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Distribution of beryllium 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, 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 southeastern 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

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 rare earths 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).

The lower limits of determination for the elements that are mentioned in this report are niobium 50 ppm, beryllium 2 ppm, bismuth 20 ppm, tin 20 ppm, and tungsten 100 ppm.

All analytical data for sample material other than concentrates are taken from reports by Heffner and Ferguson (1978) and Ferguson (1979). Such sample material is referred to as "silt" in this report.

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.

Beryl has been found in 11 pegmatite dikes that have been mined for muscovite mica in the Inner Piedmont (Griffitts and Olson, 1953) and other coarse-grained pegmatites in the same region (Wilson and McKenzie, 1978). The beryl in these coarse-grained rocks is usually pale green, less commonly white, and occurs in prisms 1 inch to 15 inches in diameter. Because of the hardness of beryl and the poorness of its cleavage, the mineral remains in large pieces in soil or sediment near its place of origin. Thus, it doesn't affect the beryllium content of alluvial concentrate or silt samples. The number of such beryl occurrences probably is greatest near the lithian

pegmatites of the tin-spodumene belt, even though only 3 sites are shown on the map near that belt. Fine-grained white beryl constitutes about 1/2 percent of the pegmatites of the tin-spodumen belt.

Chrysoberyl was found as colorless to brown pyramidal crystals in concentrates from the southern side of South Mountain and may be present in beryllium-rich concentrates from other parts of the Inner Piedmont. Bavenite, milarite bertrandite, and bityite are trace components of the lithian pegmatites (White, 1981), bityite, with a specific gravity of 3.05 can be recovered by panning and will sink in bromoform. It may account for high beryllium contents of some concentrates obtained from the tin-spodumene belt.

The most prominent feature on the beryllium map is the tin-spodumene belt and its near neighborhood (plate 1). Beryllium contents are very high in -100-mesh stream sediments and in nonmagnetic concentrates obtained there. This itself is not surprising inasmuch as fine-grained beryl has long been known to constitute about 1/2 percent of the albitic pegmatite in the belt (Griffitts, 1954). The high beryllium contents of many heavy-mineral concentrates from this and other areas must be due to incomplete removal of beryl when the other light minerals were removed or to the presence of other, heavier beryllium minerals. The area with beryllium-rich stream sediment extends about 15 miles northeast from Lincolnton, which is about at the northern end of the prominent pegmatite belt; thus, it extends beyond the pegmatite belt at least to the northeastern end of the Kings Mountain series of rocks. Presumably, structures associated with the termination of the Kings Mountain series have guided the movements of the beryllium-bearing solutions. The nature of the rock that yields beryllium-rich detritus in this northern area is not yet known. The source of beryllium may be related to or associated with the sources for tin, bismuth, and tungsten also found in concentrates of that general area.

Beryllium-rich concentrates were obtained in a large area west of the tin-spodumene belt, but in most of that area they are not accompanied by beryllium-rich fine-grained sediments. They are associated with concentrates rich in tin and niobium and indicate a widespread distribution of oxyphile elements. The eastern part of the irregular area in and near the South Mountains just north of 35°30' and east of 82°00' is evidently in part controlled by the faults mapped there by Goldsmith (written commun., 1981). Colorless crystals of chrysoberyl were found in this general area. Neither the color nor the crystal habit is like those common in pegmatitic chrysoberyl, but no further information is available about the nature of the source rock of the mineral. We might infer that chrysoberyl is in fault-controlled veins. Silt with moderately high lithium contents just east and north of the South Mountains may be related to the beryllium mineralization.

Beryllium-rich NM concentrates in the northwestern corner of the map were obtained mainly in areas of Wilson Creek gneiss, but some were also obtained from areas of Brown Mountain granite. In general, the beryllium in the northwest is accompanied by niobium and, also, near Brown Mountain, by tin. The Brown Mountain granite contains accessory fluorite, which is of interest because nearly all fluoritic granites in the western states are accompanied by beryllium minerals in nonpegmatitic deposits. However, no beryllium minerals have yet been identified in the Brown Mountain area, nor has a beryllium-rich rock been found there.

The north-central beryllium-rich area poses the same problems as the western Piedmont and Blue Ridge. It is east of the Hiddenite mine and the berylliferous pegmatites of Alexander County and western Iredell County. There is also niobium in the area, but little tin. The nature of the source rock is unknown.

The cluster of beryllium-rich concentrates south of Salisbury probably is related to the fluoritic granite pluton there that has also shed minerals of tin and niobium into the streams. The cluster of beryllian sample sites in the southeastern corner of the quadrangle must represent recycled, far-traveled detritus, inasmuch as several of them are in an area of Mesozoic sedimentary rocks that are not plausible hosts for primary beryllium deposits. No explanation can yet be suggested for the other beryllium-rich concentrates in the eastern part of the map--they may be derived from recycled sediment, or they may be locally derived from beryllium deposits that are entirely unknown.

The shape of the large area of beryllian silt sample sites near the eastern edge of the quadrangle is related to geologic structure. The northeasterly trending bulge from this area follows a synclinal axis; the embayment in the eastern side of the area and the bulge on the southwestern side lie on an anticline. Most of the samples in that area that contain 3 or more ppm of beryllium were collected over the McManus formation. The cluster of beryllian silt samples near the northern edge of the map is underlain by granite of the Churchland pluton. Several samples in that area contain 3 ppm of beryllium, which is not especially high for a granite area.

In general, the -100-mesh sample medium discloses only the largest known area with beryllium mineralization--the tin spodumene belt--and some beryllium-rich material that apparently was displaced eastward from the pegmatite belt. The Brown Mountain area is well outlined by silt samples with 2 ppm of beryllium, but similar values are found over large areas with no known beryllium mineralization so the silt is not very definitive. The granite pluton south of Salisbury does not yield beryllium-rich silt even though it is mineralized.

Hydrothermal beryllium deposits commonly contain fluorite, so the distribution of fluorine is of interest in working out the geochemistry of beryllium. The data of Ferguson (1979) show that ground water contains abnormal amounts of fluorine in sites scattered through the southwestern part of the Charlotte quadrangle, in the broad area of oxyphile metals. A prominent cluster of fluorine-rich sites forms a belt just east of the tin-spodumene belt. A more prominent area with detectable fluorine in water is in the central part of the quadrangle. This suggests that the north-central area of beryllium-rich silt may indeed indicate hydrothermal beryllium mineralization. The same might be said of the south-central area of beryllium-rich silt, but the geology does not seem as promising.

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