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Distribution of tungsten 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 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 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 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 31 elements that were determined spectrographically are as follows:

For those given in percent:

| | |
|-----------|-------|
| Calcium | 0.1 |
| Iron | 0.1 |
| Magnesium | 0.05 |
| Titanium | 0.005 |

For those given in parts per million:

| | | | |
|-----------|-----|------------|-----|
| Antimony | 200 | Molybdenum | 10 |
| Arsenic | 500 | Nickel | 10 |
| Barium | 50 | Niobium | 50 |
| Beryllium | 2 | Scandium | 10 |
| Bismuth | 20 | Silver | 1 |
| Boron | 20 | Strontium | 200 |
| Cadmium | 50 | Thorium | 200 |
| Chromium | 20 | Tin | 20 |
| Cobalt | 10 | Tungsten | 100 |
| Copper | 10 | Vanadium | 20 |
| Gold | 20 | Yttrium | 20 |
| Lanthanum | 50 | Zinc | 500 |
| Lead | 20 | Zirconium | 20 |
| Manganese | 20 | | |

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 collected 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.

The tungsten minerals that are known to occur in the Charlotte quadrangle are scheelite and wolframite. Scheelite is easily recognized in NM concentrates by its fluorescence under ultraviolet light, which permits a single grain to be found in a sample. Nearly all fluoresce bright blue to bluish white. No yellowish colors that indicate molybdenum were seen. Scheelite from a few samples collected over Wilson Creek gneiss near the northwestern corner of the quadrangle fluoresces dull green. The identification as scheelite was confirmed by X-ray diffractometry and optical studies. Wolframite was found in only a few samples, probably because of its superficial similarity to ilmenite and other dark minerals that are dominant in the M.5 concentrate in which wolframite occurs. The wolframite grains that were found are dark metallic gray. They have been rather strongly etched or corroded during weathering of the enclosing rocks or residence in the stream bed, producing a matte surface on which the high points are not abraded. The cleavage of the mineral is evident in bright light reflections from the sides of etch pits. The damage to the surface of the grains is in keeping with the reputation of wolframite as a rather unstable mineral in warm humid climates (Raeburn and Milner, 1928, p. 54-56).

Scheelite is nonmagnetic and therefore occurs in the NM concentrate. Wolframite being moderately magnetic is in the M.5 concentrate. Therefore, the distribution of tungsten in those two concentrates, as shown on the map, approximates the distribution of the two minerals. Because of the ease of determining fluorescent scheelite in concentrates, and because of the high spectrographic threshold of detection, the mineralogic determination is more sensitive than the spectrographic determination. The map accordingly shows scheelite in many samples in which tungsten was not detected. Nonetheless, there are many samples in which tungsten was detected but scheelite was not. This is unlikely to reflect errors in splitting samples because the same sample split was examined mineralogically, then analyzed spectrographically. There may, therefore, be an unidentified nonmagnetic tungsten mineral in some samples: anthoinite ($\text{Al}_2\text{W}_2\text{O}_9 \cdot 3\text{H}_2\text{O}$) might be expected because of the lateritic weathering to which the rocks of the region have been subjected but we did not recognize it.

Tungsten was detected spectrographically in amounts of 100 to 150 ppm in 5 out of 7 hand picked rutile samples from Inner Piedmont NM concentrates. Only 1 sample of rutile out of 14 samples from other parts of the quadrangle contained detectable tungsten. It contained 300 ppm and was from the Advance 7 1/2-minute quadrangle. Thus, rutile may commonly contribute tungsten to NM concentrates from the Inner Piedmont, but can only rarely do so in other areas. The rutile probably acquired tungsten during amphibolite-level metamorphism, when the coarse rutile crystals themselves were grown. One sample of spinel picked from an M1 concentrate from the Calahaln 7 1/2 minute quadrangle contained 200 ppm W. Other spinels yielded no tungsten.

In the eastern part of the Charlotte Belt, scheelite and NM tungsten are spacially closely associated with spectrographically determined gold in NM concentrates. This association is especially strong in the eastern part of the broad scheelite area, suggesting that tungsten and gold were introduced by closely related mineralizations. The Scarlet gold mine in this area was explored for tungsten during the 1940's because of the scheelite associated with the gold ore.

The scheelite in the Inner Piedmont is not closely associated with mineralized rocks and it is sparse in the known gold district of the South Mountains. Hence, scheelite is not a very useful guide to other types of ore in this western region, or a likely by-product of any base or precious metal mining. The scheelite in the Inner Piedmont may have formed during regional metamorphism by fixing the dispersed tungsten as scheelite. Such a process should take place most readily where the tungsten content of the rock is high. Unfortunately, the areas in which silt samples contain detectable tungsten, supposedly indicating high W contents of rocks, overlap only slightly with areas with scheelite so a metamorphic origin of the scheelite may be unlikely.

Scheelite is also widespread over the stanniferous southern part of the Cherryville pluton and in the Inner Piedmont just to the south and southwest of that pluton. In these areas it is associated with cassiterite and niobium and may have been formed during the widespread Sn-Nb-Be mineralization of the region. Scheelite is also associated with gold east of Gaffney, so it may have been involved with two areally overlapping episodes of mineralization. The source of tungsten in the broad area with scheelite in the north-central part of the quadrangle has not yet been identified.

Tungsten in the M.5 concentrate is largely near the eastern boundary of the Inner Piedmont in the southwestern part of the quadrangle, where it is probably a product of the extensive Sn-Be mineralization there. Wolframite was found by careful examination of a concentrate from this area and probably is in most M.5 concentrates with detectable tungsten.

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