terize reliably the quality of strippable reserves.

4. For a given coal bed, tipple and delivered samples from strip mines tend to exhibit lower average moisture contents (as-received basis), higher average ash contents (dry basis), as well as greater ranges in ash contents, and less predictable average heat values (dry basis) than expected.

5. Although for many coals tipple and delivered samples are available from both surface and deep mines, analyses of these types of samples are so dependent on the type and use of mining equipment, preparation facilities, processing, and contract specifications that they may only by chance bear a close resemblance to the coal in its natural state.

Apparently only a coal's sulfur content can be characterized accurately from existing published analyses of face, tipple, or delivered samples, as no significant differences were noted in any of the comparisons.

HANSINK, JAMES, Union Pacific Mining Corp., Denver, Colo.

CHANGING TRENDS IN URANIUM EXPLORATION

The concept so prevalent in the late 1940s and 1950s that "Uranium is where you find it" is no longer valid. Housewives and cowboys no longer find uranium orebodies. Modern uranium exploration requires a broadly based approach, well-founded on geologic, geophysical, and geochemical techniques, and one which is supported by an informed and aggressive management structure.

Methods of exploration based on flexible models of ore genesis and designed to evaluate large geologic provinces rapidly have been developed. Selective use of geophysical and geochemical tools help to define targets within a favorable province. Careful geologic mapping, sampling, and data interpretation lead to preliminary drilling and interpretation of favorable areas, usually with little or no evidence of surface mineralization. In contrast to this approach, European exploration organizations have, with government subsidy, evolved a domestic exploration philosophy built around extremely detailed surface techniques and saturation drilling of target areas. Only some of the differences in approach are explained by the different types of orebodies found.

Both of these approaches have been successful in their respective areas of use.

Fundamental to the success of any uranium exploration program in the future will be increased reliance on skillful and creative three-dimensional thinking by the technical man. As in the oil industry, the easy ones have been found, but in uranium, the "plums" remain.

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UNDRILLED STRUCTURES IN SOUTH DAKOTA

No abstract available.

HOUSTON, R. S., and RONALD W. MAARS, Univ. Wyoming, Laramie, Wyo.

EXAMPLES OF USE OF STANDARD DATA PRODUCTS OF NASA-ERTS, SKYLAB, AND AIRCRAFT PROGRAMS IN STUDY OF WYOMING SURFACE RESOURCES

Cloud-free imagery of the State of Wyoming is available from the NASA programs; ERTS (complete coverage at 560 mi), Skylab (50% ± coverage at 265 mi), and aircraft (60% ± coverage at altitudes ranging from 15,000 to 60,000 ft). Standard data products available to the public include images or photographs of scenes recorded in different bands of the spectrum and in infrared and color. Many potential users (for example, consultants, small companies, and independent geologists) are limited to visual methods of analyses of these products. Wyoming studies have employed these standard data products for a variety of geologic and economic applications: regional geologic mapping for updating and correcting existing maps and as an educational tool; illustrations of the value of seasonal images in geologic mapping; specialized mapping of such features as sand dunes, playa lakes, lineaments, glacial features, regional facies changes, and their possible economic value; and multilevel sensing as an aid in mineral exploration. Cooperative studies between botanists, plant scientists, and geologists for the preparation of maps of surface resources can be used by planners and for environmental impact studies. These maps are especially useful in areas, such as the Powder River basin of Wyoming, facing critical environmental problems that will result from the development of energy resources.

The various studies illustrate that certain user requirements can be met satisfactorily with ERTS and Skylab alone, but that others require higher cost (to the user) aircraft and ground data or special data-enhancement techniques. Perhaps the key point, however, is that the NASA system has given us both complete and sequential regional coverage at a critical time in our effort to assess the effects of resource development.

KEEFER, W. F., and RICHARD F. HADLEY, U.S. Geol. Survey, Denver, Colo.

RESOURCE AND LAND INFORMATION APPLIED TO POTENTIAL COAL DEVELOPMENT IN GILLETTE AREA, WYOMING

Some of the world's largest known coal deposits are present in the Gillette area, Wyoming. Recent demands for increased production of these resources emphasize the need for sound land-use planning, resource management, and environmental protection if future development is to be guided in the best public interest. Accordingly, the U.S. Geological Survey has begun a program of integrated geologic, hydrologic, and related studies to acquire basic land, water, and resource data. The results of the investigation are being prepared and published in forms designed for ready understanding by a wide range of potential users.

The study covers 1,500 sq mi in central Campbell County, and focuses on: (1) current land use and land and coal ownership; (2) location and extent of coal resources; (3) surface and ground water resources; and (4) potential environmental impacts of surface mining.

Geologic mapping and drill data indicate the presence of nearly a dozen individual coal beds of economic interest, parts of which are strippable. The Wyodak-Anderson coal bed is the deposit of greatest interest. This bed averages 50 to 100 ft in thickness in many places, lies less than 200 ft deep over approximately 75,000 acres of the study area, and contains more than 7 billion tons of sub-bituminous coal in the area where the overburden is less than 200 ft thick.

The study area has several hundred domestic and livestock water wells, most of which are less than 500 ft deep. Water levels in these wells generally are less than 300 ft below the surface. Delineation of the potentially strippable coal zone and determination of its relation to the shallow aquifers permit an estimate of the probable effects of surface mining on ground water.

Acquisition and interpretation of similar types of geologic, hydrologic, and related data in other areas that have potential for resource development will provide decision makers with tools necessary for proper assessment of environmental impacts.

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INTERPRETIVE TECHNIQUES IN REMOTE SENSING

With increasing availability of aircraft and satellite remote-sensor data the working geoscientist now has a new tool at his fingertips. He can gain much from some of these data simply by applying traditional photointerpretive techniques, but still more can be gained if he selectively employs some specialized interpretive techniques. Proper use of the new interpretive techniques requires that the user have a basic understanding of the data he is using—how it is obtained and what it represents. He also must keep in mind the limitations of the data, such as its spectral, spatial, and brightness resolution.

With these considerations in mind, the geoscientist can select the type of remote sensor data that will apply best to his problem and then tailor the processing and analysis of the data to obtain the maximum amount of information with the least expense.

The geoscientist may employ various forms of optical or digital image enhancement or he may choose to use the computer in helping him make his discriminations and classifications. Some enhancement techniques are employed with visual-image analysis, such as color-additive and color-subtractive viewing, stereoscopic and pseudostereoscopic photo interpretation. A few procedures can be accomplished only through computer analysis (brightness ratioing, atmospheric correction), but most are effective with either imagery or digital data. This latter group includes contrast stretching, density slicing, cluster analysis, pattern recognition, frequency analysis, and edge enhancement. Most of these procedures can be done in several ways, with the accuracy of the results and the efficiency of the operation largely dependent on the equipment used. Thus, the economics of the situation are the final consideration in the implementation of most of the more complex interpretive techniques.

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WATER AND COAL DEVELOPMENT IN POWDER RIVER BASIN

A large part of future energy demands may have to be satisfied by coal, uranium, and oil shale, with coal assuming most of this burden. By the year 2020 the value of products from coal may exceed the combined value of all products of Wyoming's other minerals. Coal can either be shipped out or used in state. In-state use has been projected to require mining 360 million tons each year by 2020. Sufficient mineable coal is available to meet the demand. To utilize this coal, large quantities of water are needed.

More than 75% of Wyoming's coal reserves are in the Powder River basin which is a water-short region. Annual water requirements for a 1,000-megawatt steam-electric power plant average 14,000 acre-ft; for a 100,000 bbl per day coal liquefaction plant 20,000 to 65,000 acre-ft; and for a coal gasification plant with a capacity of 250,000,000 MCFD of pipeline gas a minimum of 10,000 acre-ft. More than 500,000 acre-ft of water will be needed annually (10.6×10^6 bbl per day) in the Powder River basin. Three alternate schemes for supplying this water have been investigated by the Wyoming Water Planning Program. The total water demand cannot be met without importing water.

Water is the controlling factor in the in-basin use of Powder River basin coal. Large quantities of water cannot be imported without political agreement. The long-range water availability affects the feasibility of in-basin use of coal and land reclamation.

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HYDROCARBON ACCUMULATION IN SAN ANDRES FORMATION OF PERMIAN BASIN, SOUTHEAST NEW MEXICO AND WEST TEXAS

Porous limestones and dolomites in the San Andres Formation (Middle Permian) serve as reservoirs for many oil and gas accumulations found in the Permian basin of southeast New Mexico and West Texas. The mature state of field discovery, development, and exploitation associated with exploratory effort directed toward the San Andres, together with the wide range of factors which have been found to characterize its hydrocarbon traps, allow it to serve as an example which illustrates many of the basic truths and concepts of modern petroleum geology.

San Andres carbonate and evaporite rocks, together with their lateral formational and lithofacies equivalents, were deposited during a gross cycle of marine transgression and regression. Reservoir porosity is restricted generally to rocks deposited in shelf-margin reef, shallow-marine and intertidal environments. Many of these environments may be identified on the basis of characteristic lithology, depositional features, and fauna. A knowledge of environmental-lithologic patterns is essential to understand the stratigraphic controls affecting hydrocarbon accumulation.

Regional San Andres structure consists of a broad south-plunging syncline characterized by gentle easterly dips from outcrops in central New Mexico and westerly dips from outcrops in central Texas toward an axis near the New Mexico-Texas line. Local closed anticlines, noses, and flexures, which overlie either basement uplifts and faults or older shelf-margin reefs, interrupt the regional structural grain and significantly influence hydrocarbon accumulation.

Potentiometric data indicate that fresh water entering the San Andres in the high mountainous New Mexico outcrop area flows easterly through porous units and becomes highly saline before reaching a discharge area along the lower lying outcrop belt in central Texas. Groundwater movement has caused east-tilting oil-water contacts in many of the oil fields.

Examination of the productive fields indicates hydrocarbon accumulation is controlled by highly variable combinations of (1) structural, (2) stratigraphic,