for mineral deposits. Its greatest asset is the ability to cover rather inaccessible areas of the world, thereby greatly reducing the time normally used by field crews.

Undersea Mining and Exploration

Studies are still underway to improve and develop deepsea mineral exploration and mining, especially the recovery of manganese nodules. Private firms, both domestic and foreign, are working on mining vessels capable of recovering minerals from water depths as great as 14,000 ft. Universities are working on submersible vessels for exploration and mining. One firm is expressing interest in the Red Sea muds which have been reported to contain available zinc and copper minerals. Further research in this area should produce some tangible benefits for the mineral scene.

Instrumentation

Sophisticated analytical procedures capable of detecting extremely low concentrations of chemical constituents have led to the development of instrumentation that can be used to detect buried anomalous concentrations of uranium mineralization. Mercury sniffers and other types of probes have been utilized in combination with refined analytical procedures that may open the door to deeper lying orebodies.

Geophysical Methods

Geophysical methods are under constant scrutiny and efforts are continually being directed at more refinement through instrument modification. One good example would be the employment of micro-gravity techniques in karstic terrane where possible deposits of bauxite, phosphate, and barite may occur. It is entirely possible that this technique may be useful for zinc and lead sulphides in carbonate terranes as well.

We can be certain that the geophysicists will keep searching for means to improve their instruments and hopefully the ability to probe deeper into the crust is not too far into the future.

Acknowledgments

The author wishes to acknowledge the contribution of items from members of several state geological surveys, the US Geological Survey, the US Bureau of Mines, several colleges and universities, and colleagues. Some of the items were written verbatim, whereas other parts were reworked to fit the scheme of the paper.

References

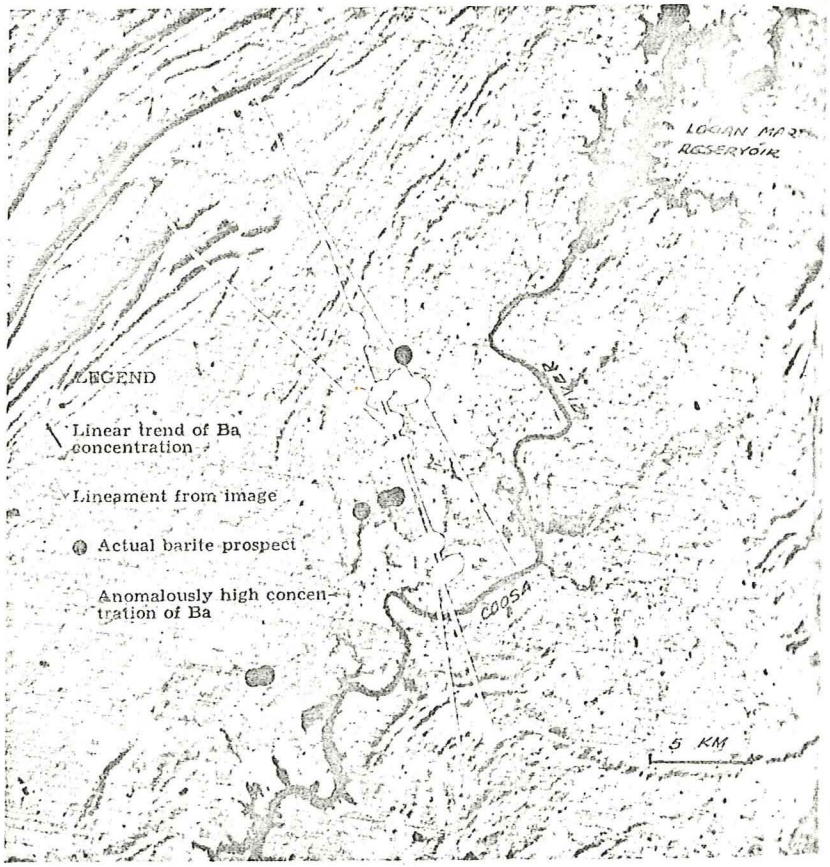
Leider, Robert, Col. USA, "The Emerging International Environment," *Marine Corps Gazette*, Feb. 1974, pp. 16-22.

Webster, C.A., Col., "Population Growth: Major Threat to Peace?" *Marine Corps Gazette*, Aug. 1974, pp. 19-25.

U. S. Department of the Interior, "Mining and Minerals Policy," *Second Annual Report of the Secretary of the Interior*, Bureau of Mines, June 1973, pp. 1-73.

U. S. Department of the Interior, "Technologic and Related Trends in the Minerals Industries, 1973," Information Circular 1974, Bureau of Mines, pp. 1-51.

Skrzyniecki, A. F., Nordstrom, H. E. Smith, W. Everett, 1974, Geochemical evi tion of lineaments, in Drahovzal, J. A. logical Survey of Alabama studies, sect of Henry, H. R., Investigations using da Alabama from ERTS-A, v. 3: University bama, Bureau of Engineering Research, 226-12-403.



Relationship of barium anomalies to ERTS-derived lineaments in northeastern Shelby Co Alabama (modified from Skrzyniecki, Nordstrom, and Smith, 1974)

Remote Sensing

Smith, Drahovzal, and Lloyd of the Alabama Geological Survey found geochemical anomalies associated with certain ERTS imagery-derived natural linear features (lineaments) in the Valley and Ridge and Piedmont provinces of Alabama. A special effort was undertaken in 1973-74 by Alan Skrzyniecki, Harold E. Nordstrom, and W. Everett Smith, using NASA funds (contract NAS5-21876) to investigate possible lineament control in mineralized districts. The Harpersville district of Shelby County exhibits barite mineralization in thrust-faulted carbonate host rocks where the intersecting lineaments occur. Anoma occur in linear arrangements that nearly parallel to traces of the ments. The lineaments appear to exerted an influence over the loc and concentration of barite mi ization. Moreover, the locations lineaments and lineament inte tions give visual clues to locat geochemical enrichment and po mineralization. Because the ments may be channelways fo eralizing fluids, this area is of interest and may become the ob future detailed geological, ge cal, and geochemical study. (Ab ed from ERTS Report (Dra dated August 1974).

Hydrology

David A. Sommers

Woodward-Clyde Consultants

Studies of hydrology related to mining proceeded along several fronts during 1974—particularly in such topics as water demand for energy production, hydrological studies, and less conventiona tions such as in-situ leach and geothermal energy deve

Water Demand in the West

In the Rocky Mountain Stat development of new coal coal-gasification plants, mouth power plants, uranium

...ovzal, J. A., Geo...
... studies, section I...
...ions using data f...
3: University, Ala...
...ng Research, p. I...

...ern Shelby County...

...ccur. Anomalies ...ements that are ...es of the linea... appear to have ...over the location ...barite mineral... ...e locations of ...ement intersec... to locations of ...nt and possible ...use the linea... ...eways for min... ...rea is of prime ...me the object of ...gical, geophysi... study. (Abstract ...port (Drahovzal...

...rological impa... ...ventional opera... ...u leach minin... ...gy developmen...

...e West

...tain States, th... ...w coal mine... ...plants, mine... ...uranium mine...

...ge large amounts of cooling water ...d processing water. In many areas ... the Rocky Mountains, unfor...nately, water is often nonexistent, ...arce, or allocated for other uses. ...n other areas having sufficient water ...pplies, cumbersome legal restric...ions and rights of competing water ...sers often preclude water use for ...ining and milling.

Not surprisingly, the development ... western energy sources and the ...ickering over water supplies be...ame political issues in the Rocky Mountain States during the 1974 ...lection campaign. In fact, many ...rojects were threatened more by ...ck of water than by the high cost ... meeting environmental regula...ions—as evidenced by the con...roversy surrounding the proposed $750-million coal-slurry pipeline to ...ransport pulverized coal from Wyoming to electric power plants in Arkansas, reported in a recent ar...icle ("Liquidity Problem—Far West's Shortage of Water May Block Many Energy Schemes," *The Wall Street Journal*, Dec. 16, 1974), which ...tated in part: "Each year an aver...ge of 15,000 acre-feet of water (an ...cre-foot would cover an acre of ...and one foot deep) would be ...eeded—enough to supply a city of ...early 100,000 people. The water would come from 40 deep wells to be ...rilled in semiarid northeast Wyo...ming. Though the present Republi...an-controlled state government has ...iven the pipeline a go-ahead, Democratic Governor-elect Ed Herschler won victory last month ...ainly on his opposition to the pipe...ine, and some victorious Democratic ...egislative candidates, demanding ...hat Wyoming water be kept in Wyoming, have promised to raise ...he issue in the legislature. The ...eighboring state of South Dakota, ...orried about a drain on its water, ...as threatened a lawsuit. Citizens ... tiny Edgemont, S.D., close to the Wyoming well sites, fear that water ...evels in their municipal wells will ...rop."

A recent national symposium, "Water Resources Problems Related ...o Mining" (sponsored by the Amer...an Water Resources Association, ...nd the Colorado School of Mines in ...operation with the Society of Min... Engineers of AIME and the As...ciation of Engineering Geologists), ...as held at the Colorado School of ...ines in Golden, Colo., July 1-2, ...974. The central theme of the con...erence was the current water-re...ources problems that occur in de...eloping mineral resources. The ...echnical sessions considered waste ...isposal methods and the control of ...tream and aquifer pollution by the ...ining industry, and reviewed the ...roblems of leaching ores and tail... transport of solids by water, ... water supply.

Also in 1974, the US Geological Wood) concluded that water availability will dictate the location of energy conversion facilities in the West. The report elaborated on water-use for mineral development activities including extraction, reclamation of mined lands, on-site processing, transportation, refining and conversion of mined material into energy.

During Oct. 23-24, 1974, the Coal and Environment Technical Conference in Louisville, Ky., sponsored by the National Coal Association, held several sessions at the "Fifth Symposium on Coal Mine Drainage Research" and the "Second Research and Applied Technology Symposium on Mined-Land Reclamation." The papers presented at the Coal Mine Drainage Symposium covered at-source drainage controls, acid mine drainage neutralization, and novel and experimental treatment processes for control of acid mine drainage. Papers at the Mined-Land Reclamation Symposium also discussed many hydrologic topics such as sedimentation control, groundwater quality in reclaimed strip mine areas, comprehensive planning, revegetation and irrigation of reclaimed mines and social and economic impacts of strip mining in water-short areas.

Hydrological Impact Studies

Although overshadowed by the water/energy situation, numerous important hydrological studies were carried out as part of environmental impact assessments required for mineral development projects.

Major aspects of hydrological assessment generally include a definition of baseline surface and groundwater conditions, identification of potential adverse alteration of these conditions, and the design of a program to mitigate such alteration.

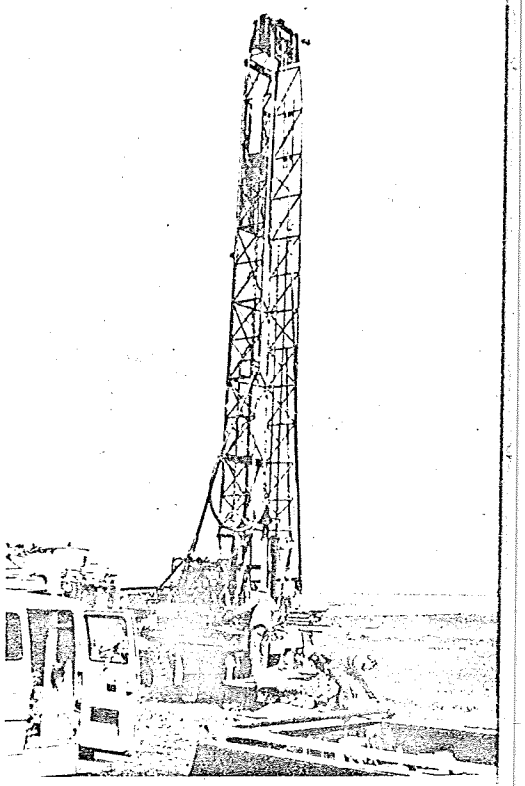
An evaluation of existing hydrological conditions near proposed mine sites often involves an extensive field program to determine local and regional water quality aspects, as well as patterns of surface and groundwater movement. In undeveloped areas where relatively little hydrological data is available, installation of testing and measurement stations may be required. This can involve the installation of specially designed test wells, stream-gaging apparatus, and various hydrological and climatological equipment. Tests which can then be performed include pumping tests; infiltration and leaching studies; measurement of permeability, porosity and water quality; determination of precipitation-runoff relationships; and recharge-discharge patterns.

Hydrological assessment includes determination of the availability of conflicting or concurrent demands on the same water sources, and the potential for interference with those demands.

Water quality studies, including both in-situ and laboratory determinations, are particularly pertinent to environmental impact assessment. All these studies provide the basis for designing monitoring programs as well as mitigating measures.

Periodic surveillance of selected water quality parameters, groundwater levels, and surface-water discharge, will then assure the early

Installation of hydrological monitoring wells for environmental assessment of proposed strip coal mine site in North Dakota.

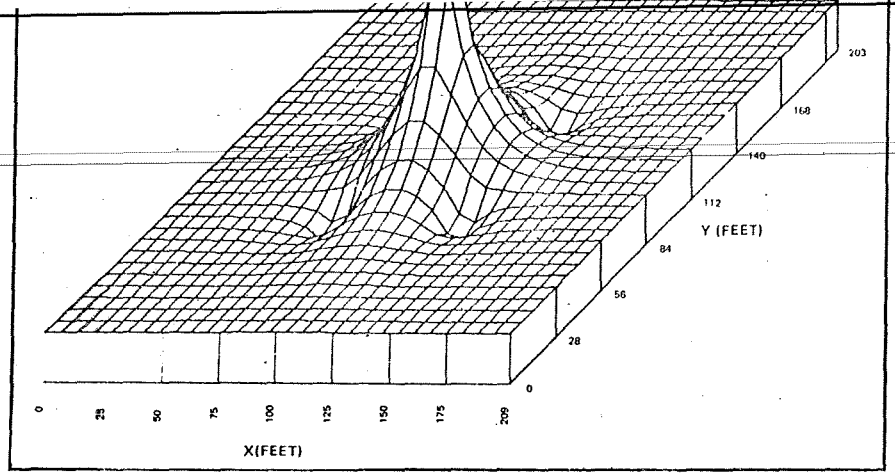


detection of any adverse hydrologic effects of mining and milling and enable effective and efficient treatment.

Numerous new techniques for evaluation and mitigation of the hydrological impacts of mining were developed during 1974. As studies continue throughout 1975 and ensuing years, new methodologies will no doubt be developed and existing techniques refined.

In-Situ Leach Mining

The Solution Mining Symposium sponsored by the Society of Mining Engineers and The Metallurgical Society of AIME, held in Dallas, Feb. 25-27, 1974, contributed significantly to the advancement of knowledge in the technology and economics of in-situ mining. During the sympo-



Computer printout of the pressure-head distribution about a hypothetical five-spot well pattern for an in-situ leaching operation.

Rock Mechanics

R. Talbot

Golder Associates, Inc.

Rock mechanics for the mining industry in 1974 has been directed toward practical problem solving and continued theoretical research. There has been a continued trend towards the application of rock mechanics techniques for solutions of real problems by operating and consulting companies, as well as by university and government research groups. A shortage of mining engineers, and in particular those with a strong background in geomechanics, has meant that many of the problems that hinder production and increase production costs are not being examined. There is an increasing need to develop methods that can observe and monitor rock behavior by the engineering or production staffs. From the observations and understanding of rock behavior, rational design procedures must emerge.

An increasing amount of case history data is being made available, and the collection and compilation of this information will undoubtedly advance the use of rock mechanics within the mining industry.

Methods of evaluating in-situ ground conditions, the application of analytical techniques to mine design, and improvements in ground support design and application have been actively pursued.

Monitoring rock movement has been more widely accepted as an indicator in difficult mining conditions. A recent publication by Hoek[1] has brought the methods of slope design in rock within the capability of operating mining engineers. This was the result of years of practical research at the Imperial College of Science and Technology in London, and was largely funded by industry. This same group is now actively involved in a similar program of research, ori-

sium, a number of hydrologic topics were considered, including impact on the hydrologic environment, hydraulic fracturing, and fluid flow through undisturbed and fractured rocks.

One recent hydrologically-related advance in the field of in-situ leach mining is the application of digital simulation models to optimize injection and production-well locations and pumping rates, to predict rates and directions of subsurface flow, and to estimate quantities of leaching fluid that may be lost by leakage into the host country rock. In addition to their applications in analyzing the mechanical-physical effects of well injection and production, the digital simulation models may be modified to aid in evaluating potential environmental effects including surface subsidence and changes in subsurface water quality and local and regional water levels.

Geothermal Energy Development

Although not usually considered an aspect of the mining industry, geothermal energy development was subject to increased attention by the industry during 1974. Evidence of this can be seen in the publication of papers such as "Salt Domes As A Source of Geothermal Energy", by Charles H. Jacoby and Dilip K. Paul, published in the May 1974 issue of MINING ENGINEERING, as well as by the attendance at geothermal energy development conferences by representatives of several mining companies and mining subsidiaries of petroleum companies. Geothermal development, as part of the total energy-production picture, can be expected to draw continued interest from the industry in the future.

The most noteworthy ... was the Third International ... on Rock Mechanics, held ... under the auspices of the ... tional Society for Rock ... The published proceed... nearly 30 major theme p... cent advances in rock ... plus 250 additional papers ... worldwide projects and ... of the five themes is sum... a major state-of-the-art ... three languages. These p... present a comprehensive ... of current worldwide ... rock mechanics, covering ... properties of rock and roc... tectonophysics, surface ... underground openings a... mentation systems.

Research Accelerates

A renewed interest in ... underground mining me... North America was encour... the adverse investment cl... many developing countries ... consequent need to mine ... grade domestic orebodies to ... US supplies of strategic m... lack of new shallow, low-gr... posits amenable to open pit ... has encouraged the initia... studies in the mechanics of ... and subsidence control. The ... of extensive oil shale dep... Colorado, Utah, and Wyom... undoubtedly require major ... in mine design due to the p... size of the operations and ... sure from environmentalists ... surface subsidence. There ap... be a tremendous scope for ... rock mechanics at the mine ... stage and hopefully the oppo... will not be lost.

Research into pillar desig... tinues. Work by Atlantic R... Co. at the experimental m... Colony Development in C... has been reported previously. ... US Bureau of Mines has awa... grant to the U. of Utah for ... on coal pillar design. This re... will involve in-situ and lab... tests from a Utah mine. Two ... square pillars will be excava... stress and deformation m... ments will be simultaneous... corded.

Hydraulic Fill Examined

Hydraulic fill has been u... underground mines for many ... The recent Symposium on Mi... ing[1] contained several excell... pers on the testing and use ... draulic fill as a structural com... in mining systems. The papers ... development and design of ... mented rock filling system at ... Isa mine, the cementing of hy... fills, and analysis of the ... properties of fill. The cemente... fill system used at Mt. Isa to ... pletely mine out a very large