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GEOCHEMICAL RECONNAISSANCE FOR GOLD IN THE CALEDONIA AND PENDLETON QUADRANGLES IN THE PIEDMONT OF CENTRAL VIRGINIA

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A study was made primarily for the purpose of evaluating geochemical methods that are best suited for finding or extending known gold deposits in Virginia. A secondary purpose was to relate the occurrence of gold to rock type and to suggest modes of origin of gold that might be useful in prospecting.

Gold is not currently produced in Virginia. It was produced, however, from a large number of mines from 1806 through the Second World War. The mines were confined to deposits in linear, northeastward-trending, mineralized belts within metavolcanic and metasedimentary rocks in the Piedmont physiographic province and in placers derived from those deposits. Associated with or close to the gold are stratiform, massive sulfide deposits, largely pyrite, but locally enriched by zinc, copper, and lead minerals. Little gold has been found in stratabound massive sulfides of the western Piedmont where the sulfide is mostly pyrrhotite.

Two areas within a gold-pyrite mineralized zone in central Virginia were selected for the study: a control area of about 20 abandoned gold mines in the Caledonia quadrangle, Fluvanna and Goochland counties, and an adjacent area of no mines in the southwestern portion of the Pendleton quadrangle, Louisa County (Figure 1).

The Caledonia 7.5-minute quadrangle is bounded by 78°00' and 78°07'30" west longitudes and 37°45' and 37°57'30" north latitudes. The Pendleton 7.5-minute quadrangle is bounded by 77°52'30" and 78°00' west longitudes and 37°52'30" and 38°00' north latitudes.

The area is a maturely dissected, gently rolling upland having elevations ranging from about 200 to 500

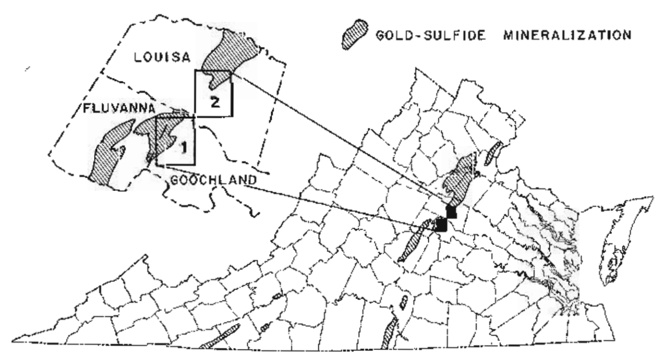

Figure 1. Index map showing location of the Caledonia (1) and Pendleton (2) quadrangles and gold-sulfide mineralization in the Piedmont province of Virginia.

feet (61 to 152 m) above sea level. In the uplands local relief is about 50 feet (15 m) and rarely 100 feet (30 m) above sea level. Along the South Anna River in the Pendleton quadrangle and Byrd Creek in the Caledonia quadrangle, entrenchment has formed rocky cliffs that are as much as 100 feet (30 m) high.

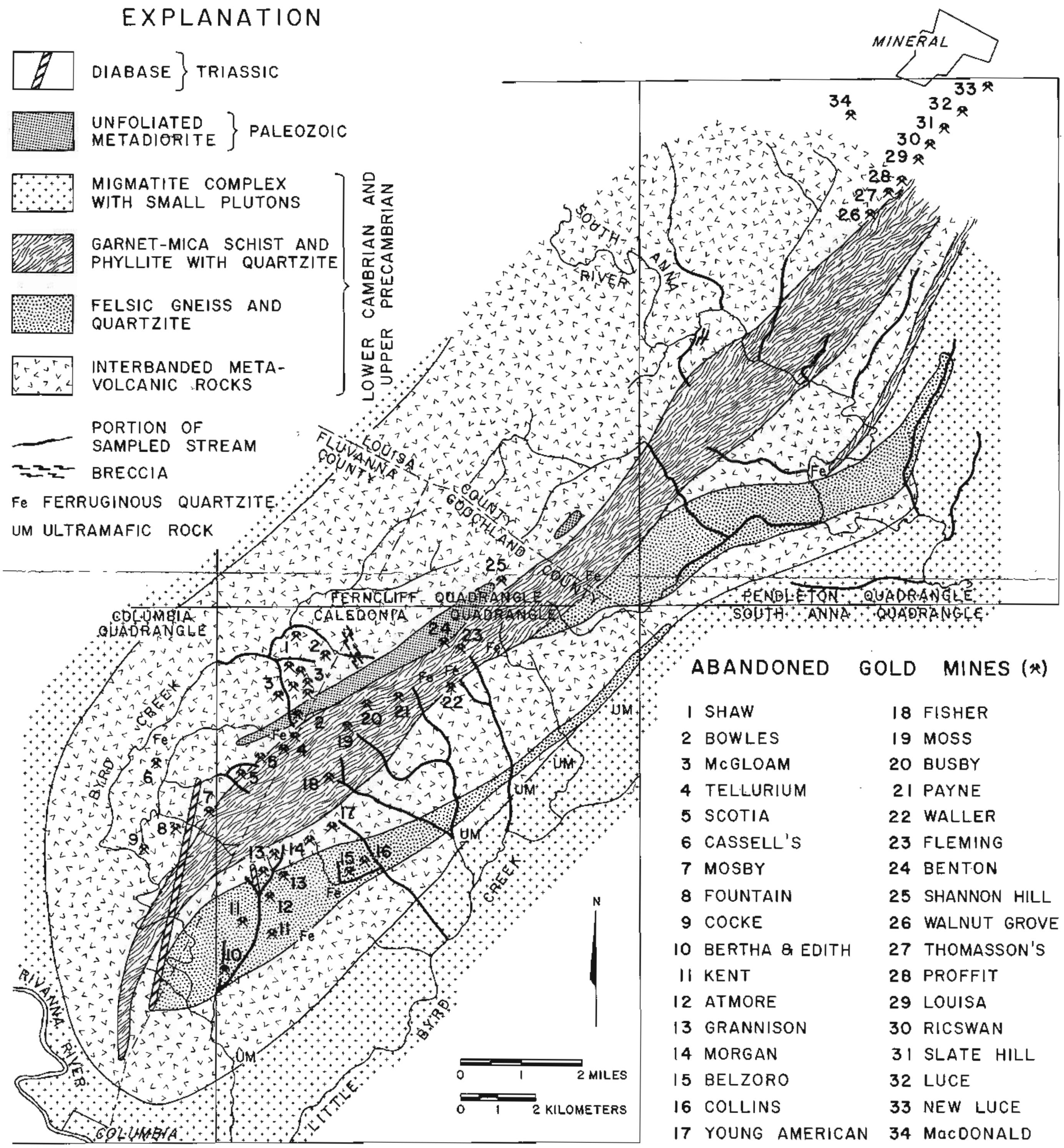

Figure 2. Generalized geologic map of parts of the Caledonia and Pendleton quadrangles and adjacent areas showing locations of abandoned gold mines and sampled streams.

Information concerning the histories, locations, and geology of gold mines in central Virginia can be obtained from Watson (1907), Taber (1913), Barton (1933), Park (1936), Pardee and Park (1948), Luttrell (1966), and Sweet (1971). Geologic mapping of Fluvanna County was done by Smith, Milici, and Greenberg (1964) and of Goochland County by Brown (1937). Lonsdale (1927) described the mines and geology of the mineralized gold-pyrite belts to the north of the study area. Poole (1974) summarized information on abandoned base-metal mines. A regional interpretation of geology, based largely on aeroradioactivity and magnetic data, was done for part of the Pendleton quadrangle by Neuschel (1970). A similar study was done by Conley and Johnson (1975) using roadcut outcrops, and aeroradioactivity, aeromagnetic, and ground-surveyed gravity for an area that includes the Caledonia and adjacent Columbia 7.5-minute quadrangles. Field work for this report was done from 1971 to 1973.

GEOLOGIC SETTING

The generalized geology of those parts of the Caledonia and Pendleton quadrangles that was studied is shown in Figure 2. The map was prepared from examination of bedrock exposed in the streams from which samples were obtained for gold analyses. Several rock outcrops were checked elsewhere but no attempt was made to map the area in detail.

The investigated area is underlain largely by metavolcanic and metasedimentary rocks of late Precambrian to Early Cambrian age. The major lithologic units that were sampled geochemically are interbanded metavolcanic rocks, garnet-mica schist and phyllite, and felsic gneiss (Figure 2). These rocks are bounded on the southeast and northwest by a migmatite complex.

The rock types of the interbanded metavolcanic unit are primarily greenstone, amphibolite, hornblende gneiss, felsite, and felsic gneiss. The rocks represent andesitic to basaltic flows and tuffs, and their reworked sediments, interlayered with lesser amounts of rhyolitic and dacitic flows and tuffs. Minor subvolcanic intrusive rocks (dikes, sills, and plugs) are also present.

Within the interbanded metavolcanic rocks is a belt of garnet-mica schist and phyllite with thin quartzite beds. The schist commonly contains both muscovite and biotite, and locally is characterized by staurolite, tourmaline, graphite, or chloritoid. The schist and phyllite interfinger with or grade into felsic gneiss (fine-grained or medium-grained biotite gneiss or biotite-muscovite gneiss) and enclose ferruginous quartzite and garnet-, kyanite-, and sillimanite-bearing quartzite. Large areas of predominantly felsic gneiss are present southeast of the schist and phyllite belt (Figure 2). Northwest of the schist and phyllite belt, small areas of interbanded felsic rocks have not been mapped separately from the interbedded metavolcanic rocks.

Other minor rock types include unfoliated metadiorite of Paleozioc age, diabase of Triassic age, and small ultramafic bodies. Except for these younger intrusive dikes or sills, all of the rocks of the interbanded metavolcanic, garnet-mica schist and phyllite, and felsic gneiss units show strong regional deformation with northeastward-trending foliation that has a dip mainly to the southeast. Metamorphic grade generally increases from the northwest to the southeast. Most of the rocks are in the amphibolite facies but some metavolcanic rocks of greenschist grade are exposed northwest of the schist and phyllite belt.

An area of mixed intrusive and metamorphic rocks that is grouped as a migmatite complex is exposed to the southeast and northwest of the metavolcanic unit. The metavolcanic rocks and felsic gneiss appear to grade into this zone of more intense metamorphism characterized by greater partial melting and local mobilization. The migmatite complex includes biotite granodiorite with epidote, coarse biotite gneiss with pink microcline pegmatite, alaskite, biotite augen gneiss, diorite, amphibolite, and hornblende gneiss with comformable pegmatoid layers. Some interbanding similar to that of the metavolcanic unit is present, but there are also areas of agmatites, nebulites, and refractory relicts.

The migmatite complex and interbanded metavolcanic units of this report are similar to the Hatcher Complex of Brown (1969) to the southwest. Fullagar (1971) dated the Hatcher Complex by Rb-Sr at 595 million years. Because the granodiorite of the migmatite complex is conformably interlayered with amphibolite of the interbanded metavolcanic unit west of Columbia, at least some of the metavolcanic rocks are believed to be Cambrian or late Precambrian in age.

In mapping the geology of Fluvanna County, Smith, Milici, and Greenberg (1964) considered the mica schist and quartzite northeast of Columbia to form the core of a syncline. The rocks were thought to be higher grade equivalents of Ordovician slate in the Arvonia syncline located about 6 miles (10 km) west of Columbia, and the schist and quartzite were mapped as the Bremo Member of the Arvonia Formation. Foliation data in this study (Figure 2) are consistent with a synform northeast of Columbia, but other folds are apparent farther to the northeast. If the garnet-mica schist and phyllite unit is younger than the metavolcanic rock unit, the major structure in the Caledonia quadrangle is a syncline overturned to the northwest. If the mica schist and phyllite unit is not younger, another interpretation, such as the presence of an anticlinal recumbent nappe, is possible.

The mafic and intermediate portions of the interbanded metavolcanic rock unit and certain layers of the mica schist and phyllite unit contain abundant accessory magnetite (1 to 5 percent). The rocks therefore show a characteristic magnetic pattern that is traceable into northern Virginia (Pavlides and others, 1974) where rocks similar to those of the Caledonia and Pendleton quadrangles have been mapped as the Chopawamsic Formation (Southwick, Reed, and Mixon, 1971). Granodiorite intruding metavolcanic rocks north of Fredericksburg in the Quantico syncline has been dated by zircons at 560 million years (Seiders and others, 1975). Thus, there is evidence to suggest a continuous belt of volcanic rocks of similar age and lithology.

SOILS

Deep weathering has destroyed most surface float other than quartz, and bedrock outcrop is almost entirely absent except in stream beds. The soil and saprolite cover ranges from a few inches to 100 feet (30 m) in thickness (Smith, Milici, and Greenberg, 1964). Much of the area is covered by mature, residual soil types commonly showing three-layer zoning. Bottom lands, steep upland slopes, and forest swamps lack this development. Where present, the A layer is typically light yellowish brown silt-loam or sandy loam. The B layer is dark red, yellowish red, or yellowish brown and is clay rich (Porter and others, 1958). The boundary between the A and B layers generally ranges from 5 to 16 inches (13 to 40 cm) below the surface.

Soil color is apt to be misleading as a guide to bedrock lithology because of modification by drainage, topography, and vegetation. However, in nearly level areas of residual soil, the heavy mineral content was of some use in identifying bedrock lithology. For example, in addition to creek-bed exposures and aeromagnetic data, nonopaque heavy minerals in soils and stream sediments helped to delineate the metadiorite body. Soil covering the metadiorite contains actinolite and little or none of the bluish-green hornblende characteristic of the metavolcanic rocks. Commonly, the nonopaque heavy mineral suites in soil over the mica schist and phyllite unit is characterized by flood amounts of garnet and staurolite and locally by tourmaline and kyanite. Soil over the interbanded metavolcanic rocks reflects the heavy minerals of the greenstone, amphibolite, and hornblende gneiss: bluish-green hornblende, actinolite, epidote, and generally garnet. Soil over the granodiorite facies of the migmatite complex contains largely epidote and some hydrobiotite.

The heavy mineral fractions of stream sediments also were found to accurately reflect bedrock lithology. Large amounts of zoisite and clinozoisite were identified in Horsepen Creek sediment where the stream flows over the metadiorite body.

Gahnite (zinc spinel) was noted in heavy mineral suites from streams in the vicinity of the Grannison and Bertha and Edith mines. This mineral is known to be associated with massive sulfides in the Mineral area (Dietrich, 1970, p. 263) and may be an indicator of the presence of sulfides in the vicinity of the gold mines.

CHARACTERISTICS OF THE GOLD DEPOSITS

The utimate source of all the gold profitably mined in the Caledonia quadrangle has been attributed to quartz veins containing the free metal or gold-bearing sulfides. According to previous descriptions (Taber, 1913; Lonsdale, 1927; Park, 1936; Pardee and Park, 1948) the gold-bearing quartz veins had the following characteristics:

Shape: tabular, lens shaped, sheetlike, podiform, or rarely cigar shaped.

Thickness: paper thin to 6 feet (2 m) averaging 1 to 3 feet (0.3-1 m).

Pattern: discontinuous, pinch and swell, en echelon, parallel, or confined to well-defined zones.

Size of zones: 50 to 200 feet (15 to 61 m) wide and from 1,000 to 10,000 feet (305 to 3,048 m) long.

Trend and dip: northeasterly trend and southeasterly dip (25-60°).

Relation to host rock: generally conformable; small veinlets may show crosscutting relationships with quartzite and mica schist; no evidence of vugs or open fissure filling.

Host rock: garnet-mica schist, interbanded mafic and felsic gneiss, quartzite, ferruginous quartzite.

Ore mineralogy: native gold; small amount of gold-bearing pyrite or chalcopyrite.

Gangue mineralogy: sericite, chlorite, calcite, ankerite.

Uncommon vein minerals: galena, sphalerite, tetradymite, pyromorphite, vanadinite (Moss mine); sphalerite, tetradymite, selenium, silver (Tellurium mine); pyrite, biotite (Waller mine); sphalerite, tetradymite (Young American mine).

Color of quartz veins: white, pink, reddish brown, or rose at surface; light gray or rarely bluish gray below water table; veins may show dark-brown or red stains from iron oxides or yellow or yellowish-white crusts from iron sulfates. Microscopic vacuoles and inclusions are thought to affect color.

Distribution of gold values in veins: highly erratic, rich

sections (shoots) may change abruptly to barren quartz.
Halos around veins: disseminated pyrite up to 100 feet (30 m) around veins but gold values not economic.
Fineness of gold: 850 to 900 (85 to 90 percent pure).

The barren quartz veins consist mainly of white "bull" quartz or glassy quartz and are as much as 20 feet (6 m) thick. Barren veins show crosscutting relationships with both gold-bearing quartz veins and country rock.

Most early mining consisted of hydraulic work on eluvial ore from pits or trenches in saprolite, soil, and stream gravel. Work was done on the free-milling gold until leaner sulfides, mainly pyrite and chalcopyrite in quartz, were encountered below the water table where mining stopped. The depth to the water table generally ranged from 25 to 50 feet (8 to 15 m). Hydraulic mining was done at the Atmore, Belzoro, Bertha and Edith, Bowles, Collins, Fleming, Grannison, Kent, Morgan, and Shannon Hill mines. In the latter part of the 1800's most of the work shifted to underground mining of lode deposits, although attempts were made to work placer gold in the 1930's at the Collins and Bertha and Edith properties. Vein gold was worked at Belzoro, Bertha and Edith, Bowles, Fleming, Grannison, and Shannon Hill. There is scant assay information but previous studies (Taber, 1913; Park, 1936; Pardee and Park, 1948) suggest that the Tellurium mine had some of the richest veins, averaging 119 ppm during the years 1832-1846. In the 1800's the Moss mine vein averaged 24 ppm gold and 3.3 ppm in the tailings; in 1936 the vein averaged 19 ppm. The Young American property had an 8.1 ppm average for the surface and 16.5 ppm for the "House" vein. Assays of the "Sulfur" vein range from 1.6 to 13 ppm with local rich shoots containing as much as 82 ppm.

METHODS AND ANALYTICAL RESULTS

Gold is one of the most difficult elements to analyze because it is rarely uniformly distributed and tends to occur in discrete particles. In soils or stream sediments these particles readily separate because of their high specific gravity. Thus, small samples of soils or sediments are likely to give erratic or misleading results (Fischer and Fisher, 1968: Clifton and others, 1969; Brown and Hilchey, 1974).

Several sampling techniques were applied to the mineralized control area in the Caledonia quadrangle: (1) vegetation (leaf ash); (2) forest mull (decomposed leaves, pine needles, or humus); (3) soil from a depth of 1.5 feet (0.5 m); (4) stream sediment from gravel bars and sandbars sieved to -10 mesh (less than 2.0 mm), and (5) heavy mineral concentrates panned from sieved stream sediment.

For reconnaissance exploration, analysis of panned heavy mineral concentrates proved to be the best method for delineating relatively strongly mineralized, weakly mineralized, and unmineralized areas. Samples were taken at 1000-foot (305-m) intervals along first-, second-, and third-order streams. The samples were collected at one or more places where heavy minerals are apt to accumulate, such as at the head or foot of gravel bars. Enough sediment was wet sieved at the site through a 2.0-mm stainless-steel screen to fill two heaping gold pans 16 inches (40 cm) in diameter. Each sieved sample weighed approximately 20 pounds (9 kg) dry. Panning was done to a point where the concentrate contained about one-half heavy minerals by weight. The amount of concentrate varied according to composition of the bedrock, generally ranging from 5 to 900 grams. Areas underlain by mica schist, phyllite, and quartzite had low yields of heavy minerals whereas areas of hornblende gneiss and amphibolite had the highest amounts of concentrate. The results show that in spite of large differences in the amounts of panned concentrates, the heavy to light mineral ratios of the concentrates do not vary significantly.

Ten grams of the panned concentrates were treated for analysis by the technique of Thompson, Nakagawa, and VanSickle (1968) and analyzed by atomic absorption spectrophotometry. The average concentration of gold in most unmineralized igneous and metamorphic rocks in less than 0.02 ppm, the minimum detection limit of the atomic absorption technique (Jones, 1969; Gottfried, Rowe, and Tilling, 1972; Wolfe, 1975). During this study it was found that gold values in soils, stream sediments, and panned concentrates from unmineralized areas were also below this value. The amount of gold in panned concentrates, however, was high enough so that values in samples from mineralized areas were well above the detection limit. Use of soils or unpanned stream sediments for reconnaissance exploration would require a more sensitive analytical technique.

Analysis of unpanned stream sediments proved not to be as useful as the analysis of panned concentrates. Samples of both were collected from identical sites at 200-foot (61-m) intervals along streams draining the Grannison, Atmore, and Kent mines. Most of the unpanned samples, even those collected very close to known deposits, showed no detectable gold.

Soil sampling applied on a reconnaissance basis — at quarter-mile intervals — outlined the mineralization in the same area somewhat better. Eleven of the 12 samples in which gold was detected were collected in the vicinity of known deposits (Figure 3).

A soil traverse was made across part of the workings of the Tellurium mine (Figures 4, 5). Samples of soil from a depth of 1.5 feet (0.5 m) and surface humus were collected every 200 feet (61 m) along a 2-mile northwest-southeast line. Only four of the humus samples and four of the soil samples contained detectable gold. The highest values (0.29 ppm in humus, 0.42 ppm in soil) were found 200 feet (61 m) northwest of one of the shafts.

In order to check for variations in gold values between sample locations, the same traverse was repeated for soils at slightly different sample sites — about a meter away. This time the anomalous soil sample was at 400 feet (122 m) northwest of the shaft and had a value of 3.1 ppm.

The pathfinder elements arsenic, mercury, and copper were also determined in the soil samples but did not show any unusual concentration at or near the shaft area. One arsenic anomaly (160 ppm versus a background of less than 10 ppm) (Figure 4) and a slight mercury high (0.06 ppm) were noted 1,800 feet (549 m) southeast of the shaft suggesting a possible occurrence of sulfides. Copper ranged from 14 to 85 ppm.

In spite of the resistance of gold to weathering, small amounts are known to go into solution and migrate (Kinkel and LeSure, 1968; Lakin, Curtin, and Hubert, 1974). Gold may be absorbed in limonite or even enter into a plant's vascular system (Warren and Delavault,

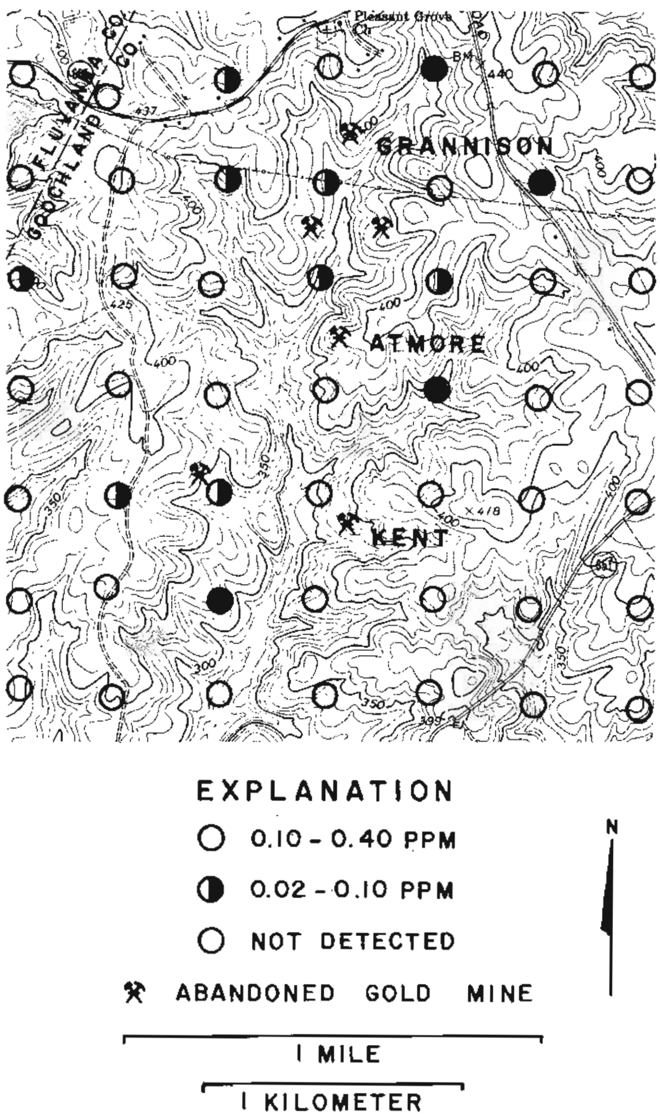

Figure 3. Gold in soil from the vicinity of the abandoned Grannison, Atmore, and Kent mines.

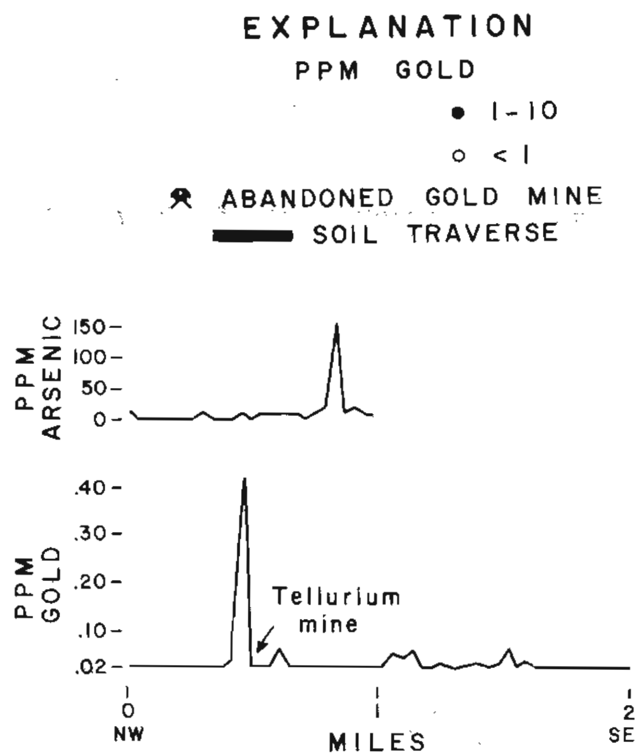

Figure 4. Gold and arsenic values along a soil traverse near the abandoned Tellurium mine, Caledonia quadrangle.

1950; Foss, 1970). Some trees offer an advantage over soil sampling because of their deep root systems. Leaves collected in June from trees growing near the Tellurium mine shaft showed gold values in ash from 0.04-0.07 ppm. Trees sampled were *Quercus alba* (white oak), *Liquidambar styraciflua* (sweet gum), and *Acer rubra* (red maple). Five hundred leaves were collected for each sample that, after drying, weighed from 222 to 329 grams before ashing. Further work is needed to evaluate the leaf-ash technqiue in Virginia.

GEOCHEMICAL RESULTS

Figures 5 and 6 show the gold values of panned concentrates from streams in the Pendleton and Caledonia quadrangles. Panned gold values from the Caledonia quadrangle plotted as group averages show a logarithmic decrease with distance from known mineralization (Figure 7). In the immediate vicinity of a mine, values of greater than 100 ppm are common. Values generally range from 10 to 100 ppm up to a mile downstream, and from 1 to 10 ppm between 1 and 2 miles (1.6 and 3 km) downstream. At distances of more than 2 miles (3 km), most gold values are less than 1 ppm or are not detectable. *It is not known what effect previous mining has had on the distribution of gold.*

In the Pendleton quadrangle more than half of the

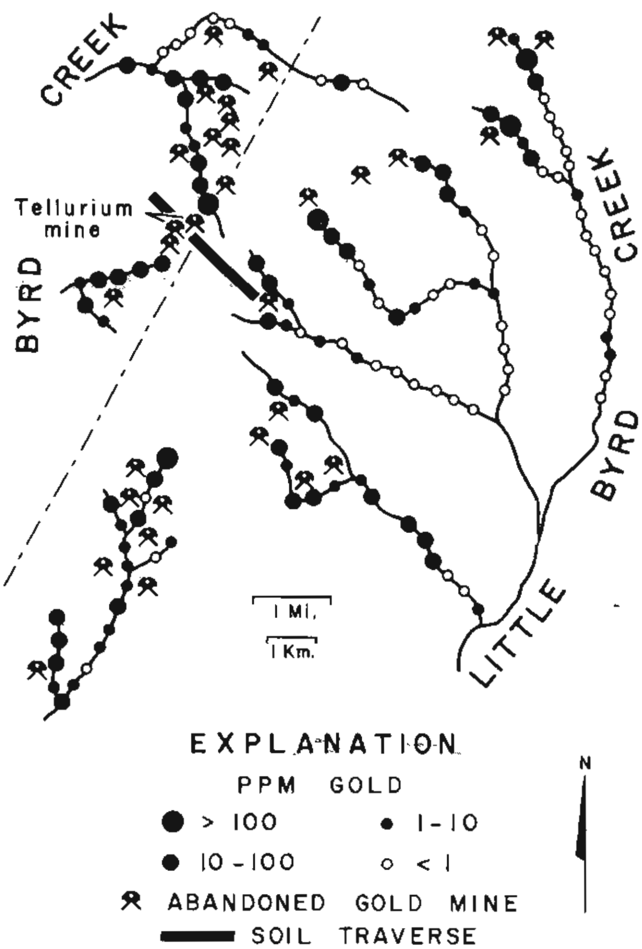

Figure 5. Gold in panned concentrates from streams draining abandoned gold mines in the Caledonia quadrangle.

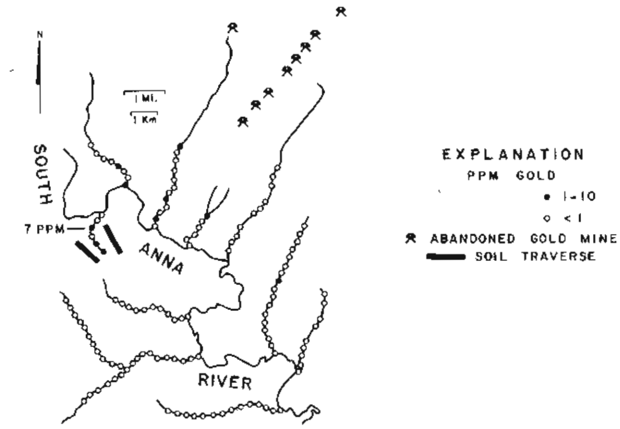

Figure 6. Gold in panned concentrates from streams in the area of no known mineralization in the Pendleton quadrangle.

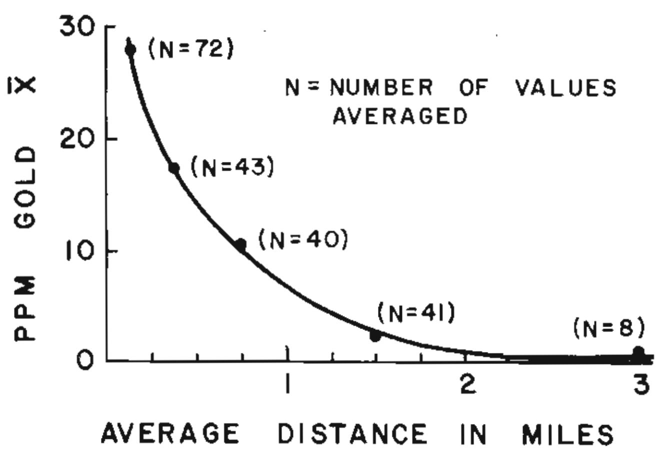

Figure 7. Gold values as a function of distance from known mineralization in the Caledonia quadrangle.

122 panned concentrates contained no detectable gold, and only 10 samples had more than 1 ppm. Nine of these 10 samples are on strike with old gold and pyrite mines in the northeastern part of the quadrangle. Somewhat farther to the northeast, near Mineral, new occurrences of stratiform massive pyrite deposits containing zinc, lead, and copper sulfides have recently been discovered (Hodder, Kazda, and Bojtos, 1977).

The highest gold value in the Pendleton quadrangle was 7 ppm. This sample was from a stream near Yanceyville from which two other samples contained more than 1 ppm gold. Further sampling by two soil traverses on either side of the stream showed only two samples (0.04 and 0.07 ppm) with detectable gold. Analysis for arsenic and mercury in the soils along the two traverses did not reveal any anomalies.

GUIDES FOR EXPLORATION

The close association of "epithermal" gold-bearing quartz veins with zones of stratiform pyrite bodies has long been recognized. The chemical stability of gold in a deeply weathered environment makes it useful as a pathfinder element for such deposits. In the gold-pyrite belt of Virginia exploration efforts have been focused on finding new Au-Ag-Pb-Zn-Cu-bearing, stratiform sulfide bodies rather than on finding gold itself.

All the gold occurrences in this study are enclosed within mafic to intermediate metavolcanic rocks interbanded with rhyodacitic members, or in mica schists, quartzites, or felsic gneiss. Within the metavolcanic unit are preserved such features as delicate laminae, graded bedding, amygdaloidal bands, porphyritic felsites, pyroclastic and autoclastic breccia, and ovoidal epidosite masses. Thin ferruginous quartzites are commonly found in or near the gold deposits and were noted by Taber (1913) at the Busby, Cassell's, Payne, Scotia, Tellurium, Waller, and Young American mines, and at several other places during field work for this study. Ferruginous quartzites have also been noted to the southwest of the area of investigation in the vicinity of gold- and copper-bearing massive pyrite (Brown, 1969, p. 65; Espenshade and Potter, 1960, p. 40) and to the northeast of the Pendleton quadrangle in the massive sulfides near Mineral (Hodder, Kazda, and Bojtos, 1977).

In known volcanic sequences elsewhere ferruginous quartzites (or banded-iron formations) occur at or near the top or on the flanks of volcanic centers or fissures in areas containing gold and stratiform massive sulfides ranging in age from early Precambrian to Holocene (Goodwin and Schlanka, 1967; Matsukuma and Horikoshi, 1970; Hutchinson, 1973; Fripp, 1976).

Volcanigenic deposits of gold or massive sulfides (chemical sediment or brines) are formed at or close to the surface, either on the ocean floor or less commonly on land, at about the same time as volcanic flows, ash, or sediments are being deposited. In New Zealand ore-grade (80 ppm) gold is forming at the surface in siliceous hot-spring precipitates from volcanic rocks (Weissburg, 1969). In the New Zealand deposits banded iron-bearing siliceous sinter is also forming, with base metals only depositing at depth. Worthington and Kiff (1970) proposed a volcanic origin for some of the gold deposits of the Carolina slate belt. Good, Fordham, and Halladay (1973, 1974) suggested a volcanigenic island-arc setting close to a welded plate boundary for the Caledonia quadrangle gold deposits. Most recently, as a result of considerable underground exploration on the Cofer property near Mineral, Hodder, Kazda, and Bojtos (1977) have interpreted the stratabound Au-Ag-Pb-Zn-Cu-sulfide mineralization in massive pyrite with some pyrrhotite as having resulted from chemical sediment deposited in a marine basin during a transition from basaltic and rhyolitic volcanism to volcaniclastic and marine sedimention.

Exploration for gold is clearly tied to the search for associated base-metal sulfides and to understanding and applying newer concepts in the relation between ore genesis and volcanism and their relation to plate tectonics (Kinkel, 1966; Tatsumi, 1970; Sawkins, 1972; Derry, 1973; Hutchinson, 1973; Brown, 1976; Gair, 1976; Strong, 1976; Rankin, 1976). Favorable areas for gold and base metals in the Virginia Piedmont are localities with (1) iron, manganese, or barite deposits in metavolcanic rocks; (2) contact zones of mica schist and quartzite with interbanded metavolcanic rocks; (3) abundant felsic metavolcanic rocks; (4) ferruginous quartzite beds; (5) gahnite in bedrock or stream sediment; (6) barite in stream sediment; (7) pyrite in stream sediment; (8) autobreccia; (9) unusually high copper, lead, zinc, or arsenic in the soil or stream sediment, and (10) airborne electromagnetic and other geophysical anomalies. The best guide for gold itself is the chemical analysis for the element in the above target areas.

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NEW TOPOGRAPHIC MAP PRODUCTS

Virginia was chosen by the U.S. Geological Survey as the first State to have a new and enlarged index and catalog of topographic maps. This new format is designed to meet the growing need to better advise users of available maps and map products. The index map shows the location of the 805 detailed 1:24,000-scale maps as well as the "birds-eye" 1:250,000-scale series, the State 1:500,000 series, and regional 1:1,000,000 and 1:2,000,000 series. Interstate and U.S. Highway routes are indicated to aid in identifying detailed maps that are needed. To accompany the index is "The Catalog of Published Virginia Maps," which lists available maps by name, survey date, revision date, and scale. Printed orthophotoquads are also listed. Map dealers and reference libraries are indicated. The index is available free from the Division of Mineral Resources, Box 3667, Charlottesville, VA 22903. The catalog can be obtained free from Branch of Distribution, U.S. Geological Survey, 1200 South Eads St., Arlington, VA 22202.

Within an experimental program to determine user's needs for folded topographic maps the following Virginia 1:24,000-scale maps are available: Harpers Ferry Va./Md./W.Va.; Vienna, Va./Md.; Waynesboro East, Va. These maps are folded and packaged in mulitcolor 5½ inch x 8 inch plastic jackets. Maps in this form will fit into either a hip pocket, jacket pocket, or carrying bag; will be protected from rain; and can be folded so that points of interest can be easily seen. A portion of the Shenandoah National Park with overlooks and trails is depicted on Waynesboro East while Vienna shows the town of Reston, many lakes, Wolf Trap Farm Park, and part of the urbanized area of Vienna. The Harpers Ferry map has a long stretch of the Potomac River, Harpers Ferry National Historical Park, and a portion of the Appalachian Trail. All of these packaged maps can be obtained from the Division for $1.30 each ($1.25 plus $0.05 State sales tax).

From that portion of Virginia between Radford and Cumberland Gap 105 quadrangles have been selected to be photorevised from cultural changes shown on Spring 1976 aerial mapping photos. As these revised maps will show new features in purple, the extent and type of growth can easily be seen. Maps of the cities of Bristol, Galax, Norton, and Radford; the Mt. Rogers National Recreational Area; Grayson-Highlands and Natural Tunnel state parks; Clinch Mountain Wildlife Management Area; and coal-rich areas are scheduled for revision. A complete listing of these maps being revised is available on request; their positions are shown on the index map on the back page of this issue of *Virginia Minerals.*

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GEOPHYSICAL MAPS AVAILABLE

The following aeromagnetic and aeroradioactivity maps are now available in addition to those listed in the Division's 1977 "List of Publications" and in the February 1977 issue of *Virginia Minerals.*

(1) Eight aeromagnetic contour maps of Virginia at the scale of 1:250,000. They are composites of aeromagnetic maps of all previously available 15-minute quadrangles (scale, 1:62,500) that have been released by the Division (see pages 18-19 of the 1977 "List of Publications"). The composites are available *only* as mylar copies at the prices shown in the explanation of the accompanying index map. Ozalid copies of the composites are not available due to poor reproduction resulting from the great amount of detail on the maps.

(2) Mylar copies of individual quadrangles of all 15-minute aeromagnetic contour maps (scale, 1:62,500) that are listed on pages 18-19 in the 1977 "List of Publications" are now available for $10.00 each.

(3) Mylar copies of individual quadrangles of all 15-minute aeroradiometric maps (scale, 1:62,500) that are listed on page 21 in the 1977 "List of Publications" and in the February 1977 *Virginia Minerals* are now available for $10.00 each.

(4) Mylar copies for the composite 1:250,000-scale 1975 aeroradiometric contour map of east-central Virginia and the 1976 aeroradiometric contour map of central Virginia are available for $15.00 each. See page 11 in the February 1977 *Virginia Minerals* for the areas covered by these maps. As noted in that issue, ozalid prints of the composites are available for $10.00 each.

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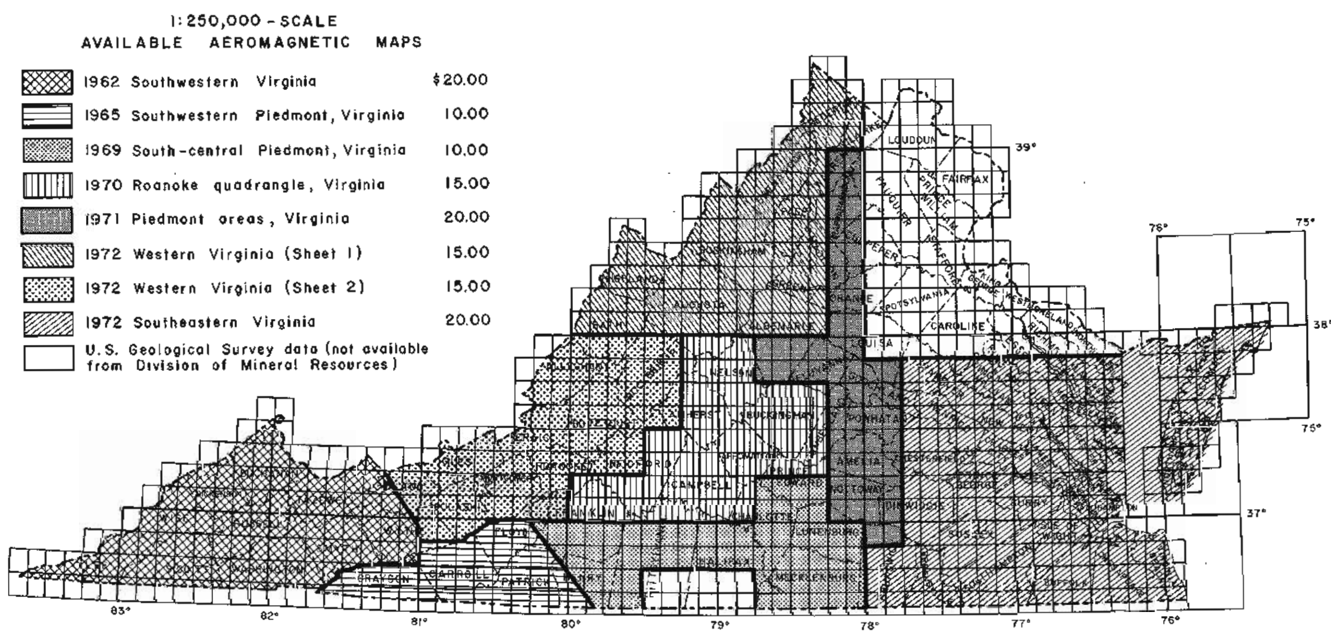

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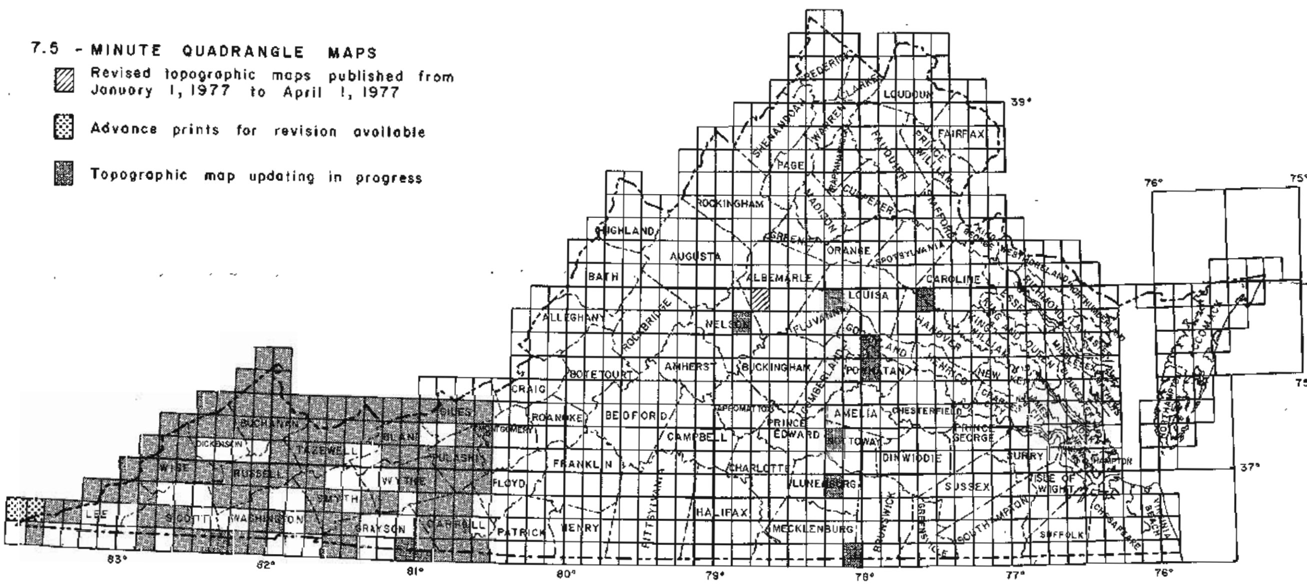

Revised 7.5-minute quadrangle maps published from January 1 to April 1, 1977:

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Advance prints are available at $1.25 each from the Eastern Mapping Center, Topographic Division, U. S. Geological Survey, Reston, Virginia 22092.

PUBLISHED TOPOGRAPHIC MAPS

Total State coverage completed; index is available free. Updated photorevised maps, on which recent cultural changes are indicated, are now available for certain areas of industrial, residential, or commercial growth. Published maps for all of Virginia are available at $1.25 each (plus 4 percent State sales tax for Virginia residents) from the Virginia Division of Mineral Resources, Box 3667, Charlottesville, Virginia 22903.