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# Distribution of antimony, arsenic, bismuth, and cadmium in heavy-mineral-concentrate samples from the Charlotte 1° x 2° quadrangle, North Carolina and South Carolina

by

W. R. Griffitts, J. W. Whitlow, K. A. Duttweiler,

D. F. Siems, and L. O. Wilch

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This map is a product of a geochemical survey of Charlotte 1° x 2° quadrangle, North Carolina and South Carolina, beginning in 1978 that is part of a multidisciplinary study to determine the mineral potential of the area. Correlative studies are the completion of a geologic map of the quadrangle and aeromagnetic, aeroradiation, and gravity surveys (Wilson and Daniels, 1980).

The Charlotte quadrangle provides a nearly complete section across the Piedmont: its northwestern corner is in the Blue Ridge, its southwestern corner is over a basin of Triassic sedimentary rocks only a few miles from the Coastal Plain. All of the quadrangle except the southeastern corner is underlain by crystalline rocks of Precambrian and Paleozoic age metamorphosed to greenschist facies in the Slate Belt and to amphibolite facies farther west. Both premetamorphic and post metamorphic intrusive rocks are present. The rocks have been weathered to permeable saprolite reaching depths of 200 feet (60 meters) in the Inner Piedmont. Because of the thorough leaching, the prevalent soils are acidic.

In making the geochemical survey, we took samples of sediment within a few miles of the heads of major streams and of the tributaries of these streams. By keeping the size of the drainage basin small we usually reduce the variety of rocks that contribute detritus to the sample, thus facilitating a correlation between sample composition and the geology of the drainage basin. At the same time we reduce the chance that a localized cloudburst has buried the sample site with sediment from a small part of the drainage basin, thus reducing the validity of the sample as an approximate composite of the rocks of the whole basin. Nevertheless, the samples are not all geologically and geochemically identical. For instance, at some sites in the mountainous area in the northwestern part of the quadrangle, many clasts in the stream sediment are several yards (meters) across and collection of fine detritus suitable for a sample required a 1/2-hour search. Not far to the east, the finer sediment was abundant. In the Piedmont, the usual procedure was to sample rather coarse sediment, pebble- or cobble-containing gravel, and to dig deeply to the bottom of the alluvial bed or to a compact clay layer. The coarsest particles--boulders, cobbles, and coarse pebbles--were excluded from the sample which consisted of about 10 lbs (4 1/2 kg) of clay to granule or fine gravel sized material. The heavy minerals were extracted from this material at the sample site with a gold pan. The concentrates were passed through a 20-mesh sieve to remove large grains that would choke equipment used in subsequent laboratory operations. Samples taken in the same manner on earlier projects were also used to get better coverage of the Inner Piedmont than we would have had otherwise.

The quartz, feldspar, and other minerals of specific gravity below 2.89 were removed from the pan concentrate by floating them with bromoform. The cleaned heavy-mineral concentrate was then separated magnetically into four fractions. The first was removed with a hand magnet, or an equivalent instrument, and not studied. The remaining concentrate was passed through a Frantz Isodynamic Separator at successive current settings of 0.5 ampere and 1 ampere with 15° side slope and 25° forward slope. The material removed from the sample at 0.5 ampere and 1 ampere will be referred to as the M.5 and M1 concentrates or fractions, respectively, and the nonmagnetic material at 1 ampere will be referred to as the NM concentrate or fraction. Most common ore minerals occur primarily in the NM fraction, making them and their contained metals easier to find and to identify. The NM fraction also contains zircon, sillimanite, kyanite, spinel, apatite, sphene, and the $TiO_2$ minerals. It is generally the most useful fraction. The M1 fraction is largely monazite in the Inner Piedmont. Because of interferences caused by cerium during spectrographic analysis and the high content of radiogenic lead in the monazite, it was necessary to remove it from the bulk concentrates. East of the Inner Piedmont the M1 concentrate contained very abundant epidote, clinozoisite, mixed mineral grains, including ilmenite partly converted to leucoxene, staurolite, and locally abundant spinel. The M.5 concentrate contains abundant garnet in the Inner Piedmont, dark ferromagnesian minerals in the Charlotte Belt, and ilmenite in most provinces.

Mineral proportions of each magnetic fraction were estimated using a binocular microscope. Minerals of special interest were identified optically or by X-ray diffraction.

Each sample was analyzed semiquantitatively for 31 elements using a six-step, D.C. arc, optical-emission spectrographic method (Grimes and Marranzino, 1968). The semiquantitative spectrographic values are reported as one of six steps per order of magnitude (1, 0.7, 0.5, 0.3, 0.2, 0.15, and multiples of 10 of these numbers) and the values are the approximate geometric midpoints of the concentration ranges. The precision of the method has been shown to be within one adjoining reporting interval on each side of the reported values 83 percent of the time and within two adjoining intervals on each side of the reported value 96 percent of the time (Motooka and Grimes, 1976).

The lower limits of spectrographic determination for the elements that are mentioned in this report are as follows, in parts per million: titanium, 0.005; antimony, 200; arsenic, 500; bismuth, 20; cadmium, 50; cobalt, 10; copper, 10; gold, 20; tin, 20; yttrium, 20; and zinc, 500.

Most samples were taken by J. W. Whitlow and W. R. Griffitts. Lesser numbers were taken by D. F. Siems, A. L. Meier, and K. A. Duttweiler. The mineral analyses were made by W. R. Griffitts, K. A. Duttweiler, J. W. Whitlow, and C. L. Bigelow, with special mineral determinations by Theodore Botinelly. All spectrographic analyses were made by D. F. Siems, in part from plates prepared by K. A. Duttweiler. Steve McDanal and Christine McDougal were responsible for entering and cleaning up the spectrographic data in the RASS computer file. Many maps were subsequently plotted from this file by H. V. Alminas, L. O. Wilch, and J. D. Hoffman. Most mineral distribution maps were plotted by K. A. Duttweiler.

Antimony, arsenic, bismuth, and cadmium are found as accessary elements in many deposits of base and precious metals, but are the principal products of few mines. They can be useful in mineral exploration as aids in delimiting mineralized districts and in predicting mineral assemblages in unknown mineral deposits. All 4 metals are used in modern society, so artificial additions to stream sediments should be expected. Antimony has been used extensively in fire-retarding treatment of wood, in type metal, paint pigments, and to harden lead for shot. Arsenic also is used in paint pigment and shot and also has been used for many decades in the Piedmont as an insecticide. Bismuth is used medicinally and to make metal alloys with low-melting points. Cadmium is a component of some silver solders and has been used to plate other metals.

Nonetheless, in spite of widespread use of the metals, we have little evidence that artifacts contributed significantly to the metal contents of our analyzed samples.

We recognized no minerals containing these metals in our samples.

Antimony, found in 9 samples, is most common in the Carolina Slate Belt and in the Gold Hill fault zone that bounds it to the west. Antimony is in or near areas with gold, but only 2 samples contain both gold and antimony; one of those is in a mineralized area near the western edge of the King's Mountain Belt southeast of Blacksburg, S.C.

Arsenic was detected in 14 samples in a large mineralized area in the southern half of the quadrangle. The broad association with gold in this area is not combined with a common association in individual samples, only 6 of which contain both gold and detectable arsenic. Other ore metals are even less common in arsenical samples. Zinc was found in 3 samples, copper in 2, and bismuth and cadmium in one sample each. Only 2 arsenical samples contained lead artifacts, so contamination by hardened lead shot is not important, and there is no indication of contamination by arsenical insecticides. Arsenic thus may indicate broad mineralized areas, but not necessarily strongly mineralized parts of those areas.

Bismuth is far more commonly found than arsenic and is markedly concentrated in the tin-spodumene belt where it is closely associated with tin. To illustrate this association in that belt, 31 samples with detectable bismuth contain at least 1,000 ppm tin, 3 samples have 500 to 700 ppm tin, 2 samples have 20 to 100 ppm tin, and only 4 samples have less than 20 ppm tin, the limit of detection. No bismuth mineral has been reported from the spodumene deposits; the bismuth may be a component of cassiterite or of a bismuth mineral that is so weathered as to have escaped recognition. Bismuth is also commonly associated with tin in the Inner Piedmont, inasmuch as tin was found in 4 of the 6 bismuth-bearing samples collected in that province. Thus, bismuth was a persistent participant in the tin mineralization of the southwestern part of the quadrangle.

The tin districts related to granite plutons in the northwestern part of the quadrangle and south of Salisbury, N.C., did not yield samples containing detectable bismuth.

Bismuth was not an important part of other types of mineralization. Only one sample from the South Mountain gold district contained detectable bismuth; it also contained tin, and 7 of the 27 bismuth-bearing samples collected in the Charlotte Belt and Carolina Slate Belt contain gold. Thus, bismuth is sporadically present in base- and precious-metal districts.

Cadmium, like bismuth, is sporadically present in places in the auriferous parts of the Charlotte and Carolina Slate Belts. It is widespread in the Carolina Slate Belt, but is found in the Charlotte Belt only near its southeastern boundary. A cluster of cadmium sites marks the minerlized district in the northeastern corner of the quadrangle, where cadmium was found in all zinc-rich samples.

## References


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