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GEOLOGICAL SURVEY

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

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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).

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 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.

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 studies by T. Botinelly.

Stream sediments in the Charlotte quadrangle contain all 5 of the most common titanium minerals; ilmenite, rutile, anatase, brookite, and sphene. Only the first two, ilmenite and rutile, are truly widespread, being found in most samples (plate 1). Ilmenite is largely in the fraction removed at 0.5 ampere and rutile, anatase, sphene, and brookite remain in the least magnetic fraction. Titanium minerals in the M1 fraction are largely in mixed grains; either ilmenite partly altered to rutile or either rutile or ilmenite intergrown with other minerals that have different magnetic properties so that the aggregates have appropriate magnetic susceptibilities to be attracted at this current setting. The mineral rutile is shown on the map in two different forms. The most widespread of these is in monocrystalline grains; the other is microcrystalline, forming light-grey to tan-colored spherules, and also hexagonal plates that are pseudomorphous after ilmenite. This material, commonly called leuocoxene, is in the eastern one-fifth of the quadrangle.

The coarse monocrystalline rutile grains are longitudinally striated prisms, typical of the mineral. Twinned crystals are rare, as are unbroken prisms. The particles in the stream sediments are coarsest west of the Charlotte Belt. Some are removed with other grains coarser than 20 mesh (0.84 mm). The grains in the Slate Belt tend to be small, but well-rounded coarse grains are plentiful in the southeastern part of the quadrangle, where they have been washed into modern streams from older sediments.

The coarse rutile particles vary from yellow or pale brown through shades of brown to black. Reddish tints are not rare. Few crystals are intact: grains are mainly fragments of prismatic crystals. Although twinned crystals are uncommon in most of the area, elegant twins are common near Hiddenite. Rutile has been derived from most kinds of rock in the Inner Piedmont and Kings Mountain Belt; especially large and well-developed crystals are contained in kyanitic quartzites of southern Lincoln and Gaston Counties and have inspired mineral collectors for many years. Equally pleasing crystals with markedly different habit are in dikes and veins in mica schist and gneiss of the Hiddenite area of Iredell County.

The fine-grained "leucoxene" is found as tiny spherules and as pseudomorphs after hexagonal tablets of ilmenite. The mineral, in both habits, consistently yields rutile patterns by X-ray diffraction. Spotty diffraction patterns are produced by single unpowdered pseudomorphs, indicating substantial but incomplete parallel alignment of the component crystallites. Thin sections of metamorphic rocks of the Slate Belt show incompletely altered ilmenite crystals that have black opaque cores surrounded by "leucoxene" as well as grains that appraently have been completely converted to the fine-grained rutile. This fine-grained rutile is found mainly in rocks of greenschist facies of metamorphism. The areas with this level of metamorphism are identified on the map by the pattern that shows the presence of clinozoisite. The clinozoisite in the central and western parts of the quadrangle results from retrograde metamorphism of rocks in which titanium had previously formed coarse rutile and ilmentie, which is unaltered. The fine-grained rutile thus appears to be the result only of progressive, not retrogressive, greenschist-facies metamorphism.

Anatase is widespread as small bypyramids, but rarely constitutes more than a few percent of the concentration. The color usually is bright blue or black. Anatase is most common in or near areas that contain clinozoisite, so it may be a product of a rather low-grade metamorphism. The outstanding exception to this is the anatase in the north-central part of the quadrangle, near Hiddenite. The anatase in that area is in larger crystals than in most places in the quadrangle. These crystals result from the post-metamorphic hydrothermal activity that produced quartz crystals--including sagenite--and coarse rutile crystals in that neighborhood. In general, the anatase is coarser grained in the Inner Piedmont, Blue Ridge, and Kings Mountain Belt than it is farther east.

Anatase was found, accompanied by rutile, by X-ray diffraction study of yellow crusts on sphene crystals from the Charlotte Belt. These crusts probably formed by weathering, unlike the "leucoxene" of the Slate Belt that contains only rutile.

Brookite like anatase, is mainly found in or near areas containing clinozoisite. It forms small striated tablets. Most are mottled, with brown or blue spots fading into colorless surroundings. Brookite is not common. Where present it forms only a few grains in the concentrate.

Ilmenite is by far the most abundant titanium mineral (plate 1; figs. A and B), and constitutes most of the material removed from many samples at 0.5 ampere during magnetic separation. It is especially prominent in the Charlotte Belt, where ilmenite may constitute two-thirds of the crude panned sample. This results from the mafic composition of most of the rocks in that belt. Where the sediment is largely derived from gabbro or other mafic rock, the ilmenite is associated with abundant apatite, sphene, and dark ferromagnesian minerals. In the Inner Piedmont the ilmenite is assocaited with abundant sillimanite, garnet, zircon, and monazite, all derived mainly from schist, with smaller amounts from granitic rocks.

Euhedral crystals of ilmenite are very rare except in the Slate Belt. Even there fresh ilmenite crystals are uncommon, most are tablets having dominant basal pinacoids with small prism and rhombohedral faces. Most are partly to completely altered to fine-grained rutile (leucoxene). Many of the larger grains are laminated, most commonly by twinning, but occasionally with layers of another mineral.

References

Wilson, F. A., and Daniels, D. L., 1980, Preliminary simple Bouguer gravity map of the Charlotte 1° x 2° quadrangle, North Carolina and South Carolina: U.S. Geological Survey Miscellaneous Investigations Series Map I-1251-A.