MINERAL PRODUCTION MAPS OF THE CHARLOTTE 1° X 2° QUADRANGLE, NORTH CAROLINA AND SOUTH CAROLINA

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INTRODUCTION

The maps and graphs in this report provide a summary of past production of mineral raw materials from the Charlotte 1° X 2° quadrangle, North Carolina and South Carolina (hereafter referred to as the Charlotte quadrangle). This study was prepared as a component of the folio of maps on the mineral-resource assessment of the Charlotte quadrangle done under the U.S. Geological Survey's Conterminous United States Mineral Resource Assessment Program (CUSMAP). This report, along with reports on the geology, geochemistry, geophysics, and mineral deposits of the quadrangle, provides information used for the resource assessment.

The report demonstrates the distribution, by geography and mineral commodity, of the quantity and value of reported production of mineral raw materials from counties of the Charlotte quadrangle through 1978. Historical records of past mineral production from the United States, Canada, and other countries have been frequently cited in the course of regional mineral-resource assessments, but few comprehensive studies of the distribution of cumulative production for areas smaller than nations and their states and provinces have been done. The purpose of this report is to analyze the distribution of the quantity and value of past mineral production.

Such an analysis provides a systematic presentation of historical information that may be a useful quantitative guide to future mineral production. This information is a "yardstick" against which resource assessments may be measured. Portrayal of past production in a graphical or tabular format shows the relative importance (in terms of reported values) of cumulative production of mineral raw materials. Of special importance in complementing other reports of the CUSMAP program, this report shows how past production has been areally distributed so that the relationship of mineral production and geology can be assessed. Finally, this report is a pilot study of the addition of past-production analyses to mineral-resource assessments. It can be used to test the usefulness of available data and techniques and possibly show how the usefulness of those data can be extended by further organization and analysis.

Essential concerns for a study of this nature are the availability of the data and the suitable methods of analysis that can provide the desired information about mineral production in the Charlotte quadrangle. The format for presenting results and for effectively communicating this information to those who may use CUSMAP reports influenced the selection of the method of analysis. For this study, small-scale maps of the Charlotte quadrangle showing the distribution of past production of individual mineral commodities were desired. Production data for counties are reported by the U.S. Bureau of Mines (USBM); in those cases where county data were withheld from publication because of their proprietary nature, data from the USBM canvass reports were obtained. These data were aggregated over time into cumulative totals for the CUSMAP report, so that proprietary information would not be released. These production data records are available for each year since about 1900.

The method of analysis selected for this study was the unit-regional-value technique used by Professor John C. Griffiths and his colleagues at The Pennsylvania State University to investigate the geographic distribution of mineral production so that its relationship to geology could be assessed for the United States, Australia, Canada, Mexico, New Zealand, Rhodesia (Zimbabwe), South Africa, the United Kingdom and Ireland, and Venezuela (Griffiths, 1978). Some of this work was supported by a grant from the U.S. Geological Survey (USGS) (Grant No. 14-08-0001-6-141, 1974-78). Computer programs (the COMOD programs) written during this research project were installed on USGS computer systems and were used to analyze past-production data from Maine, New Hampshire, and Vermont for the Sherbrooke-Lewiston CUSMAP quadrangle (Bawiec and Turner, 1983). The unit-regional-value technique provides a system for classifying mineral-production data according to the location (area) where production took place, the year of production, and the mineral commodity name from a standard choice set of commodity names.

The following two sections of this report describe the collection of historical mineral-production data and the application of the unit-regional-value technique of analyze these data. These two steps were not entirely separate or sequential. The need to organize data from several types of reports of past production into a format for analysis by computer programs involved analysis and interpretation. The method of analysis dictated the format for data collection and the interim analytical results sometimes dictated the collection of additional data or a second look at sources from which data already were collected. After describing these procedures used to analyze the production data, this report concludes with a description of the results displayed on this map sheets.

COLLECTION AND ORGANIZATION OF DATA

DATA-FILE STRUCTURE

Because the analysis of production data for the Charlotte quadrangle was performed using the COMOD computer programs (Labovitz and others, 1977), the data-file structure of those programs was used to organize the Charlotte quadrangle production data. In order to show the areal distribution of cumulative production of each mineral commodity, the collected production records had to indicate *when, where,* and *how much* of *what* was produced. These questions were answered by a file structure with the following five elements: year of production, location (county and state) of production, physical quantity produced, value of amount produced, and mineral commodity produced.

Year of production. A year of reported production may indicate the year of mining, processing, or sale. It is important that the definition be consistent from year to year for each mineral commodity so that each unit of production is counted only once. For this study, data were collected for production through the 1978 calendar year. The earliest years for which reported production figures were gathered ranged from 1804 (for gold) to 1956 (for vermiculite).

Location of production. Counties were used as the basic areal unit for the unit-regional-value study because they represent several (31) units in the quadrangle of approximately equal size (ranging from 557 to 2,152 sq km) for which many reported production data are available and for which other data can be readily calculated or estimated. Data collection for alternative divisions (areas of mapped geologic formations, grid systems, etc.) would have been *much* more time-consuming than for counties in those cases where point locations of individual mines, pits, or quarries were known. In those cases where only county totals remained from original canvasses, reconstruction to a grid or geologic-unit system was not possible.

Each record of reported production was assigned to one of the 31 counties of North Carolina and South Carolina that are totally or partially within the boundaries of the Charlotte quadrangle. The inclusion of counties that are only partially in the Charlotte quadrangle was necessary in order to consistently cover all Charlotte quadrangle production because some data were only reported as county totals. Some other production data were only reported as State totals. In order to incorporate these data into the analysis, reported production was collected for all of the counties of North Carolina (100, of which 27 are totally or partially within the Charlotte quadrangle) and South Carolina (46, of which four are totally or partially within the Charlotte quadrangle). Reported production from North Carolina that did not indicate the county of origin was assigned to an undistributed category for that State; the same procedure was followed for South Carolina.

The decision to include any county that is totally or partially within the boundaries of the Charlotte quadrangle in this analysis introduced some production data that were from areas not considered in other reports in the Charlotte CUSMAP folio. (The 31 counties considered cover 38,397 sq km, compared to the 19,950-sq-km area of the Charlotte quadrangle.) Significant production from "border counties" that took place outside the quadrangle has been noted in the text that accompanies each individual mineral commodity map. Some examples are (1) gold from Lancaster County, South Carolina, and (2) sand and gravel from Anson County, North Carolina.

Physical quantity produced. The amount of production was recorded along with a code indicating the units of measurement. All production measures were converted to metric units in the COMOD programs for calculation of cumulative totals and production per unit area (grams for gold and silver; metric tons for all other commodities).

The USBM reports of crude mineral production, used as the primary source of the mineral production information for this study, list produced quantities at several stages of processing, including ore, metallic content, or refined metal produced or sold. For this study, reported production of construction materials, nonmetallic minerals, coal, and peat represents material sold. Chromium ore, iron ore, manganese ore, thorium ore, uranium ore, vanadium ore, and zirconium ore are reported as tons of ore or mineral concentrate. Tungsten is reported as tons of tungsten trioxide (WO_3) contained in concentrates. Other metals, including precious metals, are reported as recoverable metal (element, not oxide) in ores.

Value of material produced. The reported value was collected for each production record; all values were reported in current U.S. dollars. The values were converted to 1967 constant U.S. dollars by the COMOD programs using the Wholesale Price Index.

In some cases, reported values were the actual sales values of the mineral raw materials or sales values as estimated by the USBM. In other cases, the sources of production data provided an estimate of value that was calculated by multiplying an average sales price at the time of production by the reported quantity. In either case, the reported value was determined by the selling price, which includes returns to the factors of production such as capital (including equipment and machinery) and labor in addition to the value accruing to the mineral resource (what economists call "economic rent"). The difference between values of mineral production reported in this analysis and the value of mineral resources *in situ* should be appreciated when the information presented on these maps is used.

Physical units are a more satisfactory measure than dollar value for analyzing production of each mineral commodity, but the value of production provides a common denominator for adding and comparing production statistics of several commodities. Adding grams of gold and metric tons of iron ore has little, if any, usefulness. Studies of the production of energy commodities often convert physical measures (tons, cubic feet, barrels) to heat values, such as British thermal units; monetary values, with all their flaws, seem the best method for aggregating nonfuel mineral statistics.

Classification of mineral commodities. A list of mineral commodity names was used by the writers of the COMOD programs (Labovitz and others, 1977, p. 497-498, 511-514). This list of names may be expanded to include any commodities produced in a given region. These reported commodity names were transformed by the computer programs into one of 77 standard commodity names.

Reported production for the 37 standard commodities that are listed below were included in the analysis of mineral production from the Charlotte quadrangle. Reported production of 27 of these took place in the Charlotte quadrangle counties; production of the other ten (marked with asterisks) was reported for counties of North Carolina and South Carolina that are completely outside the boundaries of the quadrangle. 1/ The numbers in parentheses with each commodity name are the commodity codes used in the program. These codes are used on the map titles and in the descriptive text to assist the reader in locating the commodity maps and descriptions. The list also contains the names and codes of the five commodity categories that are used on the maps.

Construction materials (100)
- Asbestos (101)
- Commom clay and shale (103)
- * Gypsum (105)
- Mica (106)—includes scrap and sheet mica
- Sand and gravel (107)—includes some industrial sand (421)
- Stone (108)—includes dimension and crushed stone; includes some lime (413)

Fuels (200)
- * Bituminous coal (203)
- * Peat (209)
- Uranium ore (211)

Metals—excluding gold and silver (300)
- * Chromium ore (307)
- Copper (309)
- Iron ore (310)
- Lead (311)
- Lithium (312)
- Manganese ore (314)— includes metallic ores and manganiferous brick clay
- * Tantalum (319)
- Thorium ore (320)—includes rare earths
- Tin (321)
- * Titanium (322)
- * Tungsten (323)
- * Vanadium ore (324)
- Zinc (325)
- * Zirconium ore (326)

Nonmetallic minerals (400)
- Kyanite (401)
- Barite (402)
- Kaolin and specialty clays (406)
- Feldspar (408)
- Gemstones (411)
- Graphite (412)
- Lime (413)—some reported as stone (108)
- * Phosphate rock (417)
- Pyrite (419)
- Industrial sand (421)—some reported as sand and gravel (107)
- Talc (424)
- Vermiculite (425)

Precious metals (500)
- Gold (502)
- Silver 504)

All commodities (600)—sum of the five commodity categories

Production data for two of the standard commodities in the COMOD Program were not considered in this analysis: cement (102) and mineral pigments (415). Raw materials used in the production of these commodities were reported as other commodity names. The inclusion of these two commodities in the production statistics for the Charlotte quadrangle would have presented double-counting problems and seemed to involve value added beyond the production of mineral raw materials.

DATA SOURCES

The selection of data sources was done with the objective of obtaining complete geographic coverage for as many years as possible without overlapping records and with a fairly consistent time series. The major source of data for all commodities was the microfilm records of mineral production kept by the USBM and its predecessor in U.S. mineral industry canvass work, the USGS. The data were collected by the USBM for use in preparing tables and text for the annual *Minerals Yearbook* publication and are not filed in a format that is readily useable for cumulative production analysis. The microfilm contain data that are more disaggregated than those published in *Minerals Yearbook* so that county production data can often be obtained. The annual data for individual mining operations are proprietary, but when aggregated across geographic regions (as in the *Minerals Yearbook* annual totals) or across a number of years (as in this report), they are not compromised in publication. When the data were collected in 1980-81, microfilm records were available for production through 1978. The earliest data available on microfilm are for about 1900, but the time span of data coverage is not the same for all commodities.

Other sources of mineral production statistics were consulted to supplement the data from the microfilm files for particular commodities, time peroids, or geographic regions. They included:

(1) Published production statistics from *Minerals Yearbook* and its predecessor volumes (USGS, 1983-1927; USBM, 1927-34, and USBM, 1933-81). The statistics in these reports are more aggregated than those in the microfilm records but some published reports contain records of production that do not exist in the microfilm files.

1/ Titanium was produced by ilmenite mining during 1942-52 in Caldwell county, N.C. (Ilmenite, valued at 2.6 million 1967 dollars, contained 63,700 metric tons of titanium.) The production took place in a part of the County that is outside the Charlotte quadrangle. Data on this production were not available in time to be included in the data base for this publication, but they have been incorporated into a revised data set (DeYoung and Lee, unpub. data).

(2) Reports of production in the North Carolina Economic Papers Series (Pratt, 1901-8; Pratt and Barry, 1911; Bryson, 1937). These papers contain many of the same records as the Federal government publications, but have additional detail on some North Carolina commodity production for the period around 1900.

(3) Reports on precious metal production in the United States prepared by the Director of the Mint (U.S. Bureau of the Mint, 1882-83, 1884-1906). The sections on the Appalachian States in several of these reports contain tables showing production of gold and silver by county. For the years 1881-92, the reports contain information only on dollars of precious metal production; amounts of gold and silver were estimated by using historical proportions for each county for the period 1893-1905. (For the years 1881-88, production statistics for some counties are combined in the Mint reports. County production was estimated by apportioning the totals among producing counties based on their production from subsequent years.) The Mint data were used for gold and silver production for the years 1881-1905; USGS and USBM data were used for 1906-78.

(4) A USGS report on gold deposits in the southern Piedmont (Pardee and Park, 1948, p. 31-32). This report provides State totals for earlier years (1804-80 for North Carolina and 1826-80 for South Carolina). These data were assigned to the "undistributed" category for each of the two States.

(5) A USGS report on the Deep River coal field in North Carolina (Reinemund, 1955). Records of production of mineral fuels are not available in USBM microfilm files because the responsibility for these commodities was transferred to the U.S. Department of Energy in 1977. Records of coal production in North Carolina (which took place in counties outside the Charlotte quadrangle) were compiled to complete the North Carolina-South Carolina data set.

(6) A USGS report summarizing chromium production in North Carolina (Thayer and Hobbs, 1968, p. 373). This was used to supplement microfilm data on chromium production.

(7) A report pubished by the State of North Carolina concerning metallic mineral deposits of the Carolina slate belt (Carpenter, 1976, p. 16-21). Tables of metal production were used to check and supplement data from USBM microfilms and publications.

(8) Personal assistance from USBM commodity specialists. For several commodities, especially lithium (J. P. Searls, 1982, oral commun.) and phosphate rock (W. F. Stowasser, 1982, oral commun.) USBM specialists provided production statistics for North Carolina counties that were not available from other sources.

Additional production information is available in geologic reports on deposits and mining districts, several of which refer to mine production in the early nineteenth century. However, a complete review of all such reports was not possible in the time available for the study. The addition of selected years of production for those mines where records existed would have made description of what was included in the data more difficult and thus the results would be less easily interpreted.

PROBLEMS OF INCOMPLETE DATA

Several problems were encountered when reports of production did not contain enough information to complete the required elements in the data file of production information. Some of these problems and associated assumptions inherent in the data file are listed below. Some of these topics are also discussed elsewhere in this report. The effect of incomplete data, for whatever reason, is that calculated mineral-production totals are conservative. The problems included:

(1) Information that was not reported. If companies or individual operators did not report their mineral production, it was not included in this analysis. With very few exceptions, reports on all USBM surveys have been voluntary (National Research Council, 1982, p. 30-31). The difference between reported and actual production for some periods may be significant, especially for precious metals or gemstones. Therefore, these maps are, in the strictest sense, an analysis of *reported* past production of mineral commodities from the Charlotte quadrangle.

(2) Lack of records for early years of production. The earliest years for which production reports were incorporated into the data file are indicated on the individual commodity maps. For several important commodities, including stone and sand and gravel, the tonnage of material that was produced before reported statistics were available would represent a very small part of the cumulative totals.

(3) County location not specified. Some production reports indicated only the State from which the material was produced; others listed amounts of production for groups of counties. In some of those cases, other production reports and geologic information provided guidance in assigning the amounts of production to specific counties; in other cases, the undistributed category for the producing State was used.

(4) Units of production not clearly stated. Early production reports of some commodities did not distinguish between short tons and long tons. Some more recent production records suggest which units had been used in earlier reports. In those few cases where no other information was available, "tons" were assumed to be short tons.

(5) Reports of "miscellaneous or other" production. The few cases of production statistics classified as "miscellaneous or other" were not included in this compilation. For those commodities reported as a "combined value" figure in *Minerals Yearbook*, individual production records were obtained from USBM microfilm files.

UNIT-REGIONAL-VALUE ANALYSIS

After production statistics had been collected on tabulation sheets, they were entered into a computer file using a format that accomodated all necessary information about the five elements of the file structure discussed earlier. The computer file of raw data was grouped first by commodity, next by year, and finally by State and county. Annual State production totals were calculated for several commodities (for example, sand and gravel, stone, gold, and silver) and compared with published State totals to check for keypunching errors. A visual check of computer printouts of the data files was also done at this stage. Duplicate production records that had been obtained from different sources were eliminated from the file. In those cases where reports indicated only quantity or value, but not both measures of production, the missing information was calculated by using historical price data (Potter and Christy, 1962; U.S. Bureau of Statistics, 1902).

The raw data file was then converted to the input format for the COMOD program. This conversion included expansion of the information to include codes for commodity names, States, and counties and addition of information on county and currency units required by the COMOD series of programs (Labovitz and others, 1977). These programs were used to convert reported physical units to standard metric units and reported current dollars to 1967 constant dollars; then the cumulative production per unit area (in physical units or unit regional weight, urw, and in constant dollars or unit regional value, urv) was calculated for every commodity produced in each of the 148 counties (100 in North Carolina, 46 in South Carolina, and one undistributed category for each State).

The calculated urw and urv were then entered into a data file on a microcomputer. This file was manipulated by the Micro-Grasp program (Bowen, 1982), a geologic retrieval and synopsis program used to calculate weights (physical units), urw, values (1967 dollars), and urv of cumulative production for commodities, commodity categories, and total mineral production for all counties and county groups both within and outside the Charlotte quadrangle.

The organization and comparison of the cumulative production totals of each county in the microcomputer data file provided another opportunity for revision. A comparison of mineral-production records for each county with maps showing the location of past and present producing properties (see, for example, D'Agostino and Rowe, in press) revealed several inconsistencies. Some reports were from processing plants that used "imported" raw materials from another part of the State or county for mineral products. Because the purpose of this report is to describe the distribution of cumulative production of mineral raw materials derived from geologic sources within the Charlotte quadrangle region only, these "imports" were deleted from the production records. In some cases, past producers of a commodity were located in counties for which no production data are reported in the data sources used during data collection. This situation has been indicated with a patterned overprint on the commodity maps. The reverse situation (reports of production for a county but no deposits shown on the mineral-deposit-location map of the Charlotte quadrangle) occurs when the deposits are located in parts of the bordering counties which are outside the Charlotte quadrangle. This situation has been reported in the text that accompanies each mineral commodity production map.

The main reason for these revisions to the microcomputer file, instead of an amendment to the original data set, was that the microcomputer approach was less expensive. The file of cumulative production records for each county and commodity contains less than 800 records (compared with the COMOD data set of over 14,500 records). The file can be quickly manipulated on a microcomputer (using Micro-Grasp and FORTRAN programs) to produce the tables of information which were used to prepare the maps and graphs presented in this report.

MINERAL-PRODUCTION MAPS

PRESENTATION OF RESULTS

The study of mineral production from the Charlotte quadrangle was an experiment in designing a presentation format as well as a test of the applicability of analytical methods to available data. The format for this report includes the following elements:

(1) A generalized geologic map and legend at a scale of 1:375,000. This map, which accentuates the county boundaries used in data collection, provides a visual link between the 1:250,000-scale maps in the Charlotte CUSMAP folio and the smaller-scale mineral production maps of this report. The geologic units are those of Goldsmith and others (1982) and are colored to indicate the six Piedmont lithotectonic belts that are present in the quadrangle. This lithologic, rather than time-stratigraphic, classification of belts depicts the different grades of regional metamorphic alteration. Uncorrelated units have been shown in screened colors which match those belts that they most resemble. Late plutonic rocks have not been colored on this map.

(2) A small-scale (approximately 1:2,500,000) map of the lithotectonic belts in counties that are totally or partially within the quadrangle boundaries. This map, modified from Goldsmith and others (1982), as well as from North Carolina Department of Conservation and Development (1966) and Overstreet and Bell (1965), shows the Piedmont lithotectonic belts in the same colors as the large-scale map, but on the same scale as the individual mineral commodity and commodity category production maps. This map also shows 31 counties that are totally or partially within the boundaries of the quadrangle. County boundaries are shown on the production maps, but readers should refer to this map for county names.

(3) An example of a mineral production map and charts with explanatory notes about the information presented. The map shows the first year of collected data (1804) and the last year for which data were sought (1978). The first number in each county is the units of cumulative production per square kilometer (urw—31.2 grams/sq km for Spartanburg County, S.C.); the second number (in parentheses) is the total cumulative production (67.2 kg for Spartanburg County). The counties are grouped by size classes according to urw, and a color scheme is used to show the size class of each county. The number and range of the class intervals for each commodity or commodity category were chosen so that the values would be distributed among several classes. The short text that accompanies each small-scale production map provides information about the commodity or commodity category classification, indicates where significant amounts of production from "border" counties is from areas outside the quadrangle boundaries and, when known, describes

the temporal, geologic, or geographic source of production from the 31 Charlotte quadrangle counties.

Each commodity map and commodity category map is accompanied by a set of charts: 2 pie charts and 2 bar charts. The pie charts show the amount of reported production from the entire States of North Carolina and South Carolina. The area of the larger circle is a uniform size; the smaller circle is scaled so that the areas are proportional to the States' production. For each State, the circle is divided into the amounts produced from the quadrangle counties, from other counties of the two States, and from unspecified areas of the two States (the undistributed category). The first and last years for which reported production data were collected for each State are also shown.

The production totals shown on the pie charts are the aggregate amounts produced from counties within and outside the quadrangle in North Carolina and South Carolina. Comparison of these charts does not take into account the unequal areas considered. The bar charts show the production per unit area (urw for the gold map, urv in some other cases) of North Carolina and South Carolina counties. In the case of gold, counties within the quadrangle produced much more per unit area (181 g/sq km) than the rest of North Carolina (7 g/sq km); the large production from the Haile mine in Lancaster County, S. C. (which is outside the quadrangle) accounts for the large production from the four Charlotte counties in that State (864 g/sq km).

(4) Six maps that show urv for mineral commodity categories. For each of the five categories of mineral production (construction materials (100), fuels (200), etc.) and for the category for all commodities (600), maps and graphs show the distribution of the cumulative constant dollar value of production. Instead of a descriptive text, these maps have a table showing the value of production of commodities (or categories) that contribute to the totals shown on the maps.

(5) Twenty-seven maps that show the distribution of urw for each mineral commodity that has had reported production form Charlotte quadrangle counties. The maps are presented in numerical order of the commodity codes; they show distribution of urw for asbestos (101) through silver (504). For gemstones (411), the map and charts depict urv because consistent records of physical units for this commodity are not available.

(6) A bar chart of cumulative constant dollar value of production from the 31 counties that are totally or partially within the quadrangle. This chart shows how county production totals are distributed among the five commodity categories.

(7) Two maps of North Carolina and South Carolina. One of these maps shows county names, lithotectonic belts, and the area of the Charlotte quadrangle. The second map shows the urv of the all commodities (600) category for each county. The importance of the mineral production from the Charlotte quadrangle relative to other parts of the two States is highlighted by this map. Comparison with other regions of the U.S. or the world has not been done in this report; information on the urv of mineral production for U.S. States and references to studies for other countries is presented in Griffiths (1978).

INTERPRETATION OF RESULTS

The estimation of past production of mineral raw materials from the Charlotte quadrangle provides information about the differences in importance of mineral production from the various counties in the quadrangle and demonstrates the dominant role of construction materials in the value of mineral production. The cumulative reported value of mineral production for the 31 Charlotte counties is 1.16 billion 1967 dollars, which represents 30 percent of reported mineral production for North Carolina and South Carolina combined. The urv of all mineral commodities produced in the 31 counties is $30,300/sq km, which is more than twice the $13,900/sq km produced by the other counties in North Carolina and South Carolina, excluding undistributed production.

The calculated results for urw and urv displayed on these maps highlight the importance of crushed and dimension stone (108) and sand and gravel (107) production. These commodities account for 54 and 12 percent, respectively, of the constant dollar value of reported production of all mineral raw materials in the 31 counties; together these two commodities account for 88 percent of the construction materials category, which, in turn, accounts for 75 percent of all commodities. Crushed and dimension stone contribute more than 80 percent of the cumulative constant dollar value of five of the ten counties that lead in value of all commodities produced; sand and gravel comprises 97 percent of the value of Anson County, which ranks fourth. Cleveland County, a producer of stone and lithium minerals, leads the 31 counties in value of cumulative mineral production (in 1967 dollars) with $160,000,000; it ranks second in urv with $132,000/sq km. Polk County has the smallest total production ($3,370,000) and ranks 29th in urv with $5,440/sq km; 98 percent of this production value is for construction materials. Several county totals include production of material for parts of those counties that are outside the quadrangle. Mitchell County, which ranks second in total production value ($145,000,000) and first in urv ($260,000/sq km), owes much of its cumulative value to feldspar and mica produced outside the quadrangle. Anson County's totals ($94,100,000—ranked fourth, and $68,200/sq km—ranked third) are almost entirely attributable to sand and gravel production from outside the quadrangle.

There are several possible ways of analyzing the mineral production data that have not been attempted here. Estimates of mean and variability of urv for counties in North Carolina and South Carolina could be compared with other States and regions. Such comparison would require consistency, not found in published studies, in years of data collected and definitions of commodity categories. Comparison of urv and urw for counties in North Carolina and South Carolina, with some areal measure of the different lithologies in the counties, might be used to test the importance of geology to mineral production value when compared with other variables. Other variables, particularly population, might be treated as a time series and compared with a time series of mineral production. However, such an analysis of the production data might tend to compromise the safeguarding of companies' proprietary data.

Production studies alone cannot be used to determine what guidance the value of cumulative mineral production provides to those doing mineral exploration or mineral-resource assessments. More information is required to decide if one should look for large undiscovered mineral deposits in areas that have supported large production in the past, or if high past production indicates depleted and less favorable terrain. Data such as those used in this study, when used in conjunction with other components of a mineral-resource-assessment folio (especially geologic maps inventories of identified resources, and information about the intensity and thoroughness of past exploration activities), may be extremely useful in answering questions of a quantitative nature that corporate and government policymakers face, such as how much of a specified commodity a region might be expected to produce. The information implicit in production statistics results not only from the physical existence of minerals in a region, but from the demands for these minerals that human activities have created over past years, and from the historical reporting procedures for production data. Thus, the use of past production information as a guide to mineral-resource assessment requires much interpretation using knowledge not explicitly discussed in this report. It is hoped that with the kind of information presented here for the Charlotte quadrangle and with additional knowledge and experience, better decisions may be made on the trade-offs involved in dedicating land to mineral production and alternative uses.

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