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Distribution of lead and artifacts in heavy-mineral-concentrate samples from the Charlotte 1° x 2° quadrangle, North Carolina and South Carolina

by

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This map is a product of a geochemical survey of Charlotte 1° x 2° quadrangle, North Carolina and South Carolina, begun 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). Inasmuch as lead is by far the most widespread metallic contaminant, we include a discussion of contamination in this lead report.

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, most 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 equivalent. 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 in the gravel--boulders, cobbles, and coarse pebbles--were excluded from the sample, which then 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 heavy-mineral concentrate cleaned in that way 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 mainly in the NM fraction, making them and their contained metals easier to find and to identify. The NM fraction also 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 in each magnetic fraction were estimated using a binocular microscope. Minerals of special interest were identified optically or by X-ray diffraction.

Each fraction 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).

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 T. 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.

Lead minerals are not common in the heavy-mineral concentrate. Cerussite forms white rind on lead artifacts and has been found as discrete grains, not apparently related to artifacts, near the northwestern corner of the quadrangle and in several places in the central part. Pyromorphite was found in one place near the north-central quadrangle boundary in coarse, natural grains. Red flakes of litharge were found near Matthews and plattnerite was found with cerussite south of Hickory.

The most important feature in the lead geochemistry in the Charlotte quadrangle is the high content of radiogenic lead in heavy-mineral concentrates from the Inner Piedmont and Blue Ridge. This results from the high thorium content of monazite in which there has been ample time for accumulation of large amounts of lead, several hundred parts per million, by the decay of thorium. Zircon also contains 100 ppm or more of radiogenic lead in the very old rocks of the Blue Ridge. Silt samples from the Inner Piedmont tend to contain more than 10 ppm of lead, but not consistently.

We have eliminated most of the monazite from the NM and M.5 concentrates by magnetically concentrating monazite in the M1 fraction. The NM concentrate contains most of the lead minerals and is therefore a more useful guide to mineralization.

NM concentrates containing at least 1000 ppm of Pb form a halo around the western, southern, and eastern sides of Charlotte. Lead artifacts are common on the west side of Charlotte, suggesting that the lead contents there should be given little weight. This may also be the case with the high values south of Charlotte unless some other evidence of mineralization can be found. The lead-rich NM samples east of Charlotte might partly result from unrecognized contamination but they may also be related to the gold mineralization in that area.

Lead-rich NM sample sites are sparsely strewn along the northern part of the Gold Hill shear zone, mainly north of the area where the shear zone contains zinc-rich samples. The metals probably indicate that the shear zone was mineralized, even though lead and zinc are not spacially associated with one another.

An especially interesting cluster of lead-rich NM samples is in the Thomasville area in the northeastern corner of the quadrangle. Most of the NM concentrates there contain at least 150 ppm Pb and about a third of them contain at least 1000 ppm Pb. Confirmation of mineralization is found in moderate to high contents of cobalt and copper in NM concentrates from the area and especially in very high zinc contents of NM concentrates. Yellow sphalerite was also found in some NM concentrates from this area. It is noteworthy that this mineralized area is near the boundary between the Slate Belt and the Charlotte Belt and northeast of an area in which the Gold Hill shear zone--the boundary between belts farther south--broadens into an area of scattered fractures, providing openings that could be channelways for mineralizing solutions or hosts for veins.

The significance of high lead values in concentrates farther south in the Slate Belt is not clear. The very high values along the eastern edge of the quadrangle probably reflect either mineralization or contamination with lead artifacts. The widespread lead in the Mount Pleasant area and near the southern edge of the map probably indicate mineralization.

In the Kings Mountain Belt, very high lead values are not common and in most places they are not clustered. One 1000 ppm sample and two 150-700 ppm samples taken south of Gaffney are near the old Cameron lead mine, and a group of samples with similar lead contents east of Gaffney is associated with old iron prospects and mines. In both places the high lead values probably reflect mineralized bedrock.

The NM samples with 150-700 ppm Pb in the cluster in the northwestern corner of the map consist largely of zircon, whose thorium-derived lead is shown by the analytical values. Lead, as cerussite, is associated with sphalerite in a sample taken near Ashford, indicating that lead was involved in the weak zinc mineralization in the Shady dolomite in that area.

Silt samples from the eastern part of the quadrangle have high lead contents in broad areas that cross the Gold Hill shear zone from the Slate

Belt into the Charlotte Belt. The highest contents, above 20 ppm, are in mineralized terranes in the Uwharrie Mountains and the Gold Hill district, but the broad area in the southern Slate Belt is without known mineralization and only at its southwestern edge is it associated with lead-rich concentrates.

Neither silt samples nor concentrate samples give evidence of the important lead-zinc-silver mineralization at the Silver Hill mine. The mineralization at the Silver Valley mine and the prospects east of it is reflected in an inconspicuous manner in silt samples with 20 to 30 ppm of Pb and NM concentrates with 100 to 1000 ppm Pb.

There is a tendency for the lead content of silt to be higher in areas where the pH of ground water is 8 rather than where it is 6 or 7, but lead contents are not obviously lower in areas with water pH of 5 or 6 than in areas with pH of 7.

The western part of the Brevard fault zone is apparently lead-poor, as shown by lack of detectable lead in the silt samples. Even its eastern part contains barely detectable amounts of lead. This fault zone thus differs from the Gold Hill shear zone, which commonly contains more lead than adjoining areas and seldom contains less.

The site of the Cherryville pluton and its immediate vicinity contains concentrates with either less than 10 ppm Pb or values slightly above the 10 ppm limit of detection, indicating that lead was not a part of the Sn-Nb-Be mineralization of that pluton or of the uranium mineralization of the Cherryville area. Similarly, the Sn-Nb-Co mineralization of the Salisbury pluton did not include Pb, because the silt samples of the area do not contain detectable lead.

The apparent contamination of stream sediment around Charlotte that is inferred from the concentrate data is not evident in the silt data.

Artifacts

Addition of metals and minerals to streams and soils by human activities must be expected in densely and long populated districts. Such additions were widespread in the Charlotte 1° x 2° quadrangle, in part by hunting, road building, and other common vocations and avocations, and in part by the dumping of trash into streams. Iron and steel artifacts, most commonly cans, nails, and small scraps of iron, are generally large enough to be seen and removed during sampling and panning. Smaller pieces are removed during the first magnetic separation, even when they are very largely converted to rust. We have not recognized a contamination of our samples by tin or lead from plated or soldered cans or from alloying metals in steel. The oxidation products of the very thin sheets of plating metals probably are in tiny grains that are eliminated with other clay and silt during panning. Thicker layers and lumps of solder are considered below with other lead artifacts.

To minimize the chance of getting trash in our samples, we took them upstream from bridges, not downstream, and noted if there are bridges upstream from the sample site. For quality control microscopic examination of the nonmagnetic fractions of concentrates is mandatory, because lead, copper, and tungsten artifacts, fresh or oxidized, are in that fraction. The artifacts were removed before analysis, and their presence was noted on the analytical sheet and in the optional coding in the computer file. Examination of the lead contents of the concentrates suggests that slightly higher values were reported for samples that contained white oxidized shot than for other samples. We also studied contents of common alloying elements--antimony, arsenic, bismuth, and tin--in samples that were exceptionally rich in lead. Unfortunately, most of these metals can be associated with lead in ore deposits, so samples that contain them cannot automatically be discarded. Other geologic and geochemical features of the site must be considered carefully when using such potentially misleading data.

Lead was found in nonmagnetic concentrates in several forms; round shot, bullets, irregular pieces and shavings, and fragments of automobile battery grids. The most widespread is lead shot, which is not surprising inasmuch as settlers have been hunting waterfowl in the area for at least 3 centuries. Some of the pellets are shiny and black, apparently recent additions to the stream bed. Others, presumably much older, are oxidized, with a white pulverulent rind that may constitute more than 10% of the diameter of the pellet. The white rind was identified as cerussite by X-ray diffraction. Copper plated shot was found in only a few samples and steel shot in only one. The bullets found were nearly all .22 caliber, some were copper plated but most were not. Slender bent strips of lead, resembling shavings, probably have several origins, among them the rubbing of shot along rough gun barrels during shooting, the shattering of lead bullets against rocks, the spattering of molten metal during soldering, and the rusting away of sheet iron from soldered seams. Battery grid fragments were found at only one place. The lead compounds that formerly occupied the spaces in the grid were not found; they presumably washed out of the fragmented grid before we took the sample or were washed away during panning.

Copper was found as plating on lead shot or bullets and as copper wire. The size of the wire suggests that many of the pieces are from broken-up stranded lamp cord. Many of the pieces of wire were thickly coated with cuprite; some pieces were completely oxidized so only the cylindrical shape indicated the artificial nature of the object. The rapid oxidation of copper probably is accelerated by the acidity of the soils and water of the region.

Additional evidence of rapid oxidation was the strong corrosion of a brass military cartridge case found in the northwestern part of the quadrangle. Its dated headstamp indicated that it could not have been discarded more than 20 years earlier.

A small piece of coiled tungsten wire from a light bulb was found in one concentrate and tiny flakes of aluminum were found in a few others.

The only mineral contamination that was potentially troublesome was that of corundum. The mineral in some concentrates occurs as tiny hexagonal prisms or has other characteristics of natural corundum. That in other samples is in sharply angular fragments that contain veils similar to those reported in artificial corundum (Anderson, 1979). This corundum probably came from discarded abrasive paper or grain. Most of the artificial corundum is reddish brown, darker than the usual grey, blue, or pink natural corundum.

Contamination of stream sediments by mining is, predictably, localized around or near the sites of mining. It differs from the contamination mentioned above because the contaminating metal or mineral was present in the drainage basin or a basin nearby before mining took place. Mining may have increased the amount in the sediment without adding any new substance. In contrast, the lead of lead shot and the copper of wire were added to the drainage basins from other areas, probably from other states or continents.

The largest mining operations at present are in pegmatites of the tin-spodumene belt and in marble of the Kings Mountain series. During stripping and mining of lithian pegmatites, small amounts of cassiterite, columbite, spodumene, and beryl probably have been added to the stream sediments, in amounts large enough to enhance the values in our spectrographic analyses. Quartz, clay, and feldspar added to the sediment would not be detectable by us. Mining of mica, feldspar, quartz, and clay near Kings Mountain did not change the content of metals detectably in the stream sediment. The deposits mined for those four commodities have very low contents of heavy minerals.

The marble quarries may contribute dolomite to the streams while stripping soft, weathered overburden and also may add small amounts of the accessory minerals in the marble. The most abundant of these are minerals of the mica, amphibole, garnet, and pyroxene groups.

Most of the many metal mines and prospects in the Charlotte quadrangle have been much smaller than the spodumene, mica, and stone operations, so they have had less effect on our samples. Galena was found at several mines near the northwestern corner of the quadrangle, malachite in the same area and near Cherokee Falls, and probable chalcopyrite at the Shuford mine in Catawba County, at a marble pit near the town of Catawba, at prospects near Cherokee Falls, and south of Gold Hill. We have little evidence that these minerals have been washed from the mines to the creeks in large amounts, but the possibility should be kept in mind while interpreting the geochemical data.

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