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MAMMOTH TOOTH FOUND IN ENDLESS CAVERNS, VIRGINIA

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INTRODUCTION

A tooth of a wooly mammoth, *Mammuthus primigenius* Blumenbach, was discovered in a passage of Endless Caverns in Rockingham County, Virginia in July 1996. The cavers left the tooth *in situ* for subsequent study by speleologists. This is the first record of mammoth from a cave in the Virginias and only the fifth locality within the Commonwealth.

GEOLOGIC SETTING

Endless Caverns is developed predominantly in the middle Ordovician-aged New Market and Lincolnshire Limestones in a minor anticlinal fold in the western flank of Massanutten Mountain (Brent, 1960). The cave is well known to speleologists because of its array of speleogenic features of phreatic and vadose origin. Specific references to these features are made in three classic papers on cave genesis: Davis (1930, p. 607-610), Bretz (1942, p. 740-742), and Bögli (1980, p. 159). In excess of 25,500 feet passage are mapped by cavers. Many of the western cave passages terminate in clastic fills containing large clasts of Silurian sandstone washed into the cave by surface streams sinking along the flank of Massanutten Mountain.

DISCOVERY AND RECOVERY

Cavers Wade Berdeaux and Chris Printz were digging at a clastic fill terminus in a non-commercial portion of the cave when Wade noticed the partially exposed tooth in the floor near the fill. He immediately recognized it as a large tooth and made the decision to leave it *in situ* and seek professional help.

It was September before the authors were able to meet at the cave and examine the find. The site was less than two hundred feet off the tourist route. The side passage started-off as a stoop walk, but degraded to a belly-crawl through a partial water-filled passage containing less than a foot of air space before opening up again at the dig site. The passage provided a challenge to keep equipment dry.

The tooth, a lower third molar, was embedded in sediment with only its labial (lateral) side exposed (Figure 1). Excavation revealed that it was in contact with adjacent and underlying sandstone cobbles and boulders in a silty sand matrix. This sediment deposit is at least two feet in thickness and is topped by six inch-high stalagmites. The deposit had been truncated immediately adjacent to the tooth by undercutting of an intermittent small stream trickling down through a floor to ceiling cone of boulders. The boulder cone is located 450 feet from the commercial entrance to the cave.

The tooth was pedestalled and encased in plaster bandaging before it was lifted free and the plaster bandaging completed. It was removed from the cave by Wade Berdeaux, one of the cave's owners. Laboratory processing included very slow drying, filling of the open root cavities with carbowax (polyethylene glycol 3350), and sealing of incipient cracks with butvar. Despite these precautions, some cracks developed and were treated with cyanoacrylate.

DEPOSITIONAL INTERPRETATION

The ceiling opening from which the boulder cone extends is believed to have led to a former entrance to the cave. The tooth entered the cave through this clast-choked portal. A question remains whether the tooth entered the cave as part of a debris flow or through creep. The finer sediment formerly associated with the boulder cone has long since been winnowed from the deposit. Intermittent waters infiltrating

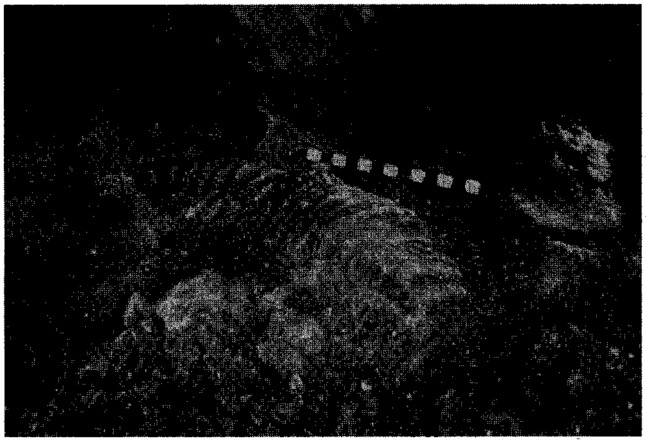

Figure 1: Mammoth tooth *in situ*. Scale in centimeters (2.5cm/inch).

through the ceiling hole were responsible for modifying the remaining extension of the cone deposit as finer sized sediment was winnowed from the cone (Figure 2). Infiltrating waters still periodically percolate through the boulder cone but bypass the truncated and isolated sediment bank along a path to the lower level cave stream.

Figure 2: Fred Grady preparing tooth for packaging in foreground of the boulder cone.

THE FOSSIL

The Endless mammoth tooth, a lower right m3, is in an excellent state of preservation. It may be missing a few unerupted plates, but the unerupted open roots are largely intact (Figure 3). Dimensionally, it is 9.4 inches (240 mm) in length, 3 inches (70 mm) in width, 5.5 inches (140 mm) in height. The 24 enamel plates are spaced about 10 plates per 3.9 inches (100 mm) of length. The enamel is very thin (less than 0.1 inch; 1-2 mm) and fine wrinkles are visible, especially on the unerupted root portions.These characteristics indicate the tooth is *Mammuthus primigenius* as defined by Maglio (1973). Approximately thirty percent of the tooth is worn through use. Correlating this degree of wear to the similarly structured teeth of the African Elephant, the Endless tooth would correspond to Laws (1966) group IX for an age of about 32 years.

Figure 3: Lateral view of the lower right m3 mammoth tooth. The erupted and worn surface is at the upper right top of the tooth.

ENVIRONMENTAL INTERPRETATION

The setting of Endless Caverns today is on the lower slope of Massanutten Mountain at the floral break from the forested slopes of the mountain and the grasslands sloping to the flood plain of Smith Creek. The presence of mammoth remains at this location is significant: the implication is that a similar floral distribution existed when the mammoth grazed in the area sometime late in the Pleistocene (100,000 bp to 11,000 bp).

PREVIOUS VIRGINIA MAMMOTH RECORDS

There are four previous records of mammoth in Virginia. The earliest record for mammoth in Virginia was that of a molar tooth reported in 1831 by Richard Harlan, apparently in the area of Warrenton, Fauquier County (Hay, 1923). The whereabouts of this tooth is unknown. Whole and fragmentary teeth were sent to the U.S. National Museum in 1914 from Mr. H.D. Mount, of the Mathieson Alkali Works of Saltville in Smyth County.They were found during excavations for a water reservoir about 1896. These remains appear to represent three or four individuals (Hay, 1923; Ray and others, 1967). Additional mammoth remains have been since found in the Saltville area (Ray and others, 1967). Eshelman and Grady (1986) and Whitmore and others (1967) record that mammoth remains have been dredged from the Continental Shelf. The proximal-end of a mammoth ulna was found at the Ratliff fossil site in Russell County in 1993 (Figure 4).

CAVE RESOURCES AND CONSERVATION

Endless Caverns and its fossils are protected, as are all Virginia caves and their contents, by the Virginia Cave Protection Act. All speleological work conducted in the cave is with the permission of its owners and under permit where applicable.

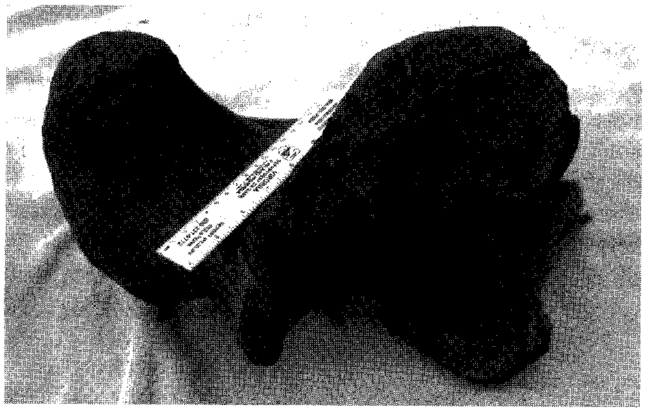

Figure 4: Proximal (upper) end of a mammoth ulna (lower, front leg bone) found in Russell County, VA. Scale is 7 inches (18 cm) in length.

ACKNOWLEDGEMENTS

We thank the management and staff of Endless Caverns, especially, Wade and Gary Berdeaux and Chris Printz, for their enthusiastic support and hospitality.

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COORDINATE SYSTEMS USED ON VIRGINIA'S TOPOGRAPHIC MAPS

Jack E. Nolde

INTRODUCTION

Throughout the ages, maps have had a profound impact on the activities of man, and today the demand for them is perhaps greater than ever. They are of the utmost importance in engineering, resource management, urban and regional planning, management of the environment, construction, conservation, geology, agriculture and many other fields. Maps are made to show topography, political and property boundaries, transportation routes, soil types, vegetation, land ownership for tax purposes, geology, mineral resource locations and so on. Maps are drawn from information obtained from surveying the area. As defined surveying is an art used to determine horizontal distances, directions, angles, locations, elevation differences, areas and volumes on or near the surface of the earth. Geodetic surveying deals with very large areas that it becomes necessary to consider the effects of the earth's curvature. Control surveys establishes a network of horizontal and vertical monuments, called benchmarks, that serve as reference frameworks for other surveys. Surveys of this kind requires the accurate location of widely separated points to control the accuracy of subsequent surveys for detail, like topographic maps.

Topographic surveys are made to determine the configuration of the earth surface, and to locate natural and cultural features thereon. A topographic map is a large-scale representation of a portion of the earth surface, showing cultural, relief, hydrography, and vegetation. By means of conventional symbols, topographic maps are produced from field data. Products of man, such as roads, trails, bridges, buildings, canals, and boundary lines, are called cultural features. The location these natural and cultural features can be plotted or located by various types of coordinate systems which are based on the shape of the earth and map projection used.

SHAPE OF THE EARTH

The term "shape of the earth" may have various interpretations, according to the sense in which it is employed and the degree of precision with which we intend to define the earth's shape. When we say the earth is spherical, we mean that the sphere is a rough approximation to the true shape.

Spheroids, which have been most extensively used, were computed by Bessel in 1841 and Clarke in 1866. Bessel's was based on surveys in Europe. The characteristics of Bessel's spheroid were used in the United States up to about 1880. The characteristics of the Clarke spheroid are that it is larger and flatter than the Bessel's. The National Geodetic Survey adopted the Clarke spheroid about 1880, after it be-came apparent that the surface in the United States has a flatter curvature than that indicated by the Bessel spheroid. When a closer approximation is required, we employ the spheroid or ellipsoid of rotation. The earth is an ellipsoid of rotation commonly called an oblate spheroid (Figure 1). An oblate spheroid is an ellipsoid whose north-south axis is shorter than the east-west. Contrary to this is a prolate spheroid whose east-west axis is shorter than the north-south. A reference ellipsoid was developed by A.R. Clarke in 1866. Early surveys were usually based on local coordinate systems or datums which were determined by astronomical observations. Because these surveys were normally of small areas, there were not sufficient survey points until 1900 to make a national geodetic datum known as the U.S. Standard Datum. This datum was based on the Clarke 1866 reference ellipsoid. In 1913 the name was changed to the North American Datum (NAD) when Canada and Mexico adopted the datum. The geodetic survey station at Meades Ranch in Osborne County, Kansas was selected as the reference station for the datum. The Survey point, Meades Ranch is located at 39° 13′ 26.686″ north latitude and 98° 32′30.506″ west longitude. New survey points and an adjustment of the original survey points were incorporated into what is known as the North American Datum of 1927. In 1971, the demands for increased positional accuracy caused the National Academy of Science to recommend that the National Geodetic Survey to undertake a readjustment of the NAD27.

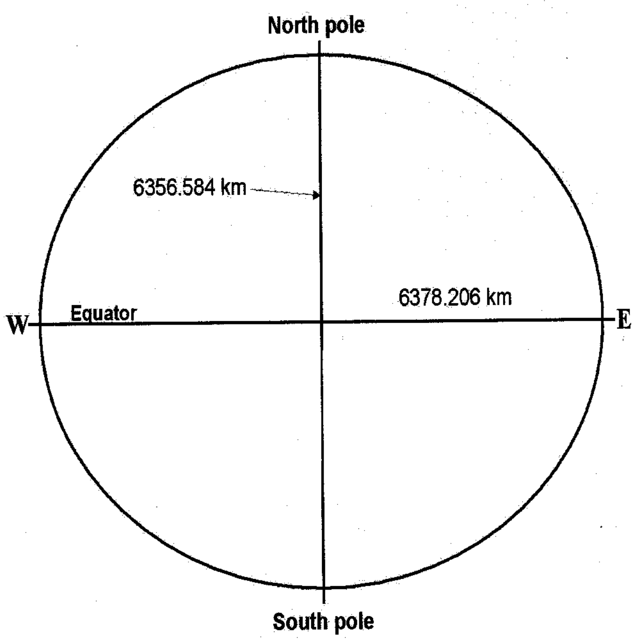

Figure 1. The general shape of the earth adopted is an oblate spheroid; the polar axis is shorter than the equatorial radius.

Development of NAD83 included a readjustment and redefinition of the NAD27 datum. To facilitate the use of satellite surveying (Global Positioning System), the new datum was redefined using the Geodetic Reference System of 1980 (GRS80)as the reference spheroid (U. S. Geological Survey, 1989). This is because this model more closely approximates the true size and shape of the earth. Unlike the Clarke ellipsoid, GRS80 is earth centered (the center of reference is at the mass center of the earth). In the Clarke ellipsoid the equatorial radius is 6,378.2064 kilometers and the GRS80 ellipsoid is 6,378.137 kilometers. In the Clarke ellipsoid the polar radius is 6356.5838 kilometers and the GRS80 ellipsoid is 6356.7523 kilometers. The polar radius, in the Clarke ellipsoid, is 21.623 kilometers or 13.43 miles shorter than the equatorial radius.

MAP PROJECTION USED IN VIRGINIA

In general terms, a projection is defined as the process of transferring the coordinate position from one surface to the coordinate position on another surface. The U. S. Geological Survey defines a map projection as (1) an orderly system of lines on a plane representing a corresponding system of imaginary lines on an adopted celestial datum surface and (2) the mathematical concept of such a system.

A spheroidal surface, such as the earth, cannot be projected on a plane without distorting it. The principles involved in map projection control the character of the distortion if the points on the surface of the earth are projected on the plane according to mathematical formulas. The two surfaces used are the cone and the cylinder, both of which can be developed into a plane without further distortion.

There have been many map projections developed, but ideally, we would like to project to maintain: (1) true area, (2) true shape, (3) true scale, and (4) shortest distance between two points a straight line. The selection of a system should have the following features: (1) should cover as large an area as possible, (2) grid distance should be as nearly equal to the geodetic distance as possible, and (3) angular relationships (shape) should be retained; that is, angles derived from coordinates should agree with angles measured in the field.

The polyconic projection was widely used in the United States by the National Ocean Survey and it was adopted as the projection for the standard topographic maps of the United States Geological Survey. The projection has a straight, standard central meridian. The parallels or latitudes are arcs of circles, and each is a standard parallel, drawn with the proper radius for its cone and hence with its own center, therefore the parallels are not concentric. Although the scale factor along each line of latitude is 1.0, the scale along the curved longitude lines is greater and increases with increasing distance from the central meridian.

For the mapping of a large area on a large scale, the development of each map sheet on its own polyconic projection is therefore an acceptable solution to the projection problem. Each such small section will fit perfectly with the adjacent ones to the north and south but, because of the curved latitude lines, they will not fit together east or west. The variations of the scale factor within a 7.5-minute and 15-minute quadrangle of the standard topographic maps is insignificant and usually less than that which results from paper expansion or shrinkage. Although it is suited for individual maps at a small scale, it is clearly not suited for maps covering larger areas. It is these reasons that lead to the choice of the Lambert Conformal Conic projection used in the Virginia State Plane Coordinate System, designed by the National Geodetic Survey. The Lambert projection having two standard parallels was invented about the middle of the eighteenth century, but has been brought into prominence through its use in French battle maps. The Lambert Conformal Conic projection uses a cone whose axis coincides with the north-south axis of the earth. The term conformal means that true angular relationships are retained around all points. The general concept of the system is shown in Figure 2. The cone intersects the surface at predetermined latitudes for the area to be coordinated these lines are called "standard parallels" of the projection. The scale along the standard parallels are "true" or "exact". The scale is too small between the parallels and too large beyond them. To apply the Lambert Conformal Conic projection to a state, the width of the projection in a north-south direction is limited to 158 miles, and the standard parallels are separated by about two-thirds this distance. The characteristics of the projection makes it best suited for areas that are narrow in a north-south direction and long in the east-west direction, such as the shape of Virginia.

The great advantage of the Lambert projection is that maps prepared with it will be compatible and fit with the most common maps of Virginia and of adjacent states, and of the United States. One disadvantage is that the change in scale across the map is greater than for some other map projection. In asmuch as the grid scale is slightly reduced by the Lambert projection, topographic map measurements must be reduced by this factor to attain true grid position.

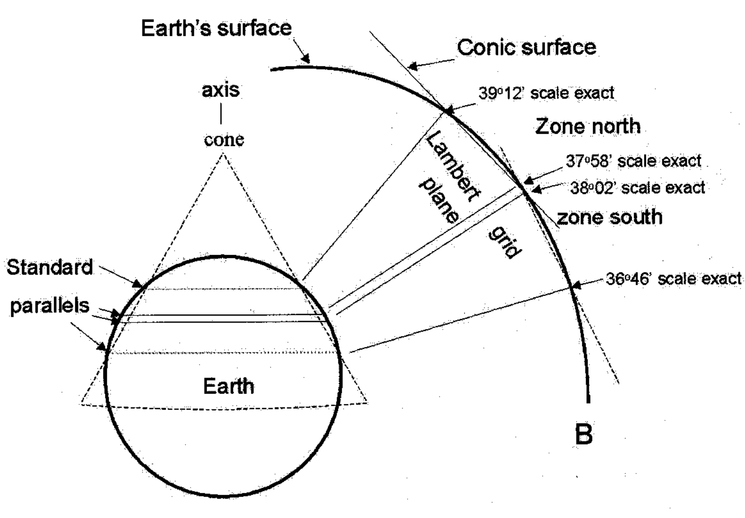

Figure 2. Lambert Conformal Conic projection diagram for Virginia.

COORDINATE SYSTEMS

The location of points can be plotted or located by various types of coordinate systems which are based on the assumed shape of the earth and map projection used (Hooijberg, 1997). Coordinate systems represented on maps of Virginia are typically two, geodetic and plane, and are plotted along the sides of the maps. The geodetic coordinate system refers to latitude and longitude. A plane coordinate system is a rectangular grid.

GEODETIC COORDINATES

Latitude and Longitude

The location of any point on the earth's surface may be indicated by specifying two angles, one called latitude and the other longitude. For large area surveys, it is necessary to consider the earth's curvature. Horizontal positions of widely spaced geodetic stations are listed in terms of geodetic positions (latitude and longitude). The north and south poles are two very special points on the earth, for they do not move due to rotation of the earth. Half-way between the poles we imagine a circle called the equator. Lines drawn parallel to the equator are known as lines of latitude. Latitude is specified as north (N) or south (S) of the equator. There are 90 lines of latitude, each separated by 1°, in each hemisphere (north and south), The Equator is at 0° latitude and the poles are at 90° latitude. Virginia lies between 36° 30′ and 39° 30′ north latitude.

In measuring east or west (longitude) there was no natural starting point and so an arbitrary choice was necessary. In the past, various meridians have been used as the zero of longitude from which other longitudes are measured. Hipparchus was the earliest astronomer to determine longitude by astronomical observations, based on the meridian of Rhodes (Beall, 1922). Eventually each country came to have its own zero meridian, usually the Capital. In order that points may be located on the face of the earth by their latitude and longitude coordinates, the astronomic latitude and longitude of several stations must be determined with also the astronomic azimuths of some lines. An azimuth is the angle measured from the meridian clockwise from the south point toward the west, from zero to 360. Based on a large number of observations of star positions which had been made at the Royal Greenwich Observatory just outside London, this location was selected as the starting point for measuring longitude. The determination of the astronomic longitude of a station, therefore, involves determining the true local time at the station and comparing it with the local time at Greenwich. The zero Longitude, is known as the prime meridian, and is, by international agreement in 1884, the meridian passing through Greenwich, England. The longitude of a point is specified as east (E) or west (W) of Greenwich, the prime meridian. There are 360 meridians, each separated by 1° of longitude. The 180° longitude is known as the International Date Line. Longitude lines converge on the poles and diverge towards the Equator. The distance between longitude lines is greatest at the Equator (about 69 miles) and zero miles at the poles. Virginia lies between 75°15' and 83°45'west longitude.

More exact locations are achieved by breaking down each degree of latitude or longitude into 60 minutes (symbol ') and each minute into 60 seconds (symbol "). For latitude, each degree measures about 69.17 miles, each minute about 1.15 miles, and each second about 101.4 feet. The same distances are also applied to the longitude in which these measurements are the same at the equator. Because of the convergence toward the poles the distance decreases. For example, the distance between the longitude lines at 38° north latitude which passes through central Virginia, is 54.6 miles.

Latitude and longitude numbers are shown at the corner of each quadrangle, and one or more subdivisions are shown between corners as black tick marks along the edge of the map, as well as by a crosshair (+) within the map. Any point on a map can be located by a unique set of latitude and longitude coordinates. For example, the McCormick Observatory in Charlottesville is at 38° 01' 58.06" north latitude and 78° 31' 20.62" west longitude.

PLANE COORDINATES

State Plane System

A state plane coordinate system provides a common datum of reference for horizontal control surveys in large areas in the same way that mean sea level furnishes a single datum for vertical control. It eliminates having surveys based on different assumed coordinates, unrelated to those employed in other adjacent work. The state plane coordinate systems were established by the National Geodetic Survey (formerly U.S. Coast and Geodetic Survey) as a network of rectangular coordinates (Mitchell and Simmons, 1945). The system could be used by surveyors and others to precisely locate points for legal descriptions in property surveys. Many other agencies and businesses use the system, where it is also known as the x-y coordinate system.

To maintain accuracy and compensate for the curvature of the earth, Virginia is divided into two zones, a north and a south (Figure 3). The Virginia Code, Title 55, Section 282 through 297, Property and Conveyance, Chapter 17, the Virginia Coordinate System sets the description of the plane coordinate system established by the National Ocean Survey/National Geodetic Survey. The boundary between the north and south zones are county lines, roughly following the 38° parallel of latitude. Coordinates using the NAD27 datum are given as distances in feet from established baselines. Distances when using the Virginia Coordinate System of 1927 are referred to the US Survey foot and decimal of feet. If the Virginia Coordinate System of 1983 is used distances are referred to meters and decimal of meters. The position in the east-west direction is the x-coordinate; the position in the north-south direction is known as the y-coordinate. The Lambert projection establishes the origin of the North zone at 37°40' north latitude and 78°30' west longitude and assigned value for the x-coordinate as 2,000,000 feet and the y-coordinate as 0 feet. Likewise the South zone has an origin at 36°20' north latitude and 78°30' west longitude and assigned value for the x-coordinate as 2,000,000 feet and y-coordinate as 0 feet. These values assures that all x and y coordinates within the grid base will be positive. Points west of 78°30' west longitude will have an x-coordinate less than 2,000,000

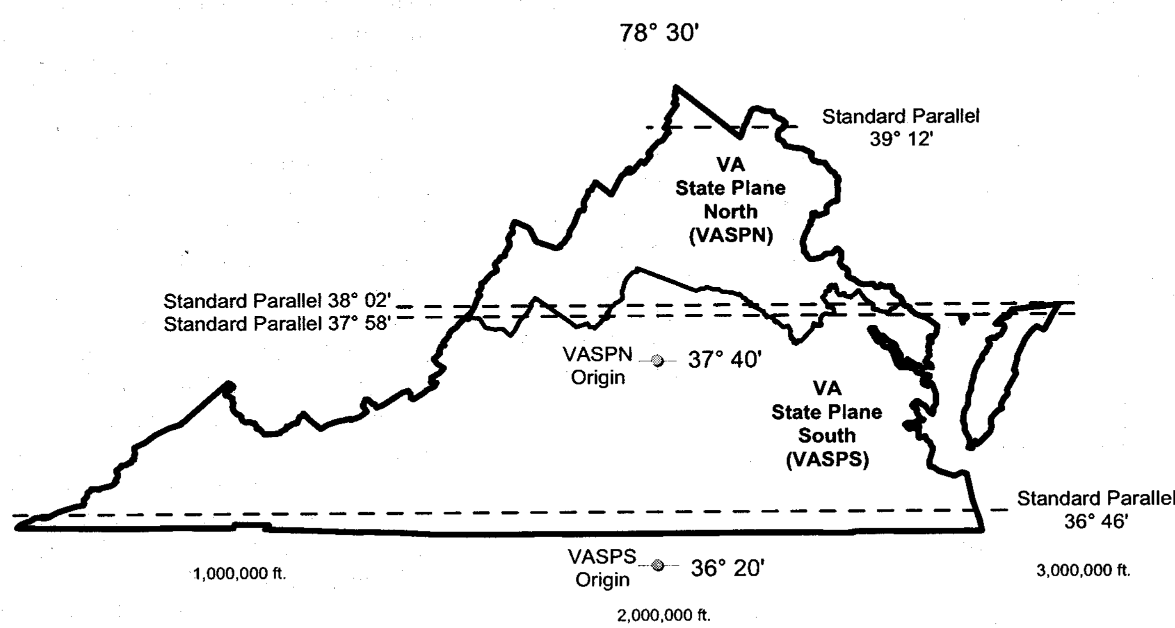

Figure 3. Virginia State Plane Coordinate System.

feet, while points east of 78°30' west longitude will be greater than 2,000,000 feet. The 10,000 feet ticks for Virginia Coordinate System of 1927 are printed in black along the edge of the 1:24,000 scale topographic maps. The 1:100,000-scale maps have a 25,000 foot grid, and the 1:250,000-scale maps have a 100,000 foot grid. As the example for the McCormick Observatory the State Plane coordinates are (NAD27) 618,770.02 feet north and 1,993,549.37 feet west in STP zone South.

Universal Transverse Mercator

The Universal Transverse Mercator (UTM) grid is a metricrectangular coordinate system adopted by the U.S. Army in 1947 for worldwide use on military maps. South to north zones is designated by letters and encompasses 8° of latitude. The system begins with the letter "C" for the area encompassed between 80° and 72° south latitude. Virginia lies between 32° and 40° north latitude and is in the "S" zone. The system divides the earth into 60 numbered zones of 6° longitude each. The grid is numbered west to east from the International Date Line, placing Virginia in UTM zones 17S and 18S. In Virginia the boundary between zone 17S and 18S is the 78° longitude line (Figure 4). About two-thirds of Virginia lies in UTM zone 17S. Each UTM zone contains a central meridian. At the central meridian for a zone the equator has a y-coördinate of 0 meters and increase to the north from the equator. The x-coordinate is set at 500,000 meters so coordinate values will always be positive. The x-coordinate increases from west to east within a zone. The grid is subdivided into squares that measure 100,000 meters on side, and then further into smaller squares to locate a place on the earth's surface. The UTM 10,000 meter grid is printed in black on a 1:100,000 and 1:250,000 scale map. The UTM 1,000 meter grid on a 1:24,000 scale map ticks are printed in blue along the edges of the map published after 1957. As the example for the McCormick Observatory the UTM coordinates are 4,212,145.61 meters north and 717,452.16 meters west in UTM zone 17S.

Relationship between geodetic and plane coordinates

The latitude and longitude of points are on the ellipsoid of reference which closely approximates the sea level surface of the earth. By mathematical operations, the position of grid lines of a state coordinate system or UTM grid can be determined with respect to the latitude and longitude on the ellipsoid of reference. Therefore the latitude and longitude of a point on the ellipsoid may be defined by x-and y-coordinates on a State or UTM grid. If either position is known, the other can be determined by mathèmatical computations. Computer software to convert between geodetic and state plane or UTM coordinates is available from both the U. S. Geological Survey and the National Geodetic Survey. The conversion between geodetic and plane coordinates, or plane coordinates to geodetic coordinates is beyond the scope of this article. Details of the computations can be found in Hosmer (1930), Sharp (1943), and Bouchard and Moffitt (1965). The shift of the geodetic, state plane and UTM coordinate positions between the NAD27 and NAD83 is described in the publication, North American Datum of 1983 (U.S. Geological Survey, 1989).

A brief description is included on determining the geodetic, state plane, and UTM-coordinate location for a point on a 1:24,000 scale topographic map by the scaling method.

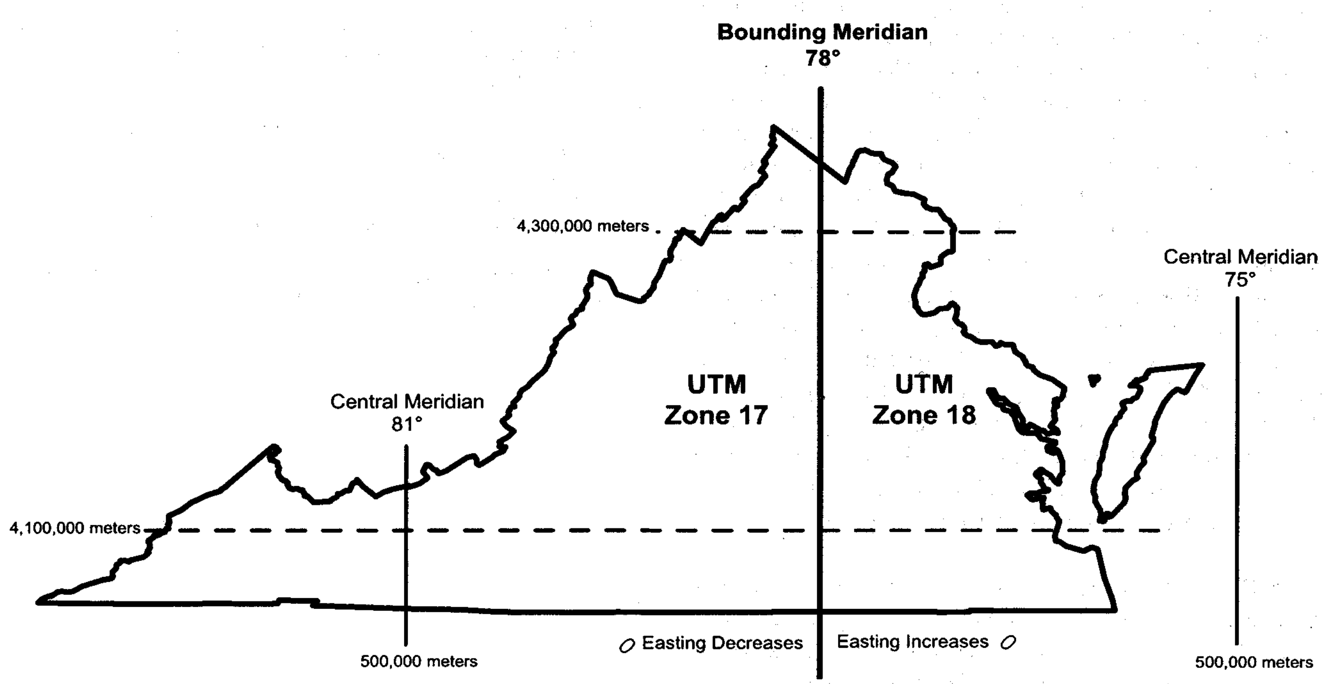

Figure 4. Universal Transverse Mecator grid system for Virginia.

Latitude and Longitude Coordinates- Tables have been developed to determine the latitude and longitude for a point using the polyconic projection on different map scales(U.S. Geological Survey, 1964). Scale distances for the 1-minute, 1.25-minute, 2.5-minute, 3.75-minute, and 7.5-minute coordinates in inches are listed in Table 10 in the above referenced publication. From this publication in measuring 1-minute of latitude (east or west) along the 36° 30' parallel equals 2.4495 inches and along the 39° 30' parallel equals 2.3517 inches (Table 1). The difference in scaled distance between these two parallels is 0.0978 inches, which represents approximately 195.6 feet. Also from Table 1, 1-minute longitude distance (north or south) along the southern boundary is 3.0338 inches and along the northern boundary 3.0354 inches.

Table 1. Scaling distances for latitude and longitude, 1:24,000 scale.

Latitude	Longitude Interval		Latitude Interval	
	1-minute	7.5-minute	1-minute	7.5-minute
39° 30'	2.3517	17.638	3.0354	22.766
39° 00'	2.3684	17.763	3.0354	22.766
38° 30'	2.3850	17.888	3.0349	22.762
38° 00'	2.4014	18.011	3.0349	22.762
37° 30'	2.4176	18.132	3.0343	22.757
37° 00'	2.4337	18.252	3.0343	22.757
36° 30'	2.4495	18.371	3.0338	22.754
Average	2.4010	18.008	3.0350	22.760

EXAMPLE: The McCormick Observatory is located in the southeastern corner of the Charlottesville West 7.5- minute topographic map. Given the southern boundary of the Charlottesville West map as 38° 00' north latitude and the eastern boundary as 78°30' west longitude, find the latitude and longitude of the observatory. On the map the observatory is located 3.25 inches west of 78°30' west longitude line and 5.95 inches north of 38°00' north latitude. From Table 1, 1-minute or 60 seconds equals 2.4014 inches along 38°00' north latitude. By law of proportions 3.25 inches equals 81" or 1' 21". Adding this to 78°30' you obtain 78° 31' 21" for the longitude of McCormick Observatory. The latitude is may also be determined by use of Table 1. One-minute or 60 seconds of latitude equals 3.0349 inches. The scaled distance is 5.95 inches. Again use of the law of proportions yields 117.6" or 1' 57.6". Adding this to 38°00' you obtain, 38° 01' 57.6" for the latitude of the observatory. Therefore scaling from the topographic map yields a latitude and longitude for the McCormick Observatory to be 38° 01' 57.6" north latitude and 78° 31' 21" west longitude. Compare these values with the values on page 6.

State Plane and UTM-Coordinates- Scaling of these rectangular coordinates on a 1:24,000 scale topographic map is easier than the geodetic coordinates. The tick marks (Figure 5) along the map margins for the State Plane Coordinate System are spaced at 10,000 foot intervals (printed in black). By the use of the 20-scale on an engineer's ruler you can determine a location within 50 feet. If you use an architect's ruler (16-scale) remember that 1 inch equals 2,000 feet on a 1:24,000 scale map. Just multiply the number of scaled inches and fraction of inches by 2,000 and then add or subtract from the nearest 10,000 foot tick mark value will yield the value for the State Plane Coordinate for the point. Add the values to the right of the tick mark and subtract to the left of the tick mark.

In the case of the UTM-coordinate of a point the value will be expressed in meters. The tick marks (Figure 5) in the UTM-coordinate system along the map margins are spaced at 1,000 meter intervals (printed in blue). On a 1:24,000 scale topographic map 1 inch equals 609.6 meters. Follow the same procedure as determining the State Plane Coordinate. Just multiply the number of scaled inches and fraction of inches by 609.6 then add or subtract from the nearest 1,000 meter UTM-coordinate tick mark value will yield the value for the UTM-coordinate for the point. Add the values to the right of the tick mark and subtract to the left of the tick mark.

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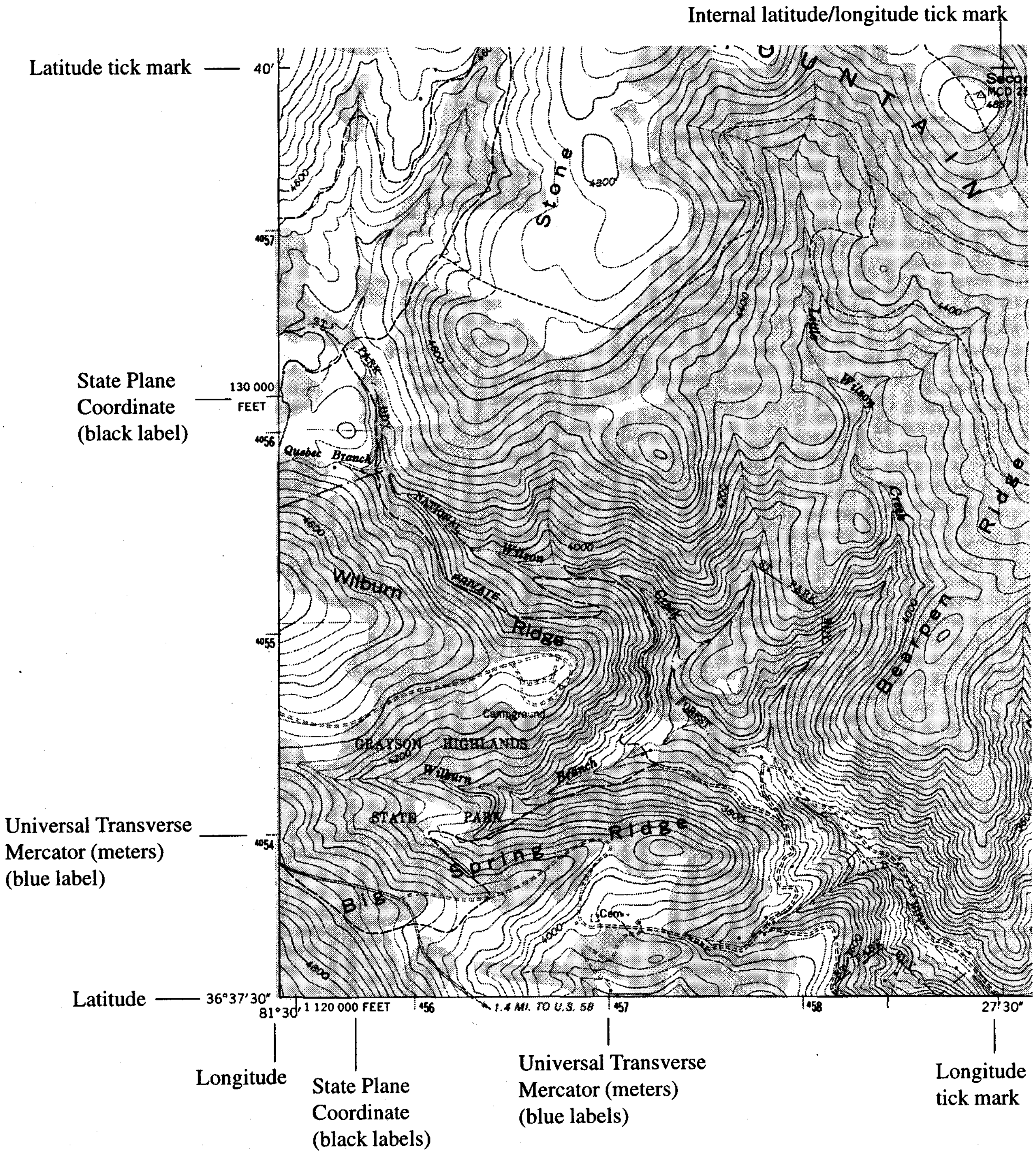

Figure 5. Border annotation for latitude, longitude, State Plane and UTM-coordinates for a 7.5-minute quadrangle.

MINERAL UPDATE

FIRST CONFIRMED VIRGINIA CHRYSOBERYL DISCOVERY IN A POWHATAN COUNTY STREAM SEDIMENT

Peter A. McCrery

In early 1998, four gem quality crystal fragments of chatoyant (cat's-eye) chrysoberyl up to 3 mm in greatest dimension were discovered by sorting heavy mineral sands. The heavy mineral sands came from the headwaters of a tiny tributary of Fine Creek in Powhatan County. The sediments of this and other streams, principally in Powhatan and Amelia counties in the Ym map unit (porphyroblastic garnet-biotite gneiss, 1993 Geologic map of Virginia) have produced a number of desirable micro-mineral specimens of hobby and academic interest.

Pegau's article (1932) states "Chrysoberyl, phenacite, topaz, and helvite are also thought to be present, but have not been definitely identified." This is the only known reference to possible Virginia chrysoberyl. The source probably was the Morefield mine, Amelia County.

The minerals in the Powhatan County creek include pale red gem almandine fragments up to a few carets of facet quality and abundant smaller fragments. Other minerals include colorless to blue kyanite and more abundant sillimanite (fibrolite as subparallel aggregates and separated chatoyant grains). Some kyanite is partially altered to a fine-grained gray muscovite. Scarce, small (1 -5 mm to rarely 15 mm) fragments and occasional tabular crystals of corundum occur. These infrequently enclose tiny blebs of ilmenite or rutile. The corundum, which are occasionally coated by fibrolite, have well developed polysynthetic rhombohedral parting planes. The majority of the corundum is pink, other colors present include ruby red, lavender, gray, orange, and brown. Some samples are chatoyant and test for moderate asterism, others fluoresce red. The intensity of the red to pink corundum fluorescence is proportional to that in visible light. Minor amounts of lodestone magnetite are noted as formless grains. Limonite after pyrite grains occur, with occasional crude cubes and pyritohedrons.

The augen of the gneiss produce chatoyant adularia, some suitable for small gems. These augen occasionally develop into small simple pegmatites of smoky quartz with graphic texture, decomposed plagioclase (kaolin), and biotite and /or muscovite. Tiny graphite masses and smears occasionally show in these structures and virtually any other bedrock structure. Coarse, well-developed pegmatites provide some buff microcline as well as massive, sheared, white to smoky quartz, although some rare fragments are transmitted-light star quartz, colorless to very faintly rose gray.

Pegmatite muscovite develops into tabular books rarely up to 10 cm or more wide, typically showing amber to pale greenish-yellow through the prism. Despite extensive search in the area, beryl has not been reported.

Schorl tourmaline is abundant in most of the pegmatites and associated well-developed alpine veins. Fragments and crystals from micro-sized to a few centimeters are common in the stream. Two tourmaline crystals (less than 1 mm in length) with visibly colorless transparent prisms and dark "cobalt" blue flat terminations were found by Jack Nelson of Poolesville, Maryland.

The stream studied lies in the "monazite belt" and is rich in mostly abraded crystal monazite grains that range from one to four millimeters in long dimension. Bedrock-derived crystals are crude and translucent brownish-orange in color. Less than 1 percent are alpine vein open pocket-derived and are transparent and sharply-faceted. A few murky greenish, square dipyramidal xenotime crystals are noted in similar sizes, representing less than 1 percent of the phosphates.

Three varieties of zircon are found in the stream sediments as well. First, the smallest (submillimeter) are elongate, prismatic, and colorless. Second, larger (to 2 mm) blocky, multifaceted, cracked and transparent crystals which exhibit several pastel colors - gray, lavender, pink, yellow, orange, and brown. The second group grades into a third which is opaque (or nearly so), gray, brown to near black. Many are flawed, and typically prismatic, some with steep pyramids are up to 3 mm. The third group is the most complex and diverse, including subradial diverging groups. These may all be bedrock-derived, but the third group <u>may</u> be associated with alpine vein vugs. Any of the varieties may fluoresce to bright yellow.

Although abundant in much of the bedrock, black hornblende is scarce in the sediments. An exposed plagioclase, hornblende diorite also has some small (1 - 5 mm) relict orthopyroxene ("bronzite") of brown color and intense, bronzy chatoyancy. Hard, dark brown, nearly transparent grains are rare in the concentrate.

The lighter fractions of the sands are mostly granular, sheared, white to gray quartz derived from bedrock of the complex (Ym) gneiss, minor quartzite, pegmatite cores, and alpine veins. The tiny, chatoyant blue quartz grains derived from dioritic facies are rare. More intensely blue, sheared masses (to larger sizes) are derived from sediments transported from other Virginia terranes as upland gravel deposits. Quartz crystals are derived from alpine veins and may be quite clear and lustrous, exhibiting a variety of habits. Typically colorless to smoky to black, they may rarely be partly amethystine.

Small rutile crystals (up to 10 mm by 1 mm) range from red to brownish-black. The well-formed red crystals are alpine vein-derived, as are some of the red blebs. Darker blebs, may also be observed as inclusions in corundum, kyanite, and sillimanite. Ultra-micro blebs of rutile may be found in gneiss-derived grains of quartz. The larger crude dark grains may be bedrock-derived. Ilmenite plates and fragments are most likely all early stage alpine vein derived. The brittle fragments may be altered, in part, to leucoxene mats of golden (to nearly white), ultra fine textured rutile. Smaller ilmenite blebs are noted as inclusions, like the rutile above. At this site, occasional chrome muscovite (fuchsite) diagnostic of alpine veins is encountered. These are smaller, well-formed tabular crystals from open aggregates in the vugs. The chrome content is chelsea verified. Saturated fuchsite is chrome green on the C-axis and through the prism, While undersaturated fuchsite is green only through the prism.

The first and, so far, the largest chrysoberyl grain was found in January of 1998 through microscopic sorting and was tentatively identified by crude optical and specific gravity observations. It is 3 x 2.6 x 2.4 mm. Although nearly flawless, it is murky, with intense whitish chatoyancy and shows pale greenish-gray in other directions when compared to white paper. One side shows crystal face interferences. All other surfaces are conchoidal fractures. A thin, transparent rind lies under the faced portions. The greatest chatoyancy proved to be in the narrowest (1.4 mm) portion, exhibiting an intense, single well-defined "eye".

Identification of the second chrysoberyl grain found was confirmed by X-ray diffraction by Dr. Lance Kearns, James Madison University, Harrisonburg, VA in March 1998.

The two others found were not as easily recognized as they superficially resemble several of the other minerals, particularly chatoyant blue quartz and adularia moonstone, but they are of the lighter fractions. The corundum and sillimanite of the heavy fraction may be more difficult to differentiate from chrysoberyl. All of the corundum from the locality exhibit rhombohedral parting planes, while the chrysoberyl grains are bounded by conchoidal fractures. The darker chatoyant fractured corundum appears very similar to like colored chrysoberyl. Chatoyancy of some smaller chrysoberyl grains and the best chatoyant sillimanite grains are very similar. The chrysoberyl grains have zones of faint greenish-gray and bounded by conchoidal fracture.

Since the chrysoberyl discovery, the other Powhatan and Amelia County streams previously prospected have not been re-examined for chrysoberyl, although some of them do have beryl. The described prospecting was conducted by members of the Virginia Independent Prospectors, part of the Eastern Federation of Mineralogical Societies. This site was discovered by Adam Oliff and Pat Gould of Richmond, VA.

VIRGINIA MINERAL RESOURCES, 1998

Palmer C. Sweet

In 1998, several companies conducted reconnaissance geologic, geochemical, and geophysical investigations for base- and precious metals in the southwestern Piedmont province of Virginia. Gold Crown Mining Company continued to permit and intermittently work the old Kentuck mine, located east of Danville, in Pittsylvania County and Southern Piedmont Mining continued to permit the old Moss mine in Goochland County.

Golden Cat, a Division of Ralston Purina Company, located about 25 miles northeast of Richmond in King William County, continued producing cat box litter. During the last few months of 1997, clay production at this site was more than 12,400 short tons.

RGC (USA) Mineral Sands Inc. continued with their titanium mining and initial processing operations in Dinwiddie County and final processing near the town of Stony Creek, Sussex County, south of Richmond. Almost 36,000 short tons of mineral sands were produced in the last few months of 1997. Seventy jobs have been created by the processing and mining operation; hauling and supply services and contract mining operations have created an additional 25 jobs. In early 1998, several faults were discovered in the pits and consequently the mining procedure was changed to take advantage of higher-grade zones within the mining area.

Vulcan Materials Company's newly reopened Lowmoor Quarry in Alleghany County, produced almost 13,000 short tons of crushed limestone in the latter part of 1997. Markets are for roadstone and asphalt stone in the western part of the State. Vulcan Materials also is now working with Chesterfield County on site plans to reopen the old Cashion quarry, which they operated from 1974-1977. The quarry, located just southwest of the City of Richmond is in granitic rock; product will be roadstone from the site they plan to reopen in the Spring of 1999.

During the year, W. W Boxley's Blue Ridge Stone Corporation proposed to open a limestone quarry sometime in the future, at a site south of Eagle Rock, in Botetourt County. Toward the end of the year, the company was in the process of obtaining State permits.

The former Tulikivi soapstone operation at Schuyler, Nelson County was purchased by New World Stone Co. in November 1998. The company purchased the 27-acre complex, including the mill building and a dozen other buildings. Mineral rights are being obtained for several of the former quarries. According to a local weekly newspaper, plans are to create an art colony to inspire architects to make soapstone as popular as vinyl siding. Initially the company will utilize some of the existing, already mined soapstone blocks to produce laboratory tops, sills, sculpture, etc. for special orders.

There continued to be increased company interest in the Cedar Grove Church and Linville high-calcium limestone

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deposits in Rockingham County in the Valley and Ridge province of Virginia. Both deposits contain high-quality New Market Limestone and are close to rail transportation.

According to the U.S. Geological Survey, production of crushed stone in Virginia was up 16.4 percent in the third quarter of 1998, compared with 1997 production figures; total production after three quarters of 1998 was 56,500,000 mt. Sand and gravel was up 7.5 percent in the third quarter of 1998, compared with 1997 production figures; total production after three quarters of 1998 was 8,400,000 mt.

The Virginia Division of Mineral Resources (geological survey) continued geologic mapping in several counties at a detailed 1:24,000 scale and continued to map, compile, and digitize 1:100,000 scale maps. They also continued field studies and compilation of mineral resources on 1:24,000 scale maps, oil and gas studies of Dickenson and Russell Counties, and a paper addressing mineral resources in comprehensive planning. Published during the year was a statistics report on coal, oil and gas, industrial and metallic mineral resources produced in the State for 1997; a report on clay deposits in Augusta and Rockbridge Counties; a report on the mining and processing by-product resources in Virginia; the history of brick production in the Albemarle County-City of Charlottesville area; and an article on the geology and history of the Civil War iron industry in the New River-Cripple Creek District of southwestern Virginia.

An ambitious program to digitize all previously published Division of Mineral Resources geologic maps is well underway, with nearly ninety percent of the maps in some stage of completion. The work is largely being done by college students under the supervision of Division geologists. In a separate program, plans are being made to scan all of the reports the Division has published since 1905. These will be made available as PDF files (Portable Document Format) on CD-ROM. Aside from the convenience of having all of our maps and reports available in digital form, previously out-of-print publications would be permanently available at the end of the project.

The Geologic Map of Virginia (1:500,000 scale) has been digitized and is in the final stages of editing. It will be issued on CD-ROM as a color raster image accompanied by digital vector data in a variety of standard formats (for example, ARC/INFO, ArcView, and AutoCAD). The digital Geologic Map of Virginia is also being prepared for presentation on the Internet as a set of interactive maps using MapGuide software.

The Division's oil and gas well database is currently being expanded to include historical production information. The Mineral Resources of Virginia database, which contains location and identification information on mines, quarries, and prospects, is being updated as field work is completed. Pilot projects to develop water-well databases are underway in four counties in an effort to establish the relationship between bedrock geology and well yields.

NEW PUBLICATION RELEASE

Publication 151. Coal, oil and gas, and industrial and metallic minerals industries in Virginia, 1997, by P. C. Sweet and J. E. Nolde, 25 pages, 16 figures, 12 tables, 1998.

Price: $8.50