing Susquehanna River into Virginia is represented by the Chesapeake \_\_\_\_\_.

21. Virginia's most active "earthquake" region, along an east-northeast oriented trend, and active since 1897, is commonly known as the \_\_\_\_\_ County Seis-

mic Zone.

22. A term applied to a calcareous clay or a mixture of sandy carbonate sediments with fragments of shells throughout Virginia's Coastal Plain, and secondary mineral deposits of white to yellowish-brown, earthy calcium carbonate along streams throughout Virginia's Valley and Ridge.

23. A general term for any precious or semi-precious stone used for ornamental purposes, many of which occur throughout Virginia.

24. The total amount of movement along a plane of movement between offset rock units is measured as the \_\_\_\_\_ slip.

25. Occurring in Grayson (County) Highlands State Park, composed of Precambrian rocks along the Blue Ridge, named after Virginia's first State Geologist, and renowned as Virginia's highest point, stands \_\_\_\_\_.

26. Attesting to a former submergence of Virginia's shoreline, formed during times when higher sea levels existed worldwide, are two interesting features along Virginia's shoreline called the Surry \_\_\_\_\_ and the Suffolk \_\_\_\_\_.

27. The greenstones found throughout Virginia's Blue Ridge are a result of very ancient extrusions of many basaltic \_\_\_\_\_.

28. Commonly called isinglass, this platy mineral splits into thin elastic sheets and has been mined in Henry and Pittsylvania Counties.

29. Probably the singlemost important result of weathering, and particularly the most important consequence of chemical weathering, is the formation of the various types of \_\_\_\_\_ found throughout Virginia.

30. Conduit siliceous sinter deposits, indicative of eruptive or explosive activity of solutions with potential for precious metal mineralization, have been described in Rockingham and \_\_\_\_\_ Counties.

31. Throughout Virginia, quarried rock produces aggregate material suitable for purposes of many types of construction and is commonly referred to as \_\_\_\_\_.

32. The principal hydrocarbon energy fuel produced from wells drilled throughout Southwest Virginia.

33. A generally elongated dark green to black mineral series, of the Amphibole group of minerals, commonly found within Virginia's Blue Ridge and Piedmont plutonic rocks, is called \_\_\_\_\_blende.

34. The Virginia State Fossil, named in 1992 because of its relative abundance within the Yorktown Formation of the Coastal Plain, is properly termed *chesapeakean* \_\_\_\_\_.

35. This common silica mineral is found in most rocks throughout Virginia, either as crystals or amorphous masses in veins or as a groundmass constituent, and occurs in a variety of colors.

36. Occurring near Bridgewater in Rockingham County, this conical shaped hill, formed by intrusive volcanic basalt, is known as \_\_\_\_\_ Hill.

37. The greenstones of Blue Ridge fame are Precambrian rocks that are formally recognized as the \_\_\_\_\_ Formation.

38. Reported from nearly every county of Virginia's Piedmont and Blue Ridge, this soft, greasy mineral was even used to produce metal workers' crayons in 1910 on the Solitude Plantation near Palmyra in Fluvanna County.

39. It is apparent that this upland area of Patrick County was once part of the Gulf Coast master streams until relatively recent, but is now drained by direct Atlantic master streams, because of stream piracy across the drainage divide. This area is called the \_\_\_\_\_ of Dan.

40. This metal has been reported from several Virginia counties, occurs as "wire-threads", has been mined in its native state, is a by-product of other non-precious metal mining, and frequently occurs with gold.

41. Particularly within (but not limited to) the Shenandoah Valley, any natural solutional or water-worn cavity or series of passageways beneath the surface and generally intersecting the surface at the base of a sinkhole, is called a \_\_\_\_\_.

42. Although found in very few Virginia counties, this generally colorless to pale blue, usually gem quality, mineral has been found in Powhatan County as nearly incredible 9 to 30 pound crystals; the largest gem quality crystal in North America.

43. Within layers of rocks, particularly stratified layers, the smallest division of these layers is referred to as a \_\_\_\_\_.

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44. Mined from many Virginia caves during the War of 1812 and the Civil War, Virginia \_\_\_\_\_ was used in making gunpowder.

45. Modern-day prospecting enthusiasts still wander along the creeks of Virginia's Piedmont where they \_\_\_\_\_ for the elusive precious yellow metal; some with great success.

46. A plane of movement, generally with a very low angle of inclination, often separating rock units by tens of miles, such as the Salem - Pulaski system, is commonly called a \_\_\_\_\_.

47. Probably the single most contributing factor promoting the weathering of Virginia's rock formations, because of our climate, is simply \_\_\_\_\_ water.

48. Within the coal producing counties, Virginia has some of the most modern production facilities of this very important reducing agent for steel production.

49. Abbreviation of the State agency now serving as Virginia's State Geological Survey.

50. Those tributary streams, generally with steep gradients, within the upper reaches of a drainage basin, and in which carry the larger fragments of weathered rock formations, are referred to as the \_\_\_\_\_ waters of that drainage basin.

51. The most common mineral found in Virginia. It is the main constituent of two rocks: limestone and marble. It commonly occurs in cave deposits. And, the peculiar "clam geodes" from Chesapeake and Virginia Beach are lined with \_\_\_\_\_ crystals.

52. Most geologists agree that Virginia has not undergone direct effects of this Age, but within the higher elevations of the Old Dominion there are a few features that may reflect a response to the harsh climate during the \_\_\_\_\_ Age.

53. Throughout Virginia are seen many artificially placed areas of large broken rock for stability purposes to protect features from various forms of natural erosion. A noteworthy amount of this rock is quarried within our State and is commonly called \_\_\_\_\_.

54. Throughout Virginia, generally in now forested areas, there are covered mounds of a sometimes multi-colored vitreous by-product from furnaces of past operations. This material is commonly called \_\_\_\_\_.

55. Noted by Thomas Jefferson in 1825, and still visible today from U.S. Highway 220 in Alleghany County, are the well known 70-foot Falls of Falling \_\_\_\_\_.

56. French word for water.

57. A record and graphic presentation of rock formations penetrated by a well-bore in drilling for hydrocarbons or water are known as a \_\_\_\_\_ of that well.

58. The largest subdivision of geologic time. There are basically three recognized grand divisions of time; each called an \_\_\_\_\_.

59. Throughout Virginia, particularly in the Valley and Ridge, compressive forces have deformed and distorted strata into various bends and undulations commonly referred to as \_\_\_\_\_.

60. This soft, generally white mineral was mined near Locust Cove in Smyth County, and is a principle ingredient used in Plaster of Paris and manufacturing wallboard.

61. Mined from the Old Hickory deposit in Dinwiddie County, these various heavy minerals represent production of \_\_\_\_\_-bearing minerals.

62. A result of erosion, along vertical joints, these vertical columns of dolomite and limestone with solution tunnels at their base, are towers of rock near Mt. Solon in Augusta County known as Natural \_\_\_\_\_.

63. Occurring throughout Virginia's Piedmont and Blue Ridge rocks, these sometimes gem-quality, typically red minerals have produced faceted stones up to 100 carats.

64. Located in a gap near Iron Gate in Alleghany County, this classic large Central Appalachian geologic structure is locally called Rainbow \_\_\_\_\_.

## VIRGINIA MINERALS ON THE WEB

Beginning with the February 2000 issue, *Virginia Minerals* will be available on the INTERNET at [www.geology.state.va.us](http://www.geology.state.va.us). Printed copies will continue to be available to those on our mailing list, at least through the year 2000 (Volume 46).

## Puzzle Answer

The answer to the crossword puzzle will appear in the August 2000 issue of *Virginia Minerals* and will be available on the Web page at [www@geology.state.va.us](http://www@geology.state.va.us).