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GEOLOGICAL SURVEY

Distribution of tin 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 the 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, 1981).

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 to keep the size of the drainage basin small. By doing so, 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 unsifted material at the sample site with a gold pan. 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 cerium during spectrographic analysis and the high content of radiogenic lead in the monazite, it was necessary to remove it from the bulk concentrates to improve the quality of analyses and to permit recognition of lead, possibly derived from mineral deposits, in the NM and M.5 fraction. 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. The time available did not permit a thorough mineralogic study of all concentrates. Metal-rich minerals were sought in all samples that were shown by the spectrograph to contain metal in unusually high concentrations. After establishing the presence of a metal-rich mineral, the variations in metal contents among the concentrates were inferred to indicate variations in the content of metalliferous minerals.

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 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 5 elements that are mentioned in this report are, in parts per million: beryllium 2, molybdenum 10, niobium 50, tin 20, and tungsten 100.

All analytical data for sample material other than concentrates are taken from a report by 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 editing 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.

The total tin content of sediment samples is not as important economically as the content of tin that is easily recovered by simple mechanical means. We, therefore, have relied upon the tin content of heavy-mineral concentrates obtained with the gold pan while evaluating the tin potential of the Charlotte quadrangle. Most of the tin used industrially has come from placer deposits; for some of the biggest deposits there is no known bedrock source; hence the presence of discrete tin minerals in stream sediment is crucial in determining the tin potential of our study area and the neighboring areas--placers derived from deposits in the Charlotte quadrangle may be outside of it.

The similarity between cassiterite and rutile prevents accurate rapid visual estimates of the cassiterite contents of the samples. Spectrographic tin determinations are not handicapped in that way, showing the tin content but offering no proof that the tin is in cassiterite. Cassiterite has been identified in the tin-rich samples from all stanniferous areas in the Charlotte quadrangle.

The cassiterite was found in the concentrates as lumps as much as 1/2-inch in diameter and as silt-sized particles. Most commonly cassiterite is among the coarsest components of the pan concentrate. The main exception to this is in the Salisbury area, where the cassiterite is rather fine grained. The color of the mineral ranges from tan, pale-red or yellow-brown to very dark brown. The largest grains are subround, with dull rough abraded surfaces whereas the smaller ones may be smooth and shiny. Many of the smaller grains are striated prisms that are very similar to those of rutile, a mineral that is found in nearly all samples. All but the darkest colored cassiterite can quickly be distinguished optically from rutile by its lower refractive index, about 2.0, much below the indices of rutile.

Four major areas in the Charlotte sheet yield tin-rich sediments from moderately well-defined sources. Tin-rich sediments found outside of these 4 major areas are of two types; those from unidentified source rocks and those that contain stanniferous minerals that have entered the modern sediment from detritus that litters the Piedmont Plateau surfaces after having been moved away from the bedrock source. These areas are discussed below.

Tin-spodumene belt

In the long known tin-spodumene belt (Keith and Sterrett, 1931; Kesler, 1942) cassiterite is in pegmatite and greisen. The pegmatite is a fine-grained aggregate of albite, quartz, and muscovite in which are embedded coarser masses of microcline and, in many dikes, spodumene. The latter two minerals are very coarse grained; the largest is about 4 feet in length. Beryl, apatite, cassiterite, and columbite are widespread accessory minerals. Griffitts (1954) gave a figure for cassiterite content of 0.024 percent in pegmatite based on recoveries in the concentrator once operated by the Foote Mineral Company south of Kings Mountain.

The greisen is composed of white mica and quartz. Cassiterite is locally abundant and the high beryllium contents of a few greisen samples suggest the presence of beryl. Although Sterrett's field notes of 1912 mention that the richest pods of greisen in the northern part of the belt contained about 30 percent by weight of cassiterite most greisen bodies contain much less than 1 percent. Before 1906, about 130 tons of concentrate were obtained from the Ross mine, near Gaffney, South Carolina (Keith and Sterrett, 1931). The bedrock deposit at the Ross mine has been described in several ways, but apparently was mainly in greisen (E. B. Ward, oral communication, 1948). Much of the Ross mine production was from an eluvial placer.

Cherryville pluton and vicinity

The broad area with tin-rich sediment that extends west from the tin-spodumene belt to about latitude 35°15', longitude 81°30' is underlain largely by the Cherryville pluton of biotite and biotite-muscovite quartz monzonite. South of about latitude 35°25' this pluton is rich in muscovite, probably as a result of alteration. Some of the muscovite is disseminated in the rock; some is concentrated in epigenetic pods of pegmatite or of quartz-muscovite rock, with or without accessory feldspar. This altered part of the pluton sheds cassiterite into the creeks that drain it. Cassiterite was not found in the small number of pegmatite bodies in that area that were sampled for heavy minerals so cassiterite probably weathers from the quartz-muscovite rock or from the muscovitic quartz monzonite. The altered areas are probably in the upper part of the pluton, a relation that is common in plutons of tin-bearing granites (Taylor, 1979). The stanniferous area traceable southwestward from the Cherryville pluton may be a mineralized hood over the southwesterly plunging pluton. Tin is accompanied by niobium and beryllium at the Cherryville pluton.

Southwestern area

Tin-rich alluvium was found in a broad area that extends westward from the vicinity of the Cherryville pluton to the western boundary of the Charlotte quadrangle. Pods of greisen several inches thick and as long as two feet were found in the gneiss and schist in the southeastern part of this area, but no potential tin source was seen while sampling farther west and northwest. Richard Goldsmith of the U.S. Geological Survey mapped metamorphic rocks containing muscovite in the general area (written commun., 1980) and there are small bodies of muscovitic granitic rock, the largest centered about at latitude 35°15', longitude 81°50', near a cluster of tin-rich sample sites; these might represent rocks that were altered or emplaced during tin mineralization, but they have not yet been examined in detail. Tin was not found in the areas that have sheet-mica deposits (Griffitts and Olson, 1953, pls. 18, 19).

The stanniferous area clearly crosses the northeast- to north-trending rock units of the region, so it is not related to any known structure, but it is in a very broad low-gravity area (Wilson and Daniels, 1980). This gravity low may indicate that the small exposures of muscovitic granitic rock may be offshoots of a large deep intrusive mass, which could be a source of tin.

In the southwestern area, we find that beryllium and lithium are associated with tin and that molybdenum is sporadically associated with them. The near absence of molybdenum from stanniferous concentrates gotten over the Cherryville pluton and the presence of molybdenum just south of the pluton suggests that molybdenum may be concentrated above the top of the intrusive mass. Thus, small clusters or even single samples containing molybdenum may reveal small outcrops or buried intrusives genetically related to the broad tin mineralization.

Passing northward along the Inner Piedmont, the concentrates contain less tin although the beryllium and lithium continue.

Tungsten is present, as wolframite, in the eastern part of this area, near Gaffney, which indicates that tungsten was involved in the Sn-Be mineralization.

Brown Mountain area

The Brown Mountain granite is a medium- to coarse-grained slightly foliated gray to light-red biotite granite. Coarse microcline grains are surrounded by smaller grains of albite, quartz, biotite, and microcline. Accessory minerals reported by Bryant and Reed (1970) are fluorite, allanite(?), epidote, sphene, zircon, ilmenite, magnetite, and stilpnomelane. The granite is cut by small dikes of quartz-perthite pegmatite and by quartz veinlets. Some joint surfaces have discontinuous coats of fluorite. Cassiterite and columbite can be recovered by panning gravel from most creeks that drain the Brown Mountain granite but neither mineral has been found in place. Beryllium and niobium are associated with the tin, but not lithium.

The Brown Mountain granite is unconformably overlain by the Precambrian Grandfather Mountain formation, indicating that the upper part of the pluton had been removed in Precambrian time. There has, of course, been additional erosion since the Precambrian to form the present exposures, thus insuring the removal of any intensely mineralized top that the pluton may have had. Much of the main pluton is bounded by faults or by the younger Grandfather Mountain Formation--places where veins peripheral to the intrusive should not now be expected. Thus, dispersed cassiterite in the pluton itself is the probable source of the alluvial cassiterite.

Salisbury area

The Salisbury adamellite of Phillips (1967) and Fullagar and others, (1971), is a pink to gray rather coarse grained and somewhat gneissic rock. The feldspars are white to pink. The ferromagnesion minerals have nearly everywhere been chloritized and particles of purple fluorite are not rare near the deuterically altered grains. According to Phillips (1967), the accessory minerals are sphene, chlorite, biotite, monazite(?) calcite, muscovite, fluorite, epidote, and a "staurolite-like mineral". Fullagar and others (1971) indicate that Nb contents of the granite are as high as 235 ppm. The values are highest in albite-rich rocks in the northern and southern parts of the pluton. The same general areas also contain abnormal Y, Zn, Th, and V. Tin was not reported but might well be associated with the other metals as is suggested by the presence of ixiolite [(Ta, Fe, Sn, Nb)O_2] among our heavy minerals. It is possible that the "staurolite-like" mineral of Phillips (1967) is cassiterite. Staurolite would not be expected in the greenschist facies environment that is indicated by rocks that enclose the pluton, and the two minerals can be difficult to distinguish in thin section. Our samples show that tin and niobium are closely associated and beryllium is present but less consistently associated with tin than in niobium.

Transported cassiterite

The tin-rich samples sites shown southeast of the Salisbury area and east of the tin-spodumene belt are the result of transport across the Piedmont Plateau before it was dissected to form the present drainage system. This old detritus was earlier reported by White and Stromquist (1961) who found it being washed from remnants of the plateau surface into modern sediment in the east-central part of the Charlotte 1° x 2° quadrangle. The tin-rich samples taken in the southeastern corner of the quadrangle certainly contain recycled cassiterite because they were taken over Triassic sedimentary rocks that postdate the mineralization. This cluster of samples is important because it indicates that cassiterite was carried seaward to the edge of the Coastal Plain, which may therefore contain beach placers. The age of sediments that might contain such placers could be rather old inasmuch as the lowest Cretaceous formation contains coarse kyanite which resembles that associated with tin in our samples (E. R. Burt, oral commun., 1978).

The landward boundary of the Coastal Plain may be an especially favorable place for the accumulation of heavy minerals because of the change in stream gradients that commonly takes place there, producing the "Fall Line" that has affected human activities since earliest colonial times. The monazite placer near Aiken, South Carolina is at the edge of the Coastal Plain, confirming that the Fall Line can be a locus for placer accumulation.

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