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PRELIMINARY INVESTIGATION AND FEASIBILITY STUDY OF ENVIRONMENTAL IMPACT OF ENERGY RESOURCE DEVELOPMENT IN THE DENVER BASIN

An open-file report

By

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INTRODUCTION

Prior to the undertaking of a full-scale, three-year study of environmental impact of energy development in the Denver Basin, the Colorado Geological Survey conducted a three-month preliminary investigation and feasibility study of the longer term project. This report presents the findings of that study. Funding for the preliminary investigation was provided by the U.S. Geological Survey through U.S.G.S. Grant No. 14-08-0001-G-453.

Two primary topics were analyzed in the preliminary investigation. One, the technical feasibility of the three-year project and the other, possible coordination with local planning agencies. Factors addressed under technical feasibility are the limits of the study area, availability of information (old mine records, drill hole logs, proprietary company records, etc.), operating, licensed, and proposed mines in the study area, preliminary analysis of resource distribution, a bibliographic compilation, map availability, and determination of the best method of approaching the resource and environmental analysis during the long-term study. Coordination with local planning agencies involved inquiry into their knowledge of energy resources in their jurisdiction and analysis of their regulations or policy guidelines related to development of those resources. Also, the various agencies were asked for suggestions to improve the usefulness of our three-year study.

TECHNICAL FEASIBILITY

Delineation Of the Study Area.

In our original proposal the study area was to include only the area defined by the outcrop or subcrop of the Laramie-Fox Hills contact from Colorado Springs to near Greeley. However, after review of the resource distribution and determination of areas with considerable potential for development, the study area was expanded to include the region from Greeley north to the Wyoming-Colorado border. This area has the only active uranium mine in the Denver Basin and holds great potential for the discovery of additional deposits. Furthermore, this area contains known deposits of subbituminous coal that are currently undergoing significant leasing activity. The revised outline of the study area is shown in Figure 1.

Map Availability.

A variety of map bases at different scales cover the approximately 10,000 square mile area of interest. These include maps by the U.S. Geological Survey, Colorado Department of Highways, and Bureau of Land Management. The most useful map bases for the Denver Basin project appear to be those prepared by the U.S. Geological Survey. A 1:1,000,000 scale map base is available on which the study area is approximately 5¼ X 10¼, a size appropriate for page-sized illustrations. A 1:500,000 scale map uses the same cultural and topographic information as that on the 1:1,000,000

scale map, but is at a larger scale. At this scale the study area is about 10 1/2" X 20 1/2", a size too large for page-size illustrations and not detailed enough for use as a base for larger illustrations. The most useful map bases for plates which cover the entire study area are the 1:250,000 scale AMS 1° X 2° maps. A composite of the Greeley, Denver, Pueblo, Lamar, Limon, and Sterling sheets results in a map of approximately 21" X 41" which covers the entire study area.

Three series of more detailed maps ranging in scale from 1:24,000 to 1:100,000 are available or in preparation for most of the study area. These maps can be used when detailed topographic or cultural bases are needed for study of selected portions of the Denver Basin. These include the following map series: (1) the U.S.G.S. 7 1/2 minute quadrangles published at a scale of 1:24,000. Maps of this series cover the entire project area, but some of the quadrangle maps are not published in final form. Reproducible versions of these particular maps, however, are available from the National Cartography Information Center, U.S.G.S.; (2) a series of topographic county maps at a scale of 1:50,000 are currently being prepared by the U.S.G.S. in cooperation with the Colorado Division of Planning. Maps of this series which cover our study area are expected to be completed by June 30, 1978; and (3) the U.S.G.S. Front Range Urban Corridor Map Series at a scale of 1:100,000 cover a portion of the Denver Basin project area.

PRELIMINARY ANALYSIS OF ENERGY RESOURCES

Subbituminous coal, lignite, uranium, oil, and gas are present throughout much of the Denver Basin. Past development of these resources dates back to the late 1800's, when coal and oil were first extracted in the Denver Basin. As the demand for energy increases, so does the potential for future development of resources. The following is a brief description of the extent and past and proposed developments of these resources.

Subbituminous Coal

Subbituminous coal of the Denver Basin occurs in the Upper Cretaceous Laramie Formation. Figure 1 shows the portion within the study area that is underlain by this coal resource, as well as the area underlain by potentially strippable subbituminous coal. As shown in Figure 1, much of the study area is underlain by coal-bearing rocks, however, some of this area does not contain commercially economic coal reserves. Determination of areas which are underlain by economic coal deposits will be a prime topic of the full-scale Denver Basin project.

Historically, there has been considerable subbituminous coal produced in the Denver Basin. Most of this mining occured in two fields, the Boulder-Weld and Colorado Springs Fields. Numerous isolated mines are scattered throughout much of the remaining area (see Fig. 1). There are two operating or licensed coal mines in

the study area, the Eagle and Lincoln Mines, both in the Boulder-Weld Field. A fairly large mine (producing up to 1 million tons per year (MTPY)) is proposed to be developed near Cedar Point in Elbert County. Some problems have been encountered during initial developmental phases, but it is quite likely that this mining operation may begin production in the next few years. A recent investigation by a firm interested in the Boulder-Weld Field has delineated three blocks of coal which will be feasible for extraction in the near future. Other areas of economic importance undoubtedly will be discovered in the near future.

Lignite And Associated Kaolin

Low-sulfur lignite deposits of Paleocene age are found in the upper portion of the Denver Formation. The known extent of these lignite deposits and areas where they are believed to be strippable are shown in Figure 1. Numerous small mines have extracted lignite for domestic use for the past several decades. An engineering firm is currently proposing development of a 12 MTPY lignite mine and a "mine-mouth" gasification plant located near Watkins, just east of Denver. A 1 MTPY lignite mine 5 miles southeast of Kiowa is proposed to aid in supplying fuel to the Watkins gasification plant.

Interbedded with the lignite deposits are thin beds and lenses of kaolin, claystone, shale, and sandstone. The primary mineral constituent of kaolin is kaolinite, a proven potential source of aluminum. It is possible to extract alumina from kaolinite through

an acid-leaching process at high temperature. This process is not yet commercially economic, but ongoing research and mineral economics may provide a breakthrough in the near future. When this extraction technique is perfected, the lignite and kaolin-bearing beds of the Denver Formation will become a viable dual-resource and extensive development most likely will result.

Uranium

Uranium is a relatively "new" resource to the Denver Basin. Numerous radioactive showings have been noted in several portions of the basin, but it wasn't until the last decade or so that the Denver Basin became an area suspected of containing economically extractable uranium deposits. There presently is one active uranium operation in the study area located near Grover in Weld County. Current production is limited to a pilot solution-mining system which extracts uranium from a marine sandstone in the Laramie Formation. The purpose of this project is to develop the most suitable process to use on the extensive, low-grade deposits found in this area. A second uranium deposit has been discovered in the north-central portion of the Denver Basin. Additional evaluation of this deposit is underway to further assess its value. Uranium exploration and active leasing are also occurring in other portions of the study area, with primary targets being the Laramie and Fox Hills Formations in Larimer and Weld Counties, and the Dawson Arkose in Douglas and Elbert Counties.

Petroleum And Natural Gas

Petroleum and natural gas have been the primary energy resource in the Denver Basin since discovery of the Boulder Field in 1892. Approximately 190 million barrels of petroleum and 450 million cubic feet of natural gas have been produced in the Basin through 1976. During the last ten years exploration for and development of these resources has greatly increased. Favorable price structures, increased demand for domestic supplies, and more effective completion technology will undoubtedly contribute to continuing resource development throughout the Denver Basin.

INFORMATION AVAILABILITY

Information concerning energy resource distribution, quality, quantity, economic feasibility, and the environmental impacts of development of these resources will be obtained from a variety of sources during the three-year study. To help accomplish this goal, a bibliography of publications relevant to study has been started with the preliminary result contained in the bibliography at the end of this report. The preliminary bibliography will be expanded during our three-year study.

Mine maps and coal production records held by the Colorado Bureau of Mines and the U.S. Bureau of Mines will furnish past histories of mining activity in the Denver Basin. Current investigations by the Colorado Geological Survey's Mineral Fuels Section

will provide up-dated information and other pertinent data. A number of energy-oriented companies who either are in production or are actively exploring for coal, uranium, petroleum, and/or natural gas have indicated that information about their activities in the study area will be available for our use. Additional sources of information are oil and gas drill hole logs held by the Colorado Oil and Gas Commission, Petroleum Information, and American Stratigraphic Company, water well logs held by the State Engineer's office and private well drillers, logs of drill holes used in seismic exploration work for oil and gas, proprietary logs from holes drilled for coal, lignite, and uranium exploration and geologic field investigation.

ENVIRONMENTAL ASPECTS

Review of our original environmental impact analysis investigation, in light of findings from our preliminary study, revealed the need for certain alterations in our proposed approach. Our original approach was to study the Basin as a whole. A more suitable approach, however, would entail detailed study of smaller areas, each of which may be developed for either subbituminous coal, lignite and kaolin, uranium, petroleum, or natural gas or for a combination of these resources. Our study could then be used by local planners to evaluate the adequacy of environmental statements and other technical documents which accompany proposed specific energy developments. It also could be

used to aid in the establishment of regulations to deal with the impact of such developments.

COORDINATION WITH PLANNING AGENCIES

All county planning agencies within the study area and several state and city planning agencies were contacted during this preliminary study. Each agency was asked questions about their knowledge of energy resources in their area and about their policy guidelines and regulations concerning development of energy resources. All agencies were asked to comment on the applicability of our study to their needs and how we could approach the study to be of maximum use to them. The results of this portion of the study are briefly summarized in Table 1.

Several local agencies had conducted studies of energy resources in their county or area. However, these reports are limited to a compilation of previously published information. All agencies agreed upon the need for additional detailed information on the distribution, quality, and quantity of energy resources, but especially the need for information on the feasibility or likelihood of commercial development. Another serious need is information about the environmental impact of development of these resources. All contacted agencies also agreed upon the rationale that the environmental impact segment of our study would be most useful if small "pilot-study" areas were selected and studied in detail, providing guidelines with

which to evaluate impact studies in their particular area or aid in the establishment of regulations on energy development.

SUMMARY

The preliminary phase of the Denver Basin project has been completed and the results of this study are summarized in this report. There is a significant potential for further development of coal, lignite, uranium, petroleum, and natural gas in this area. If any or all of these energy resources are developed, the resulting environmental impact could have a profound effect on both the urban and agricultural environments. Furthermore, past urbanization has caused the loss of extractable energy resources, a phenomenon which our energy-consuming world cannot afford to let continue. With these facts in mind, we at the Colorado Geological Survey anxiously initiate the cooperative three-year study with the U.S. Geological Survey entitled "Environmental Impact Of Energy Development In The Denver Basin."

Table 1

Summary Of Information Obtained From Coordination With Planning Agencies

Agency	Contact	Potential Energy Resources*	Status
Adams County Planning Dept. 450 S. 5th St. Brighton 80601 659-2121	Gail Seeburger	C,L,U,O	County has prepared a "Mineral Extraction and Conservation Plan" but it has not yet been adopted. A comprehensive plan for the east end of the County is being developed. It will include designated mineral resource areas in which other types of development are prohibited. Presently, proposed energy development must go through regular zoning procedure. County has had considerable involvement with the Watkins Project. A list of studies related to this project was supplied by the County. The County conducted a preliminary study of regulations concerning coal development and is anxious to establish such regulations.
Arapahoe County Planning Dept. 5334 S. Prince Littleton 80166 795-4450	Don Paul Tom Stamm	C,L,U,O	County has prepared maps and regulations for coal, oil, and gas resources. Proposed development within resource areas must submit studies identifying potential conflicts with resource development when applying for permits or zoning changes.

Agency	Contact	Potential Energy Resources*	Status
Boulder City Planning Dept. Municipal Building P.O. Box 791 Boulder 80302 441-3210	Jim Pendleton	C,U,O	Staff Geologist has prepared a report entitled "Proposed Master Plan for Mineral Extraction for the Boulder, Colorado Urban Area". The only energy resource studied in this report is coal. The City concluded that the subbituminous coal of the Laramie Formation in the City of Boulder area is not commercially extractable at this time. For this reason, coal was not included in the proposed master plan for mineral extraction. However, the city recognized that these deposits may become commerical in the future. Therefore, the Staff Geologist prepared a set of proposed land use regulations for special use review of coal extraction and a coal occurrence inventory map. The City and County of Boulder cooperatively prepared the Boulder Valley Comprehensive Plan. This plan includes information on coal resources and hazards related to coal mining (i.e. mine fires, subsidence of undetermined areas).
Boulder County Planning Dept. P.O. Box 471 Boulder 80302 441-3930	Tom Gray	C,U,O	County has studied coal resources for H.B. 1529 and reported this information in "A Report on Environmental Geology of Boulder County, Colorado." The County recently gave approval to conduct public hearings on "Environmental Geology and Land Use Policy, Boulder County, Colorado." The County located potential coal resource areas on maps included in these studies, but they do not believe any of the coal resources are economically feasible at this time. Presently, all proposed energy development must go through Special Review to obtain the necessary permits.

Agency	Contact	Potential Energy Resources*	Status
Colo. Land Use Commission 1313 Sherman (4th floor) Denver 80203 839-2778	Jim Ohi	-	The Commission is conducting a program to establish guidelines for inter-County planning of energy development.
Colo. State Div. of Planning 1313 Sherman (5th floor) Denver 80203 839-2351	Charlie Jordan	-	Div. of Planning is interested in achieving maximum utilization of the Denver Basin study by local planning agencies.
Denver Regional Council of Governments 1776 S. Jackson, Suite 100 Denver 80210 758-5166	Gail Hill	C,L,U,O	DRCOG compiled information about distribution of coal, oil, and gas on maps at scales of 1"=2 miles and 1"=2000'. DRCOG discusses their policies concerning the extraction of these energy resources in the proposed "Regional Growth and Development Plan for the Denver Region". They emphasize the need for preservation of energy resources, coordination of resource extraction with urban development, and impact analysis of extraction on existing development.
Douglas County Planning Dept. 301 Gilbert Castle Rock 80104 688-4852	Bill Noe	C,U	County developed a land use plan which included protection of energy resource areas, but the plan was not adopted.
Elbert County Planning Dept. P.O. Box 205 Kiowa 80117 621-2173	Dan Kimzey	C,L,U,O	As a result of our contact with the County, it has established a study to evaluate their energy resources.

Agency	Contact	Potential Energy Resources*	Status
El Paso Community Development Dept. 27 E. Vermejo Colorado Springs 80903 471-5742	T. M. Sundaram	C,L	County has studied energy resources and certain environmental aspects. Their "Master Plan for the Extraction of Commercial Mineral Deposits" includes policy guidelines and information on the distribution, quality, and quantity of coal. Past mining activity and historic potential subsidence hazards are the topics of "Mining Report-Colorado Springs Coal Field; A Guide for Future Land Use." Water resources in the County were studied in "Water Resources of El Paso County, Colorado." Proposed coal developments must presently go through Location Approval.
Jefferson County Planning Dept. 1700 Arapahoe Golden 80419 279-6511	Paul Gesso Paul Banks	C,U	County is currently preparing additional information on coal development which will be added to the Mineral Extraction Policy Plan. Policy regulations and maps are scheduled for completion by April, 1978. The Master Plan should be ready by December, 1978. The County has contracted work on a coal and clay resource inventory and hazard evaluation to Amuedo and Ivey, Geological Consultants and a soil survey to the U.S.D.A. Soil Conservation Service. Proposed energy extraction is reviewed through a modified form of the present Mineral Extraction Policy Plan with considerable input from the Colorado Mined Land Reclamation Board.
Larimer County Planning Dept. 200 W. Oak Fort Collins 80521 221-2100	Keith Leyden Rex Burns	C,U,O	County has not conducted studies of energy resources. It is funding a U.S. Geol. Survey groundwater investigation in the north end of the County, an area which includes a proposed coal-fired power plant site. All proposed energy development presently must go through Special Review before approval is granted.

Agency	Contact	Potential Energy Resources*	Status
Morgan County Planning Dept. P.O. Box 596 Fort Morgan 80701 867-8202	Vince Porreca	C,O	County has not studied their energy resources. Any proposed energy developments currently must obtain approval through Special Review permitting process.
Weld County Planning Dept. 915 10th St. Greeley 80631 356-4000	Roy Jost	C,U,O	County has prepared a two volume study of mineral resources, including coal, entitled "Weld County Mineral Resources." The study contains information on the distribution, quality, and quantity of coal resources, planning for extraction and reclamation, and amendments to the Weld County Zoning Resolution which involve application, operation, and reclamation requirements. Proposed coal developments must obtain a Special Use Permit before initiating mining.

* C=Coal, L=Lignite, U=Uranium, O=Oil & Gas

BIBLIOGRAPHY

COAL

Averitt, Paul, 1975, Coal resources of the United States, January 1, 1974: U.S. Geol. Survey Bull. 1412, 131 p.

Berthoud, E. L., 1874, Section of the lignitic strata at Golden City: Hayden Survey 7th Ann. Rept., p. 109.

Bohor, B. F., Hatch, J. R., and Hill, D. J., 1976, Altered volcanic ash partings as stratigraphic marker beds in coals of the Rocky Mountain region: Am. Assoc. Petroleum Geologists Bull., v. 60, no. 4, p. 651.

Boreck, D. L., and others, 1977, Colorado coal analysis, 1975: Colorado Geol. Survey Inf. Ser. 7, 112 p.

Campbell, M. R., and Clark, F. R., 1916, Analyses of coal samples from various parts of the United States: U.S. Geol. Survey Bull. 621, p. 251-370.

Cooper, H. M., and others, 1937, Analyses of Colorado coals: U.S. Bur. Mines Tech. Paper 574, 327 p.

Dapples, E. C., and Hopkins, M. E., eds., 1969, Environments of coal deposition: Geol. Soc. America Spec. Paper 114.

F. M. Fox & Associates, Inc., 1977, Engineering geology and groundwater evaluation on a 430 acre tract of land, W 1/2 and S 1/2, Sec. 30, NE ¼, Sec. 31, Township 3 South, Range 64 West, Adams County, Colorado: unpublished report prepared for Horton-Cavey Realty Co., Job No. 2102-1990.

Goldman, M. I., 1910, The Colorado Springs coal field, Colorado: U.S. Geol. Survey Bull. 381, p. 317-340.

Griswold, C. G., 1912, Lignite mining in Colorado: Coal Mining Inst. America Proc., p. 321-330.

Grosvenor, N. E., 1964a, Coal mines of Colorado, Boulder County (map): Colorado School Mines Research Found.

_____1964b, Coal mines of Colorado, Adams County (map): Colorado School Mines Research Found.

_____1964c, Coal mines of Colorado, Weld County (2 maps): Colorado School Mines Research Found.

Hayden, F. V., 1868, Notes on the lignite deposits of the west: Am. Jour. Sci., v. 45, no. 134, art. 22, p. 198-208.

Henry, C. D., 1976, Land resources inventory of lignite strip mining areas, east Texas--An application of environmental geology: Texas Bur. Econ. Geology Geol. Cir. 76-2, 28 p.

Holt, R. D., 1972, Bibliography, coal resources in Colorado: Colorado Geol. Survey Bull. 34-A, 32 p.

_____(in preparation), Coal resources in Colorado: Colorado Geol. Survey Bull. 34-B.

Hornbaker, A. L., and Holt, R. D., 1973, 1972 summary of coal resources in Colorado: Colorado Geol. Survey Spec. Pub. 3, 15 p.

Hornbaker, A. L., and others, 1976, 1975 summary of coal resources in Colorado: Colorado Geol. Survey Spec. Pub. 9, 17 p.

Jones, D. C., 1976a, Active/licensed coal mines of Colorado: Colorado Geol. Survey open-file rept., 1 pl.

_____1976b, Coal mines and coal fields of Colorado: Colorado Geol. Survey Inf. Ser. 1, 1 pl.

Jones, D. C., and Murray, D. K., 1976 Coal mines of Colorado--Statistical data: Colorado Geol. Survey Inf. Ser. 2, 27 p.

Kingman, Jerry, 1888, Coal mines of Jefferson County, Colorado: Colorado School Mines, M. S. Thesis T-92.

Landis, E. R., 1959, Coal resources of Colorado: U.S. Geol. Survey Bull 1072-C, 101 p.

Landis, E. R., and Cone, G. C., 1971, Coal resources of Colorado tabulated by bed: U.S. Geol. Survey open-file rept., 512 p.

Lowrie, R. L., 1966, Analysis of the coal industry in Boulder-Weld coal field, Colorado: U.S. Bur. Mines Rept. Inv. 6726, 79 p.

Martin, G. C., 1910, Coal in the Denver Basin, Colorado: U.S. Geol. Survey Bull. 381, p. 297-306.

Murray, D. K., ed., 1977, Geology of Rocky Mountain coal--A symposium, 1976: Colorado Geol. Survey Resource Ser. 1, 175 p.

Osterwald, F. W., and others, 1973, Preliminary investigation of seismic tremors in the general area of the Leyden coal mine-gas storage reservoir, Colorado: U.S. Geol. Survey open-file rept., 23 p.

Parry, V. F., and Goodman, J. B., 1939a, Friability, slacking characteristics, and low temperature carbonization assays of subbituminous coals of the Denver region, Colorado: U.S. Bur. Mines Rept. Inv. 3457, 12 p.

_____1939b, Subbituminous coals of the Denver, Colorado region; friability-slacking characteristics-low-temperature carbonization assays: Mines Mag., v. 29, p. 369-374.

Sanchez, J. D., 1976, Correlation of shallow lignite beds in the Denver Formation near Watkins, Colorado, using lithologic and gamma ray logs: U.S. Geol. Survey open-file rept. 76-279.

Sanchez, J. D., and Hobbs, R. G., 1977, Chemical analysis, physical property tests, and lithologic description of cores and cuttings of lignite and overburden rocks from an area near Watkins, Colorado: U.S. Geol. Survey open-file rept. 77-628, 22 p.

Schopf, J. M., 1960, Field description and smapling of coal beds: U.S. Geol. Survey Bull. 1111-B, 70 p.

Soister, P. E., 1974, A preliminary report on a zone containing thick lignite beds, Denver basin, Colorado: U.S. Geol. Survey open-file rept. 74-27, 64 p.

Speltz, C. N., 1974, Strippable coal resources of Colorado--location, tonnage, and characteristics: U.S. Bur. Mines Prelim. Rept. 195, 68 p.

Spencer, F. D., and Erwin, M. I., 1953, Coal resources of Colorado: U.S. Geol. Survey Circ. 258, 17 p.

U.S. Geological Survey, and Colorado Geological Survey, 1977, Energy resources map of Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-1039.

Vanderwilt, J. W., 1947, Mineral resources of Colorado: Colorado Mineral Resources Board, p. 266-276.

Walter, A., 1868, The coal deposits of Boulder County: Am. Jour. Sci., v. 4, p. 242.

Weimer, R. J., 1976, Cretaceous stratigraphy, tectonics, and energy resources, western Denver basin, in Epis, R. C., and Weimer, R. J., eds., Studies in Colorado field geology: Colorado School of Mines Prof. Contr. 8, p. 180-227.

Whiteside, F. W., 1912, Coal measures of the Front Range of the Rocky Mountains in Colorado: Univ. Colorado Jour. Eng., no. 8, p. 50-55.

Woodward-Thorfinnson & Associates, Inc., 1974, Sand, gravel and coal investigation, Box Elder Property, Adams County, Colorado: unpublished report prepared for Horton-Cavey Realty Co., Job No. 18029-17396.

Yinst, P. O., 1960, Coal resources of Colorado: Colorado School Mines Mineral Industries Bull., v. 3, no. 5, 8 p.

ENVIRONMENTAL CONSIDERATIONS

Amuedo and Ivey, Geological Consultants, 1975, Ground subsidence and land-use considerations over coal mines in the Boulder-Weld coal field, Colorado: Colorado Geol. Survey Environmental Geology 9, 6 plates.

Blake, Wilson, 1972, Rock-burst mechanics: Colorado School Mines Quart., v. 67, no. 1, 64 p.

Caruccio, F. T., 1968, An evaluation of factors affecting acid mine drainage production and the groundwater interactions in selected areas of western Pennsylvania, in Proceedings of the Second Symposium on coal mine drainage research: Mellon Institute, p. 107-151.

Colorado Springs Planning Department, 1967, Mining report, Colorado Springs coalfield, a guide for future land use: Colorado Springs Planning Dept., Geol. Sec., 10 p.

Colton, R. B., and Lowrie, R. L., 1973, Map showing mined areas of the Boulder-Weld coal field, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-513.

Cook, C. W., and others, 1974, Revegetation guidelines for surface mined areas: Colorado State Univ. Range Sci. Dept., Sci. Ser. 16, 70 p.

Dunrud, C. R., 1976, Some engineering geologic factors controlling coal mine subsidence in Utah and Colorado: U.S. Geol. Survey Prof. Paper 969, 39 p.

Grim, E. C., and Hill, R. D., 1974, Environmental protection in surface mining of coal: U.S. Environmental Protection Agency, Environmental Protection Tech. Ser., 277 p.

Guilbert, J. M., 1977, Geologic considerations, in Thames, J. L., ed., Reclamation and use of disturbed land in the southwest: Tucson, Univ. Ariz. Press, p. 55-62.

Halpenny, L. C., 1977, Environmental aspects of Hydrology, in Thames, J. L., ed., Reclamation and use of disturbed land in the southwest: Tucson, Univ. Ariz. Press, p. 156-160.

Hebb, David, ed., 1975, Impact of energy supply policies in Colorado, summary report: Colorado School Mines Quart., v. 70, no. 2, 134 p.

Hutton, T., 1956, Deep hole closes Lafayette street as old mine caves in: Denver Post, May 27.

Kennedy, A. S., and others, 1977, Surface-mined land reclamation methods, in Thames, J. L., ed., Reclamation and use of disturbed land in the southwest: Tucson, Univ. Ariz. Press, p. 26-40.

Johnson, E. A., 1965, Forest restoration of strip-mined land--a research challenge, in Proceedings of the First Symposium on acid mine drainage research: Mellon Institute, p. 199-206.

Thurman, A. G., 1977, Geologic aspects of environmental planning and reclamation, in Murray, D. K., ed., Geology of Rocky Mountain Coal--A symposium, 1976: Colorado Geol. Survey Resource Ser. 1, p. 169-172.

GENERAL GEOLOGY/MAPS

Anderman, G. G., and Ackman, E. J., 1963, Structure of the Denver-Julesburg basin and surrounding areas, in Katich, P. J., and Bolyard, D. W., eds., Geology of the northern Denver basin and adjacent uplifts: Rocky Mtn. Assoc. Geologists 14th Field Conf. Guidebook, p. 170-175.

Bryant, Bruce, and Wobus, R. A., 1975, Preliminary geologic map of the southwestern quarter of the Denver 1° X 2° quadrangle: U.S. Geol. Survey open-file rept. 75-340.

Chase, G. H., and McConaghy, J. A., 1972, Generalized surficial geologic map of the Denver area, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-731.

Colton, R. B., and Anderson, L. W., 1977, Preliminary geologic map of the Eire quadrangle, Boulder, Weld, and Adams County, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-882.

Finley, E. A., and others, 1955, Preliminary structure countour map of the Colorado plains: U.S. Geol. Survey Oil and Gas Inv. Map OM-176.

Gardner, M. E., and others, 1971, Preliminary engineering geologic map of the Golden quandrangle, Jefferson County, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-308.

Hershey, L. A., and Schneider, P. A., Jr., 1972, Geologic map of the lower Cache La Poudre basin, north-central Colorado: U.S. Geol. Survey Misc. Geol. Inv. Ser. Map I-687.

Lindvall, R. M., 1972, Geologic map of the Arvada quadrangle, Adams, Denver, and Jefferson Counties, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-348.

Maberry, J. O., and Lindvall, R. M., 1972, Geologic map of the Parker quadrangle, Arapahoe and Douglas Counties, Colorado: U.S. Geol. Survey Misc. Inv. Map I-770-A.

Maberry, J. O., and Lindvall, R. M., 1974, Geologic map and engineering data for the Highlands Ranch quadrangle, Arapahoe and Douglas Counties, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-631.

Machette, M. N., 1975, Geologic map of the Lafayette quadrangle, Adams, Boulder, and Jefferson Counties, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-656.

Romero, J. C., and Hampton, E. R., 1972, Maps showing the approximate configuration and depth to the top of the Laramie-Fox Hills aquifer, Denver basin, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-791.

Scott, G. R., 1962, Geology of the Littleton quadrangle, Jefferson, Douglas, and Arapahoe Counties, Colorado: U.S. Geol. Survey Bull. 1121-L, p. L1-L53.

_____1963, Bedrock geology of the Kassler quadrangle, Colorado: U.S. Geol. Survey Prof. Paper 421-B, p. 71-125.

_____1968, Geologic and structure contour map of La Junta quadrangle, Colorado and Kansas: U.S. Geol. Survey Misc. Geol. Inv. Map I-560.

_____1972, Geologic map of the Morrison quadrangle, Jefferson County, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-790-A.

Scott, G. R., and Cobban, W. A., 1965, Geologic and biostratigraphic map of the Pierre Shale between Jarre Creek and Loveland, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-439.

Scott, G. R., and others, 1976, Geologic map of the Pueblo 1° X 2° quadrangle, south-central Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-775.

Scott, G. R., and Wobus, R. A., 1973, Reconnaissance geologic map of Colorado Springs and vicinity, Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-482.

Sharps, J. A., 1976, Geologic map of the Lamar quadrangle, Colorado and Kansas: U.S. Geol. Survey Misc. Geol. Inv. Map I-944.

Smith, J. H., 1964, Geology of the sedimentary rocks of the Morrison quadrangle, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-428.

Soister, P. E., 1965a, Geologic map of the Fort Lupton quadrangle, Weld and Adams Counties, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-397.

_____1965b, Geologic map of the Hudson quadrangle, Weld and Adams Counties, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-398.

_____1965c, Geologic map of the Platteville quadrangle, Weld County, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-399.

_____1968a, Geologic map of the Hanover NW quadrangle, El Paso County, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-725.

_____1968b, Geologic map of the Corral Bluffs quadrangle, El Paso County, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-783.

_____1972, Geologic map of the Peoria quadrangle, Arapahoe and Adams Counties, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-875.

Spencer, F. D., 1961, Bedrock geology of the Louisville quandrangle, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-151.

Trimble, D. E., 1975, Geologic map of the Niwot quadrangle, Boulder County, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-1229.

Tweto, Ogden, 1976, Preliminary geologic map of Colorado: U.S. Geol. Survey Misc. Field Studies Map MF-788.

Van Horn, Richard, 1957, Bedrock geology of the Golden quadrangle, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ-103.

_____1972, Surficial and bedrock geologic map of the Golden quadrangle, Jefferson County, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-761-A.

_____1976, Geology of the Golden quadrangle, Colorado: U.S. Geol. Survey Prof. Paper 872, 116 p.

Varnes, D. J., and Scott, G. R., 1967, General and engineering geology of the United States Air Force Academy site, Colorado: U.S. Geol. Survey Prof. Paper 551, 93 p.

Weimer, R. J., 1973, A guide to uppermost Cretaceous stratigraphy, central Front Range, Colorado--Deltaic sedimentation, growth faulting, and early Laramide crustal movement: Mtn. Geologist, v. 10, no. 3, p. 53-97.

Welch, Fred, Jr., 1969, The geology of the Castle Rock area, Douglas County, Colorado: Colorado School Mines M. S. Thesis T-1154, 93 p.

HYDROLOGY

Anna, L. O., 1975, Map showing availability of hydrologic data, published as of 1974, Colorado Springs - Castle Rock area, Front Range Urban Corridor, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-8570.

Babcock, H. M., and Bjorklund, L. J., 1956, Ground-water geology of parts of Laramie and Albany Counties, Wyo., and Weld County, Colo., with a section on the chemical quality of the water, by L. R. Kister, U.S. Geol. Survey Water-Supply Paper 1367, 61 p.

Bingham, D. L., and Klein, J. M., 1972, Extent of development and hydrologic conditions of the alluvial aquifer, Fountain and Jimmy Camp Valleys, Colorado: Colorado Water Conservation Board, Circ. 16, 28 p.

Coffin, R. C., 1921, Ground waters of parts of Elbert, El Paso, and Lincoln Counties: Colorado Geol. Survey Bull. 26.

Davis, S. N., and DeWiest, R. J. M., 1966, Hydrogeology: New York, John Wiley & Sons, Inc., 463 p.

Duke, H. R., and Longenbaugh, R. A., 1966, Evaluation of the water resources in Kiowa and Bijou Creek basins, Colorado: Colorado State Univ. Eng. Research Center rept. CER66HD-RAL19, 87 p., 3 pls.

Edward E. Johnson, Inc., 1966, Ground water and wells: St. Paul, Minn., Edward E. Johnson, Inc., 440 p.

Erker, H. W., and Romero, J. C., 1967, Ground water resources of the upper Black Squirrel Creek basin, El Paso County, Colorado: Colorado Div. Water Resources Ground Water Sec., 53 p., 3 pls.

Hampton, E. R., 1975, Map showing availability of hydrologic data in the greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-856-C.

Hampton, E. R., and others, 1974, Map showing availability of hydrologic data, Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-855-C.

Hershey, L. A., and Schneider, P. A., Jr., 1964, Ground-water investigations in the lower Cache la Poudre River basin, Colorado: U.S. Geol. Survey Water-Supply Paper 1669-X, 22 p.

Hurr, R. T., 1976, Hydrology of a nuclear-processing plant site, Rocky Flats, Jefferson County, Colorado: U.S. Geol. Survey open-file rept. 76-268, 77 p.

Hurr, R. T., and others, 1972, Hydrogeologic characteristics of the valley-fill aquifer in the Brighton reach of the South Platte River Valley, Colorado: U.S. Geol. Survey open-file rept.

Hurr, R. T., and others, 1972, Hydrogeologic characteristics of the valley-fill aquifer in the Greeley reach of the South Platte River Valley, Colorado: U.S. Geol. Survey open-file rept.

Jenkins, E. D., 1964, Ground water in the Fountain and Jimmy Camp Valleys, El Paso County, Colorado, with a section on Computation of drawdowns caused by the pumping of wells in Fountain Valley, by R. E. Glover and E. D. Jenkins: U.S. Geol. Survey Water-Supply Paper 1583, 66 p.

Konikow, L. F., 1974, Hydrogeologic maps of the alluvial aquifer in and adjacent to the Rocky Mountain Arsenal, Colorado: U.S. Geol. Survey open-file rept. 74-342.

Kuhn, Alan, 1969, Hydrogeology of the Fox Hills aquifer, North Kiowa-Bijou District, Colorado: Colorado State Univ. M. S. Thesis

Livingstone, R. K., and others, 1976, Water resources of El Paso County Colorado: Colorado Water Conserv. Board Circ. 32, 85 p.

McConaghy, J. A., 1964, Hydrogeologic data of the Denver basin, Colorado: Colorado Water Conserv. Board Basic Data-Rept. 15, 224 p.

McGovern, H. E., and Jenkins, E. D., 1966, Ground water in Black Squirrel Creek Valley, El Paso County, Colorado: U.S. Geol. Survey Hydrol. Atlas HA-236.

Mundorff, J. C., 1964, Fluvial sediment in Kiowa Creek basin, Colorado: U.S. Geol. Survey Water-Supply Paper 1798-A, p. A1-A70.

_____1968, Fluvial sediment in the drainage area of K-79 Reservoir, Kiowa Creek basin, Colorado: U.S. Geol. Survey Water-Supply Paper 1798-D, p. D1-D26.

Owens, W. G., 1967, Ground water resources of the Lost Creek drainage basin, Weld, Adams, and Arapahoe Counties, Colorado: Denver, Willard Owens and Associates, rept. prepared for Colorado Ground Water Commission.

_____1971, Hydrogeologic study of bedrock aquifers in the North Kiowa-Bijou Ground Water Management District, Colorado: Denver, Willard Owens and Associates, rept. prepared for North Kiowa-Bijou District.

Owens, W. G., and Hamilton, J. L., 1971, Groundwater resources of the Big Sandy Creek drainage area in southeast Colorado: Denver, Willard Owens and Associates, prepared for Colorado Div. Water Resources.

Robson, S. G., 1977, Ground-water quality near a sewage-sludge recycling site and a landfill near Denver, Colorado: U.S. Geol. Survey Water-Resources Inv. 76-132, 137 p.

Romero, J. C., 1976, Ground-water resources of the bedrock aquifers of the Denver basin, Colorado: Colorado Div. Water Resources, 109 p., 12 pls.

Slichter, C. S., and Wolff, 1906, The underflow of the South Platte Valley: U.S. Geol. Survey Water-Supply Paper 184, 42 p.

Smith, R. O., and others, 1964, Ground water resources of the South Platte River basin in western Adams and southwestern Weld Counties, Colorado: U.S. Geol. Survey Water-Supply Paper 1658, 132 p.

Weist, W. G., Jr., 1965, Reconnaissance of ground water resources in parts of Larimer, Logan, Sedwick, and Weld Counties, Colorado, with a section on the chemical quality of the water, by Robert Brennan: U.S. Geol. Survey Water-Supply Paper 1809-L, 24 p.

Wilson, E. M., 1974, Engineering hydrology: London, MacMillan Press Ltd., 232 p.

LAND USE

Allen, E. G., and Lutz, G. A., 1976, Leasable mineral and water-power land classification map, Denver quadrangle, Colorado: U.S. Geol. Survey open-file rept. 76-508.

Arapahoe County Planning Commission, Zoning ordinance for the County of Arapahoe, state of Colorado: Arapahoe County Planning Comm.

Arapahoe County Planning Commission, 1972, Regulations for the subdivision of land for Arapahoe County, Colorado: Arapahoe County Planning Comm.

Boulder County Land Use Department, and City of Boulder Planning Department, 1977, Boulder Valley Comprehensive Plan: Boulder County Land Use Dept. and City of Boulder Planning Dept., 90 p.

Denver Regional Council of Governments, 1977, Draft (of) regional growth and development for the Denver region: Denver Regional Council of Govts.

Douglas County Planning Department, 1974, Land use plan, Douglas County, Colorado: Douglas County Planning Dept., (plan is now void).

Driscoll, L. B., 1974, Land-use classification map of the Boulder-Fort Collins-Greeley area, Front Range Urban Corridor, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-855-B.

Driscoll, L. B., 1975a, Land-use classification of the Greater Denver area, Front Range Urban Corridor, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-856-E.

_____1975b, Land-use classification map of the Colorado Springs - Castle Rock area, Front Range Urban Corridor, Colorado: U.S. Geol. Survey, Misc. Geol. Inv. Map I-857-B.

Gray, T. C., 1977, A report on environmental geology of Boulder County, Colorado: Boulder County Land Use Dept., 113 p.

Henderson, R., and others, 1973, What land use planners need from geologists, in D. E. Moran and others, eds., Geology, seismicity, and environmental impact: Assoc. Eng. Geol. Spec. Pub., p. 37-44.

Jefferson County Advanced Planning Section, 1977, Documentation for the mineral extraction policy plan: Jefferson County Advanced Planning Sec., 31 p.

Pendleton, J. A., 1977, Proposed master plan for mineral extraction and proposed land use regulations for special use review of mineral extraction for the Boulder, Colorado urban area: prepared as a portion of the Urban Geology Program, Div. of Engineering, Dept. of Public Works and Facilities, City of Boulder, Colorado.

Smith, H. L., and others, 1976, Leasable mineral and water-power classification map, Greeley quadrangle, Colorado - Wyoming: U.S. Geol. Survey open-file rept. 76-175.

Soule, J. M., 1974, Gravel resources, urbanization, and future land use, Front Range Urban Corridor, with a section on Calculation of gravel reserves, by H. R. Fitch: U.S. Geol. Survey open-file rept. 74-178.

Sundaram, T. M., and Lewis, J. H., 1976, Master Plan for the extraction of commerical mineral deposits: El Paso County Community Devel. Dept.

Weld County Planning Commission, 1975a, Weld County mineral resources Vol. 1--mineral resources: Weld County Planning Comm.

_____1975b, Weld County mineral resources Vol. 2--extraction plan: Weld County Planning Comm.

OIL & GAS

Bass, N. W., 1958, Subsurface geology of the Dakota Sandstone in the oil-fields area of the Denver basin, Colorado and Nebraska: U.S. Geol. Survey open-file rept.

Chancellor, R. E., 1967, Economic analysis of Cretaceous oil exploration, Denver basin, Colorado and Nebraska: Mtn. Geologist, v. 4, no. 1, p. 23-34.

Fenneman, N. M., 1903, The Boulder, Colorado oil field: U.S. Geol. Survey Bull. 213, p. 322-332.

_____1904, Structure of the Boulder oil field, Colorado, with records for the year 1903: U.S. Geol. Survey Bull. 225, p. 383-391.

Geyer, A. P., 1971, Latigo field, Arapahoe County, Colorado: Mtn. Geologist, v. 9, no. 1, p. 33-40.

Colorado Oil and Gas Conservation Commission, 1977, Oil and gas statistics, 1976: Colorado Oil and Gas Conserv. Comm. 168 p.

Ingham, W. I., 1934, Wellington oil field (Larimer County), Colorado: Colorado School Mines M. S. Thesis T-550.

Jones, D. C., 1975, Oil and gas fields of Colorado: Colorado Geol. Survey open-file rept.

Jones, D. C., and Murray, D. K., 1976, Oil and gas fields of Colorado--Statistical data: Colorado Geol. Survey Inf. Ser. 3, 53 p.

Matuszczak, R. A., 1973, Wattenberg field, Denver basin, Colorado: Mtn. Geologist, v. 10, no. 3, p. 99-105.

Miller, Floyd, 1963, Cretaceous oil in the Denver basin, in Katich, P. J., and Bolyard, D. W., eds., Geology of northern Denver basin and adjacent uplifts: Rocky Mtn. Assoc. Geologists 14th Field Conf. Guidebook, p. 211-214.

Nering, Lee, 1963, Lyons Sandstone oil production in the northern Denver basin, Colorado, in Katich, P. J., and Bolyard, D. W., eds., Guidebook to the geology of the northern Denver basin and adjacent uplifts: Rocky Mtn. Assoc. Geologists 14th Field Conf. Guidebook, p. 239-247.

Nolte, C. J., 1963, Potential stratigraphic accumulation of oil and gas in the Upper Cretaceous of the Denver bain, in Katich, P. J., and Bolyard, D. W. , eds., Geology of the northern Denver basin and adjacent uplifts: Rocky Mtn. Assoc. Geologists 14th Field Conf. Guidebook, p. 156-161.

Roberts, A. A., and others, 1976, A possible petroleum related helium anomoly in the soil gas, Boulder and Weld Counties, Colorado: U.S. Geol. Survey open-file rept. 76-544, 7 p.

Stewart, W. A., 1953, Structure and oil and gas possiblities of the west flank of the Denver basin, north-central Colorado: Colorado School Mines D. Sc. Thesis T-777.

Swetland, P. J., and Clayton, J. L., 1976, Source beds of petroleum in the Denver basin: U.S. Geol. Survey open-file rept. 76-572.

Volk, R. H., 1935, An oil play for eastern Colorado: Mines Mag., v. 25, no. 1, p. 12-14.

Volk, R. W., 1971, Petroleum potential of eastern Colorado, western Nebraska, southeastern Wyoming, and northeastern New Mexico, in Future petroleum provinces of the United States, their geology and potential: Am. Assoc. Petroleum Geologists, Mem. 15, p. 637-691.

_____1972, Petroleum and natural gas--The Denver basin and the Las Animas Arch, in Geologic atlas of the Rocky Mountain region: Rocky Mtn. Assoc. Geologists, p. 281-282.

Washburne, C. W., 1910, Development in the Boulder oil field, Colorado: U.S. Geol. Survey Bull. 381, p. 514-516.

Whitney, F. L., 1956, The Boulder oil field, Boulder County, Colorado: Univ. Colorado M. S. Thesis.

Wilson, J. H., 1949, Case history of the Fort Collins Extension (oil field), Larimer County, Colorado: Geophys. Case Histories, v. 1, p. 483-491.

URANIUM

Energy Research And Development Administration, 1976, National uranium resource evaluation, preliminary report: Grand Junction, Colo., ERDA, 132 p.

Grutt, E. W., 1955, Uranium deposits in Tertiary sedimentary rocks in Wyoming and northern Colorado: U.S. Geol. Survey Prof. Paper 300, p. 361-370.

Landis, E. R., 1960, Uranium content of ground and surface waters in a part of the central Great Plains: U.S. Geol. Survey Bull. 1087-G, 35 p.

Reade, H. L., 1976, Grover uranium deposit a case history of uranium exploration in the Denver basin, Colorado: Mtn. Geologist, v. 13, no. 1, p. 21-31.

Reimer, G. M., and Otten, J. K., 1976, Helium soil gas and well water in the vicinity of a uranium deposit, Weld County, Colorado: U.S. Geol. Survey open-file rept. 76-699, 10 p.

Stevens, D. N., Rouse, G. E., and DeVoto, R. H., 1971, Radon-222 in soil gas--three uranium exploration case histories in the western United States: Canadian Inst. Mining and Metal Spec., v. 2, p. 258-264.

Wyoming Mineral Corporation, 1976, Grover uranium solution mining test site: report prepared for Colo. Dept. of Health, 38 p.

WATER REQUIREMENTS

Bishop, A. B., and others, 1975, Water as a factor in energy development: Utah State Univ., College of Eng., Utah State Research Laboratory.

Gertsch, W. D., The water for energy question in the west--State perspectives: Univ. Calif., Los Alamos Scientific Laboratory, Los Alamos, New Mexico, prepared for U.S. Water Res. Council.

Giusti, E. V., and Meyer, E. L., 1977, Water consumption by nuclear powerplants and some hydrological implications: U.S. Geol. Survey Circ. 745, 14 p.

Ken R. White Company, 1973, Watkins development study: prepared by Ken R. White Co.

U.S. Environmental Protection Agency, 1977, Water requirements for steam electric power generation and synthetic fuel plants in the western United States: EPA Rept. no. 600-7-27-037, prepared by Water Purification Assoc. for "Technology Assessment of Western Energy Development," Univ. Okla.

FIGURE 1

COAL AND URANIUM RESOURCES AND DEVELOPMENTS IN THE DENVER BASIN

by
R. M. Kirkham and
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EXPLANATION

Outline of coal-bearing region, dashed where approximately located; based on the Laramie-Fox Hills contact

Strippable subbituminous coal region; depth less than 150 feet

Strippable lignite region; depth less than 150 feet

Extent of lignite deposits at a depth of 150 to 1000 feet

Active uranium operation

Underground coal mine; solid box indicates mine is active and/or licensed

Abandoned surface coal mine

Operating coal-fired or nuclear power plant

N

0 10 20 30 40 miles

0 10 20 30 40 50 60 kilometers

SOURCE:

Jones, D.C., Murray, D.K., and Schultz, J.E., in preparation, Coal resources and development map of Colorado: Colo. Geol. Survey, Map Series 9.

U.S. Geological Survey and Colorado Geological Survey, 1977, Energy resources map of Colorado: U.S. Geol. Survey, Misc. Invest. Map I-1039.

1977