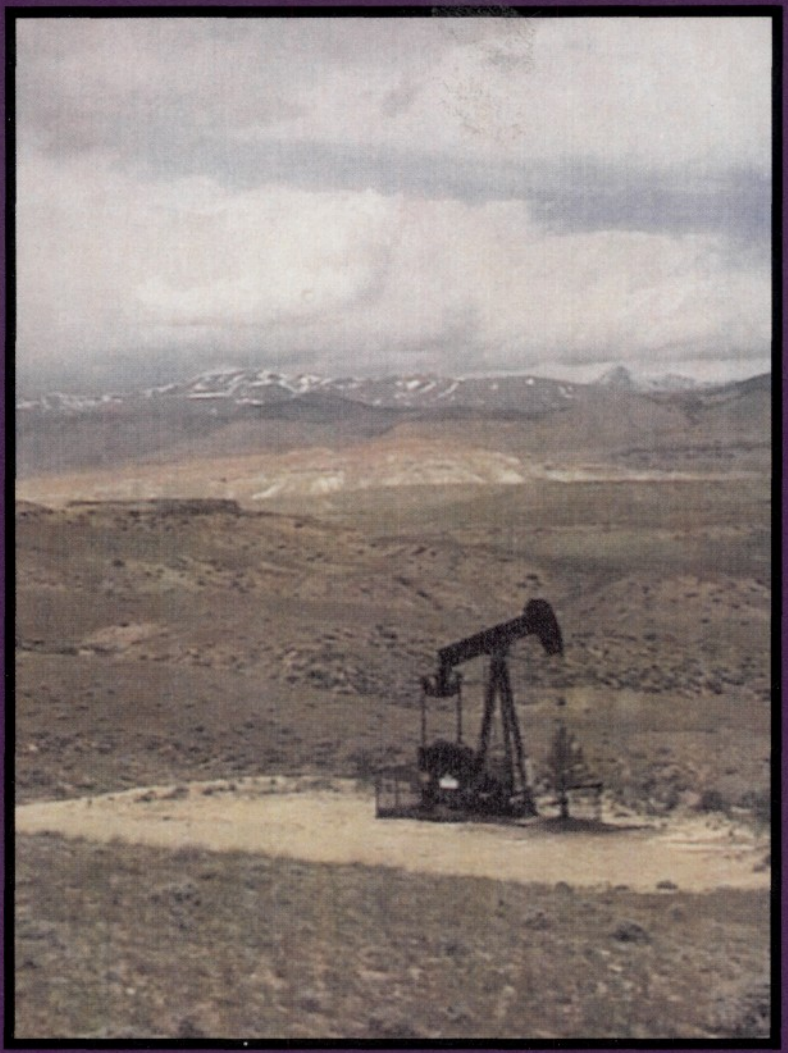
Bureau of Indian Affairs
Office of Trust Responsibilities
Division of Energy and Mineral Resources

1999 Annual Report



Stephen A. Manydeeds, Editor

Bureau of Indian Affairs
General Publication
G-99-1

Cover Photograph: Horesehead Oil Pump in the Sweetwater Basin on the Wind River Indian Reservation, WY. Photograph courtesy of John Zeise

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Division Chief's Comments

The 1999 Annual Report is a focused look at the nationwide Indian mineral resource income and the current activities of the Division of Energy and Mineral Resources. We hope that this Annual Report will assist the Bureau and tribes in better understanding the role of the Division and the complexities of collecting and disseminating scientific and technical knowledge on Indian energy and mineral resources. Each tribe needs to participate as a partner in the development and management of the energy and mineral resources on their Indian Trust land.

This book is part of the Division's outreach program which was developed to educate and inform both the tribes and Industry. This conference and the conferences of professional societies and organizations allow tribes to present information on energy and mineral resource potential on their land to the public. Hopefully these presentations will stimulate interest in developing these Indian Trust lands. The Tribes benefit from the public exposure and the societies, organizations and industry learn about tribal concerns in mineral development.

The Division of Energy and Mineral Resources looks forward to this opportunity and others that arise to assist tribes to become self-reliant through mineral development. If we can help by answering your questions or providing any other service, please feel free to contact me or any of my staff.

Richard N. Wilson, Chief
Division of Energy and Mineral Resources,
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Bald Ridge Aggregate Study area on the Annette Island Reserve, AK. The Metlakatla Indian Community has expressed interest in evaluating the suitability of the rock east of Fish Hatchery Road on Bald Ridge as crushed aggregate and/or rip-rap. Photograph courtesy of John Zeise

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STATUS OF INDIAN MINERAL INCOME

Stephen A. Manydeeds[1]

Introduction

Income from production of both solid mineral resources and fluid mineral resources, is still the largest single source of lease income to Tribes and allottees from trust lands. In Fy 1997, income from sub-surface production, bonus and annual rentals was 88% of all income generated from Trust Resources **(Figure 1)**. This percentage is down from Fy 1996 when 90% of all income generated from Trust Resources came from minerals. Income from mineral production remains the economic mainstay for many Tribes in the nation.

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Mineral Income

In 1997 Indian minerals owners received more than **$210 million** from minerals produced on their lands, with a sales value of over **$1.5 billion (Figure 2)**. Preliminary information from Minerals Management Service indicates that in 1998 Indian minerals owners will have received more than **$185 million** from minerals produced on their lands, with an estimated sales value of over **$1.3 billion**. This 12% decrease in income reflects a down turn in the price of oil. In 1997 the price of oil decrease from $17.23 in 1997 to $10.66 in 1998 or a 38% decrease.

Prior to 1989 the revenue from Indian minerals would of mirrored the price of oil. But, since the commencement of DEMR programs in 1989, nationwide Indian mineral income has increased and remained stable, even though oil prices has declined in some of those years. Part of this is due to the DEMR being able to assist Tribes in distributing production among their other mineral resources. The Division of Energy

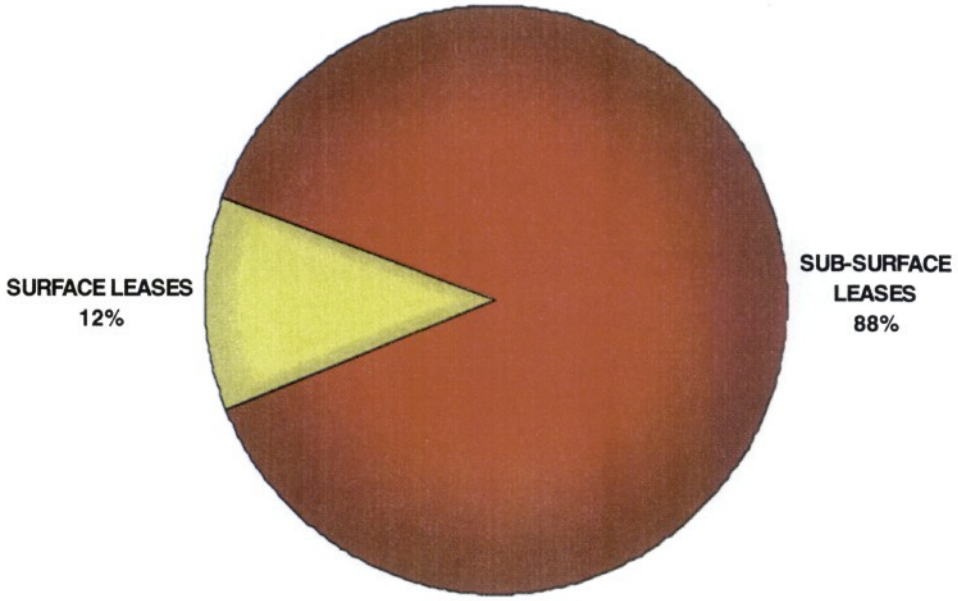

Figure 1 - Income from the Production of Indian Trust Resources for FY 1997

and Mineral Resources (DEMR) provides geo-technical services to the Indian mineral owner that are unique within the Department of Interior. In addition, by using information generated by the Division, Tribes have increased their efforts to enter into mineral agreements. By having a more thorough understanding of both the geo-techncial data and economic information, Tribes are now entering into agreements which are highly complex, but economically beneficial to the Tribes.

Also, since 1986 the average royalty rate in Indian mineral leases has also increased relative to other federal on-shore leases **(Figure 3)**. The 1997 nationwide average lease royalty rate **(Figure 4)** shows this gap between Indian and Federal leases. This reflects the new mineral agreements that Tribes are entering into with companies. While these agreements are complex, they can be economically beneficial to the Tribes.

The size of the gap can be directly related to the 1982 Indian Mineral Development Act (IMDA), new regulations (developed by the Division), and improved information that Indian Tribes have been receiving from the Division's programs. Tribes may negotiate directly with mineral companies under the authority of the Indian Mineral Development Act of 1982. This Act empowers tribal governments to enter joint ventures, operating and production sharing, service, managerial, leasing or any other type of contract arrangement. Agreements negotiated under the authority of the IMDA do not have a prescribed form. All terms of the agreement are negotiable (e.g., rents, royalty, shut-in royalties, exploration rights, length of term, etc.).

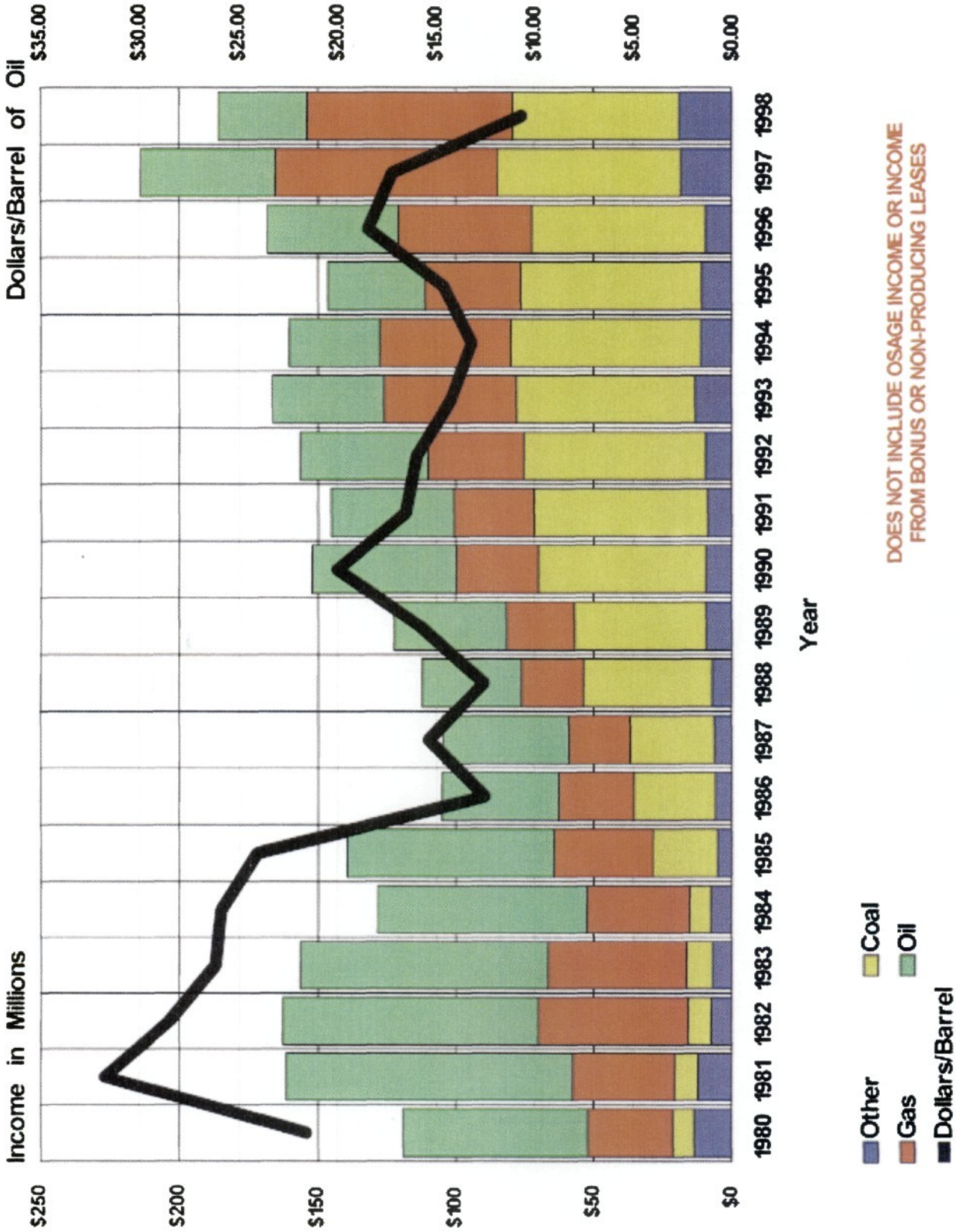

Figure 2 - Income from Minerals

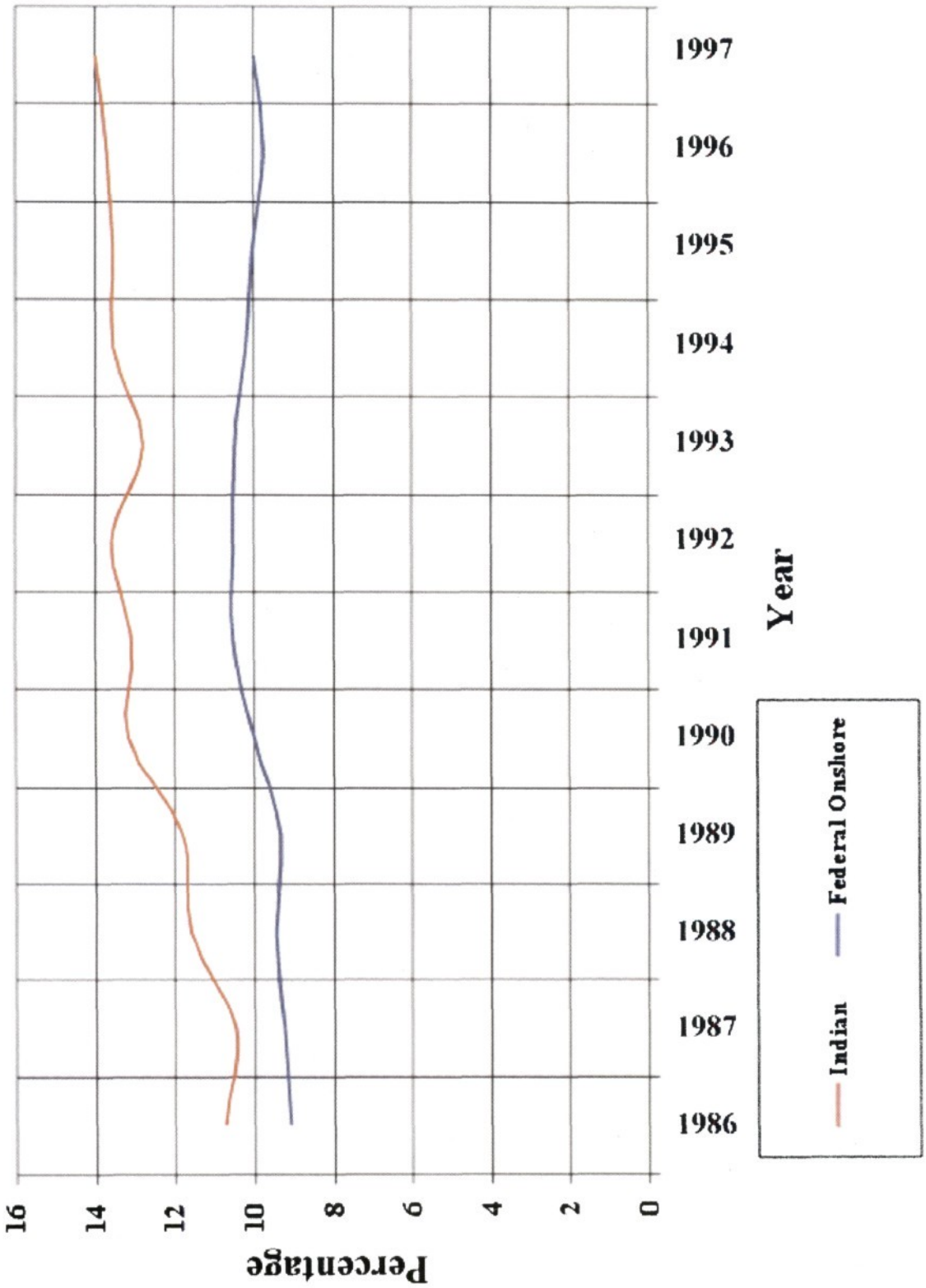

Figure 3 - Nationwide Royalty Rates

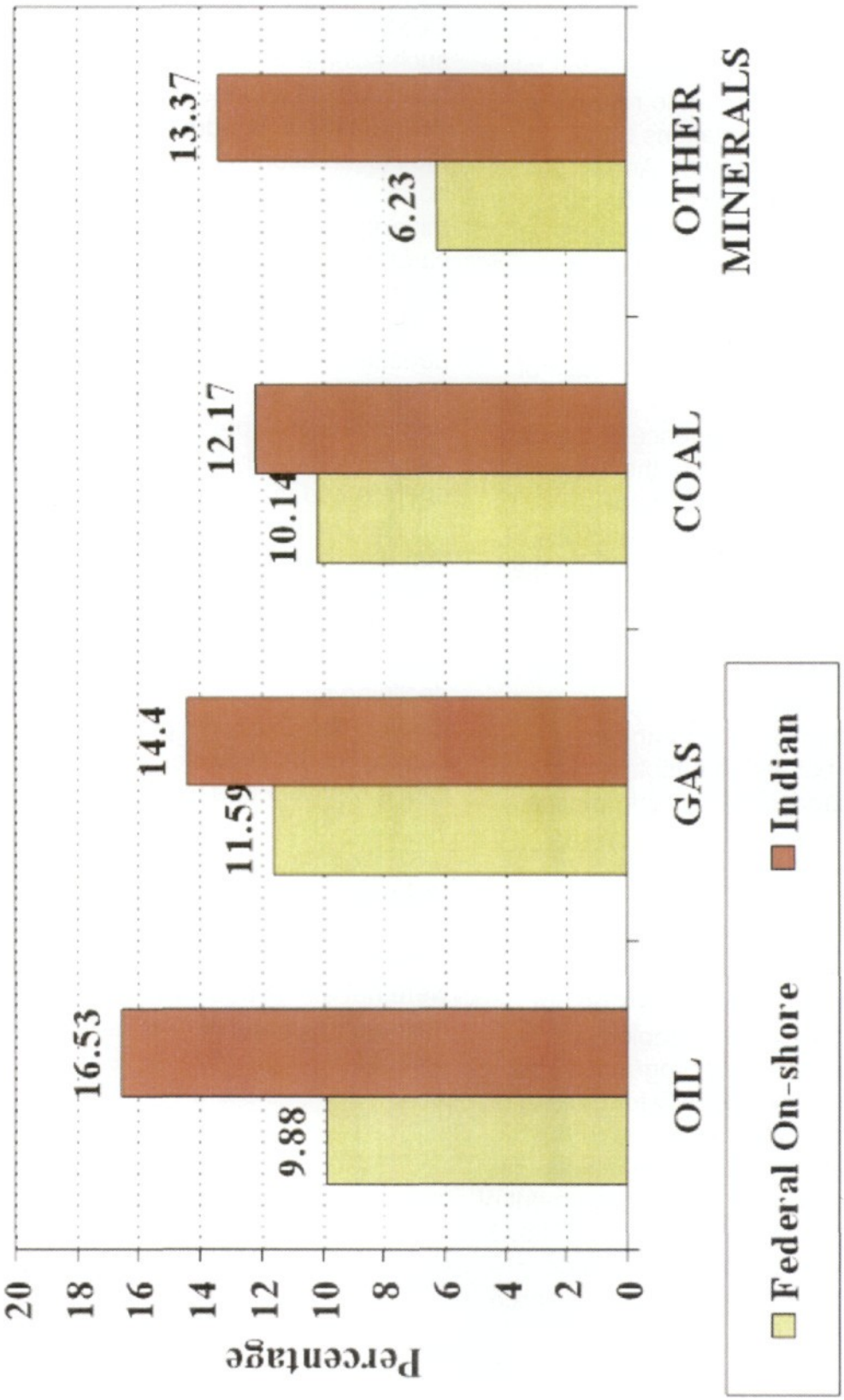

Figure 4- 1997 Nationwide Average Royalty Rate

The final release of regulations 25 CFR Parts 211 and 212 must rank as a major accomplishment for which the Division takes the most pride. The attempt to revise the old, outdated set of regulations began in 1976, and were published on August 7, 1996. This event, coupled with the 1995 publication of the IMDA regulations, 25 CFR 225, gave Tribes and industry the first modern set of regulations in over 20 years. With the regulations now in place, we are seeing the Tribes taking full advantage of the flexibility the IMDA allows.

However, as a consequence of the new flexibilities of the regulations, the Tribes are developing more complex mineral agreements. They force Tribal and BIA mineral personnel to become better versed in mineral economics, mineral negotiation, mineral resource identification and mineral resource management. For these reasons the DEMR has established programs that, not only, provide the Tribes with geo-technical data, but also the tools and the training to use and apply this information.

Conclusion

The DEMR provides technical support to the Tribes interested in developing their mineral resources. These Tribes do not need or can afford full time geologist and engineers to support their programs. The DEMR, is taking responsibility for making such scientific expertise available to the Tribal Council and Tribal Natural Resources department, in conducting an assessment of the their mineral potential. The DEMR by providing technical support to the Tribe hopes to set a standard of technical service by which other agencies can imitate. The DEMR by taking responsibility for making such scientific expertise available to the tribal council and tribal natural resources department, in conducting an assessment of the Reservation's mineral resource potential hopes to aid the Tribes in managing their mineral resources. Programs have been carefully designed to anticipate the direction that self-determination will be taking the Tribes in future years. Each new program benefits Tribes by assisting them to become more directly involved in the control of their resources, or to provide specialized services that are too costly for an individual Tribe to operate and maintain themselves.

The Division takes great pride in the fact that nationwide Indian mineral revenue, mineral production and the share of the minerals income or royalty rate has steadily increased and remained stable in spite of declining mineral prices since 1989, when many of the Division's programs were first commenced. However, according to the Office of Inspector General's Audit Report No. 94-I-39, October 1993, insufficient funds prohibited the Division from financing all technically acceptable tribal proposals for assistance in assessing the potential for mineral development. As a result, minerals were not developed expeditiously, and the resultant revenues to the Tribes were delayed.

OUTREACH PROGRAM

Stephen A. Manydeeds[1]

Abstract

The Division's highly successful Outreach program provides opportunities, in the form of marketing events, for Tribes to promote development on energy and mineral prospects on their reservations. Several different factors play a part in a successful mineral agreement; 1) Tribes willingness to develop their mineral resources, 2) Geological resources must be present, 3) Companies must be aware that Tribes are interested in development and that geological resources exist, 4) Tribe must be comfortable with a company (i.e. eye ball chemistry), 5) Companies want to know if the Tribal Government is stable and if the Tribe is committed to the project and 6) Satisfactory economic terms. The Outreach program is design to address the first five factors in successful mineral agreement. In order to do this the Outreach program utilizes an integrated approach assisting Tribes promoting mineral development on their respective reservations.

Introduction

The Division of Energy and Mineral Resources has an "outreach program" which provides opportunities for Tribes to present the results of mineral assessment projects and the mineral resources discovered on their reservations to industry. The outreach program brings Tribes and their mineral assessment studies to industry's attention at national conferences and regional symposia. It assists both Tribes and industry in the development of energy and

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mineral prospects on Indian lands. This effort is unique within the Federal Government.

Background

In 1988, the Division began providing opportunities forTribes to present the results of the minerals assessment projects on their reservation to industry. The purpose of the outreach program is to stimulate interest in developing energy and mineral resources on Indian lands. The Division publishes the results of the mineral assessment studies for those Tribes wishing to promote their resources. Industry can use the information to generate plays and prospects on Indian land. The annual Indian Minerals conference in Denver in February is part of the Division's Outreach Program.

For over ten years, the Division has assisted Tribes to assess their reservations for energy and mineral resources. Many Tribes wished to promote mineral development on some of the prospects discovered by these mineral assessment studies, but did not have the background nor knowledge of how to proceed. The Division has sponsored eight annual national meetings in Denver and five regional conferences (San Juan Basin, Paradox Basin, Uinta Basin, Utah, Wind River Basin, Wyoming, Williston Basin, North Dakota & Montana). The Division has also attended, with various Tribes, the Northwest Mining Conference ten times, the Industrial Minerals Conference twice and numerous American Association of Petroleum Geologists (AAPG) Conferences.

As the "outreach" effort grew, it became apparent that several different factors play a part in a successful mineral agreement;

1. Tribes willingness to develop their mineral resources,
2. Geological resources must be present,
3. Companies must be aware that tribes are interested in development and that geological resources exist,
4. Tribes must be comfortable with a company (i.e. eye ball chemistry),
5. Companies want to know if the Tribal Government is stable and if the Tribe is committed to the project and
6. Satisfactory economic terms.

The Division developed an integrated approach assisting Tribes promoting mineral development on their respective reservations. The Outreach Program is designed to address the first five factors in successful mineral agreement.

"Outreach" goals

The "outreach" program is designed to stimulate interest on Indian Reservations by:

- Identifying Indian Tribes that are interested in considering a mineral proposal.
- Publishing geotechnical data on mineral resources on Indian Trust Lands.
- Discussing the positive effects of doing business on Indian lands .
- Establishing ground rules for mineral proposals and negotiations.
- Providing a neutral environment for both theTribe and companies to interact.

The Division has made the following observation. When Tribes present at a technical conference companies will become interested in that reservation. However, before they approach that Tribe

they will want to review the geological data on the Reservation to re-confirm the interpretation. This review may take up to a year to perform. The company will then return to the conference to see if the tribe has returned. This tells the company two things 1) The Tribe is really interested in the development of their minerals and 2) as the development of most mineral properties take between 2 to 10 years (depending on whether it is oil and gas or mineral property), the company wants to know whether theTribe has the "staying" power to see the project to the end. Often a company will wait for two to three years before they even approach a Tribe at a conference.

Once the company is satisfied the Tribe has the "staying" power they want to see, the next critical step is taken. The company and a Tribal representative will meet for the first time. Often it is this meeting that sets the tone for the relationship. With Tribes the "eye-ball" chemistry is critical to any business relationship that may develop. Tribes may end a negotiation with a company not because of the economics but because they did not like the individual. One of the key elements to making this first meeting a success is to hold this meeting at a neutral site, such as a conference. This assures that no party has a "home field" advantage, this limits the amount of posturing that both parties would do if the meeting was in their respective headquarters. If this first meeting ends favorably, then additional meetings can occur that discuss ground rules for mineral proposals and negotiations. This allows both parties to be better prepared for the formal meeting with the company andTribal Council.

Figure 1. David Head and Gary Deters demostrating NIOGEMS at the 1998 National Indian Conference

Conferences and Symposiums

The Division advises any Tribe interested in participating in the Outreach Program that while the purpose of the outreach conference is to stimulate interest in developing Indian lands, participation in the Outreach Program by a Tribe does not commit Tribes in any way in leasing or developing any of their lands. The Tribes, themselves, control all mineral leasing activities on their respective Reservations.

Technical papers describing the energy or mineral resources on the reservation are presented at a technical meeting attended by industry personnel (Figure 1). Tribal representatives present poster displays at these conferences and meeting and participate in the conferences attempting to focus attention on the resources on their Reservation.

If the Tribe chooses to participate in a conference, it's technical staff or contractor will be asked to prepare technical posters and charts that will highlight the areas of high mineral potential on its reservation. This office provides editorial assistance to Tribal's technical staff or contractor. All posters, charts and articles are presented before the Tribal Council for their approval before sending them to the conference. These materials will provide the energy and mineral industry a "first look" at the respective Reservation and should start to activate the promotional process.

The Division has sponsored nine annual national meetings in Denver and five regional conferences (San Juan Basin CO & NM, Paradox Basin UT & CO, Uinta Basin, UT, Wind River Basin, WY, Williston Basin, ND & MT). The Division has also attended, with various Tribes, the NorthWest Mining Conference nine times, the Industrial Minerals conference twice and numerous American Association of Petroleum Geologists (AAPG) conferences.

At last year's NWMA conference the Tribes that chose to participate by sending Tribal representatives were: Annette Island, AK; San Carlos, AZ; Torres Martinez, CA; Goshute, UT & NV, Walker River, NV; and Wind River, WY. In addition, the Division display geo-technical data on the Reservations in the states of Washington, Oregon, Idaho, Nevada, Montana and Wyoming.

A geo-technical talk was presented at the Conference, the title was: **Indian Lands in the United States**. These talks provided up-to-the-minute news on where the hot exploration areas are on Indian lands. Indian lands represent one of the least explored areas in the United States.

As a result of the booths and talks, over 150 companies (see Attachment A) met with Tribal representatives to discuss possible mineral agreements and services. These discussions with Tribes which had a physical presence at the conference have lead to serious mineral proposals for areas on their reservation. Some reservations received more than two, such as the Torres Martinez who by the end of the first day had received 18 serious inquiries.

The Division also attend the 35th International Forum on Industrial Minerals. At this conference the Division sponsored a booth entitled "Industrial Minerals on Indian Lands." Within the booth there was three different subheadings: Wind River Indian Reservation Gypsum Resources, Annette Islands Reserve Aggregate Resources, and National Indian Land Aggregate Resources. Two geo-technical talks were given; "Economical Gypsum Deposits on the Wind River Indian Reservation" by Lynne Chastain, ACS Government Solutions

Group and "Economic Incentives to Work on Annette Island Reserve, AK" by Terrance Booth, Metlakatla Indian Community.

World Wide Web and Publications

Tribes that wish to have their mineral assessment information public can have their data published (Figure 2). Published information is distributed to libraries, state geological surveys, and university geology departments. Thus their Indian energy and mineral resource information becomes available to any company conducting a literature search. Of course publication of Indian mineral information can only occur with the consent of the Indian owner.

The major publications for the Division are:

"Hydrocarbon and Mineral Resources of the Uinta Basin, Utah and Colorado" Thomas D. Fouch, Vito F. Nuccio, Thomas C. Chidsey, Jr., editors, Utah Geological Association, Guidebook 20 1992 Special Symposium

"Economic Mineral Resources of the Annette Island Reserve, Alaska" Larry H. Godwin and Bruce D. Smith, editors, Northwest Mining Association Special Symposium 1993.

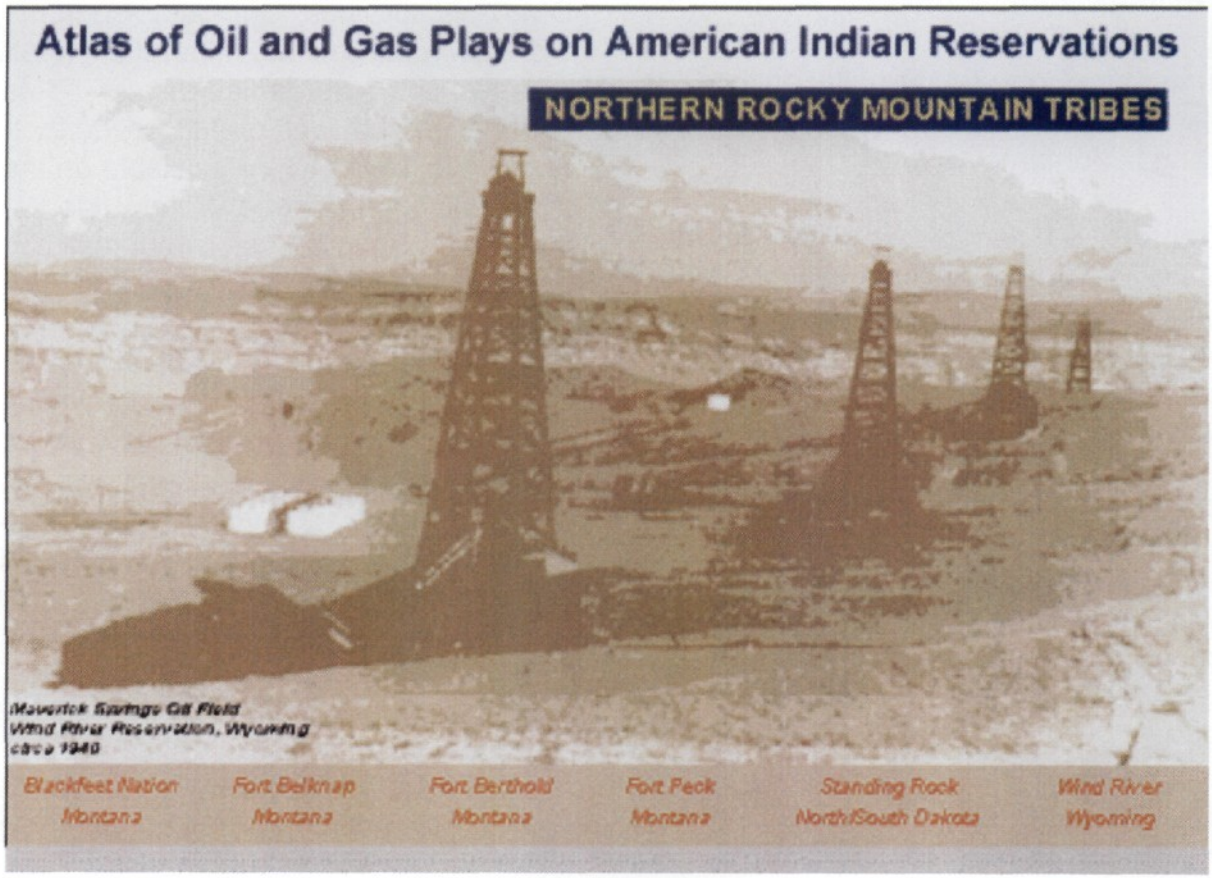

Figure 2. Front cover of the Division's 1998 publication "Atlas of Oil and Gas Plays on American Indian Reservations

"Oil and Gas and Other Resources of the Wind River Basin, Wyoming", William R. Keefer, William J. Metzger and Larry H. Godwin, editors, Wyoming Geological Association Special Symposium, 1993.

"Economic Mineral Resources of the Goshute Indian Reservation, Nevada - Utah" Larry H. Godwin and Bruce D. Smith, editors, Northwest Mining Association Special Symposium, 1994.

"Economic Mineral Resources of the Red Lake Indian Reservation, Minnesota" Larry H. Godwin and Bruce D. Smith, editors, Northwest Mining Association Special Symposium, 1995.

"7th International Williston Basin Symposium, 1995 Guidebook", L.D. Vern Hunter and Robert A. Schalla, editors, 7th International Williston Basin Symposium - Billings, Montana, 1995.

"Geology & Reseources of the Paradox Basin" 1996 Special Symposium, Utah Geological Association and Four Corners Geological Society, Guidebook 25, A. Curtis Huffman, Jr., William R. Lund and Larry H. Godwin, Editors, 1996.

"Atlas of Oil and Gas Plays on American Indian Reservations, Northern Rocky Mountain Tribes", Robert Anderson and Roger Slatt, Editors, Bureau of Indian Affairs, Division of Energy and Mineral Resources, General Publication G-97-2, 1997.

"1998 Annual Report" Larry H. Godwin and Stephen A. Manydeeds, Editors, Bureau of Indian Affairs, Division of Energy and Mineral Resources, General Publication G-98-1, 1998.

"1999 Annual Report", Stephen A. Manydeeds, Editor, Bureau of Indian Affairs, Division of Energy and Mineral Resources, General Publication G-99-1, 1999.

As part of the Division's Outreach Program, in August of 1994, the Division announced, its World Wide Web hypertext information site. Information concerning the Division's activities, Outreach Programs, CD-ROM publications, mineral exploration potential and other Indian mineral related information are available on the Internet. The Division's Web site address can be accessed at **http://snake1.cr.usgs.gov**.

In December of 1997, the Division re-designed its World Wide Web hypertext information site. Information concerning the Division's activities, Outreach Programs, CD-ROM publications, mineral exploration potential and other Indian mineral related information, that was pre-approved by the respective Tribes, were available on the INTERNET through the World Wide Web interface. Specifically, current topics include descriptions and graphic images describing:

MINERAL INCOME - Mineral income from resource development on Indian Lands provides significant income to Tribes and individual Indians who have chosen to develop those resources. Historically, economic return to the Indian mineral owner ranges between 75 to 85% of the total lease income generated on Indian Trust lands. This page shows historical income data and royalty rates on Indian lands.

MINERAL ASSESSMENT - The Division manages a Mineral Assessment Program which provides annual funds to Tribes in helping them achieve these key goals and benefits: 1)evaluate the mineral resource potential of Indian reservations;

2) provide Indian Tribes with geological, geophysical, and geochemical data concerning their mineral resources; 3) furnish Tribes with technical assistance on how to use the data; and 4) provide an outreach effort to promote Indian lands to private industry.

OUTREACH - The Division through its outreach efforts provides: 1) opportunities for Tribes to present the results of minerals assessment projects and the mineral resources discovered on their reservations to industry and 2) assistance to tribes in promoting development of their energy and mineral prospects. The Outreach Program uses national conferences and regional symposia, presented in cooperation with the Federal and state agencies and professional groups. The Division of Energy and Mineral Resources also sponsors an annual Indian Minerals conference in Denver.

NIOGEMS - The National Indian Oil and Gas Evaluation and Management System (NIOGEMS) program is an oil and gas management database system which Tribes use to monitor oil and gas production on a day to day basis.

NAEMI - The Native American Energy and Minerals Institute (NAEMI) program is a series of intensive short courses specifically designed to train Tribal resource personnel to take a leadership role in the management of their Tribe's resources.

NISES - Under the National Indian Seismic Evaluation System (NISES), the Division collects, archives, and manages seismic exploration data,, a valuable resource for identifying new petroleum reserves on Indian lands. A large amount of seismic data already exists on Indian lands, while new data continues to be acquired by private companies exploring for oil and gas resources. Often the seismic information is available to Tribes, and may be viewed by interested parties planning to lease Indian lands. Permission to view any seismic data must first be obtained from the respective Tribe.

NIEMR - The Division developed the National Indian Energy and Mineral Resources Data Base (NIEMR), to collect and archive all Indian Energy and Mineral resource data and information nationwide. The Division maintains unique geoscientific data pertinent to evaluation of undiscovered Indian energy and mineral resources.

Just during the month of February, 1999 over 3081 users (Figure 3) have downloaded over 25,938 pages (Figure 4) on the division's web site. These files represents over 581 Mbytes of data (Figure 5). As shown in the graphs, traffic on the Division's website has increased by at least a factor of 5 since August, 1998.

Conclusion

Several different factors play a part in a successful mineral agreement; 1) Tribes willingness to develop their mineral resources, 2) Geological resources must be present, 3) Companies must be aware that tribes are interested in development and that geological resources exist, 4) Tribes must be comfortable with a company (i.e. eye ball chemistry), 5) Companies want to know if the Tribal Government is stable and if the Tribe is committed to the project and 6) Satisfactory economic terms. The Outreach program is design to address the first five factors in successful mineral agreement.

By using the INTERNET, the Division is assisting those tribes interested in

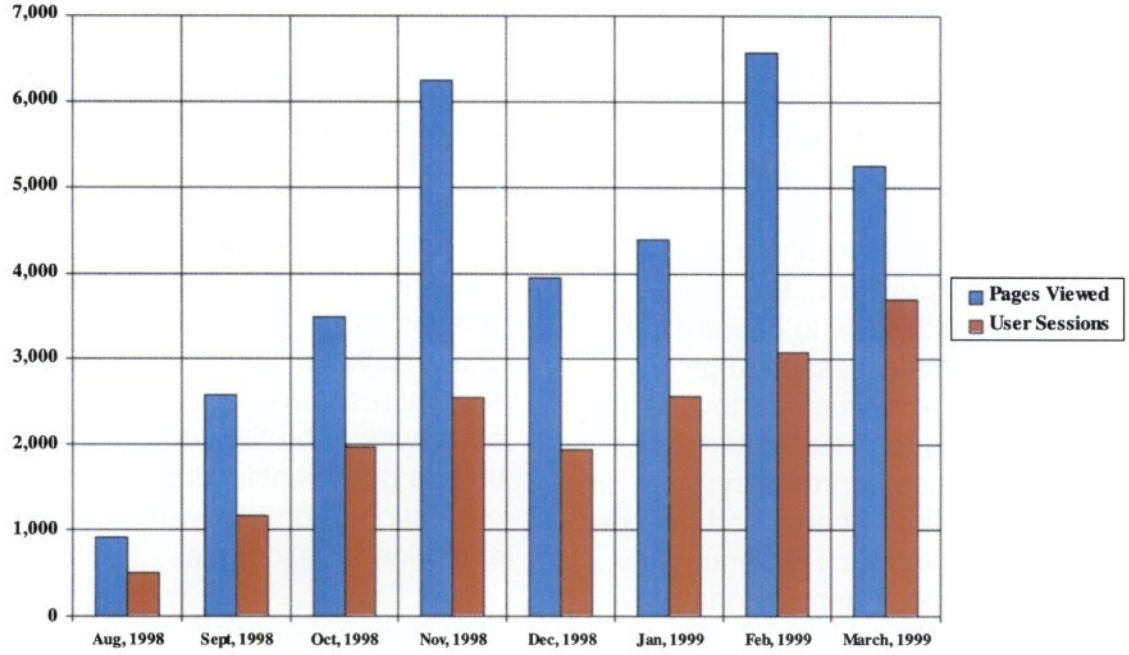

Figure 3. Number of User Sessions and Pages Viewed for the Division of Energy and Minerals Web Site

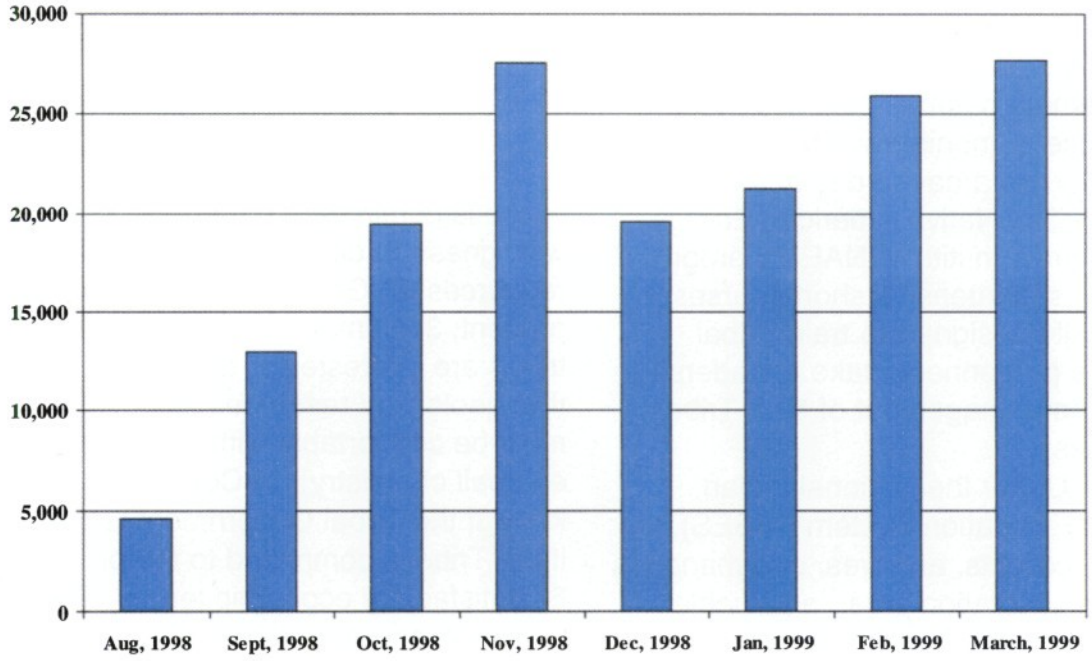

Figure 4. Number of Files Transferred from the Division of Energy and Minerals Web Site

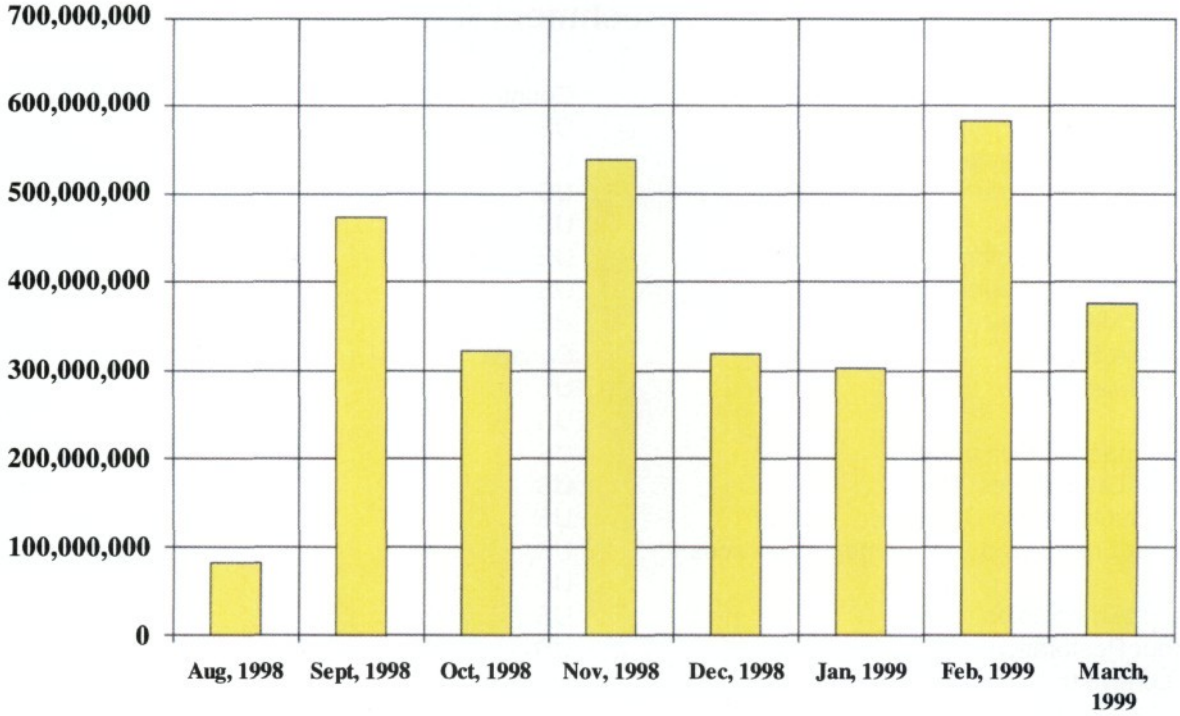

Figure 5. Number of Bytes Transferred from the Division of Energy and Minerals Web Site

developing their mineral resources by making their information and data available to the widest audience quickly and efficiently. In presenting technical papers and talks at national conferences the Division is making companies aware that individual Tribes are interested in developing their respective mineral resources. By providing booths for individual Tribes at conferences the Division helps in setting up a neutral site. This assures that no party has a "home field" advantage and this limits the amount of posturing that both parties would do if the meeting was in their respective headquarters. This allows both the Tribes and companies the "eye-ball" chemistry which is critical to any business relationship that may develop. The neutral site provides for a climate that allows for the discussion of ground rules for mineral proposals and negotiations. This allows both parties to be better prepared for the formal meeting with the company and Tribal Council.

The Outreach Program utilizes an integrated approach assisting Tribes promoting mineral development on their respective reservations. Since the Division has started placing data and information on its Website, traffic has increased by at least a factor of 5 since August, 1998 and conference foot traffic has also increased, as can be seen by Attachment A, the list of companies that visited the Division's booths at the December, 1998 Northwest Mining Conference.

Attachment A

Company	Country
Actlabs Inc.	US
Advanced Heavy Equipment	US
Alaska Division of Trade & Development	US
Alaska Marine Lines	US
American Colloid Company	US
American Assay Laboratories	US
American Mine Services, Inc.	US
Anachemia Science	Canada
Austin Power CO	US
Baroid	US
Barr Engineering Company	US
Barringer Laboratories, Inc.	US
Battle Mountian Gold Company	US
Beartooth Energy and Environmental Services	US
BHP	US
BioHeap technologies	US
Bitterroot Restoration	US
Boart Longyear	US
Boise Casacade Corp	US
Bon Terra	US
Bush Drilling	US
Cambior Exploration Company	Canada
Campen Consultants, Inc.	US
Cascade Mining Company	US
CDM	US
CETCO Colloid Environmental Technologies	US
CGS, Inc. Contract Geological Services, Inc.	US
Chemex Labs	Canada
Christensen Porducts	US
Cominco American	US
Cone Geochemical Inc.	US
Connors Drilling Ltd.	Canada
Construciton Machinery Inc	US
Cowboy Exploration and Development Company	US
CRS (Contruction Related Services)	US
D. Keith Murray and Associates, Inc.	US
D. H. Blattner and Sons	US
Dateline Drilling, Inc.	US
Datamine	England
Deakin Equipment Ltd.	Canada
Decommissioning Corporation	US
Deggerstrom Mining Company	Canada
Deloro Minerals Limited	Canada
Delta Western	US
Derrick Corporation	US
Dhackworth Drilling Inc.	US
Drafting Media	Canada
Drilling Services - Boyles Bros. Drilling	US
Eklund Drilling Co	US

Emerson Power Products, Inc.	US
Entranspro	US
Environmental Reclamation Inc	US
Environmental West Exploration, Inc.	US
ERA Aviaiton	US
First point U.S. Minerals Inc	US
Gateway Technologies, Inc.	US
Geodyssey	US
Geographe International MFS Inc	Canada
Geoline Positioning Systems, Inc.	US
Geologic Data Systems	US
Geosoft	US
Geostat International Inc.	Canada
Goldbelt	US
Hagby USA Inc	US
Harding Lawson Associates	US
Hazen Research, Inc.	US
Henkle and Associates	US
Horizons, Inc	US
Hydrometrics, Inc.	US
IBS	US
IDHW Division of Environmental Quality	US
Inco Tech	US
Independence Mining Company	US
Interdex Exploration Software	Canada
International Plasma Laboratory Ltd.	US
Intertek Testing Services	US
Intertek Testing Services	Canada
JKS Boyles	Canada
Kappes, Cassiday and Associates	US
Kettle Drilling	US
Kinross Gold USA Inc	US
Knight Piesold	Canada
Kvaerner Metals	US
Lafarge Aluminates	US
Lakefield Research	Canada
Land Management Services, Inc.	US
Lang Exploration Drilling	US
Legend, Inc.	US
Liebherr	US
Lyntek	US
Majesty Inc	US
MapInfo	US
Maptek	Australia
Maxim Technologies Inc.	US
McCulley, Frick and Gilman, Inc.	US
MK Gold Company	Canada
Mineral Exploration Services	IRELAND
Mineral Environments Laboratories	Canada
Minitec, inc	Australia
MRDI	US
MSE Technology Applications, Inc	US

Nevcros	Canada
Newmont Exploration Limited	US
Norlander	Canada
North Mining Inc	Canada
Northwest Drilling	US
Northwest Machine Works	US
Oasis Montaj	Canada
O'Keefe Drilling Co	Canada
Olympus Environmental, Inc.	US
OXIDOR Laboratories	US
Paterson, Grant and Watson Limited	US
PC Exploration, Inc.	US
PCI Pacific	Canada
Pearson, deRidder and Johnson, Inc.	US
Pelican Products, Inc.	Canada
Peter Kirwin	US
Pittston Nevada Gold Company	US
Placer dome U.S. Inc	US
Poly-Drill Drilling System	Canada
Pothier Enterprises Ltd.	Canada
Queenstake Resources Ltd.	US
Randol	US
Rimrock Explosives	US
Road Machinery	US
Robertson Info-Data inc.	Canada
S, B, Enterprises, Inc.	US
Sam McNary, Consulting Geologist	US
Schafer and Associates, Inc.	US
Shasta Geochemistry Laboratory, Inc.	US
Shepherd Miller, Inc.	US
Silver State Surveys, Inc.	US
Silver Trend Mining	US
Spectra Consulting	US
Svedalla	US
SVL Analytical	US
Tech Minerals	Canada
Techno Drill Ltd.	US
Terrasource	Australia
Trimble	US
Tonto Drilling Services	Canada
TYDAC	Canada
Van Waters and Rogers Ltd.	US
Eric Cheney, Washington State University	US
Western Pioneer, Inc.	US
Western States Minerals	US
Wilder	US
Wildlands, Inc.	US
WVCO	US
XRAL Laboratories	Canada

Using NIOGEMS to Manage Tribal Oil and Gas Resources

Gary Deters[1], David Head[1],Carrie Vogt[1] and Stephen Manydeeds[2],

ABSTRACT

To help Tribes collect realty, production and royalty data from more than a dozen separate data bases, the Division of Energy and Mineral Resources (DEMR) constructed the National Indian Oil and Gas Evaluation Management System (NIOGEMS). NIOGEMS uses an integrated data base manager and a graphic user interface to assemble and present lease, production, and royalty information data in a "point and click" environment. The DEMR continues to develop and enhance NIOGEMS. This system is an automated, graphically driven, information storage and retrieval system that can assist Tribal energy resource managers with strategic management decisions. NIOGEMS' graphical interface greatly simplifies information retrieval, inspection and analysis procedures.

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INTRODUCTION

The Bureau of Indian Affairs, Division of Energy and Mineral Resources (DEMR) initiated the National Indian Oil and Gas Evaluation and Management System (NIOGEMS) program in 1993. This computer-based system is designed to assist oil and gas producing Indian Tribes achieve their goals towards self governance and compacting. Under compacting, Tribal resource managers will need to readily access financial, realty, geo-technical information and complex resource data for management decisions on leasing, developing and managing minerals. The DEMR recognized the need for an automated system which would contain two major structural components: 1) a comprehensive database integrated by the data elements required to manage Tribal oil and gas resources, and 2) a graphical user interface

which provides "user friendly" methods to implement complex data management operations.

Many oil and gas management operations are currently performed as a trust responsibility for Indian lands by three separate agencies of the Department of Interior. The Bureau of Indian Affairs (BIA) performs prelease activities, lease negotiation and post lease activities for Tribes and Indian mineral owners. The Bureau of Land Management (BLM) manages exploration, development, inspection and enforcement. The Minerals Management Service (MMS) processes production and royalty accounting information. NIOGEMS consolidates data on these operations into a single management system, which has been tailored to the specific needs of Indian lands owners.

BACKGROUND

The primary goal of the Division of Energy and Mineral Resources is to provide the best available technical, economic, and land-use data, advice to Indian landowners, and to assist Tribes in achieving the maximum income and employment returns from the development of their mineral resources. Mineral resource development provides significant income to Tribes and individual Indians. The economic return of the development of mineral resources to the Indian mineral owner has historically been between 75% and 95% of the total lease income generated on Indian Trust lands. On some Indian lands the mineral income has been over 95% of the total income generated. Decreases in the mineral income often mean economic hardship for the Indian mineral owner. During FY 1996 (latest information available) minerals produced on Indian Trust lands had a sales value of over $1.39 billion. From this amount the Indian mineral owner has received over $168 million.

In 1992, with funding from DEMR, the Osage Tribal Council commissioned a workload analysis of the Branch of Minerals of the Osage Agency. The Osage Agency is unique in that the BIA is responsible for management of all oil and gas activities on that Reservation. The work load study compared various other offices supporting oil and gas development on Indian lands and recommended proper staffing levels. The study, performed by Coopers & Lybrand, recommended 14 new positions in the BIA's Branch of Minerals agency office to bring the workload to a comparable basis with the other agencies. The Osage Tribal Council sent the results of this study to Congress with a request for supplemental funding for these positions. The US Senate requested the BIA to correct the problem using available resources. The Division of Energy and Mineral Resources recognized that in the tight budget arena, funding for fourteen additional positions was not feasible. A more viable solution was to improve productivity of the available work force by computerizing some of the work. Consequently, the Division begin developing NIOGEMS to meet the needs of the Osage Tribe.

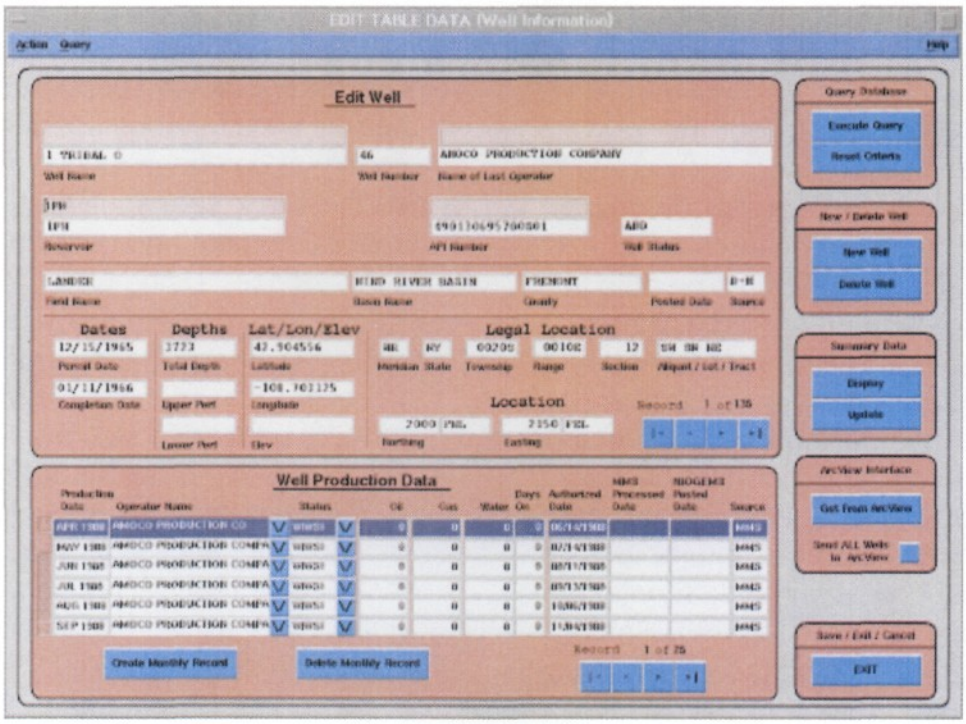
As NIOGEMS was developed, it was reviewed by several agencies, Tribes and other interior agencies. At the request of these agencies and Tribes, additional beta test and user sites for the system were established. Minerals Management Service (MMS) and the Division are now coordinating to link the Tribes and agencies via DOINET to share information. MMS is designing its systems that will be installed at various Tribal sites to include the NIOGEMS system. The BIA has selected NIOGEMS

as one of it's key programs, and NIOGEMS is reviewed annually for performance assessment.

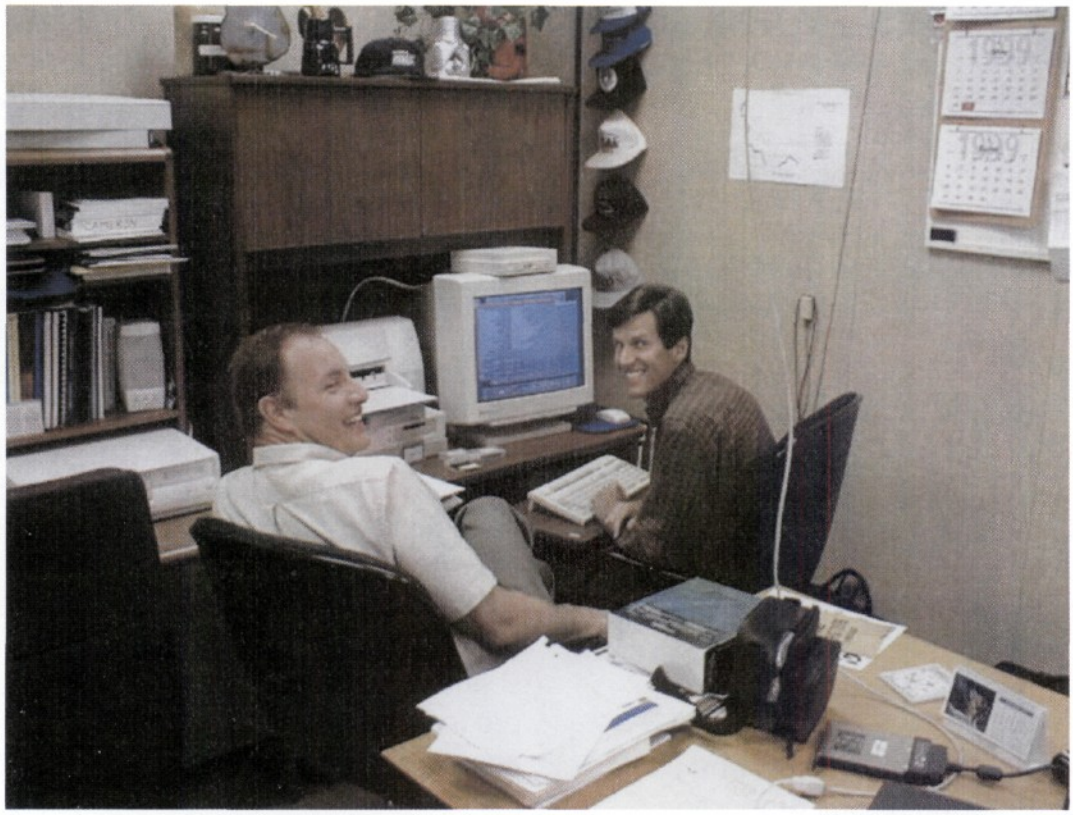
NEW DEVELOPMENTS

A key feature in Graphic User Interface (GUI) application design is ease of use for resource managers with basic computer skills. New developments for the NIOGEMS GUI are centered on a button and icon point-and-click driven interface. Coupled with this, two commercial applications are being utilized to meet the tabular and spatial information requirements: ORACLE Relational Database Manager Server and the ARCVIEW Geographic Information System (GIS). A table-like Forms GUI link with ORACLE, allows the user, through pressing a few buttons, to query, review and print customized reports of well production, lease, and mineral ownership information. ARCVIEW is seamlessly linked with ORACLE, providing functions to view and generate graphs of production data, maps, and create production decline curves. Since ARCVIEW is a general GIS widely used in the market place and by government agencies that utilizes standard data formats, a user at a site can easily exchange and add spatial data to tailor NIOGEMS to their needs.

NIOGEMS production data is updated regularly by a site with MMS production data transmittals. This ensures that the reservation has the latest data for analysis. NIOGEMS also includes an online user's guide documentation, including several scenarios that lead a user in a step-by-step procedure on how to use NIOGEMS to accomplish a task.



Edit Screen from NIOGEMS



Gray Deters and David Head holding Training at Uintah & Ouray Reservation

Tabular Interface Architecture

Database management software is key to implementing a successful information management application such as NIOGEMS. NIOGEMS must be able to manage large amounts of tabular data reliably. The Division has selected the ORACLE RDBMS Server and Developer/ 2000 application design tool to store and display the wide variety of attribute data used in NIOGEMS. Oracle software facilitates information storage, and rapid development of tabular attribute data entry tools and user reports. The ORACLE Server provides efficient solutions for data management in several areas:

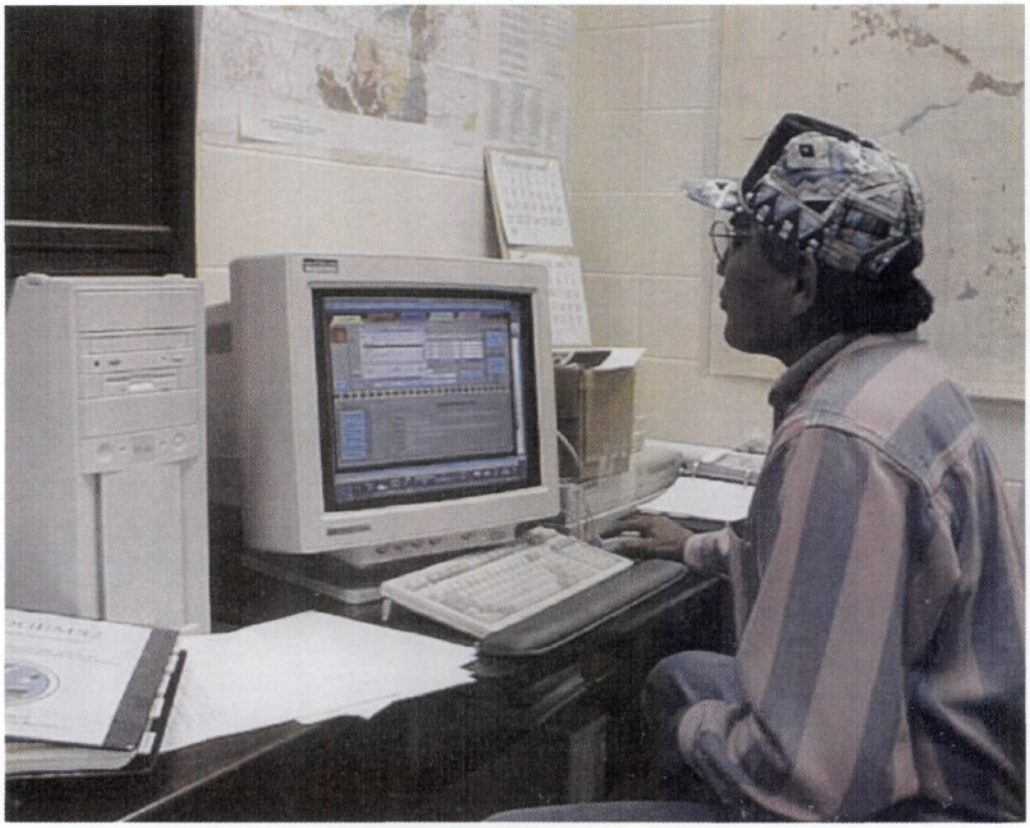
- *Large databases*_- supports data storage to potentially hundreds of gigabytes in size.
- *Concurrent users* - supports large numbers of simultaneous users executing a variety of database functions operating on the same data source. It minimizes data contention and guarantees data concurrence. Using ORACLE, NIOGEMS can take advantage of full client/server application architecture in the event that an installation site requires multiple user work stations.
- *Data security* - provides NIOGEMS with built in, security features to limit and monitor data access as required by an installation site.
- *Portability* - allows applications designed on the Division's HP-UX platform to be ported to work under other operating systems with minimal modification. ORACLE also provides connectability across multiple network systems.

On the user interface side of the picture, point and click user access to NIOGEMS attribute data is made possible by Developer/2000 tools. The DEMR has created graphical data entry forms that support: query, insert, update, delete capabilities, user reports, graphics, and online documentation. Developer/2000 simplifies NIOGEMS maintenance and allows rapid enhancement development with a uniform GUI.

Spatial Interface Architecture

Current enhancement efforts of NIOGEMS centers around the use of ARCVIEW, a spatial information display tool (i.e., GIS). For NIOGEMS' on-screen map display objectives, the benefits afforded by ARCVIEW include:

- *Supports rapid application development* - GUI applications may be built much more quickly using commercial tools rather than using a lower level programming language such as C or Fortran. ARCVIEW's application development language (Avenue) is a powerful, object oriented programming language well suited for rapid NIOGEMS development. Because of this, enhancements can be added quickly to the system using code that is reusable by other modules with little, if any, modification.
- *Easily integrated for input/output* - ARCVIEW supports external interface devices such as plotters or printers for map output, and more importantly for



Chester Pingree using NIOGEMS at the Wind River Reservation

NIOGEMS, allows direct connection to the attribute data in ORACLE.

- *Supports for third-party libraries* - Many commercial organizations distribute pre-built library routines and utilities. The use of these libraries saves on development costs and yields a more standardized application.
- *Cross-platform development tool* - NIOGEMS applications, initially developed and distributed for Hewlett-Packard workstations running HP-UX will, with minimal porting effort, also execute on: Sun SPARC Workstations, PC's running Windows or NT, and Apple Macintosh.
- *Supports ARC/INFO format spatial data* - NIOGEMS can import, with minimal processing, data from many different sources, including imagery.

Automated Parcel Generator

For creation and maintenance of the Lease theme in the mapping part of NIOGEMS, a Jeffersonian survey-based parcel generation methodology was employed to translate land descriptions associated with a lease to lease map features. When a user saves the edits for a lease (whether modifying or adding lease land descriptions), NIOGEMS automatically invokes the parcel generator to update/ create that lease's spatial feature in the Leases theme of the ArcView map.

The parcel generator is based on the use of four components, namely: a Reservation's section land grid (i.e., the Sections theme), Premier Data Services' CarteView package (PC-based land description-to-polygon translator software), Premier Data Services' LotFinder package (PC-based software/database containing BLM standardized special survey legal land descriptions), and the translation/retrieval software module in NIOGEMS. Before installation at a reservation, the first three components are used to pregenerate data to populate the NIOGEMS database. The translation/retrieval software then uses that data for creation of the lease features. These components are used in the following manner for generating the lease features in Niogems.

A land description and a serial number for all possible aliquots down to the fourth level (e.g., NWNENWSE) for each section are created using the reservation Section land grid. This list of land descriptions and serial numbers are then used to populate a large table in the NIOGEMS Oracle database providing a reference between an aliquot with its full land description (i.e., meridian, state, township, range, section, aliquot) and a corresponding unique serial number. A table is also created containing a full land description of each section and township within the reservation.

The list of aliquot land descriptions is passed to the CarteView software. This software translates each aliquot land description into a polygon and assigns the corresponding serial number to that polygon. Four ArcView shapefiles (one for each aliquot level; called q1shapes, q2shapes, etc.) that contain the aliquot polygons with their serial numbers are created. These shapefiles are stored with the other delivered spatial themes in NIOGEMS.

The LotFinder software is used to populate another table in the Niogems Oracle database to provide a reference for all possible special surveys that occur on the reservations lands. This data is based on the BLM's Legal Land Description (LLD) database and thus reflects the national standards for describing lands (including acreage) within NIOGEMS. This data also contains the approximate nominal quarter-quarter aliquot locations that most closely

Table 1 - Source Data

Data content	Source	Use
Well lat/lon, legal location & information.	PI/Dwights, AFMSS	current potential
Production data with dates up to the start of MMS 3160 production data.	PI/Dwights	current
3160 Production data with dates after Aug. 1988; MMS takes precedence over Dwights when dates overlap.	MMS	current
Reservation Boundary theme, PLS theme.	Tribal, Agency, Premier Data Services, Tobin Data Graphics, BIA-GDSC, USGS , BLM	current
Agreements to Leases to Wells links.	AFMSS, MSS	current potential
Lease/Agreement information (& resulting Lease/Agreement theme).	MMS, Tribal, Agency IRMS	current future
2014 Royalty Income information.	MMS	future
Subsurface ownership information (& resulting subsurf. own. theme).	Tribal, Agency LRIS, LTMS	current future
Inspection Reports.	AFMSS	future
APDs.	AFMSS	future
Sundry Notices.	AFMSS	future
Survey Data	Premier, Data Services, Tobin Data Graphics, BLM	current

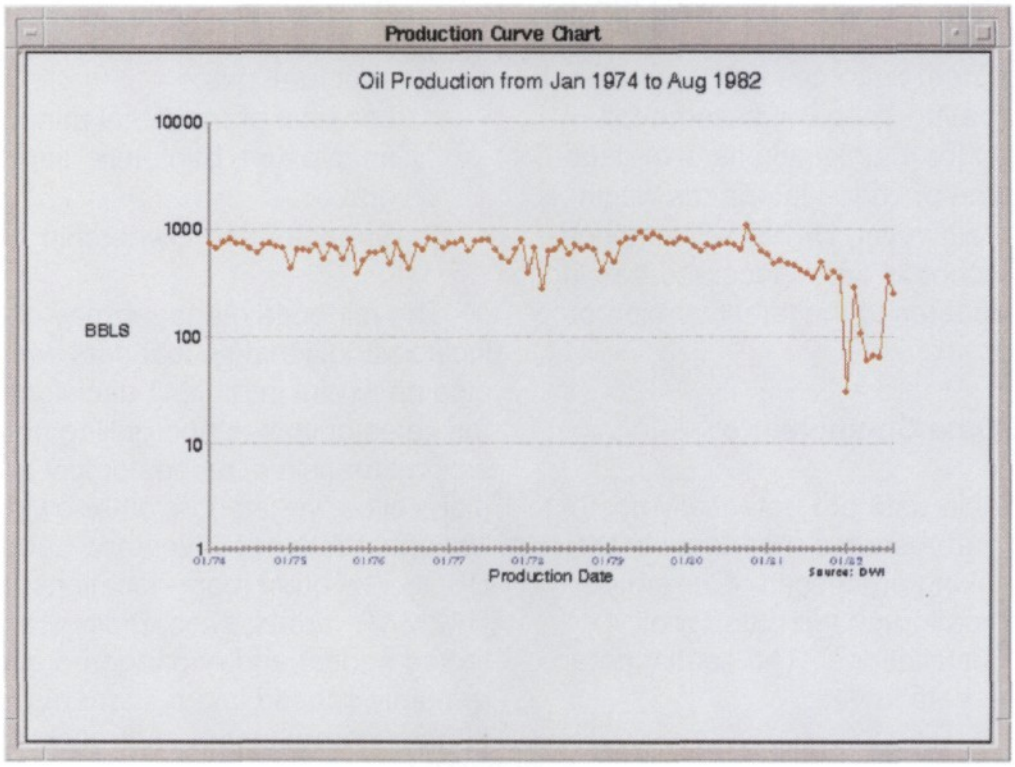
Table 2 – Site Software and Data Status

Reservation Site	Software Status	Reservation Boundary	Public Land Survey	Wells	Leases	Subsurface Ownership
Alabama-Coushatta	Update to new version	complete	complete	complete	complete	complete
Blackfeet	Future installation	complete	complete	in-progress	in-progress	in-progress
Ft. Peck	Update to new version	complete	complete	complete	complete	partially complete
Jicarilla Apache	Future installation	complete	complete	in-progress	in-progress	in-progress
Southern Ute	Future installation	complete	complete	in-progress	in-progress	in-progress
Ute Mountain Ute	Update to new version	complete	complete	complete	complete	complete
U&O	Update to new version	complete	complete	partially complete	partially complete	partially complete
Wind River	Updated to new version	complete	complete	complete	complete	complete

describe where in a section(s) a special survey is located.

Once these tables and shapefiles are created, NIOGEMS is ready for use to generate lease parcels whenever a user sets or modifies the land descriptions for a lease using the NIOGEMS Lease Editor. During specification of lands for lease, the user chooses from the reservation's list of townships and sections pulled from the previously generated table. Then the user can select a special survey or specify an aliquot down to the fourth level.

After saving the land edits for a lease, NIOGEMS automatically invokes the translation/retrieval software module (written in ArcView's Avenue scripting language) to take the list of land descriptions and translate these into the aliquot land descriptions that compose the land descriptions. Special surveys are translated into the nearest quarter-quarter aliquot land descriptions and any half aliquot descriptions (e.g., N2) are translated into their corresponding quarter part aliquot land descriptions (e.g., N2 -> NE and NW). The software module retrieves the corresponding serial number for each aliquot land description using the land shape table. It then gets the polygons that match each serial number from the aliquot shapefiles (e.g., q1shapes). If the user specified any section or township land descriptions, the software will retrieve the section or township polygons from the Section or Township themes of NIOGEMS,



Sample Chart Showing Oil Produciton Curve from NIOGEMS

respectively, as needed. The software module finally merges the gathered polygons into a single lease feature. This module can process a single lease or multiple leases in one pass.

The Present

The system is now being tested and used on five reservations/agencies and one Federal bureau site. These include:

- Alabama-Coushatta, Houston, TX
- Fort Peck Tribal Office, Poplar, MT
- Ute Mountain Ute, Towaoc, CO
- Uintah and Ouray, Ft. Duchesne, UT
- Wind River, Fort Washakie, WY
- Minerals Management Service, CO

The Division designs and places the system, and trains the prospective users. Once the system becomes fully operational, each participating Tribe will assume full responsibility for maintaining its own database using the provided interfaces within NIOGEMS. However, DEMR will continue to provide technical assistance and training, as well as updates to the latest version of the software.

NIOGEMS Data Components

All available data are potentially useful to Tribal land and resource managers in their decision- making processes. Currently, DEMR pre-configures the data for all NIOGEMS installations. The spatial data includes five data layers:

1) Reservation boundary,
2) public land survey (township/range and section),
3) Oil and gas wells,
4) mineral leases, and
5) subsurface ownership.

The tabular data include well legal descriptions and locations, production, operators, and leases. These data are provided as complete as possible at the time of initial installation to enable NIOGEMS operations to commence quickly. Each reservations' data are in many varied and unique formats and preparation of the data for an installation can be a challenge. DEMR assists the Tribal resource managers to review the database for completeness and accuracy and trains them on editing and maintaining the data to keep it current.

Additional spatial data may be added to the NIOGEMS system at a site. Examples could include:

- Seismic line locations
- Geology - surface, subsurface, structural maps
- Location of Industrial minerals such as gypsum, bentonite, sand and gravel.
- Surface Land Ownership

The minerals manager may choose to include additional spatial data which can also be useful in making decisions regarding the sales of leases and drilling permits, such as: cultural sites, archeological and religious sites, vegetation, other ownership, National Wetlands Inventory, Land Usage, USGS 7½' quad map - locations, names, HAZMAT - areas, sites, Biological - protected habitat and endangered species, remotely sensed images and digital aerial photos, game habitat and range data.

If basic information is not available in the proper digital format for reservations' NIOGEMS, sources and procedures for creating the proper digital data will be evaluated. Often a major part of this task will

prod_per_lease_by_lease: Previewer

File Edit Windows Help

Prev Next First Last Page: 1 Print Close New

Production for Lease
0058
Monthly Totals of Wells Combined
JAN 1997 To DEC 1997 02-JUL-98

Lease and Lessee Information

Lease No: 0058
Lessee: PIONEER OIL AND GAS Phone No:

Lessee Info

Wells included with lease

Well Name	Reservoir	Api No	
12-1		490132153500S01	Well Info/Prod
12-1		490132153500X01	Well Info/Prod
42-1	1TN	490132153300X01	Well Info/Prod
SHELDON TRIBAL NE NW	1TN	490132153300S01	Well Info/Prod
SHELDON-TRIBAL NE NW	1CU	490130657000S01	Well Info/Prod
SHELDON-TRIBAL NE NW	1CU	490130657400S01	Well Info/Prod
SHELDON-TRIBAL NE NW	CURTIS	490130657400	Well Info/Prod
SHELDON-TRIBAL NW NW	1PH	490130657500S01	Well Info/Prod
SHELDON-TRIBAL NW NW	1CU	490130657600S01	Well Info/Prod

Production Information Summary

Detail Report by Well

Year	Month	Oil	Gas	Water
1997	JAN	1,150	134	31,775
	FEB	1,033	116	28,350
	MAR	1,119	58	30,875
	APR	1,014	108	29,600
	MAY	1,097	120	31,978
	JUN	1,127	120	34,560
	JUL	514	60	17,897
	AUG	729	120	27,678
	SEP	893	120	29,090
	OCT	1,114	124	35,185
	NOV	1,056	120	33,904
	DEC	1,015	124	32,092
	Totals for 1997	11,861	1,324	362,984
Totals for Period		11,861	1,324	362,984

Example of a Production Report from NIOGEMS

involve establishing efficient procedures for converting legal lease descriptions into accurate digital maps. It appears that the key to efficiently undertaking this conversion process is the availability of suitable digital Public Land Survey maps showing all section corners. Such geographic locations can define geographic boundaries that form the basis for the automated generation of land parcels, or lease polygons, to which attributes such as lessee names and production statistics can be attached.

Distribution of Information

DEMR is coordinating with other BIA offices, MMS and the BLM to build automated data sharing/transfer avenues. Table 1 shows how NIOGEMS currently utilizes and plans to utilize data from these agencies and commercial sources. NIOGEMS will continue to be revised to include additional data sources as users identify additional data sources.

The Future

Future versions of NIOGEMS are being considered to include capabilities for the Tribal resource manager to maintain Royalty Income Information, Inspection Reports, ADPs, Sundry Notices, and for keeping agreements and subsurface ownership up-to-date (see Table 1). Work will begin in the near future on version 3 of NIOGEMS. This will include user login security and data protection (e.g., certain users may only see or edit certain data), functions to load and store of royalty data, decline curves showing dollars from production, lease agreements and participating areas, and an enhanced user query interface. This version is planned for Beta testing in latter 1999.

NIOGEMS is being developed as a single point data information warehouse providing 'one-stop-shopping' for the Indian mineral resource manager's information demands. To meet this goal, the Division is working with other BIA offices, MMS and the BLM to add more automated data sharing/ transfer avenues in the future (see Table 1).

NIOGEMS will be placed at some additional sites over the next year. The current software and data development status of existing and proposed NIOGEMS site's data is listed in Table 2.

Summary

Under compacting, Tribal resource managers will need to be able to access financial, realty and complex resource data in order to make management decisions on leasing and developing minerals. When the Tribes assume the mineral services from the BIA, BLM, and MMS, the Tribes will need to acquire large qualities of highly complex geo-technical data along with the need to hire highly skilled geo-professionals. NIOGEMS will reduce this need of the Tribes to acquire highly skilled and trained geo-professionals, provide an easy to understand interface for the Tribal managers, and make effective use of the highly complex geo-technical mineral data.

Relative to NIOGEMS, the Division plans to accomplish the following goals in FY 1999 and 2000:

• Continue to provide support, maintenance, and population of databases as needed for the NIOGEM systems for the Alabama-Coushatta, Fort Peck, Uintah & Ouray, Ute Mountain Ute, and Wind River Indian Reservations.

• Populate databases, train personnel, and install systems for the Blackfeet, Jicarilla Apache, and Southern Ute Indian Reservations.

• Assist the above Tribes in populating the databases with data that are unique to their respective reservations.

•Refine reporting, existing decline curves and economic analysis.

• Research development on an exploration module that will display geo-technical data located and provide information on data quality, type, year collected and contact for additional information.

•Develop interfaces with MMS, BLM, and BIA-Albuquerque to assist the Tribes in receiving the most up-to-date information.

Managing Indian Mineral Resources Using Digital Information

Stephen A. Manydeeds[1] and Lynne M. Chastain[2]

ABSTRACT

The Division developed the National Indian Energy and Mineral Resources Database (NIEMR), an automated database, to archive all Indian Energy and Mineral resources, nationwide. The Division maintains unique geoscientific data pertinent to evaluation of undiscovered Indian energy and mineral resources. Over 90 million dollars in mineral resource data have been collected from past investigations for undiscovered energy and mineral resources. The Division has the lead role within the Department of the Interior for managing Indian energy and minerals data. The development of the automated National Indian Energy and Mineral Resources data base allows the Division to house, maintain, and manage these resources data for the individual Tribes. The Division can provide these data to the specific Tribe (mineral owner) as needed.

The NIEMR database is computerized and will eventually include most energy and mineral resource data on Indian Trust Lands. Developing the database requires archiving all energy and mineral resource data on specific tracts of Indian Lands. Part of the data will be housed in the Oracle relational data base management system.

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INTRODUCTION

The foundation to any sound management program is reliable and consistent data. The Division of Energy and Mineral Resources (DEMR) has developed the National Indian Energy and Minerals Resource (NIEMR) database program to collect, edit, digitize, and archive energy and mineral resource data on Indian trust lands. Under this program, DEMR is transcribing hard copy data and reports into digital data. As sections of the database are completed, they will be digitally published in several forms for easy distribution. Proprietary data will remain under control of the Tribes, while public data will be provided in standard media formats accessible to agencies and individuals who wish to retrieve data for review and further analysis.

BACKGROUND

The Division of Energy and Mineral Resources maintains unique geo-scientific data pertinent to evaluation of undiscovered Indian energy and mineral resources. More than 90 million dollars in mineral resource data have been collected from past investigations for undiscovered energy and mineral resources. These data exist primarily in paper reports, maps, cross-sections and magnetic tapes in both analog and digital form. The vast majority of these data are in analog form. There existed the danger of the loss of this data due to inadequate data archiving. Those data that were in digital form were in several different formats, which made the data difficult to access and evaluate. In addition the Division needed a low cost and efficient method to distribute these data to Tribes, other government agencies and to the public.

The Division has the lead role within the Department of the Interior for managing Indian energy and minerals data. The development of the automated National Indian Energy and Mineral Resources data base allows the Division to house, maintain, and manage these data for the individual Tribes and to provide these data to the specific Tribe (mineral owner) as needed. The Indian Minerals Development Act (P. L. 97-382, December 22, 1982, 25 U.S.C. 2101) and the Federal Oil and Gas Royalty Management Act of 1982 (P.L.97-451) mandate that mineral information and economic data related to mineral development on Indian Trust lands are proprietary to the individual Tribe or allottee and are not to be disclosed without consent of the individual Tribe or allottee.

The National Indian Energy and Mineral Resource (NIEMR) database will eventually include most energy and mineral resource data on Indian Trust Lands. Developing the database requires archiving resource data pertaining to specific tracts of Indian Lands. Also, easy retrieval of the data for further analysis and use in future projects is a prerequisite. The means of retrieving the data must also meet the needs and requirements of a spectrum of users, e.g., Tribal mineral owners, personnel from other governmental agencies, and private industry.

INDIAN TRUST LAND GEOLOGIC REPORTS

Past Literature Reports

One of the first tasks under the program is to digitally capture all reports written under the many BIA supported assessment grants and contracts. Information recorded will include all of the text from the reports, tables, numeric values, scanned figures, illustrations, photographs, and maps. The first NIEMR CD-ROM product contains 113 non-restricted regional geological reports on Indian Reservations. These regional energy and mineral assessments cover most of the Indian reservations in the United States. The reports provide a regional overview of each reservation and contain information about the geologic framework and energy and mineral resources potential within the various reservations.

Beta copies of this CD-ROM were released for review and comment. Based on the feedback received, these regional geological reports are being re-formatted into an Adobe Acrobat's PDF file. Acrobat's PDF file is becoming recognized among industry as ideal for electronically publishing documents. The advantage of this type of file is ease of use, with a standardized operation that is familiar to all desktop PC owners. By adhering to a standard file format, all BIA published disks are ensured of being playable on any standard PC computer with appropriate free software.

The PDF files will be available on the DEMR's web page, and archived on CD-ROM. Distribution via the web solves a critical problem for the distribution of data.

Currently, the majority of figures from all 113 reports has been scanned and will be linked as TIF files. Text from 60 reports has been re-formatted. Tables in the reports will be scanned and linked to the report as a TIF unless they can be incorporated into the text. See Attachment A for specific information of the report status.

Geological, Geochemical, and Geophysical Data

The Colorado School of Mines (CSM) and ACS - Government Solutions Group (GSG), under a contract with DEMR, are inventorying and cataloging the geological, geochemical, and geophysical data from past mineral assessment projects, collected by the U.S. Bureau of Mines (USBM), the U.S. Geological Survey (USGS), and other private contractors. In this project, CSM personnel are transcribing paper data into digital format, inventorying the maps and physical samples, and performing preliminary geologic interpretation. Transcribing the data into digital format will make the data more easily accessible to the Tribes. The data can then be used to determine potential mineral resources on the Reservations.

The GSG personnel are the focal point for all geologic data coming into the DEMR office, including that input by CSM personnel. GSG personnel organize and cataloge the data and are designing a relational Access database to accomodate a wide variety of data types. GSG personnel then perform advanced geologic analysis and modeling with the emphasis on resource management.

As of April 30, 1999 over 58,000 individual rock records have been successfully digitized (Attachment B). In addition, over 79,000 individual digital rock records have been collected from government and private sources. Some of these data are available on DEMR's web page. Converting all paper geological data to digital format may take up to three years given the volume of data (approximately 60,000 additional records). To each record, twelve standard fields are added: Filename, Reservation, State, Table Title, Report Title, Report Number, Author, Agency, Year, Sample Type, Analytical Method, and Access ID. To further aid in the description and identification of samples, location data such as latitude and longitude are currently being added to all tables when possible. This is difficult because the necessary information is supplied in a variety of formats including UTM, metric, and latitude and longitude. In reports without sample location data, sample locations are being digitized from supplemental report maps.

Three reservations, the Wind River Reservation in Wyoming, the Torres Martinex Reservation in California, and the Annette Island Reserve in Alaska, have been the focus of GSG personnel work. These three Reservations have widely varying data type, ranging from airborne magnetic data on the Annette Island Reserve to drillhole data on the Torres martinez to gypsum data on the Wind River Reservation. The incorporation of data from different sources can be difficult and time consuming, as much of the data is not registered correctly geographically. These three reservations are serving as prototypes for the development of the relational Access database, geological block-models, and comprehensive ArcView coverages.

DEMR also maintains a secure warehouse off site where Tribes can store drill core and other rock samples long term. Currently, DEMR is storing approximately

20,000 feet of core and over 30,000 rock samples for the following reservations in the warehouse:

Acoma, NM
Annette Island, AK
Blackfeet, MT
Duck Valley, NV and ID
Flathead, MT
Fort Apache, AZ
Fort Hall, ID
Fort McDermitt, NV and OR
Goshute, NV
Mole Lake, WI
Pyramid Lake, NV
Quinalt, OR
Rocky Boys, MT
Spokane, WA
Tule River, CA
Walker River, NV
Wind River, WY

Airborne Geophysical Data

Airborne geophysical data was originally stored on 8 and 9 track computer tapes and are being recorded permanently onto CD-ROM disks. The following table summarizes data sets that have been archived. Data sets that have been published in forms other than administrative reports are publicly available and are also part of the USGS geophysical database. Administrative reports are the property of the Tribal government who must give written permission for public release.

The airborne surveys used the following geophysical methods as abbreviated in the following table:

MAG - Airborne magnetics. These were the first digital geophysical surveys carried out on Indian reservations. The main objective of this type of survey is to map the subsurface magnetic properties of rocks.

TEM - Time domain electromagnetic surveys. These surveys are done with fixed wing aircraft. The object of electromagnetic surveys is to map subsurface electrical properties of rocks. These surveys were carried out in the Great Lakes region of the United States for massive sulfide mineral resource assessment projects.

HEM - Helicopter electromagnetic surveys. The objective generally is the same as TEM above.

Table 1. Archived airborne geophysical data

RESERVATION	STATE	SURVEY TYPE
Annette Island Reserve	AK	HEM
Cherokee	NC	HEM
Fond du Lac	MN	?
Hualapai	AZ	MAG
Lac Du Flambeau	WI	TEM
L'Anse	MI	TEM
Mole Lake	WI	HEM and TEM
Potawatomi	WI	TEM
Mescalero	NM	MAG
San Carlos	AZ	MAG
Southern Ute	CO/NM	MAG
Standing Rock	ND	MAG
T'hono O'hdom	AZ	MAG
Ute Mt. Ute	CO/NM	MAG
White Earth	MN	TEM

PRODUCTS

Mineral Projects

The Mineral Assessment program makes funds available to Tribes for specific resource identification and evaluation on their respective reservations. This program supplies Tribes with resource information before any negotiations begin. By providing this type of information to the Indian landowner, his ability to maximize mineral income from the development of the mineral resources is greatly enhanced. By utilizing information in the NIEMR database Tribes can better plan and coordinate new studies. Often the NIEMR data can be re-processed to yield an improved interpretation of the geology. In addition, areas of mineralization that may not have been economical when the studies were done may become economical due to changing market conditions. The NIEMR database makes it easier for the Tribes to re-evaluate their mineral resource potential to reflect these ever changing economic conditions.

DEMR and contract personnel have provided technical assistance to many Tribes as part of the Mineral Assessment Program. Personnel have assisted the Arapaho and Shoshone Tribes of the Wind River Reservation with the assessment of their bentonite and gypsum, as described in another article in this report. Personnel have also assisted the Metlakatla Indian Community with their crushed aggregate assessment. Other Tribes assisted include those of the Fort Apache Indian Reservation, in which personnel assisted in rock analyses, and those of the Mole Lake Indian Reservation, in which we assisted with the long-term storage of drill core.

National Indian Oil and Gas Evaluation and Management System

To help Tribes collect realty, production and royalty data from as many as 27 separate data bases, the Division of Energy and Mineral Resources (DEMR) constructed the National Indian Oil and Gas Evaluation System (NIOGEMS). NIOGEMS uses an integrated data base manager and a graphic user interface to assemble and present lease, production, and royalty information data in a "point and click" environment. The Division of Energy and Mineral Resources (DEMR) continues to develop and enhance the National Indian Oil and Gas Evaluation and Management System (NIOGEMS). This system is an automated, graphically driven information storage and retrieval system that can assist Tribal energy resource managers with strategic management decisions.

The NIEMR database assists the Tribes in the identifying, and evaluation of the quality of the digital data for their respective reservations. The NIEMR database provides the minerals manager with a choice in additional map coverages which can also be useful in making decisions regarding the sales of leases and drilling permits, such as: Seismic line locations, Geology - surface, subsurface, structural, remote sensing images, Land Ownership, sub-surface and surface ownership; and USGS 7½' quadrangle map locations.

CONCLUSION

As Tribes seek to effectively develop and manage their mineral resources, the Division of Energy and Mineral Resources directed its efforts to assist and support energy and mineral development on Indian lands. The economic return of the develop-

ment of mineral resources to the Indian mineral owner has been historically between 80 and 85% of the total income generated on Indian Trust lands. These new national programs like the NIEMR, that the Division has initiated, has addressed the needs of the Tribes as they seek to effectively develop and manage their natural resources and improve their revenue return. The Division has carefully designed these programs anticipating the direction that self-determination will take the Tribes in upcoming years. This program ensures that the Tribes benefit by becoming more directly involved in the control of their resources.

Data sets which are publicly available can be viewed at the Division's web site http://snake1.cr.usgs.gov/demr/. All other reports are the property of the Tribal government who must give written permission for public release. The Indian Trust act of 1982 assures that these data remain proprietary to the Tribal government until such time as they agree to public release.

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Attachment A. Status of Phase 1 text and figure reformatting.

Book No.	Tribe/ Reservation	Text Status	Graphics Status	Acrobat (*.PDF)
1	FOND DU LAC, GRAND PORTAGE, LEECH LAKE, MILLE LACS, NETT LAKE, & WHITE EARTH, Minnesota	Done	Done	Done
2	RED LAKE, Minnesota	Done	Done	Done
3	NORTHERN CHEYENNE, Montana	Partial	Done	
4	UINTAH & OURAY, Utah	Done	Done	Done
5	COLVILLE, Washington	Done	Done	Done
6	CHEROKEE, North Carolina	Partial	Done	
7	CROW, Montana	Done	Done	Done
8	WIND RIVER, Wyoming	Done	Done	Done
9	GILA BEND, PAPAGO, SAN XAVIER, Arizona	Done	Done	
10	SPOKANE, Washington	Done	Done	Done
11	L'ANSE, ONTONAGON, HANNAHVILLE, Michigan	Done	Done	Done
12	PINE RIDGE, South Dakota	Done	Done	Done
13	GOSHUTE, Nevada and Utah	Done	Done	Done
14	LAGUNA, New Mexico	Done	Done	
15	FORT BELKNAP, Montana	Done	Redo all figures	
16	MESCALERO, New Mexico	Done	Done	Done
17	UTE MOUNTAIN UTE, Colorado	Done	Done	Done
18	ACOMA, New Mexico	Done	Done	
19	SOUTHERN UTE, Colorado	Done	Partial	
20	BAD RIVER, LAC COURTE OREILLES, LAC DU FLAMBEAU, MOLE LAKE COMMUNITY, POTAWATOMI, RED CLIFF, PUBLIC DOMAIN AND ST. CROIX, AND STOCKBRIDGE-MUNSEE, Wisconsin	Done	Done	Done
21	WALKER RIVER, Nevada	Done	Done	Done
22	FLATHEAD, Montana	Done	Done	Done
23	CHEYENNE RIVER, South Dakota	Done	Done	
24	BLACKFEET, Montana	Done	Done	
25	JICARILLA APACHE, New Mexico	Done	Done	Done
26	WARM SPRINGS, Oregon	Done	Done	Done
27	ISLETA, New Mexico	Done	Done	Done
28	FORT PECK, Montana	Done	Done	Done
29	FORT HALL, Idaho	Partial	Redo all figures	
30	ROSEBUD, South Dakota	Done	Done	Done
31	HUALAPAI, Arizona	Done	Done	Done
32	RAMAH, New Mexico	Done	Done	Done
33	CANONCITO, New Mexico	Done	Redo all figures	
34	ROCKY BOYS, Montana	Done	Done	Done
35	BIG CYPRESS, BRIGHTON & MICCOSUKEE, Florida	Partial	Done	
36	YAKIMA, Washington	Done	Done	
37	ZUNI, New Mexico	Done	Done	Done
38	PYRAMID LAKE, Nevada	Done	Done	Done
39	TULE RIVER & Other Central California Lands, California	Partal	Redo all figures	
40	FORT BERTHOLD, North Dakota	Done	Done	Done
41	STANDING ROCK, North and South Dakota	Done	Partial	
42	HAVASUPAI, Arizona	Done	Done	Done
43	KAIBAB, Arizona	Done	Redo all figures	
44	SISSETON, North and South Dakota	Done	Done	
45	CHITIMACHA, Louisiana	Partial	Redo all figures	

Attachment A (con't). Status of Phase 1 text and figure reformatting.

Book No.	Tribe/ Reservation	Text Status	Graphics Status	Acrobat (*.PDF)
46	CHOCTAW, Mississippi	Partial	Done	
47	OSAGE, Oklahoma	Done	Done	Done
48	THREE EASTERN & FIVE WESTERN NEVADA RESERVATIONS	Done	Done	Done
48a	MOAPA RIVER, Nevada	Partial	Partial	
49	CASCADE RANGE, KLAMATH MOUNTAINS, NORTHERN COAST RANGES & GREAT VALLEY PROVINCES, California	Partial	Redo Figures	
50	COLORADO RIVER, AZ and CA	Done	Done	Done
51	JEMEZ and ZIA, New Mexico	Done	Done	Done
52	UMATILLA, Oregon	Done	Done	Done
53	COCHITI, New Mexico	Done	Done	Done
54	KOOTENAI & COEUR D'ALENE, Idaho	Done	Done	Done
55	SANDIA PUEBLO, New Mexico	Done	Done	Done
56	MARICOPA & GILA RIVER, Arizona	Done	Done	Done
57	SAN FELIPE PUEBLO, New Mexico	Done	Done	
58	ALAMO, New Mexico	Done	Redo Figures	
59	SANTO DOMINGO, New Mexico	Done	Done	Done
60	SANTA ANA PUEBLO, New Mexico	Done	Done	Done
61	DUCK VALLEY, Nevada and Idaho	Partial	Done	
62	19 Indian Lands in Western Washington	Done	Done	Done
63	SALT RIVER & FORT McDOWELL, Arizona	Done	Done	Done
64	YAVAPAI, Arizona	Done	Done	Done
65	LOWER SIOUX, UPPER SIOUX, PRIOR LAKE, & PRAIRIE ISLAND, Minnesota	Done	Done	Done
66	MENOMINEE, ONEIDA, WINNEBAGO, Wisconsin	Partial	Redo Figures	
67	OMAHA, Nebraska	Done	Done	Done
68	WINNEBAGO, Wisconsin	Done	Done	Done
69	KICKAPOO, Kansas	Partial	Redo Figures	
70	IOWA and POTAWATOMI, Kansas and Nebraska	Done	Done	Done
71	SANTEE, Nebraska	Done	Redo Figures	
72	SKULL VALLEY, Utah	Done	Redo Figures	
73	CROW CREEK, South Dakota	Done	Done	Done
74	LOWER BRULE, South Dakota	Done	Done	Done
75	FORT TOTTEN, North Dakota	Done	Redo Figures	
76	YANKTON, South Dakota	Done	Done	Done
77	FORT APACHE, Arizona	Done	Done	
78	FORT MOJAVE, Arizona, California and Nevada	Done	Redo Figures	
79	TAOS & PICURIS, New Mexico	Done	Done	Done
80	TURTLE MOUNTAIN, North Dakota	Done	Redo Figures	
81	NAMBE, POJOAQUE, SAN ILDEFONSO, SAN JUAN, SANTA CLARA, & TESUQUE, New Mexico	Done	Done	Done
82	FORT McDERMITT, Nevada & Oregon	Done	Done	Done
83	CHEMEHUEVI, California	Partial	Redo Figures	
84	ANNETTE ISLANDS, Alaska	Partial	Done	
85	FORT YUMA, California	Partial	Done	

Attachment A (con't). Status of Phase 1 text and figure reformatting.

Book No.	Tribe/ Reservation	Text Status	Graphics Status	Acrobat (*.PDF)
86	FLANDREAU, South Dakota	Partial	Redo Figures	
87	SAN CARLOS, Arizona	Done	Done	
88	SAC & FOX, Kansas & Nebraska	Partial	Redo Figures	
89	ABSENTEE SHAWNEE, Oklahoma	Done	Redo Figures	
90	CITIZEN BAND / POTAWATOMI, Kansas and Oklahoma	Partial	Redo Figures	
91	SAC & FOX, Oklahoma	Partial	Redo Figures	
92	ASSORTED LANDS IN WEST COAST STATES	Partial	Done	
93	PASCUA-YAQUI, CAMP VERDE & PAYSON INDIAN COMMUNITY, Arizona	Done	Done	
94	CHEYENNE & ARAPAHO, Oklahoma	Partial	Redo Figures	
95	WICHITA, CADDO & DELAWARE, Oklahoma	Done	Done	
96	THIRTY MISSION RESERVATION, Southern California	Partial	Done	
97	CREEK NATION, Oklahoma	Partial	Done	
98	ISABELLA, Michigan	Partial	Redo Figures	
99	IOWA, KICKAPOO, & SAC & FOX, Oklahoma	Partial	Done	
100	KIOWA, COMANCHE, APACHE, FORT SELL APACHE, Arizona	Partial	Done	
101	CHOCTAW NATION, Oklahoma	Partial	Redo Figures	
102	CHICKASAW NATION, Oklahoma	Partial	Redo Figures	
103	BAY MILLS & SAULT SAINTE MARIE, Michigan	Partial	Done	
104	EASTERN SHAWNEE, QUAPAW, SENECA-CAYUGA & OTHERS, Oklahoma	Done	Done	Done
105	SEMINOLE, Oklahoma	Partial	Redo Figures	
106	OTOE-MISSOURIA, PONCA & TONKAWA, Oklahoma	Done	Done	Done
107	PAWNEE, Oklahoma	Done	Done	Done
108	BATTLE MOUNTAIN, ELKO, LAS VEGAS, ELY LOVELOCK WELLS, RENO-SPARKS, Nevada	Partial	Done	
109	CHEROKEE NATION, Oklahoma	Partial	Redo Figures	
110	SHIVWITS, Utah	Partial	Partial	
111	HOPI, Arizona	Partial	Partial	
112	SOME EASTERN & SOUTHERN RESERVATION	Partial	Partial	

Attachment B. Digital and hard copy data on file at DEMR.

Reservation	hard copy records	digital records
Alamo	33	
Annette Island	6160	
Blackfeet	320	
Canoncito	10	
Cheyenne River	7	
Colville		2696
Crow	203	29715
Crow Creek	10	
Duck Valley	3311	1717
Flathead	19209	
Fort Belknap	65	
Fort Berthold	10	
Fort Peck	31	
Goshute		2533
Laguna	85	
Lower Brule	9	
Mescalero Apache	408	
Mole Lake	392	
Northern Cheyenne	1886	
Nett Lake	9961	
Papago	3129	
Penobscot	1811	
Pine Ridge	775	
Pyramid Lake	3202	55
Red Lake	1843	
Rocky Boys	2716	1246
Rosebud	122	
San Carlos		15812
Santa Ana	38	
Southern Ute	93	
Standing Rock Sioux	7	
Torres Martinez		25716
Ute Mountain Ute	675	
Walker River	1262	
Wind River	541	
Yankton	70	
Zuni	56	
TOTAL	**58450**	**79490**

New Atlas Release - Oil and Gas Plays for Reservations Located in Southern Rocky Mountain States

Robert Anderson[1] and Roger Slatt[2]

Abstract

Soon to be released in a series of geologic publications devoted to promoting oil and gas opportunities on Indian reservations is an atlas describing petroleum plays and potential exising on Tribal lands located in southern Rocky Mountain states. This new atlas continues with the design format established for the atlas of reservations located in northern Rocky Mountain states. The large format layout will better communicate complex geologic and engineering data to Tribes, industry, and other government agencies. Completed by a cooperative effort of Tribes and the Colorado School Mines Department of Geology and Geologic Engineering, the atlas provides the most current knowledge database of information to support those Tribes seeking new development and economic benefits. The title of the publication is "Atlas of Oil and Gas Plays on American Indian Reservations - Southern Rockies Edition".

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Introduction

Another soon to be released publication from Division of Energy and Mineral Resources is an atlas of oil and gas plays for reservations located in several southern Rocky Mountain states - Colorado, Utah, and New Mexico. The atlas is a successor to the atlas published last year for reservations located in northern Rocky Mountain states (Montana, Wyoming, North Dakota, South Dakota). The format and layout will remain nearly the same (except for a slight size reduction to allow for easier shipping). It is the goal of the Division of Energy and Mineral Resources to provide a current knowledge base of information in support of Indian Tribes in the U.S. seeking new petroleum development and economic benefits for their people.

The atlas provides important information

about the exploration potential and leasing opportunities on some of the remaining large tracts of underdeveloped lands in the U.S. – the American Indian Reservation. Both editions of the atlas were produced in co-operation with the Colorado School of Mines' Department of Geology and Geologic Engineering (CSM). Reservations included in the southern Rocky Mountain states are listed below in Table I, and shown on the map, Figure 1.

Each reservation is a chapter in the atlas, and each chapter contains geologic data, structure and stratigraphic maps, cross-sections, description of analog fields, and production information. Based on U.S. Geological Survey play-type categories, the oil and gas potential of each reservation is characterized by their important conventional and unconventional play types. Outside parties will find the atlas useful for quickly assessing the potential of oil and gas properties on reservations, reducing the time and efforts required to perform similar investigations themselves.

The atlas may be downloaded directly from the Division's Web site in Acrobat PDF format. The atlas is also available on CD-ROM, which may be obtained free by charge by writing or e-mailing the Division. The printed form of the atlas is more costly to produce, and therefore a moderate charge is applied to offset printing and handling costs. Information on ordering a printed form of the atlas is discussed under the ordering information below.

Similar to the atlas covering Tribes in northern Rocky Mountain states, this atlas was also cooperatively produced by DEMR and the Colorado School of Mines' Geology & Geologic Engineering Department. Graduate and undergraduate students performed the literature search, derived the relevant information to describe the play types, and re-drew all of the illustrations into high quality computer vector images so that figures could be published onto a variety of media types for distribution, such as printed form, CD-ROM, and Internet (via the World Wide Web), and still retain all of the resolution of the original image.

The Division's Web site provides downloadable copies of each chapter of the reservation in Adobe Acrobat™ format. This popular exchange format was chosen because it has become very popular for storing high quality imagery, and can be viewed with a free reader software program, easily acquired from Adobe.

ORDERING INFORMATION

To order copies of the printed version of the Atlas:

Currently the publication, *Atlas of Oil and Gas Plays on American Indian Reservations, Northern Rocky Mountain Tribes Edition*, can be purchased through the Colorado School of Mines

TABLE 1

List of Tribes Participating in the Southern Rockies Atlas

Ute Mountain Ute Tribe, Colorado
Southern Ute Tribe, Colorado
Unitah and Ouray Tribes, Utah
Jicarilla Apache Tribe, New Mexico
Pueblo Indian Tribes of New Mexico (refer to map)

Reservations included in the Atlas of Oil and Gas Plays, Southern Rocky Mountain Edition

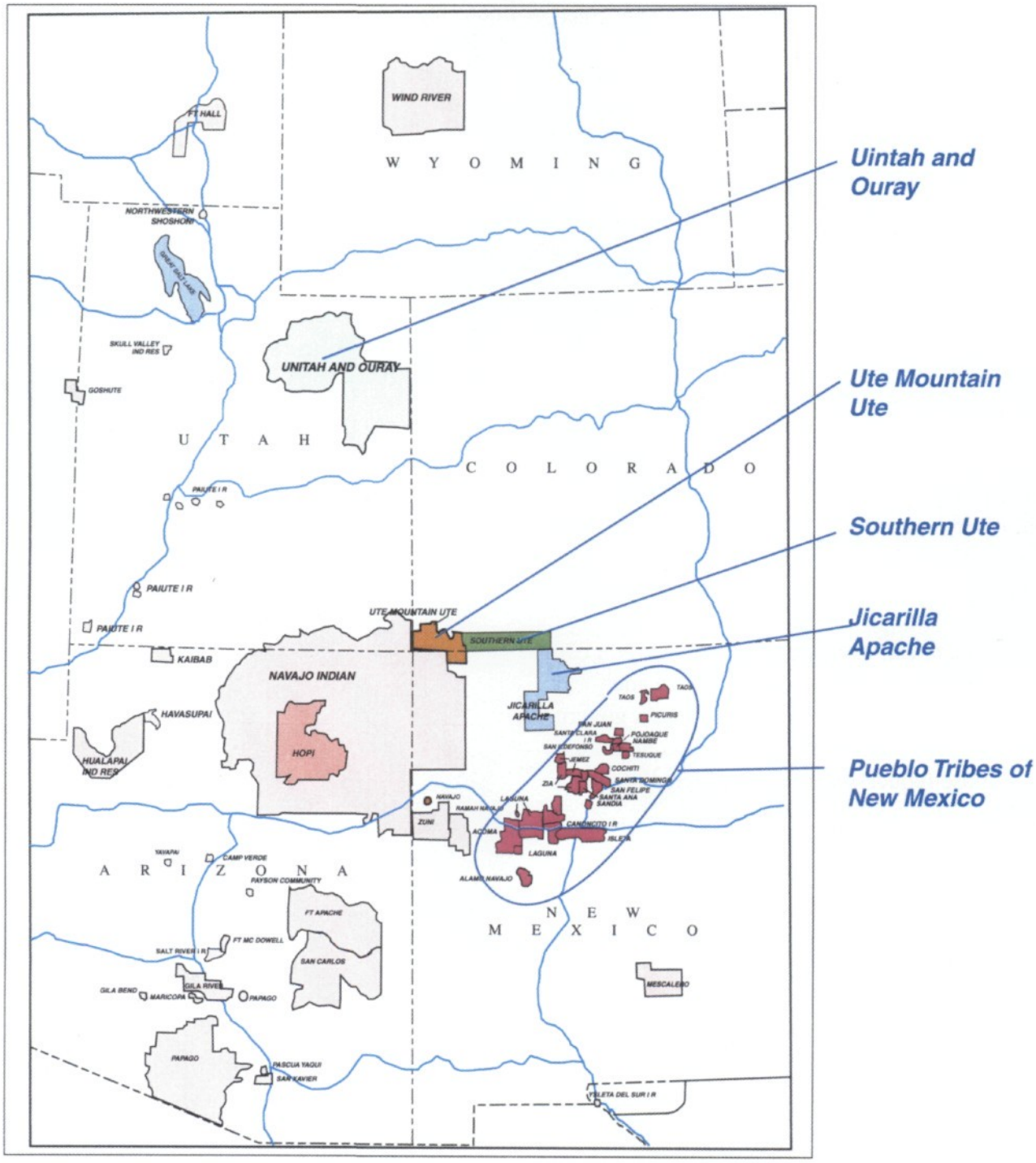

Figure 1. Index map showing the location of reservations included in the publication – *Atlas of Oil and Gas Plays on American Indian Reservations, Southern Rocky Mountain Tribes Edition*

for $50.00 (including shipping and handling). Both the bound printed version and a CD-ROM version will be shipped for this price. The Atlas for the southern Rocky Mountain Tribes is expected to be available by mid-summer, 1999. Please check the Division's Web site for ordering information for this edition.

To order a printed copy of the northern Rocky Mountain atlas, please contact:

Jim Proud
Denver Earth Science Project
Office of Special Programs and Continuing Education
Colorado School of Mines
Golden, CO 80401

Local phone:	(303) 273-3038
Out-of-area phone:	(800) 446-9488, ext. 3038
Fax:	(303) 273-3314
E-mail:	jproud@mines.edu

Payment can be made by check or credit card.

Single copies of the Atlas will be made available free of charge to Indian Tribes, government agencies, and public or government libraries. Those requests should be directed to the Bureau of Indian Affairs as follows:

Bureau of Indian Affairs
Attn: Robert Anderson
12136 W. Bayaud Ave., Ste. 300
Lakewood, CO 80228

Phone:	(303) 969-5270 ext 227
Fax:	(303) 969-5273
e-mail:	randerso@snake1.cr.usgs.gov

Requests for just the CD-ROM version of the Atlas will also be provided free of charge to all interested parties. Please direct that request to the Bureau of Indian Affair's address above.

Geological, Geophysical and Engineering Elements for a Comprehensive Assessment of Oil and Gas Potential

Ron Lloyd[1], Don Loomis[1], and Robert Anderson[2]

Abstract

This paper describes the many geotechnical and engineering elements that contribute to making a successful oil and gas resource assessment study. All of the methodologies and types of data described are standard in the petroleum exploration industry. While nearly all of the technical methods are applicable for any study area, many Reservations unfortunately lack the data required to fully characterize their remaining undiscovered oil and gas resources. Still, areas of prospectiveness can be defined and ranked for future assessment studies to follow.

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Mineral Assessment of Oil and Gas Potential for Reservations Located in "Mature" Sedimentary Basins

Many Tribes are now either entering (or are already there) into the next phase of their mineral assessments analysis of their oil and gas potential, having already performed comprehensive literature reviews, regional geological investigations, and even site specific data collecting. The next phase involves the following tasks:

- locate prospect areas to define the higher probability of oil and gas occurrence
- have a knowledge of the costs associated with these efforts
- provide a technical assessment focused primarily on hydrocarbon resources and secondarily on surface mineral resources on Tribal lands utilizing current geoscience technology.

- provide an economic appraisal of the potential resources.
- create a foundation by which the Tribal Council can solicit, evaluate and/or negotiate earth resource exploration and development proposals or explore and develop these potential resources themselves.

Exhaustive Review of Past Investigations and Reports

A review of all available literature was most likely performed during the Phase I types of mineral assessment investigations. These reports need to be reviewed and updated as required. Unfortunately, due to limited mineral assessment funding, recompilation of literature searches can no longer be supported. Copies of reports should be on file at both the Tribal office, and at the Division of Energy and Mineral office in Lakewood, CO.

Types of Geologic, Geophysical and Production Data Comprising a Comprehensive Assessment Study

Well logs – Well logs are measurements of physical properties of a well bore (electrical, sonic, density, micrologs, etc.), and provide a detailed description of the reservoir and source rock properties in a well. Commercial paper copies of geophysical logs can be commercially purchased for the area within the assessment study boundaries. Logs should be annotated with formation tops, drill stem test information, cored intervals, and initial production data (where appropriate) for delivery as part of the report package. Often it is beneficial to include microfilm copies of other well logs and data from areas surrounding the study area, and these should also be annotated and included into the file.

Well data – Digital exploration and development well data include location, formation tops, drill stem test information, etc. These can be purchased commercially for inclusion in a the well file, and is also useful for mapping efforts.

Production data – Oil, gas, and water production data detailed on a monthly basis can be obtained from commercial services, one of the more popular ones being Petroleum Information/Dwights LLC. Data can be obtained on CD-ROM or in printed form, but usually only through subscription. There are geologic libraries run by organizations that also have datasets which can be downloaded for a one time fee. All data acquired using mineral assessment funding should be included in the report package.

Digital Land grid – A digital land grid is a description of the locations of sections, township, and range lines, described in common mapping coordinates (latitude and longitude), or map projections (UTM, State planar). Several commercial vendors provide digital land grid data, which can be selected to cover the area of study. The land grid should include a buffer zone surrounding the study area, so that geologic mapping can include information from the surrounding the boundaries of the Reservation. Land grids are usually provided on floppy diskette, and can be obtained in a variety of digital formats compatible with most mapping packages in use today.

Geographic data – Geographic data includes topography, rivers and streams, cultural (cities, roads), and political boundaries (states and county lines, city limits and Reservation boundaries). The U.S. Geological Survey, and other agencies provides much of this information on the Internet, and can be downloaded free of charge digital

mapping purposes.

Seismic data – Seismic data is the most valuable geophysical tool for exploration, although it might also be the most expensive per amount of subsurface evaluated. Seismic data can be purchased through several commercial data brokers, along with digital tapes. With the digital field data, seismic records can be reprocessed and interpreted to yield highly detailed information about the subsurface geology, and determine where new oil and gas prospects may be located.

Magnetic data – Aeromagnetic data originally acquired for the U.S. government for uranium studies (National Uranium Resource Evaluation or NURE) can be purchased commercially, and processed for analysis and mapping of subsurface geology.

Maps and Publications – Surface geologic maps can be obtained from state geological surveys.. Bulletins, papers, and other maps from various sources can also be purchased or copied and included in the report package.

Geological Data and Maps

Geologic Structure - A geologic structure map describes the regional setting of the geology of a Reservation with respect to its location within the sedimentary basin, and relationships to major structural or tectonic environments. A mineral assessment should describe the structural fabric of the basin at the Reservations in terms of trend directions and rate of dip. It should also describe trends of major structural features near the Reservation, supported by structural maps and isopach maps from previous studies or from the literature.

Use isopach maps to show the depositional history of the stratigraphic layers, and if periodic movement has occurred through time, or if differential movement of various fault blocks has occurred.

Describe all major normal or reverse faulting, and where it occurs on the Reservation. If the area was influenced by wrench-style (strike-slip, or lateral) deformation, mark on maps where major lineaments occur. If enough well data or seismic data exist, indicate where strike-slip movement exists, or has influenced nearby structural environment.

Lineaments, which are large-scale linear and curvilinear features, can be visible on satellite imagery or high-altitude aerial photographs. The features are caused by patterns in topography, vegetation, or stream courses (they may be subtle, or bold, as in the case of the many major rivers. A river's course, for example, discounting its meanders, can be generally linear across a broad area). Lineaments are often found to represent faulting or fracturing at varying scales in the subsurface rocks that translate to surface material. Lineaments may bear a relation to the presence of hydrocarbons. These features should be considered in interpreting structural setting and in determining prospective areas for oil and gas exploration.

Include any mapping of surface anticlines, synclines, and small displacement faults done by previous investigators. Note whether these may represent true structures at depth or are only apparent features caused by other mechanisms, such as slumping or compaction.

Stratigraphy - A mineral assessment study should describe the stratigraphic sequence and thickness of all sedimentary rocks in the basin in the area of study. The report must note those formations which are known to produce oil and gas.

Surface Geology - A complete mineral assessment study would determine if any

mapping of surface geology has been performed, and if so, it should be included as a reference. Reference all of the USGS or state geological quadrangle maps that are publically available in the study area. Outcrops of the main petroleum reservoir or source rocks may occur on or nearby the Reservation, and these should be made know in any study. Outcrops of other types of rocks may be useful for planning a future exploration efforts. For example, consolidated sandstone and shale will provide better coupling for seismic data acquisition than areas where gravels, conglomerates, coal, or other unconsolidated sediments occur on the surface.

Geophysical Data

There are several types of geophysical data which are useful for exploration of oil and gas, and many of these can be acquired through commercial data brokers. In terms of "what is best" depends on whether the assessment is a large area reconnaissance type survey, or is more prospect oriented, intended to determine locations of undiscovered petroleum deposits.

Gravity and Magnetics - Gravity and magnetic data are classified as "potential field" methods, and are frequently used as reconnaissance tools in the early stages of exploration. The method measures the gravity field at the surface and when corrected properly can estimate the depth to higher or lower density materials underlying an anomaly. These geophysical techniques are cost effective in determining overall basin configuration and in estimating thickness of the sedimentary (prospective) section.

The areas of study can be selected, and digitized, so the data can be edited and manipulated, including redisplaying the data in proper projection coordinates with other data. Gravity maxima usually indicate structurally high areas. Gravity minima indicate structurally low areas. These data indicate only the most general structures such as regional basin configuration and relative depth to basement.

Large scale structural trends can be noted in the study area, and correlated with known oil and gas fields. All anomalies indicated on the magnetics or gravity should be noted, as they most likely related to structural changes, interbasement rock type changes (an indicator of faults or lineaments), and other tectonic movement. Structural development in basement usually controls the pattern of sedimentary deposition of shallower rocks, and there are examples where these correlate to areas of oil and gas trapping.

Surface Magnetic Data: Magnetic methods have evolved from surface magnetics to aeromagnetics to high-resolution surface magnetics. Today, high-resolution surveys are being conducted with very close data point and line spacing. Under favorable geologic conditions, a high-resolution surface magnetic survey could be effective in helping define faults and other subsurface exploration objectives. Current cost of acquiring these data is $140/mile for 100 ft data point spacing.

Aeromagnetic Data: These surveys can cover large areas very quickly. Surveys such as those conducted for the NURE project covered large portions of the country very quickly and at a reasonable cost. The inline spacing of data point is excellent but the cross line spacing is course. Many small anomalies can be identified on the individual lines but it is impossible to tie these anomalies to adjacent lines that are 6 to 12 miles apart. Line location was based on vertical aerial photos. Current surveys are flown at lower altitudes and with closer

line spacing. Modern magnetometers are more sensitive than previous units and the survey lines are located very accurately using satellite navigation. Costs for a high-resolution aeromagnetic survey would be fairly high due to the need to mobilize and integrate the instrumentation an airplane. The amount of data available, subsurface well data as well as other gravity, magnetic and seismic data limit the actual benefit that would be achieved in conducting an aeromagnetic survey over the Reservation area.

A magnetic map can also be digitized from reports available through federal or state governments. Data points (x,y,z values) from the original map can easily be digitized and re-contoured for interpretation. Surveys with large sampling distances can only delineate very large geologic features, but is useful in establishing overall basin configuration.

Describe all anomalous magnetic maxima and minima, along with their trends, closures and other patterns, and note these on a map. Report on whether any wells or fields exist over, or nearby, similar magnetic patterns. Make an interpretations as to the cause of these magnetic anomalies, .e.g., intrabasement variations in the mineralogy between basement blocks of varying lithologies, structural changes, etc.

Usable aeromagnetic data and results can be obtain from NURE (National Uranium Resource Evaluation), a data set acquired by the government while conducting exploration for uranium. While this data is relatively inexpensive, the data usually requires editing and reprocessing. There are several consulting or service firms who can process magnetic data. The mineral assessment report should describe the spacing of the in-line flight lines, and the spacing of the cross-lines. Anomalies identified on the aeromagnetic map should be cataloged, and each one anomaly should have a short description with a reference number to the map.

Geochemical Surveys: - In recent years, surface geochemical data acquisition and analysis, such as iodine, soil gas, etc., have evolved into economical reconnaissance tools. Examples of geochemical survey types include:

Soil Gas Hydrocarbons: Samples are collected at 36"-42" depth. Analysis is nine component hydrocarbon plus pH, Eh and conductivity. Cost varies from $80/sample to $110/sample for collection and analysis depending on the sampling spacing. If the sample interval were 660', or eight points per mile, the cost per mile would be $720/mile.

Surface "grab" samples can be analyzed for iodide, chloride, bicarbonate and carbon dioxide for $6/sample or a cost of analysis of $144/mile for 220' sample spacing. Iodine sample analysis can be done for $10/sample for a cost of $240/mile. To reduce the cost per mile the initial analysis can be carried out at a coarser spacing and then infilled in anomalous areas. Average cost for total analysis of the surface "grab" samples might be $200-$250 per mile. Data collection cost is in addition to this cost. This type of survey can be combined with a surface magnetic or radiometric survey and the collection cost can be minimized - $5/sample; $120/mile or less.

Radiometrics - Radiometrics are a relatively new and poorly understood technique. Cost is $25-$40/mile depending on the terrain being traversed. The quality of the results may be proportional to the costs. If other surveys, such as surface magnetometer or geochemistry, are being conducted, it might be beneficial to obtain a radiometric survey with the intent of evaluating the use of the method.

2-D CDP (Common Depth Point) Seismic Data: The main type of geophysical data used in exploration is seismic. Acquisition techniques for seismic data have gone through many changes, from single point, correlation data, then to 100% "2-D" (two-dimensional or along a profile); Modern 2D data today is called "multifold", in which a single point in the subsurface is imaged by more than one seismic reflection. Finally, multi-fold "3-D" data acquisition and interpretation is being applied on a wide basis in the world today. Recording of seismic data has progressed from using paper documents to analog tape to the modern standard of digital recording.

Seismic data has often been acquired over and near Reservations by various oil and gas exploration companies over the past years.. Maps of where data are located can be obtained from several data brokers, without cost, and reviewed the location and availability of these data. Purchasing data is relatively expensive, however, and mineral assessment funding often does not provide the amounts necessary to acquire large amounts of data. Two-dimensional data runs between $500 per mile up to $1,500 per mile, depending on the efforts make in the original acquisition. Some of the very old seismic data, acquired in the 1950's, can also be useful. These data are not multifold, and have only one reflection point per depth point (data is referred to as 100% data). While not high resolution data, the price for 100% is very low, and can add information to the overall interpretation.

After acquiring the seismic data, post the line locations on a map, with clearly annotated line numbers and shotpoint numbers. Make special efforts to acquire data that crosses wells or fields, for correlation purposes. Sometimes a company can be approached by the Tribe to receive the data as a donation, perhaps with only charges for copying of tapes and other records. The DEMR can provide monetary assistance for those special cases.

Acquiring new 2D seismic data over a study area would be the most desirable goal, as new data provides higher resolution results than older data could offer. However the costs are acquiring new data are quite high. Crew costs can be $2,500/mile if access is easy and shooting parameters are nominal, but can range upwards to $5,000 per mile, depending on topography and access.

3D Seismic Data: Costs to conduct a 3D seismic data surveys vary today between $20,000-$30,000/square mile, including acquisition and processing. The wide range in costs is due to the variations in field parameters that might be employed. The cost/square mile for small – 2-4 square miles – surveys is significantly higher than for larger – 10+ square miles – surveys.

Interpretation of Seismic Data: Interpretation of seismic data can be performed manually on paper seismic records, with data picks measured by hand and transferred to a map for posting and contouring. Today, most companies and consultants interpret seismic data on a computer (usually PC computers). The digital processed seismic section is loaded onto the PC, and all interpretation and event timing is done with the aid of the interpretation software. Timing values can easily be transferred to a mapping package for posting and automatic contouring. Interpretation software packages can range in cost from $8,000 for PC packages, up to $80,000+ for heavy duty workstation systems.

Geologic horizons on seismic must first be identified by correlation with the synthetic seismograms derived from well log

data. The number of horizons to identify on the seismic must be guided by the number of geologic layers that potentially could produce oil and gas. Marker beds are also sometimes used because they can be traced over a long distance, and serve as geologic timing references of sedimentary deposition.

Seismic Modeling: Seismic models are used as an interpretation aid to identify various potential anomalous seismic events. Models are constructed from well log data, and simulate the response of an actual seismic line collected in the field. Models can be varied to emulate the seismic response to porosity or thickness changes in each reservoir rock being studied. The response from the model can then be compared to actual field data to determine if a match occurs. The variation of model parameters can be nearly limitless, so often there is not a unique solution, but modeling is a power interpretation tool that should be incorporated into any assessment study.

Mapping

An interpreter must select the appropriate number of horizons to map so that all probable leads and prospects will be identified. However the number of horizons to be mapped also depends on the quality of the seismic data.

The BIA's mineral assessment program usually cannot provide the level of funding required to purchase a sufficient number of seismic lines in a study area, and this makes it difficult to create reliable maps. Many anomalous features can occur along each individual seismic line, but without a nearby adjacent line, there would be way to connect or completely delineate an anomalous feature.

Time maps which are constructed should use a map scale and contouring interval that best represents the data to be interpreted. Data points should be posted on the map so that a reviewer may see the raw data from which the contours were drawn.

Isochron Mapping: Interval maps called isochrons can be generated by calculating the time differences between various important events for the picked time intervals. These maps can be contoured at similar map scales as the time maps were done.

Studies of Existing Oil and Gas Fields To Establish Analogs

Field Studies

Select fields that have produced commercial amounts of petroleum within the Reservation. If analogs do not exist inside the Reservation, select the nearest field outside the Reservation that characterize the particular geologic play, and where potential might exist within the Reservation boundaries. The study should describe the production histories of key wells, noting also the amounts of water produced.

The study should describe the stratigraphic interval which produces the hydrocarbons, down to the specific subinterval of the formation. A description should characterize the type of reservoir rock, and characterize those zones to other fields in the area as to whether they are typical or if there are aberrations. Also the study should discuss porosity and permeability of the reservoir rocks.

The oil (or gas)-water contact in the field should be described, if it is readily definable, or if it has not yet been defined. If water flushing is apparent, describe the regional water flushing problem, and characteristics of the water, such as its salinity, pressures, and trend of the local water flow.

The study should describe the structural

environment on which the field is located, and whether is was detected with any of the geophysical tools discussed previously. Note whether faulting is also part of the structure, and if faults can be interpreted from well log data.

Structure / Isopach Maps - The appropriate structure and isopach (interval) maps of the field areas should be constructed. Notation of the geologic patterns on these maps will show primary and secondary structural trends. If secondary patterns exist, then relate how regional strike-slip or wrench faulting plays a role in the field development.

Core Data - Core data is useful to review to show the detailed nature of formation lithologies. Include in the assessment report any core photographs or photomicrographs. Include other references to cores and core descriptions for future work. Note in the report where cores may be stored, such as at the U.S.G.S. core facility in Lakewood, CO.

Drilling activity and hydrocarbon shows: Require a description of the local drilling activities and associated test and shows. A brief chronological historical review of wells drilled and developed on the Reservation may help an explorer to define trends that have been bypassed, or with new geologic thinking, may point to areas which should be revisited.

Potential for Hydrocarbon Production: The presence of oil and gas requires a number of conditions. First, a source bed must exist. Usually, this is an organic-rich marine shale, but may be a limestone. Secondly, sufficient heat and pressure are required to generate petroleum from the organic material, which normally requires burial at considerable depth. Third, the oil and gas need to migrate from the source bed into a reservoir (porous and permeable rock) from which the hydrocarbons can be produced. This is usually up-dip because the petroleum is lighter than water. Fourth, in order for the petroleum to accumulate, a trap must be present, i.e., the migration halted by a domal feature or pinchout of the porous beds. Note any factors that can influence or modify the process, for example, if there is a strong hydraulic flow through the reservoir, or whether flushing has occurred.

The assessment report should contain information on locations where oil and gas are produced in the region and from the similar formations, and if conditions for accumulations of hydrocarbons exist in the area of study. Describe the horizons which are potential producers, from oldest formation to youngest. Note which horizons are targets for oil and gas production. If abnormally high water production occurs, then report on the hydrologic regime, salinities, and flushing which may have occurred.

Cross sections are useful for showing the character of producing formations across the Reservation. Report on the log responses of these rock units, and which curve combinations are best used for interpretation. Discuss which logs show the porosity of the reservoir rocks, and which logs can be used as indicators of oil and gas, and if there are interpretation problems (low oil saturation, reservoirs contains a mixture of other mineral types, invasion problems, etc.

If fracturing is present in the reservoir, and has enhanced the production flow, then report on importance of siting new wells in fracture zones, and if flexuring or folding can be detected on seismic.

Elements of an Oil and Gas Exploration Program

Techniques and Estimated Costs

Data utilized in oil and gas exploration is acquired in many ways, as described in the previous pages of this report. Some of the inexpensive techniques are effective for regional exploration but do not have the resolution for siting a wildcat location. The following discusses some of these techniques and provides a rough estimate of the cost of conducting an appropriate survey.

Cost Analysis for a Hypothetical Exploration Program

The following hypothetical program combines various geophysical and geochemical data acquisition programs in an effort to obtain cost effective drilling prospects the Reservation under study. An essential objective of the exploration program is to evaluate the effectiveness of the various, low cost geochemical and geophysical techniques that are offered by industry.

Select an area for the exploration survey based on well shows, regional geology, acreage considerations and review of available geophysical data. A "reconnaissance" type survey of the area would consist of about 25 miles of surface magnetic data and 25 miles of surface "grab" sampling. Cost of the magnetics would be $3,500. The 25 miles of sample collection and analysis at $350/mile would be $8,750. Acquire 15 miles of similar data over Field "A" at a cost of $7,500, to correlate oil/gas production with seismic waveform characteristics. Total estimated cost for would be $20,000.

Survey one or two additional areas using selected methods developed with the above program. Cost for two areas is estimated at $15,000.

Interpretation and project management costs for this work would be $5,000 plus expenses. The results of this interpretation could be one of three options: 1) no further action – no prospects defined; 2) select a drillable location or 3) continue with #4 (following paragraph) and obtain modern seismic data over selected area.

4) Based on the results of these surveys, select one or two areas for seismic detailing. Acquire 6-10 miles of 2-D seismic data over each selected prospective areas. Cost for shooting and processing a 30 mile program would be $50,000-$100,000. The range in costs is due to the remote location and the difference in cost for shallow seismic versus seismic to evaluate a deep objective.

Estimated costs to interpret and manage a project of this size would be around $10,000, plus expenses. Total cost to survey and interpret three exploration areas and develop an analog over a producing field could be as low as $40,000 if no seismic is obtained. Costs could escalate to $95,000-$145,000 if it is determined that seismic data is required for prospect definition.

A program like this may yield one or more drillable locations. Costs will vary as actual bids are taken and the final details of the program are determined. The most expensive part of the program is the seismic data acquisition. If previously acquired seismic data is available, then this data can be purchased and would therefore decrease program costs significantly.

Engineering Studies

Drilling and Completion Private drilling companies can provide cost estimates for exploratory well drilling and testing of se-

Table 1

Formation	Drilling	Completion	Total
1500' Niobrara	$64,570	$108,295	$172,865
3000' Dakota	$158,730	$133,650	$292,380
5500' Red River	$205,832	$179,080	$397,120

lected formations at different depths. Drilling costs approximate dry hole costs, but plugging a well and restoration of the drillsite have to be added to the drilling costs. A cost report from a company can be included as an attachment to a comprehensive mineral assessment study.

The following is an example (Table 1) of drilling and completion cost description for three formations.

It is possible to drill a hole for less money with better knowledge of drilling conditions in the area and different methods than those considered in any company's cost analysis. One factor influencing drilling costs in the area is distance from current activity and suppliers. Provide in the report a list of the nearest oilfield service centers to the Reservation, and discuss impact of mobilization costs. Also, having a well drilled when a rig is already nearby could drop costs considerably.

Gas Production

Natural gas production is pipeline dependent; therefore distance between a producing well and a pipeline is critical. Describe the transmission lines which run through the area, providing maps to show where lines are located. Note the distances to the pipelines, and what standards would have to be met to sell gas into those pipelines.

Gas pipeline costs for gathering and transmission are generally estimated at about $50,000/mile for a buried steel 4" pipe and go up in price according to diameter of the pipeline, depth of burial and difficulty of construction (terrain). Compression may be a significant cost requiring capital expenditures ranging from $50,000 to $500,000 per compressor unit, dependent on volume and relative formation and pipeline pressures. Before a pipeline could be justified from the Reservation to either of these lines, a substantial amount of gas reserves would have to be proven.

Oil Production

Oil can be trucked to refineries, and so is not dependent on pipeline for production, as is gas. However, distance to a refinery or oil pipeline terminal is a factor. Drilling costs are essentially for gas and oil are essentially the same, but completion costs for oil are usually higher because of the need for pumping units and storage tanks.

Gas for Local Use and Co-generation

Using Produced Oil/Gas for Local Use: An economical and practical system for capturing the gas for local use may be a requirement of the mineral assessment. Essential equipment in the two-stage system includes a free water knockout for initial separation and a gas/water separator to capture the gas. A final design would require testing of individual wells to determine flow rates and relative amounts of gas and water. Cost for this type of system is estimated at just over $36,000. If produced water temperatures are high, the well should be considered for geothermal use.

For local consumption, similar consideration must be given to pipeline and delivery, as well as compression costs. The costs for gathering and transmission would be comparable to commercial lines discussed above. Distribution systems vary widely in cost depending on the infrastructure repair and replacement necessary (street repairs, etc.)

Other possible gas uses include manufacture of ammonia and methanol from gas; local heating or businesses including greenhouses, manufacturing, (i.e. bricks, ceramics); powering irrigation pumps; and compressed natural gas for vehicle use (i.e., fleet vehicles, school buses, etc.)

Co-generation or electric power generation at the well site (also known as distributed power generation) is another potential resource use. This allows for energy transfer without the cost of pipelines, allowing for the use of existing power lines. New technology is allowing smaller scale distributed generation. Small electric generators are located in the field and are driven by small gas-fired turbines. These "micro-turbines" are becoming less costly, more reliable, and highly automated. Electricity may be sold into electric grid or used locally. Note in the report who controls the rural electrical power distribution, and who they purchase their power from.

Gas Research Institute technology transfer agent is IPAMS (the Independent Petroleum Association of Mountain States). GRI has a considerable amount of information on conventional and non-conventional gas uses, as well as ideas for economic development connected with gas production. The institute may be able to recommends looking into other projects in the state where natural gas is used for co-generation.

Co-generation

A hypothetical case of generation at the well site:

> A 75 kW/hour Turbogenerator is estimated to cost $30,000. These machines requires about 1,000,000 BTUs per hour, or 1,250 cubic feet of gas with a heating capacity of 800 Btu/ cubic foot at a pressure of 75 psi. This translates to a requirement of 30 Mcf gas per day from the well, which is not a very large production figure.

A typical home uses 500 kW-hours of electricity per month. A 75 kW/hour generator operating 24 hours a day for 30 days a month would generate 54,000 kW/month. At 30% efficiency, this system could serve 32 homes (54,000 /500 x 30%).

Other Resources

Geothermal

A good literature study in the area will note other energy resources might exist on

a Reservation, such as geothermal potential and coal, and coal bed methane. Waters produced from the deeper wells on the Reservation have elevated temperatures and may have potential for economical geothermal heating, especially where the wells flow. Uses of geothermal resources in the state should be documented. Information on and contacts for using geothermal resources can be obtained from federal sources.

Contacts and Resources

Provide in the report a list of contacts and resources so that it is easy to find and obtain services if future investigations continue. To often there is duplication of previous work because of poor references.

References would includes utility companies, technology transfer groups, consulting geologists, petroleum engineers with experience in the area of study, attorneys, oil field testing companies, and drilling companies.

NATURAL AGGREGATES PROGRAM

Jerry D. Higgins[1], Ph.D., P.G.

Abstract

A study of potential aggregate resources on Tribal lands in the western United States is being conducted by the Colorado School of Mines and the Bureau of Indian Affairs. The scope of the project includes a compilation and evaluation of existing geologic information. Summaries of geologic deposits with potential for use as aggregates (crushed rock or sand and gravel) are being prepared for each Tribal land. The summaries are being made available to the public through the Bureau of Indian Affairs web page.

INTRODUCTION

The United States produces approximately 2.1 billion tons annually of natural aggregate in the form of crushed stone and sand and gravel. These materials are primarily used for aggregate in the construction industry, especially in portland cement concrete for residential and commercial buildings, bridges, highways and airports, and as bituminous mixes for road construction and parking lots, or as road base, railroad ballast, erosion control, landscaping and road surfacing. Aggregate production accounts for about half of the nonfuel-mining volume in the United States. Income to Tribal governments from sales of natural aggregates far exceeds income from any other mining activity. Potential income from new development of natural aggregate resources near the area of use is very significant as demands for aggregates are increasing because of growth and infrastructure replacement. However, no comprehensive source of information on this subject exists for all Tribal lands.

The Colorado School of Mines and the Bureau of Indian Affairs is conducting an inventory of aggregate resources for Tribal lands in the western United States. The inventory consists of a compilation of published information on surficial and bedrock deposits and an assessment of the potential

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for mining these deposits for aggregates, either crushed stone or sand and gravel. The compiled information is available on the Division of Energy and Mineral Resources, Bureau of Indian Affairs web page.

The purpose of the project is to make information on aggregate resources located on Indian lands in the western United States readily available to the Tribes and the public. The information from these studies should be a useful first step for planning the development or preservation of aggregate resources on each property.

METHOD

The study is being conducted by compiling geologic information from previous studies in which most were not focused on aggregate resources. The descriptions of geologic formations are evaluated with respect to desirable geologic properties for aggregate sources (either crushed rock or sand and gravel). The deposits are then classified on the basis of the potential (high to low) for use as aggregate.

A summary of findings for each Tribal land is being written, tables are being compiled by state, and general geologic maps are included when available. The summary includes location of the land, size, ownership, access, road type and condition, descriptions of bedrock and surficial deposits, history of past aggregate mining, classification of potential of geologic units for use as aggregates, and a reference list of geologic

Table 1: Aggregate Webpage Progress by State

State	Online	Summary Text *Not* Complete	Geologic Maps Complete	Tables *Not* Complete
Alaska	X			
Idaho	X			
Montana	X			
Oregon	X			
Washington	X			
Wyoming	X			
Iowa		X		
Minnesota		X	X	
Oklahoma		X	X	
South Dakota		X	X	
Wisconsin		X	X	
North Carolina		X	X	
North Dakota			X	
Colorado				X
Nevada				X
Utah				X

information for the site. Tables include the name of the reservation, location and size of the reservation, aerial extent and thickness of the deposits, whether or not there is current mining of aggregate on the reservation, the quality of information on potential deposits, general aggregate information, and aggregate potential based on the geology of the deposit

PROGRESS THROUGH 1998

The plans for next year include adding all of the aggregate assessments, geologic maps, and tables for Alaska, Idaho, Montana, Oregon, Washington, and Wyoming online (Table 1). The same data sets will start to be added to the web page for Nevada, Utah, Arizona, New Mexico and California to our web page (Table 2).

EXAMPLES OF AGGREGATE SUMMARIES

Included here are examples from the state of Washington of aggregate potential summaries (Figure 1), a state table (Figure 2), and a geologic map (Figure 3) that are presently available on the web page. The web page can be found at (http://snake1.cr.usgs.gov/demr/niemr/aggregate).

Clallam County

Reservation	Location and Size	Aerial Extent, Thickness of Deposit, and Map Scale	Active Mining	Quality of Information on Potential Deposits	General Aggregate Information	Aggregate Potential Based on Geology of Deposit
Lower Elwha Reservation	Clallam County, Washington **Size:** unknown	**Thickness:** unknown **Aerial Extent:** The alluvium is 0.45 sq. miles **Map Scale:** 1 in = 0.42 mi	**Yes** A gravel pit is located near the reservation at SE 1/4, NW 1/4, Sec. 35, T. 31 N., R. 7 W. The Slater Quarry (trap basalt) is located in SE 1/4, NW 1/4, Sec. 35, T. 31 N., R. 7 W.	**Good**	The entire reservation is underlain by Quaternary-age alluvium.	**Good** Limited information is available on the thickness and composition of the alluvial deposits. Gravel pits and basalt quarries are located on or near the reservation.
Makah Reservation	Clallam County, Washington **Size:** 27,013 acres	**Thickness:** unknown **Aerial Extent:** The alluvium is 8.32 sq. miles **Map Scale:** 1 in = 1.5 mi	**Yes** A basalt quarry is located in SE 1/4, Sec. 17, T. 33 N., R. 15 W.	**Good**	Beach sand is located on Makah Bay and gravel beaches are located on Neah Bay. Basalt from the Eocene-age Crescent Formation is also located on the reservation.	**Good** Limited information is available on the thickness and composition of the alluvial deposits. A sand and gravel pit was located on the reservation, but is no longer in operation.
Quileute Reservation	Clallam County, Washington T. 28 N., R. 14 W. **Size:** 719 acres	**Thickness:** unknown **Aerial Extent:** The alluvium is 0.62 sq. miles **Map Scale:** 1 in = 1.1 mi	**No**	**Good**	Pleistocene-age glacial deposits composed of moraines and stratified sand, gravel, silt, and clay are located on the reservation.	**Fair** Limited information is available on the thickness and composition of the glacial deposits. The southern portion of the reservation is undergoing archeological investigations which may limit mining development.
Quileute Reservation	Clallam County, Washington T. 28 N., R. 15 W. **Size:** 594 acres	**Thickness:** unknown **Aerial Extent:** The alluvium is 0.41 sq. miles	**Yes** An alluvial pit is located in SW 1/4, SE 1/4, Sec. 20, T. 28 N., R. 14 W.	**Good**	The beaches and valley floor have Holocene-age alluvium composed of sand, silt, and gravel. Pleistocene-age glacial deposits consisting of moraines and stratified sand, gravel, silt, and clay are located in the south.	**Good** Limited information is available on the thickness and composition of the alluvial and glacial deposits.

Example of a Tables which includes the name of the reservation, location and size of the reservation, aerial extent and thickness of the deposits, status of mining of aggregate on the reservation, the quality of information on potential deposits, general aggregate information, and aggregate potential based on the geology of the deposit

The Quinault Indian Reservation is located on the Olympic Peninsula in Gray's Harbor and Jefferson Counties, Washington. It consists of 189,061 acres, 4,414 of which are tribal owned (U.S. Department of Commerce, 1974). It is accessible by State highway 109 to the south and U.S. Highway 101, which traverses the reservation in the north (Watamaker, 1980).

There are three potential sources of aggregate on the reservation. The first potential source is a Holocene-age alluvium composed of sand, silt, and gravel that is located in the northern portion along the beaches and valley floors (Watamaker, 1980). The second potential source is a 100-foot thick, Pleistocene-age, alpine glacial deposit composed of channeled and cross-bedded gravel that originated from the Olympic Mountains. Some areas of the formation are composed almost entirely of sand. The third potential aggregate source is the Pliocene-age Quinalut Formation. This deposit consists of coarse-grained, cross-bedded sandstone, siltstone, and conglomerate and is located in the western portion of the reservation.

Gravel mining along stream terrace deposits has occurred for more than thirty years. The material has been used for local road surfacing and concrete aggregate. Watamader (1980) reported that the sandstone on the reservation is, "probably suitable for riprap, crushed rock, and dimension stone." Limited information is available on the thickness and composition of the alluvial and glacial deposits.

References

NIEMR | Aggregate | Geological | To Map

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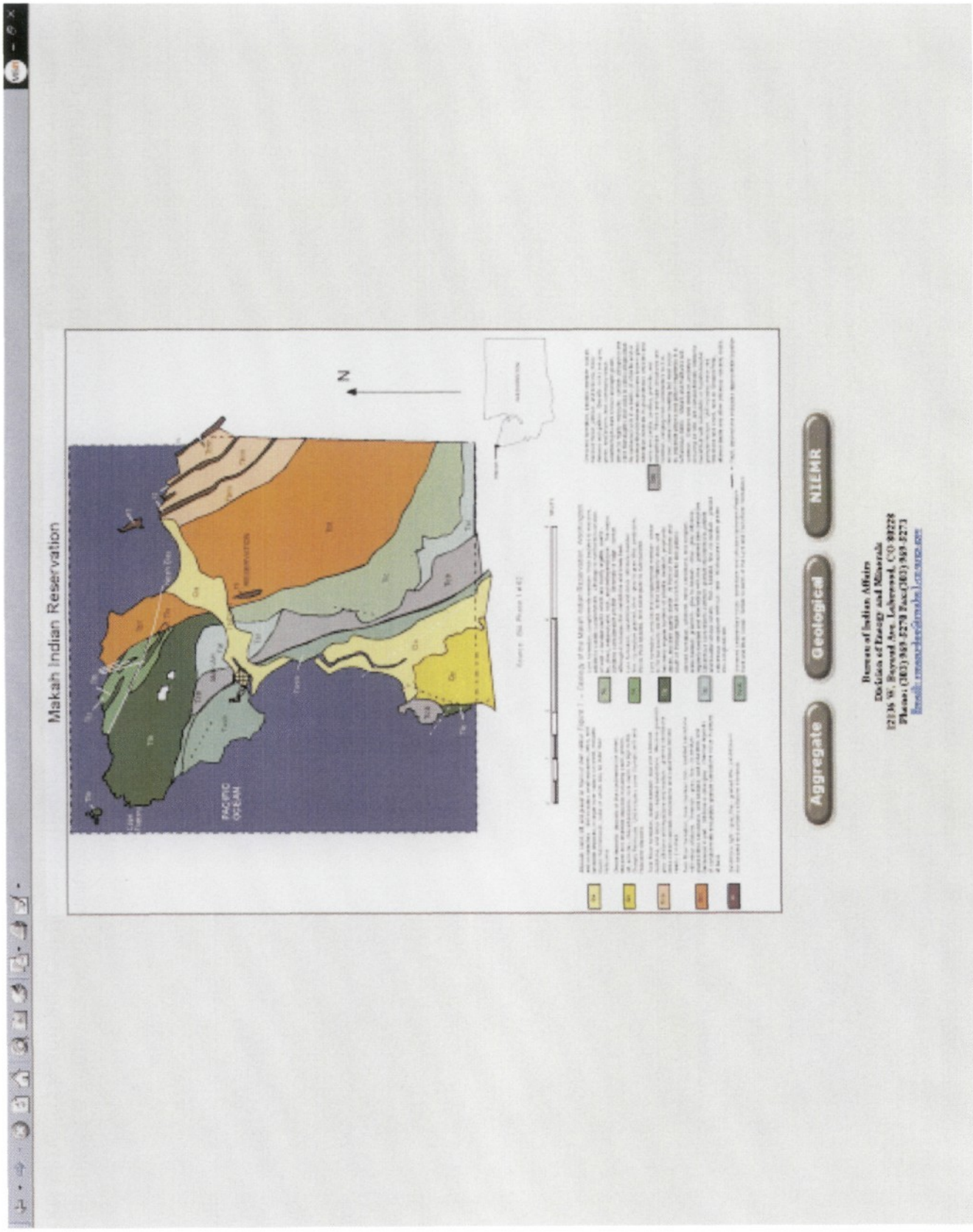
Example of a summary which includes location of the land, size, ownership, access, road type and condition, descriptions of bedrock and surficial deposits, history of past aggregate mining, classification of potential of geologic units for use as aggregates, and a reference list of geologic information for the site.



Example of a geological map of a Reservation

Status of the Evaluation of the Crushed Aggregate Potential in the Southern Portions of Annette Island, Alaska

Stephen A. Manydeeds[1] and Lynne M. Chastain[2]

Introduction

The Tribal Council of the Metlakatla Indian Community (MIC), Annette Islands Reserve, Alaska (Figure 1) has requested an assessment of the aggregate resource potential of the southern portion of their reservation. The aggregate would serve as asphalt, concrete, roadbase, and rip rap grade aggregate for both roads within the reservation for commercial use in the surrounding areas, particularly Seattle, WA.

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The Bureau of Indian Affairs Division of Energy and Mineral Resources (DEMR), is providing technical support to the Metlakatla Indian Community. The MIC does not need or can afford full time geologist and engineers to support their programs. The DEMR is taking responsibility for making such scientific expertise available to the Tribal Council and Tribal natural resources department, in conducting an assessment of the Reserve's aggregate resource potential.

In the first step of this project, existing aggregate pits and areas on the Metlakatla Peninsula and Fish Hatchery Road is being sampled by Tribal personnel. DEMR personnel will be testing the collected rock with the L. A. Abrasion (Hardness) Test and the Sulfate Soundness Test. DEMR is also evaluating existing geological, geochemical, and geophysical data for potential areas of new aggregate sources on the Metlakatla Peninsula and the southern portions of the island. Recommendations for target areas of new aggregate sources would be given to the MIC.

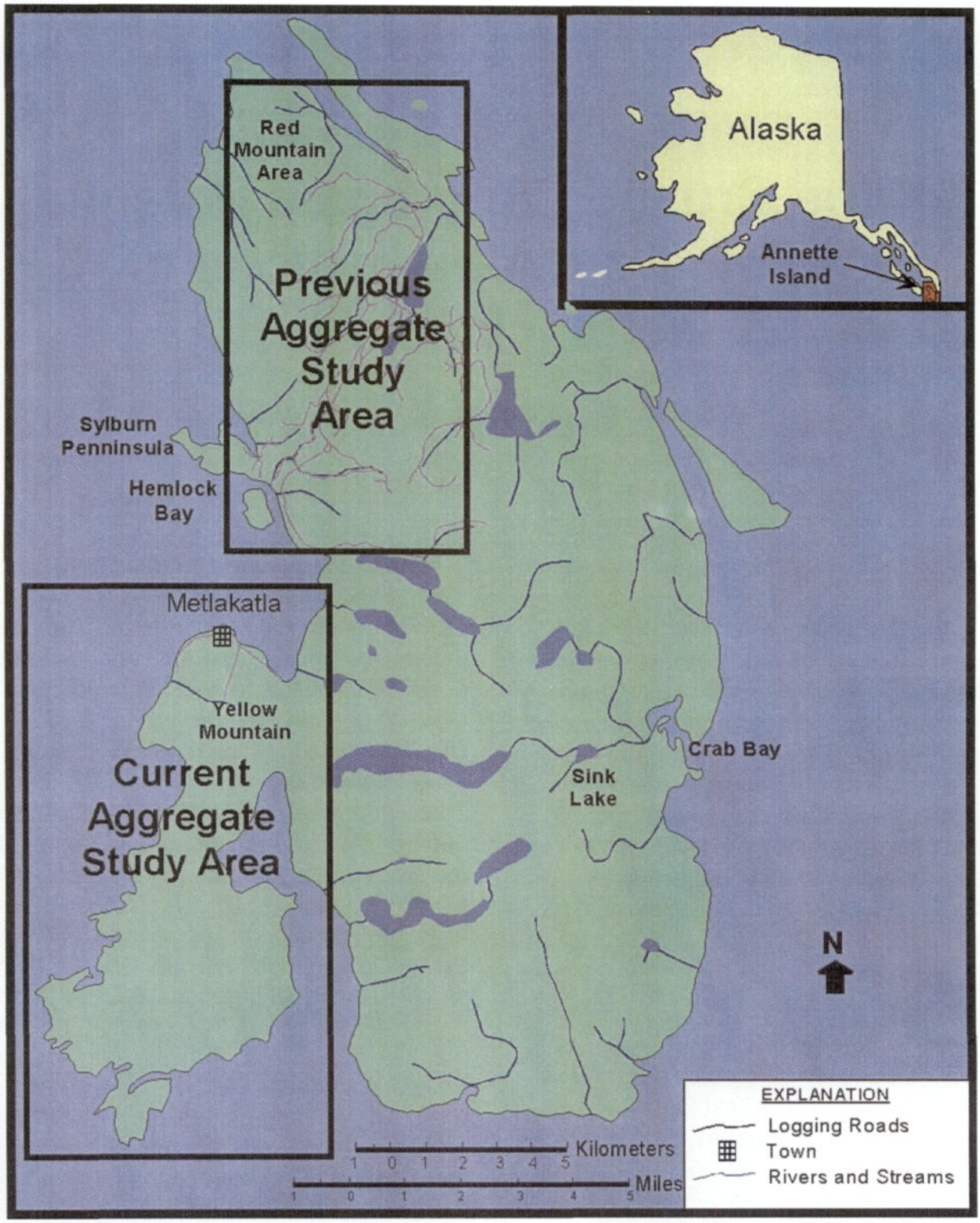

Figure 1. Location map of the Annette Island Reserve, Alaska

In the second step of this project, existing pits would be evaluated for production life and recommendations would be made for mine design and/or reclamation. The Tribally selected target areas would be sampled and analyzed. In addition, geochemical data from previous work would be combined with geochemical data from this project to generate a background geochemical survey of parts of the island.

Bedrock Geology

Bedrock units in Southeast Alaska have been divided into fault-bounded stratigraphic groups called terranes. Terranes may be further subdivided into smaller fault bounded entities called subterranes. The bedrock units of the Annette Islands Reserve are part of the Annette subterrane of the Alexander terrane. The island is dominated by the Silurian-aged, granitic Annette Pluton, which is moderately to strongly deformed and was intruded into greenschist to amphibolite grade metamorphic rock. The Annette Pluton ranges in composition from granite to leuco-trondhjemite to quartz diorite. Host rocks to this pluton include meta-diorite, marble, quartzite, pelite, and greenstone. The Annette Pluton is overlain by metamorphosed Devonian and Silurian marine rocks including meta-conglomerate, marble, meta-pelite, greenstone, and meta-volcaniclastic rocks.

Upper Triassic shallow marine sedimentary and volcanic rocks, including conglomerates, tubiditic limestones, carbonaceous mudstones, pillow basalt, and pyroclastic rhyolite, overlie the Devonian and Silurian rocks. The Upper Triassic rocks, in turn, are overlain by Upper Mesozoic marine sedimentary and volcanic rocks. Since the accretion of the Alexander terrane onto the North American continent in Late Cretaceous time, high angle dextral faults have occurred throughout southeast Alaska.

Tectonic Setting

Basement rocks of the Alexander terrane suggest that it was originally part of the North American continent. These rocks rifted away from the continent in late Proterozoic or earliest Paleozoic and became a volcanic island arc with episodes of arc volcanism that extended through the Permian. By Pennsylvanian time, it was amalgamated with another terrane. Another rifting event occurred, and another amalgamation with another terrane occurred. The resulting composite island was accreted onto the western edge of the North American Continent in the Late Cretaceous. Since the Late Cretaceous, terranes in the vicinity of southeast Alaska have been splintered by dextral faults related to the changing trajectories of the North American and Pacific plates.

Previous Aggregate Studies on the Annette Islands Reserve

A previous study by a graduate student at the Colorado School of Mines, Golden, CO has outlined the quantity and quality of crushed rock along existing logging roads on the northern portions of the island (Figure 2). The project was directed at assisting the Walden Point Road Project by finding aggregate that could be used to maintain logging roads between the landing dock in Hemlock Bay and the military base camp on the eastern side of the island.

This study collected samples from the Annette Pluton and the Silurian to Devonian aged greenstone and greenschist surround-

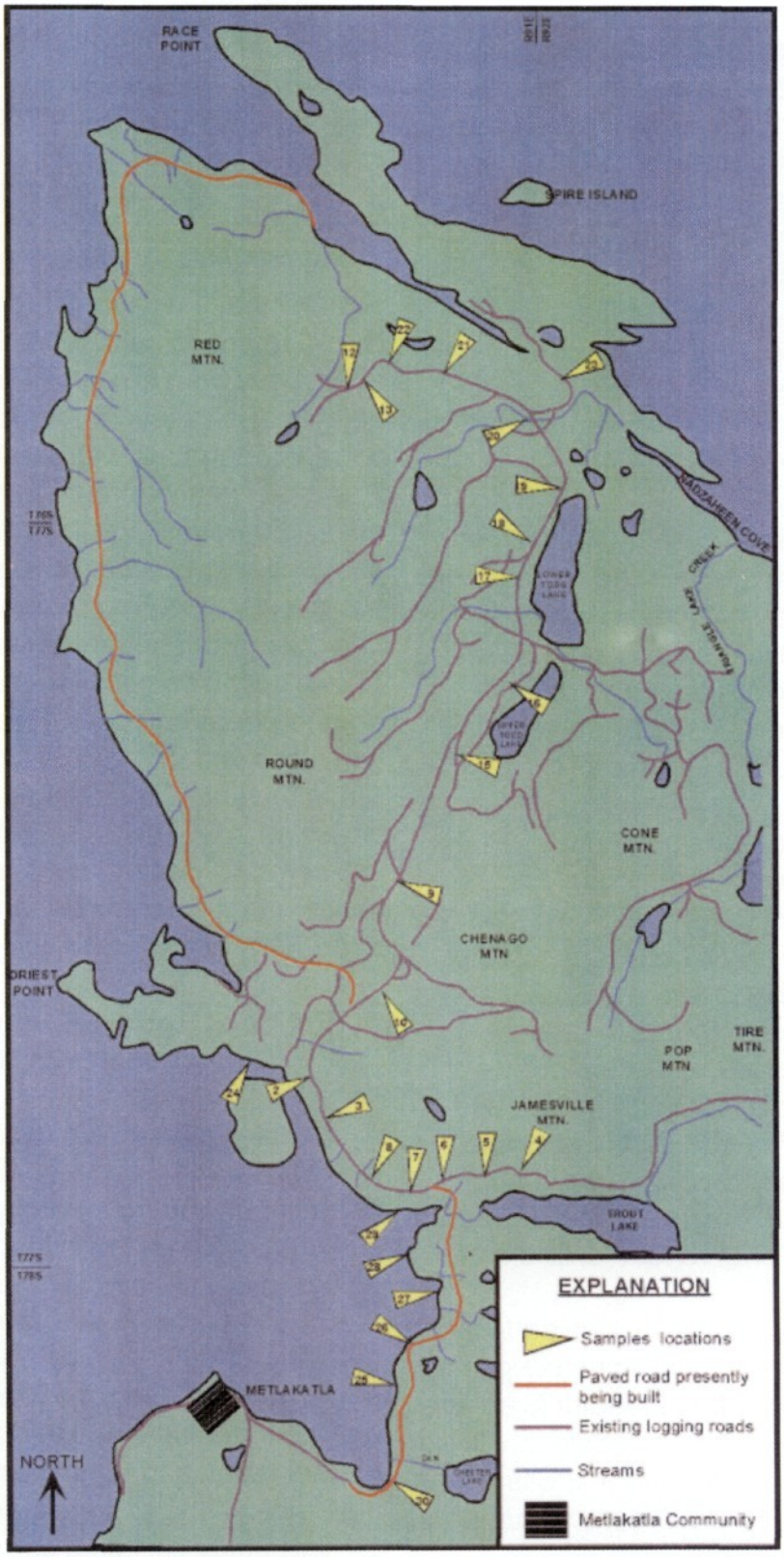

Figure 2. Northern Study Area

ing the pluton. The findings indicate that there is potential for crushed aggregate on the island. Two of the three of the best sites were located in intrusive rocks; the most promising site was located within the Annette Pluton.

On Going Market Study for Aggregate Materials

The Metlakatla Indian Community (MIC) is currently undertaking a market assessment for crushed rock produced on Annette Island Reserve. Market potential will be evaluated with emphasis on the highest income production end uses (asphalt and cement). Lower income-generating uses such as roadbed aggregate and jetty/rip-rap grade aggregate will also be considered.

The potential market areas for investigation will include:

1) Annette Island: Walden Point road construction project, and other recurring uses.
2) Southeast Alaska: Principally Ketchikan and Prince of Wales Island
3) Central Alaska: Juneau and vicinity
4) Washington State: Seattle/Tacoma metropolitan area
5) British Columbia, Canada: Vancouver, British Columbia metropolitan area

Finally, this analysis will look at the competition the MIC would face for supplying aggregate products. In particular, the analysis will evaluate the known or expected capacity for quarry rock production in the supply region outlined above which competes with MIC.

Project Description

The purpose of this project is to determine:

1) The quality of the rock currently being mined from existing pits.
2) Locations of new aggregate resources on the Metlakatla Peninsula (Figure 3).

In order to accomplish this the Division has developed an integrated approach evaluating the aggregate resource of the Annette Island Reserve. A regional exploration program normally involves the defining of smaller areas of interest within the larger or regional area of general interest. The first step in reconnaissance is the process of screening or highlighting smaller areas of interest. This begins in the office by gathering all available data in the area and starting the process of highlighting smaller areas of interest. In the Annette Island Reserve this reconnaissance data would be a combination of airborne geophysics and aerial photography, geochemical data, and previous field work.

Aerial photography provides a synoptic or general view of the Metlakatla Peninsula. The Division has acquired recent (flown May, 1995) high quality color aerial photography of the Metlakatla Peninsula. These photos will provide a general idea of topographic relief and indicate areas of possible changes in rock types, intrusive contacts, faults, as well as existing aggregate pit locations.

This information will then be used to aid in the interpretation of the existing airborne geophysics. The airborne geophysics was originally flown in 1986 as part of an exploration effort to define the Reserve's base

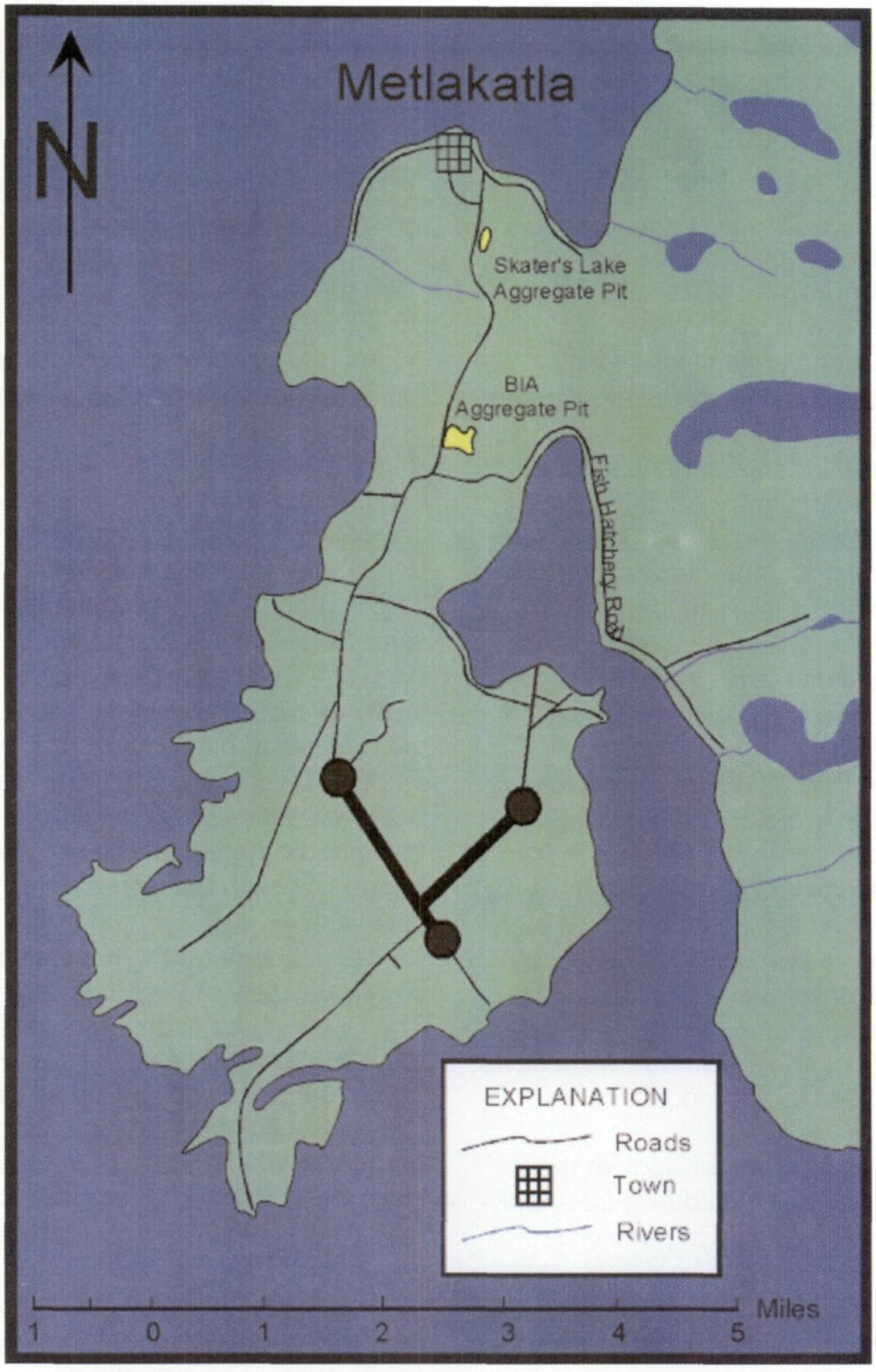

Figure 3. Southern study area

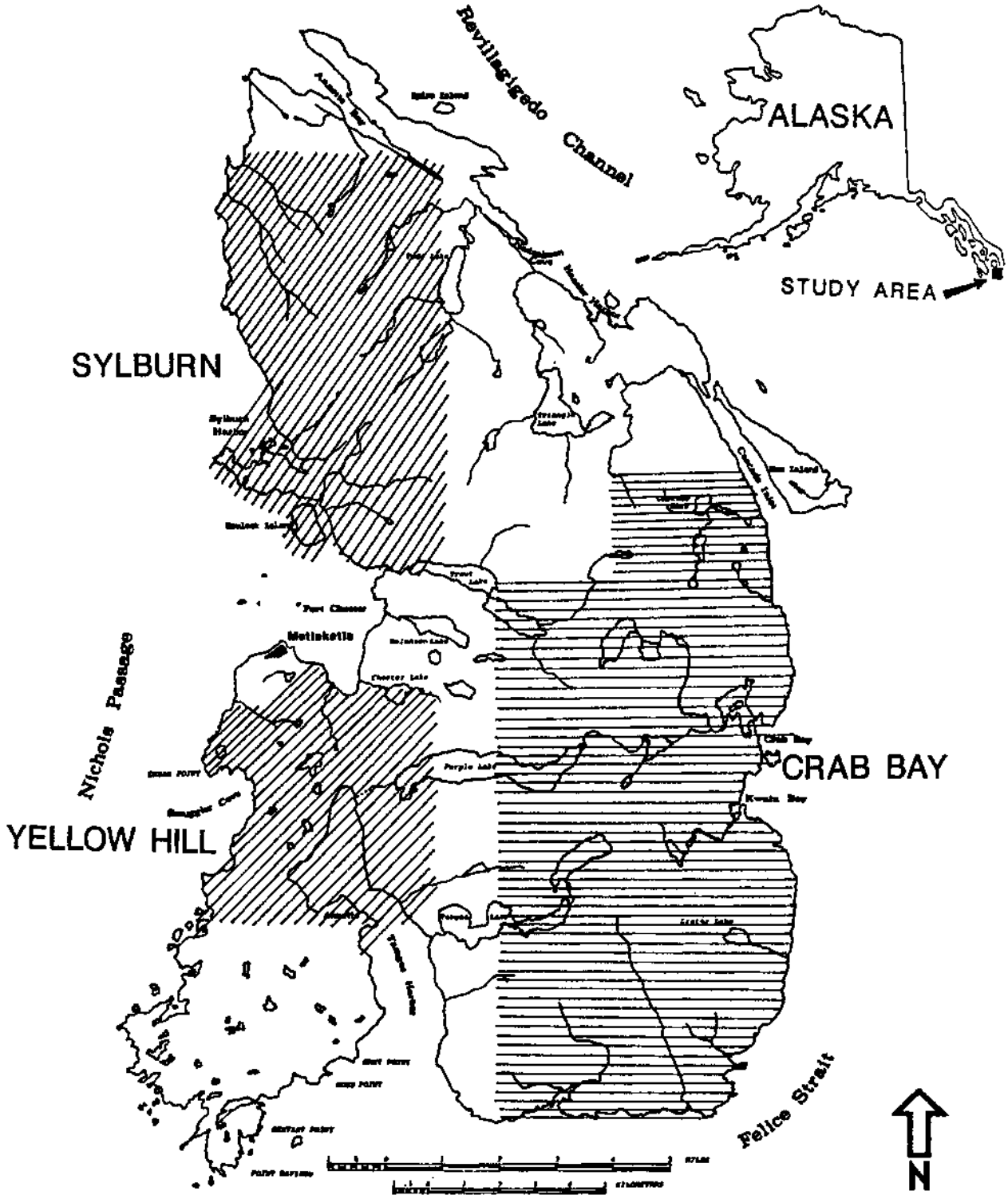

Figure 4. Loaction of three airborne surveys areas

and precious metal potential. The original survey was flown in two parts 1) the entire Reserve was flown and magnetic and very low frequency (VLF) data was collected, 2) three small areas: Sylburn, Yellow Hill and Crab Bay were flown using a much closer flight lines (Figure 4). In addition to magnetic and very low frequency (VLF), electromagnetic (EM) data was also collected at three frequencies. This geophysical data was originally gathered to provide detailed information for refining geological contacts, delineating faults and fracture systems and identifying conductive zones that may represent host mineralized areas.

Several geochemical studies have been performed on the island. Humble Oil (now Exxon), Hawley and Associates, and the United States Geological Survey (USGS) have collected a significant number of geological samples. Humble Oil and Hawley and Associates collected 488 stream sediments throughout the island in 1969 and 1975. Hawley and Associates also collected 427 soil samples. Houston Minerals Exploration (HOMEX) collected forty rock and soil samples. Personnel from the USGS, under a variety of projects, have collected approximately 750 rock, stream sediment, and water samples from the island since the late 1960s. These data were collected for mapping and exploration purposes.

This project will be using the above data slightly differently. Previous studies on the Reserve have indicated that the best aggregate is in areas of intrusive rocks; the most promising site was located within the Annette Pluton. These areas were not close to any major faulting or fracture systems and were not mineralized. The Division will be integrating the aerial photography, airborne geophysical data, and geochemical data to locate areas of intrusive rock, not close to any major faulting or fracture systems, and void of any mineralization.

Field Reconnaissance

Once existing pits and any new target areas are defined, Tribal and DEMR personnel can collect rock samples for the analyses described below. Filed mapping around existing pits and within new target areas may occur if deemed necessary.

Sampling and Analyses

Approximately seventy pounds of material are required in order to ensure enough sample for analysis. Samples should be collected as rock chips from fresh exposures. At least one sample large enough to produce a 6 in length, 50 mm diameter of unfractured core must be collected.

Los Angeles Degradation Test

Aggregate material used in road construction must be able to uphold under high traffic and under heavy loads. The material must also meet regulations for road base standards in order to be used for commercial use.

The Los Angeles Degradation Test (ASTM C 131) is used to evaluate the hardness and the durability of a rock. A sample of 5,000 grams would be quartered into 1250 gram specific size fractions. The sample is placed in a steel drum along with twelve 420 gram steel balls (Figure 5). The drum is rotated and the steel balls and the sample are dropped twenty-seven inches with each revolution. As the particles rub together, the more brittle or softer rock fragments are broken down. After the first

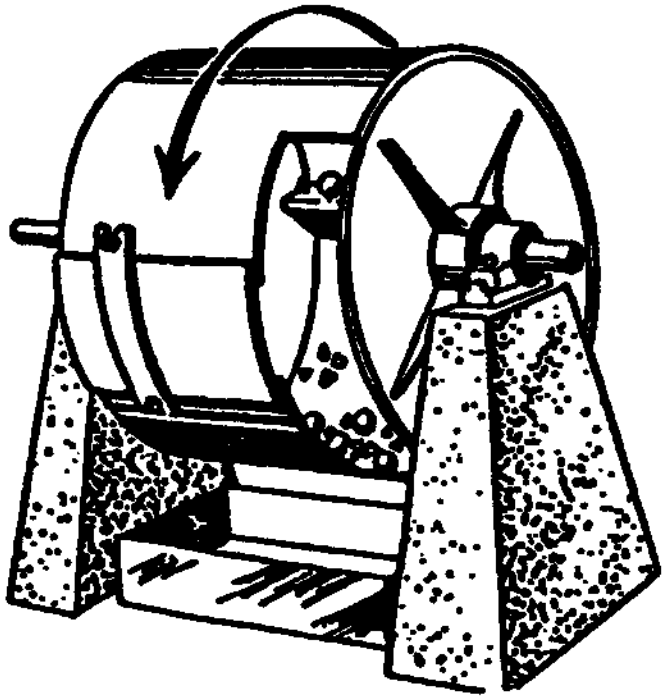

Figure 5. Los Angles Degradation test equipment

100 rotations, the sample is removed and separated by a No. 12 sieve. The percentage of rock that passes through the sieve is the percent wear. This loss is measured and is the recorded Los Angeles Degradation Value. The sample is returned to the drum and rotated an additional 400 revolutions and then the wear is remeasured.

Sulfate Soundness Test

The Sulfate Soundness Test (ASTM C 88) is a test which is used to determine a rock=s reaction to freeze-thaw cycles. A sample is submerged in either sodium sulfate or magnesium sulfate for sixteen to eighteen hours at a constant temperature of 70 +/- 2 F. The sample is then drained and placed in a drying oven at 230 +/- 9 F until the sample reaches a stable weight. During the immersion portion of the test, the salt solution penetrates the permeable pore spaces in the rock. As the sample is dried, the salt precipitates in the pore spaces in the rock, mimicking a freeze thaw cycle. This process is repeated five times to achieve the same effect as a freeze-thaw environment. The sample is sieved and then measured. The weighted average loss for each size fraction is calculated and then used to determine the freezing durability of a sample.

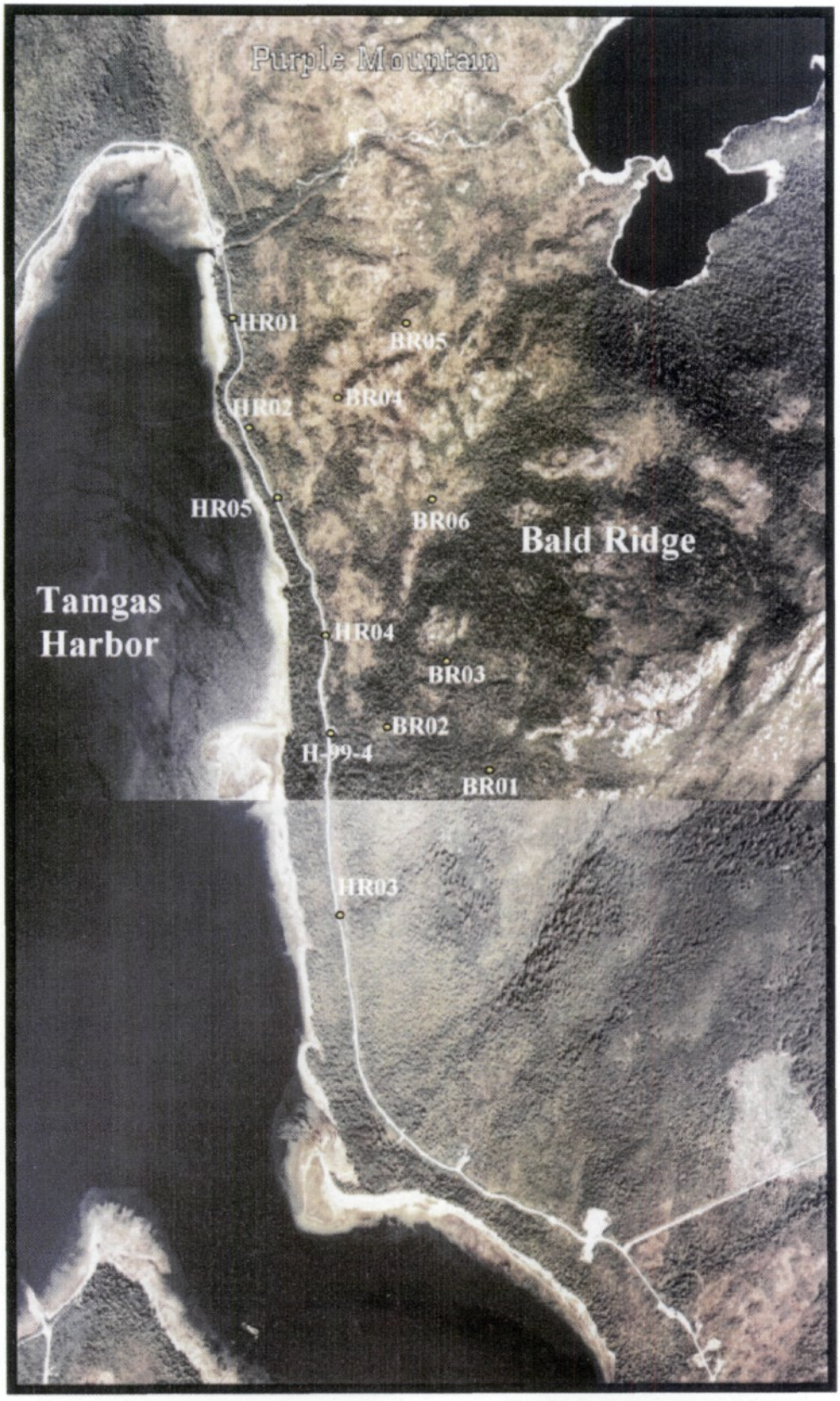

Figure 6 Sample sites from along Fish Hatchery Road on Tamgas Harbor. Samples were collected in July, 1999, testing results to be completed September, 1999.

Figure 7 Road cut along the northern edge of the Annette Pluton

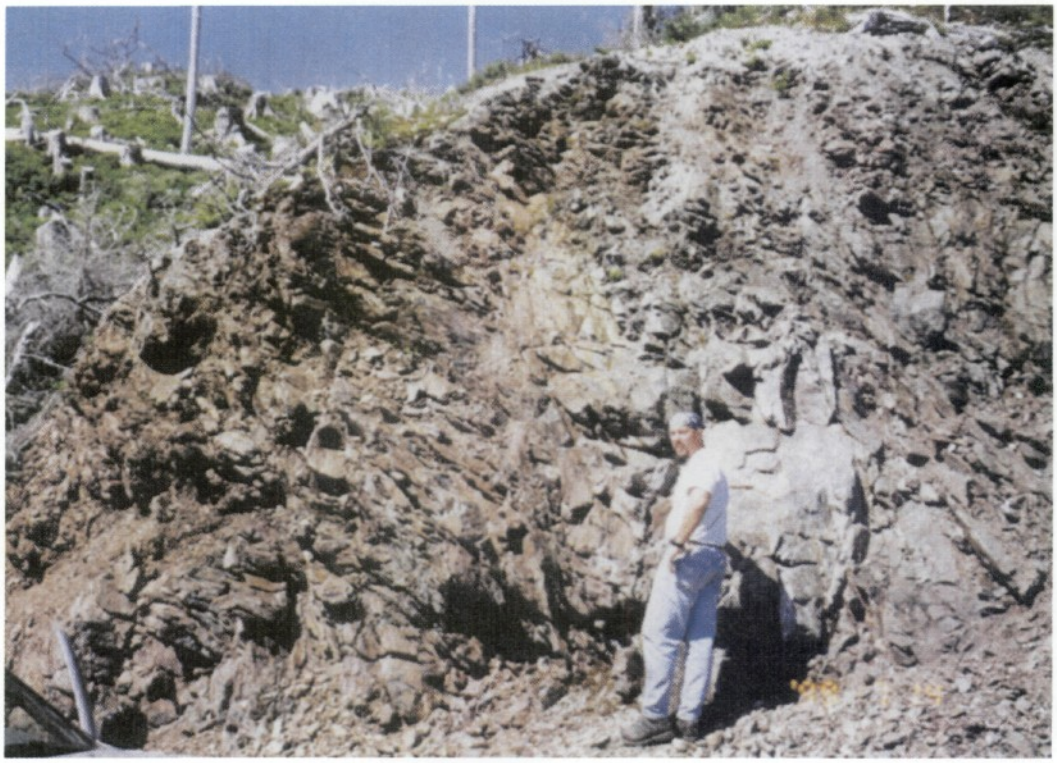

Figure 8 Road cut along the northern edge of the Annette Pluton showing fracture pattern

Schedule

Ongoing

- Review of existing data and reports (DEMR personnel).
- Examination of existing geological, geochemical, and geophysical data and aerial photographs to locate non-altered rock and assign target areas on the Metlakatla Peninsula and the southern portions of the island (DEMR personnel).
- Location of existing aggregate pits within the Reserve (Tribal personnel).
- Collection of samples from existing pits on the Reserve (Tribal personnel).
- Collection of rock samples along Fish Hatchery Road on Tamgas Harbor-Sections 22 and 27, T78S, R92E (Tribal personnel) (Figure 6).
- Testing of collected rock samples (DEMR personnel).

Future Work

- Recommendations for target areas for new aggregate resources (DEMR personnel).
- Selection of target areas on the Metlakatla Peninsula and in southern portions of the island (Tribal personnel)
- Field mapping of resources surrounding existing pits with good quality rock (as required) (DEMR personnel).
- Field mapping and sample collection of new target areas (DEMR and Tribal personnel) (Figure 7 and 8).
- Testing of collected rock samples (DEMR personnel)
- Mine plan modeling or mine reclamation design for various pits on the Reserve, as determined by the Tribe (DEMR personnel)

At the end of this preliminary study, a report would be provided to the reservation containing all information concerning the assessed sites and the outcome of the rock quality determination testing.

Conclusion

The Bureau of Indian Affairs Division of Energy and Mineral Resources, by providing technical support to the Metlakatla Indian Community, hopes to set a standard of technical service by which other agencies can imitate. The Metlakatla Indian Community, like most Tribes, does not need or can afford full time geologist and engineers to support their programs. By taking responsibility for making such scientific expertise available to the Tribal council and Tribal natural resources department, the DEMR, in conducting an assessment of the Reserve's mineral resource potential, hopes to aid the Tribes in managing their mineral resources.

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Sand and Gravel Assessment of the Flathead Indian Reservation

Eric P. Bunnell[1] and Jerry D. Higgins[2], Ph.D., P.G.

Introduction

The Bureau of Indian Affairs Division of Energy and Mineral Resources (DEMR), is providing technical support to the Confederated Salish & Kootenai Tribes of the Flathead Indian Reservation. In conducting an assessment of the reservation's sand and gravel potential we hope to delineate the best locations to further develop sand and gravel pits. These pits will be utilized to obtain material for future highway improvements and other development. This research is required because there is no comprehensive plan for aggregate resource development and existing data concerning durability, grain size and weathering reactions of the various glacial deposits on the Reservation is limited.

The Tribe does not have the need or the extra resources to hire a full time geologist or engineer to support their programs. The DEMR is taking responsibility for making such scientific expertise available to the Tribal Council and Natural Resources Department. By providing technical support to the Tribe, the DEMR, hopes to set a standard of technical service by which other agencies can imitate. Through taking responsibility and providing technical support to the Tribal Council and Tribal Natural Resources Department, in

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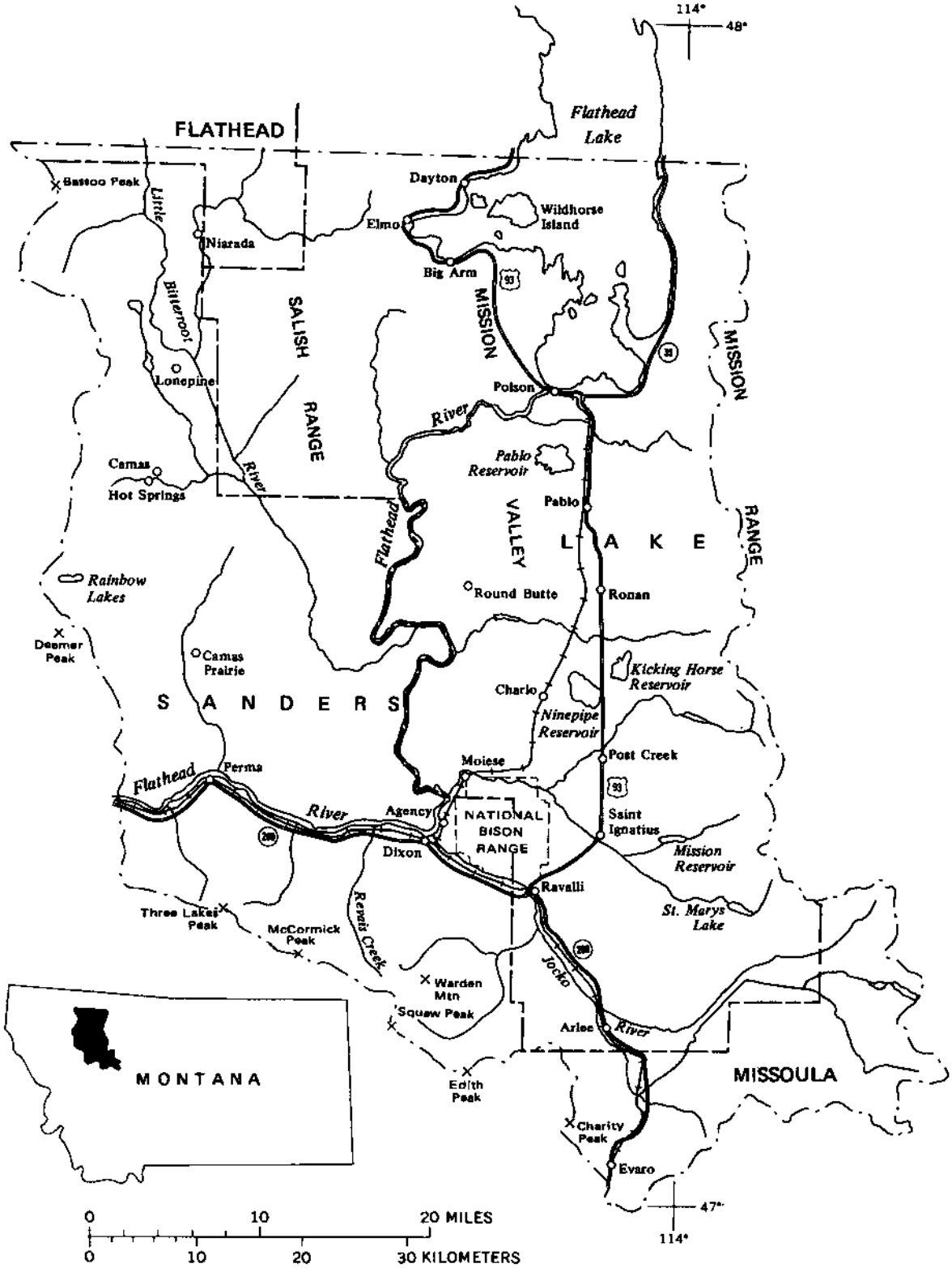

Figure 1 Index map of Flathead Indian Reservation, Montana

Figure 2 Sorted Gravel in the Pablo Pit

Figure 3 Sampling the Elmo Pit

conducting an assessment of the Reservation's mineral resource potential, the DEMR hopes to aid the Tribes in managing their mineral resources.

Objectives

The objectives of this study are:

1) To perform literature searches and compile a database.
2) To conduct a reconnaissance survey of existing pits to evaluate geologic setting.
3) To obtain samples for aggregate quality tests.
4) Determine the durability, grain size distribution, and freeze – thaw reactions of materials sampled.
5) Determine which pits are the best for future development.

Scope of Work

The study consists of seven phases:

1) Review of existing information and compilation of a database.
2) Collection of samples from sand and gravel pits and field reconnaissance.
3) Determination of the size of the material using a dry sieve analysis.
4) Determination of the durability of the samples using the Los Angeles Abrasion test.
5) Petrologic examination of coarse particles in the lab and the field.
6) Determination of the weathering reactions (freeze and thaw) of the material using the Sulfate Soundness test.
7) A report identifying recommended sites for future development.

The report will contain all information gathered from the tested samples, maps showing locations of sampling, geologic maps of the highest quality deposits and results of the aforementioned tests.

Methods

Literature Search and Database Compilation

A literature search for all information that could pertain to this project is necessary to prepare for a field reconnaissance. From this information a database will be created and certain parameters will be used to narrow down the number of potential sites to visit during the reconnaissance.

Field Reconnaissance and Collection of Samples

Field reconnaissance of the area is necessary to gain general knowledge of the area and to determine if any unknown complications occur at the site. Once in the field, there will be a better understanding of the area and an efficient plan to collect samples can be finalized.

Existing roads provided access to the existing pits. All pits identified by the Tribal Council were reviewed and reconnaissance sampling was done only on those sites that appeared to have the best potential for use as aggregate. The decision was based on a visual classification of the deposit materials and approximate volume. Seven pits were sampled using a trenching method. This provided a representative sample from different depths and different points within the deposit with varying sizes and similar physical appearances. Descriptions of each site were recorded in a field book and a global positioning system (GPS) was used to determine each sample location (200 ft.).

Los Angeles Abrasion Test

Aggregate material used in road construction must be able to withstand the heavy loads associated with large volumes of traffic and be resistant to abrasion of automobile tires. The most common test used to determine a rock's durability and resistance to impact is the Los Angeles Abrasion Test (ASTM C 131). The test consists of placing a rock sample and ball bearings into a drum, rotating the drum, and impacting the particles and ball bearings against one another. The vigorous tumbling, surface wear, and abrasion causes the more brittle particles to shatter as the particles rub against one another and against the ball bearings. The percentage of sample lost during this process is called the Los Angeles Abrasion Number.

Standards

The Federal Highway Administration (FHA) requires that aggregate material used for road base must have a Los Angeles Abrasion value of less than 50. Table 1 summarizes the FHA's standards for aggregates used for road construction.

Grain Size Analysis

Aggregate material used as a base or subbase in road construction shall consist of durable particles of crushed stone, gravel, or slag. ASTM C 136 Test Method for Sieve Analysis of Fine and Coarse

CONSTRUCTION MATERIAL	LA ABRASION NUMBER
Coarse Aggregate for Portland Cement Concrete	< or = to 40%
Subbase, Base, and Surface Course Aggregate	< or = to 50%
Hot Asphalt Concrete Pavement Aggregate	< or = to 40%
Emulsified Asphalt Pavement Aggregate	< or = to 40%
Asphalt Surface Treatment Aggregate	< or = to 40%
Slurry Seal Aggregate	< or = to 35%
Subpave Asphalt Concrete Pavement Aggregate	< or = to 35%

Table 1. The Federal Highway Administration's Los Angeles Abrasion standards for aggregate used in road construction.

Aggregates will be used to determine the quality of the mix at each site. Following, is a table of grading requirements for the final road base and road subbase mixtures from ASTM D 2940 – 92.

The grain size distribution analysis will provide information on whether excess fine material is contained in the deposit. It will also give some indication as to the amount of crushing required.

Sulfate Soundness Test

The Sulfate Soundness Test, AASHTO Method T 104 (ASTM C 88), is used to estimate the aggregate's reaction to freeze-thaw cycles. The test involves weighing the sample, soaking it in magnesium or sodium sulfate, allowing it to dry, weighing the sample, and repeating the process for five cycles. During the immersion cycle, the sulfate salt solution penetrates the permeable pore spaces of the aggregate. Partial or complete oven drying dehydrates the sulfate salt precipitated in the pores. During re-immersion the internal expansive force is derived from the expansion of the sulfate salt as it re-hydrates within the rock simulating the effects of freezing water. After the desired numbers of cycles are performed the sample is dried to a constant weight and sieved. The weighted average loss for each size fraction is determined and

Sieve Size (Square Openings)	Design Range (Weight Percentages Passing)		Job Mix Tolerances (Weight Percentages Passing)	
	Bases	Subbases	Bases	Subbases
2 in. (50 mm)	100	100	- 2	- 3
1 1/2 in. (37.5 mm)	95 to 100	90 to 100	± 5	+ 5
3/4 in. (19.0 mm)	70 to 92	...	± 8	...
3/8 in. (9.5 mm)	50 to 70	...	± 8	...
No. 4 (4.75 mm)	35 to 55	30 to 60	± 8	± 10
No. 30 (600 mm)	12 to 25	...	± 5	...
No. 200 (75 mm)	0 to 8	0 to 12	± 3	± 5

Table 2. Grading Requirements for road base and subbase.

used as a rough estimate for the aggregate's freezing durability. A magnesium sulfate number less than 18 or a sodium sulfate number less than 12 is suitable for most uses.

Petrologic Examination

A petrologic examination of the particles greater than 2" will be performed on samples taken during the preliminary sand and gravel assessment. If there are not enough particles retained on the 2" sieve during the grain size analysis then particles retained on the 1.5" sieve will also be analyzed. The particles will be classified as Sedimentary, Volcanic, or Metamorphic.

During the focused sand and gravel assessment a pebble count will be taken. The pits will be paced off and every couple of paces a random pebble will be chosen and classified as Sedimentary, Volcanic, or Metamorphic. The analysis will be performed until 100 pebbles have been classified.

Mapping of Deposits

Geologic maps created from aerial photographs will be field checked during reconnaissance for the highest quality materials.

Work Completed to Date

Coordinating with personnel from the Confederated Salish and Kootenai Tribes, BIA DEMR, USGS, Montana Bureau of Mines, Montana Department of Transportation, and Colorado School of Mines a literature search has been performed for all information that pertains to this project. The information that was found was put into a database that was used in conjunction with Arcview to narrow the 110 possible development sites down to about thirty.

Type of mining, distance from major highway, depth and aerial extent of deposit, and surface ownership (did not know subsurface ownership) were used to narrow the number of pits down.

After narrowing down the pit, a field reconnaissance was performed, with Louis McDonald of the Confederated Salish and Kootenai Tribes. Sixteen sites were visited and seven of these sites were sampled. The Los Angeles Abrasion tests have just been completed and the Grain Size Distribution test is being finished up at the Bureau of Reclamation Materials Testing Laboratory in the Denver Federal Center.

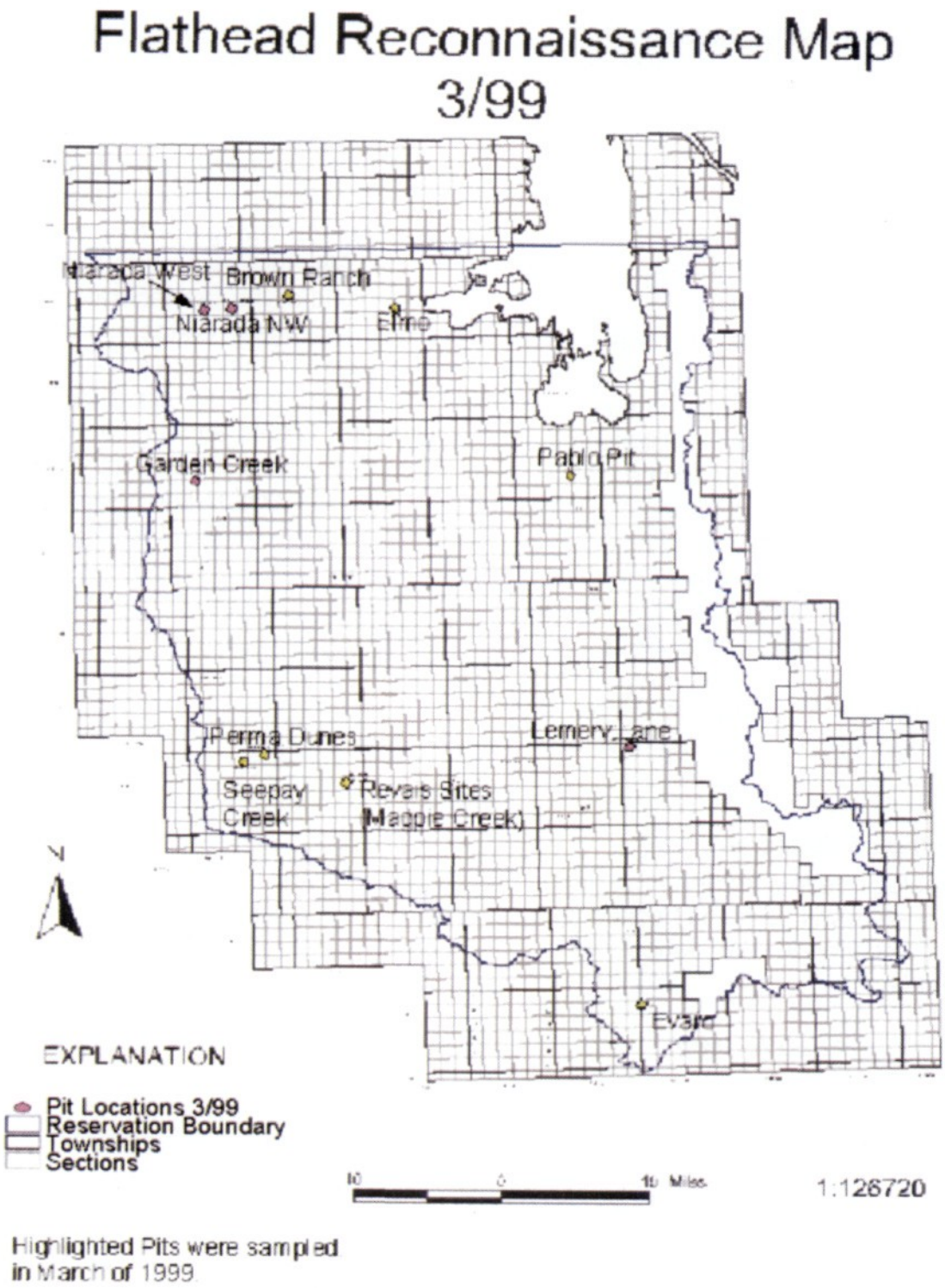

Figure 4 Reconnaissance completed in March of 1999

Figure 5 Reconnaissance in the Evaro Pit

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Geologic Modeling and Evaluation of Mineral Occurrences on Indian Lands Using Mining Software: Torres Martinez Cahuilla Gold/Silver Deposit, a Case Study.

Henrique M. da Silva[1]

Introduction

The Bureau of Indian Affairs (BIA) Division of Energy and Mineral Resources (DEMR) is providing technical support to Indian Tribes interested in evaluating their mineral resources economic potential. DEMR provides geologists and engineers to Tribes that do not need or can not afford a full time technical staff. DEMR has recently updated its technical tools by acquiring Vulcan and Whittle 4X software packages. These packages are among the state of the art mining software currently available to the mineral industry. Vulcan allows the creation of three-dimensional geological models of a deposit and posterior estimation of its mineral potential. Whittle uses the model generated by Vulcan and calculates optimal open pit outlines provided that basic assumptions about costs, recoveries, and general engineering parameters are made.

These two packages will enhance the BIA's marketing of mineral deposits on Indian lands to mining companies. The 3D outputs from these programs allow a better understanding of the geological setting in which the deposit was formed and of the potential economic value of the deposit. Furthermore, the software could expedite the interested mining company evaluation of a deposit by exporting model files in a format easily readable by most common mining packages used by the mineral industry. Thus, the interested parties could quickly and efficiently evaluate the deposit using their own software packages.

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The Torres Martinez Cahuilla Gold deposit is the first property to be modeled using Vulcan. A Geologic model is being constructed based on information from surface mapping, drill hole logs and assays. A brief description of the geologic setting, an overview of the modeling process, and Software features are discussed in this paper.

Cahuilla Gold Deposit Overview

The Cahuilla gold deposit is located in northwest Imperial County, approximately two miles west of the community of Salton Sea Beach, California, in the eastern foothills of the Santa Rosa Mountains. The project lies in portions of Sections 19, 20, 28, 29, and 30 of T.9S., R.9E. Sections 20, 28, and 30 are Torres Martinez Desert Cahuilla Indian Reservation lands. Sections 19 and 29 are privately owned lands. Site access is from State Highway 86, which is the route from the city of Indio to the city of Brawley. Figure 1 shows the general location of the Torres Martinez Reservation and current private land status around the Reservation. Drill roads are also shown in green.

The project site is located in an area of desert scrub and alluvial wash habitat. The climate is hot and dry, and the annual precipitation is less than six inches. Topography of the site is variable, ranging from gently sloping alluvial fans with elevation of (-95') mean sea level (MSL) on the east to steep rocky foothills with elevations of 1400' MSL on the west. The project area is classified as Sonoran Desert Scrub and vegetation is very sparse. No state or federally listed threatened or endangered plant or animal species occur at the site.

The earliest gold mining in the area was initiated around 1896 in the Montezuma and Rice districts about 30 miles southwest of the Cahuilla gold deposit. The nearest gold deposits in the vicinity of Cahuilla are about 15 miles to the northeast in the Orocopia Mountains on the East Side of the Salton Sea. However, production figures are not known for the mines, which include the Charity, Dos Palmas, Fish, Free Coinage, and Messenger mines. There are two small prospect pits on the Cahuilla property. These prospect pits are located directly on the Modoc fault. No known production occurred from the small prospects, which are believed to date circa 1912.

In 1987 Fisher-Watt Gold Company leased private land adjacent to the Indian Reservation and entered a joint venture with Homestake Mining Company. In 1989, Homestake drilled 23 holes. Newmont Exploration Ltd. also leased 80 acres of private ground in 1988 and conducted a 21-hole exploration program. Results from both drilling programs were encouraging, but indicated that the most favorable targets were situated on the adjacent Torres Martinez Reservation. In 1990, the Torres Martinez Desert Cahuilla Indians obtained Federal funding through the Bureau of Indian Affairs to undertake a gold mineral assessment. In 1991 and 1992, 57 holes were drilled on the Tribal lands with positive results. In 1993, Kennecott Exploration Co. acquired 390 acres of private fee lands from Fisher-Watt. In 1994, the Torres Martinez Tribe offered the Cahuilla gold deposit to the mineral industry for lease, and in 1995, Kennecott was successful in obtaining exploration/mineral rights to the property. Between 1995 and 1996 Kennecott drilled a total of 114 drill holes with positive results. Currently the property is available for leasing from the Torres Martinez Tribe.

Figure 2 shows the topography and all available drill holes on the property. The surface expression of these drill holes is represented

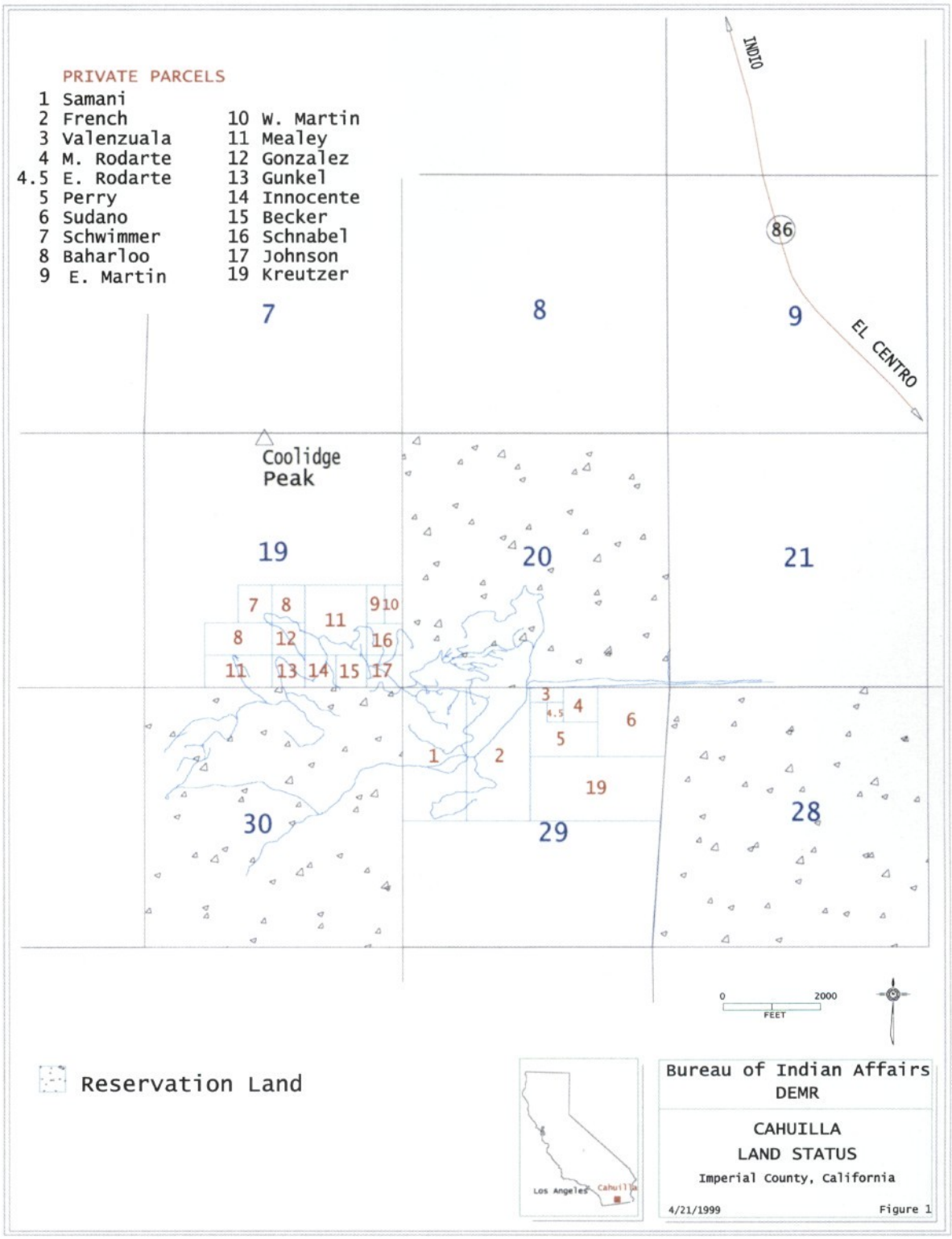

Figure 1 – Torres Martinez Reservation general location and private land status around the Reservation.

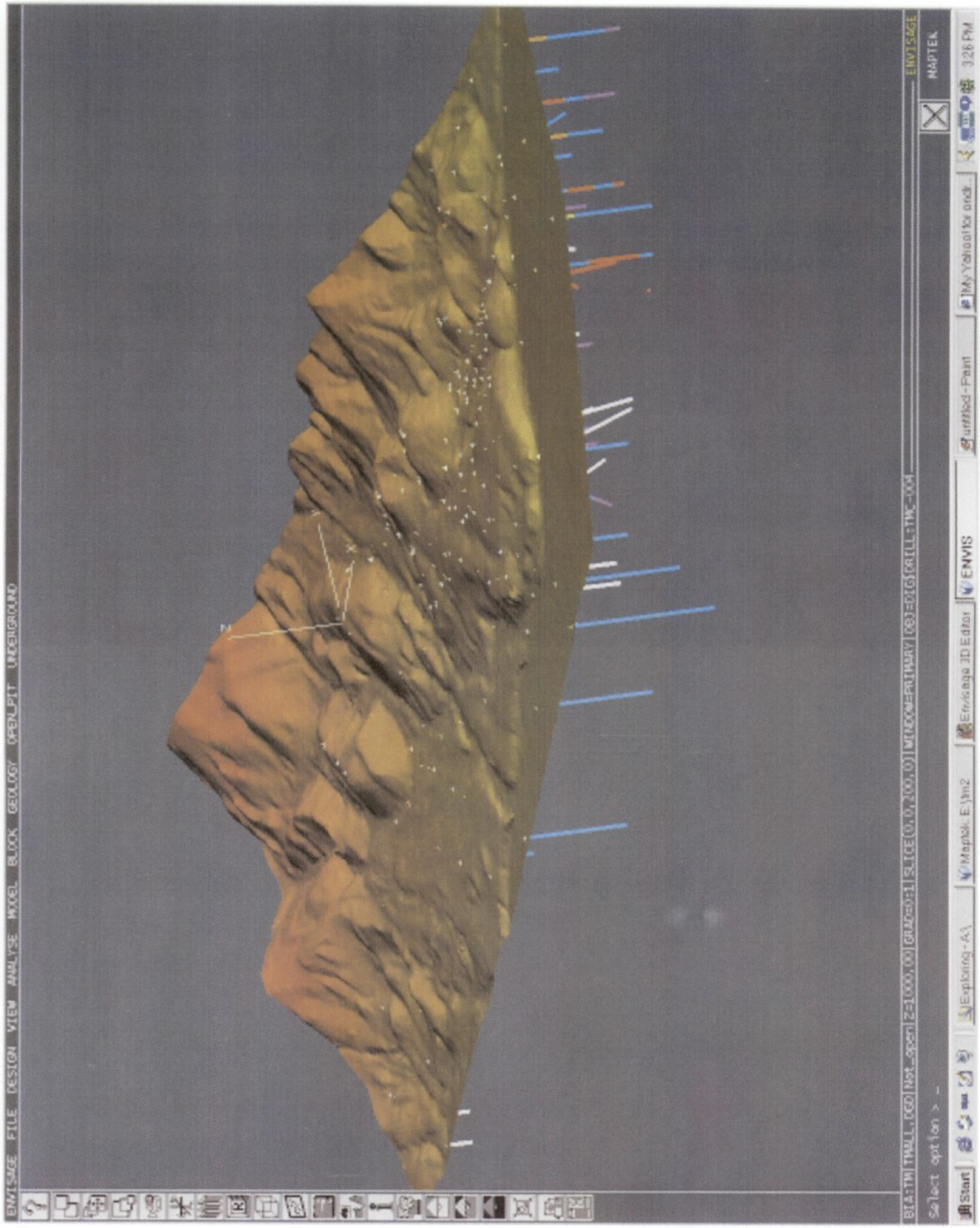

Figure 2 – Cahuilla deposit topography and available drill holes.

by a white dot on the topography. The logged lithologies are shown in the holes.

Geology

The Cahuilla gold deposit occurs along the western edge of the Salton Trough. The Salton Trough is the landward extension of the Gulf of California and is characterized by active crustal extension between the peninsular ranges to the southwest and the chain of desert ranges to the northeast. The Salton Trough occupies a portion of the San Andreas fault system where crustal mobility involving right lateral strikeslip movement of up to 200 miles has occurred over the last 8 to 10 million years and is still active today.

Jurassic quartz monzonite outcrops on the north to northwest side of the Modoc fault, forming the footwall block along the Modoc fault. The quartz monzonite is usually unaltered with occasional hydrothermally altered zones along the Modoc fault.

The Quaternary Palm Springs Formation unconformably overlies the Jurassic quartz monzonite in fault contact along the Modoc fault system. The Palm Springs Formation is a thick succession of claystones, siltstones, arkosic mudstones, arkosic sandstones, sandstones, siliceous sinter, and fanglomerates. It grades laterally into the Canebrake conglomerate, which is considered the coarse marginal facies of the Palm Springs Formation. The presence of coarse-grained conglomerates and fanglomerates in the Palm Springs Formation suggests an interface zone with the Canebrake conglomerate. The thickness of these sediments varies from a few feet to over 700' in the project area, with a maximum thickness of over 7,000' in the adjacent Salton Sea Trough basin.

The Modoc fault zone is the major east-west to northeast trending structure with 55° to 75° south to southeast dip. The Modoc fault zone has experienced both right lateral and left lateral oblique movement resulting from strike-slip activity along the San Jacinto fault to the west and the San Andreas fault system to the east. Surface mapping and cross-sections indicate sub-parallel faults in both the footwall and hanging wall. The Modoc fault zone is commonly offset in the Cahuilla area by younger north-south, near vertical faults. Figure 3 shows a northeastern-looking screen dump view of the 3D geologic model created in Vulcan. It shows all the major lithologies, including quartz monzonite (purple), Palm Springs Formation (cyan), and alluvium in active channels (yellow) and recent fans (red). Additionally, the major structures are shown in white.

An apparent graben occurs in the central portion of the main deposit area and may be genetically related to the precipitation of gold mineralization through structural preparation and/or lithologic favorability. Detailed surface geology reveals numerous north-south and east-west near vertical structures which host significant precious metal mineralization and may have acted as important pathways for epithermal fluids.

At Cahuilla, gold and silver mineralization is commonly associated with silicification. Two distinct styles of precious metal mineralization have been identified. First, as disseminations within the Palm Springs Formation sediments occurring as flat, tabular bodies in the hanging wall of the Modoc fault. Second, as sheeted quartz veins (1'-15' thick) localized along the Modoc fault zone.

Structurally controlled higher-grade mineralization occurs along near-vertical, east-west and north-south structures with associated stockwork feeder zones. This type of mineralization is most common in the Palm Springs Formation and occurs more frequently within and around the graben area, but is also ob-

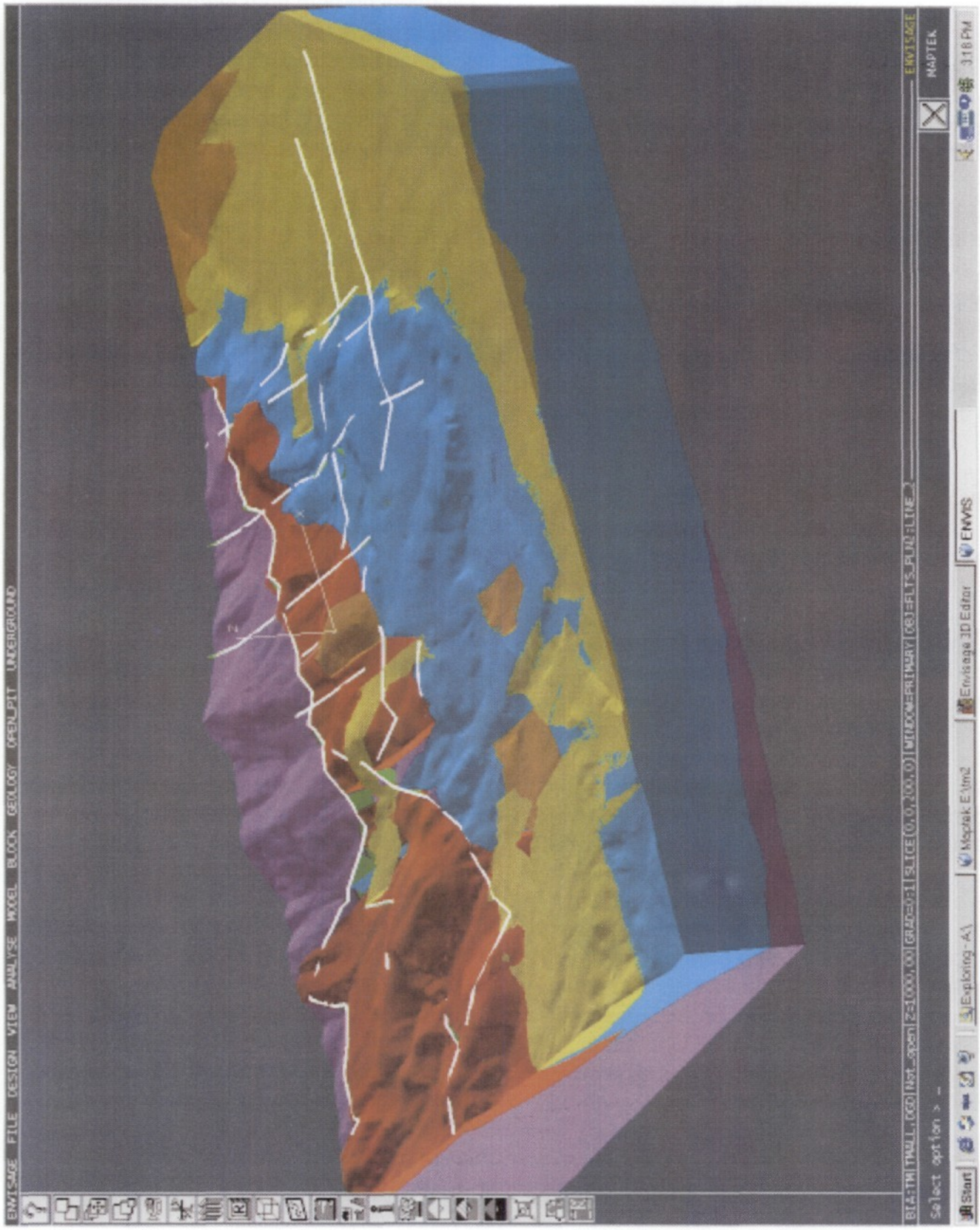

Figure 3 – Three-dimensional view of structures and major lithologies in the Cahuilla gold deposit

served along the Modoc fault in the quartz monzonite.

Silicification is the most intense and widespread type of hydrothermal alteration in the deposit area. In the hydrothermally altered areas, virtually all of the rocks in the Palm Springs Formation have been partially to entirely replaced by silica deposited as chalcedonic quartz. Figure 4 shows a Vulcan screen dump portraying a north-south cross-section through the main part of the deposit. It depicts lithologies, drill holes, and gold grades. The mineralized envelope is drawn based on a 0.003 opt cutoff.

Multi-phase quartz veining is common in structurally prepared zones (structural intersections) and is associated with higher-grade gold mineralization. Mineralization in the quartz monzonite is solely related to quartz veining.

Weak to intense argillization is localized along smaller structures and adjacent to the Modoc fault, and may represent supergene alteration resulting from paleo-hotsprings activity. Weak to moderate propylitization occurs sporadically within the quartz monzonite stock.

Modeling

Geologic modeling consists of building shapes representing different geologic features based on information logged from drill holes and/or surface mapping. These shapes are drawn in section and have to be reconciled in three-dimensions before they can be used in ore reserve estimation. The process is repeated for each lithology, structures (faults), alteration (silicification, clay alteration, oxidation, pyritization, etc.), and mineralization (gold and silver) that might be present. Additionally, shapes defining zones of same densities and metallurgical characteristics are defined. Figure 5 shows a north-south cross-section through the deposit and corresponding drill holes with logged and modeled lithologies.

Once the geologic framework is complete, the geostatistical analysis of the deposit follows. In this phase, the deposit is sub-divided into domains containing similar geologic characteristics. A comprehensive statistical analysis of the drill hole data determines the validity of the domain definition and usually refines the boundary extents. Variograms are used to test the continuity of variables within each domain and parameters are defined for each domain. Gold values are estimated using parameters exclusively developed for each domain creating a block model. Block models use blocks to represent smallest mineable units of a deposit. Each individual block contains information on the rock type, density, gold grade, alteration, and possible metallurgic processes applicable to the gold recovery.

Vulcan has features that enable the development of a block model spanning all phases described above. It has good three-dimensional geologic modeling capabilities, solid generation, and real-time rotation in 3D. Additionally, it offers good statistical tools and a comprehensive geostatistical tool set based on the Gslib software, developed by Stanford University.

The final phase involves the economic analysis of the deposit including determination of the optimal open pit limits and cash flow analysis for foreseeable gold prices. In this phase, an optimal open pit outline is generated based on a given gold price and some engineering constraints. Geotechnical parameters describing geotechnical domains and maximum slopes allowed, metallurgical recoveries for all ore types, associated production and processing costs, are a few of the parameters used in this phase. Grade/tonnage curves for a given gold price are evaluated Net Present Value (NPV) calculated.

Whittle software is used in this phase. It looks at all blocks from the block model and

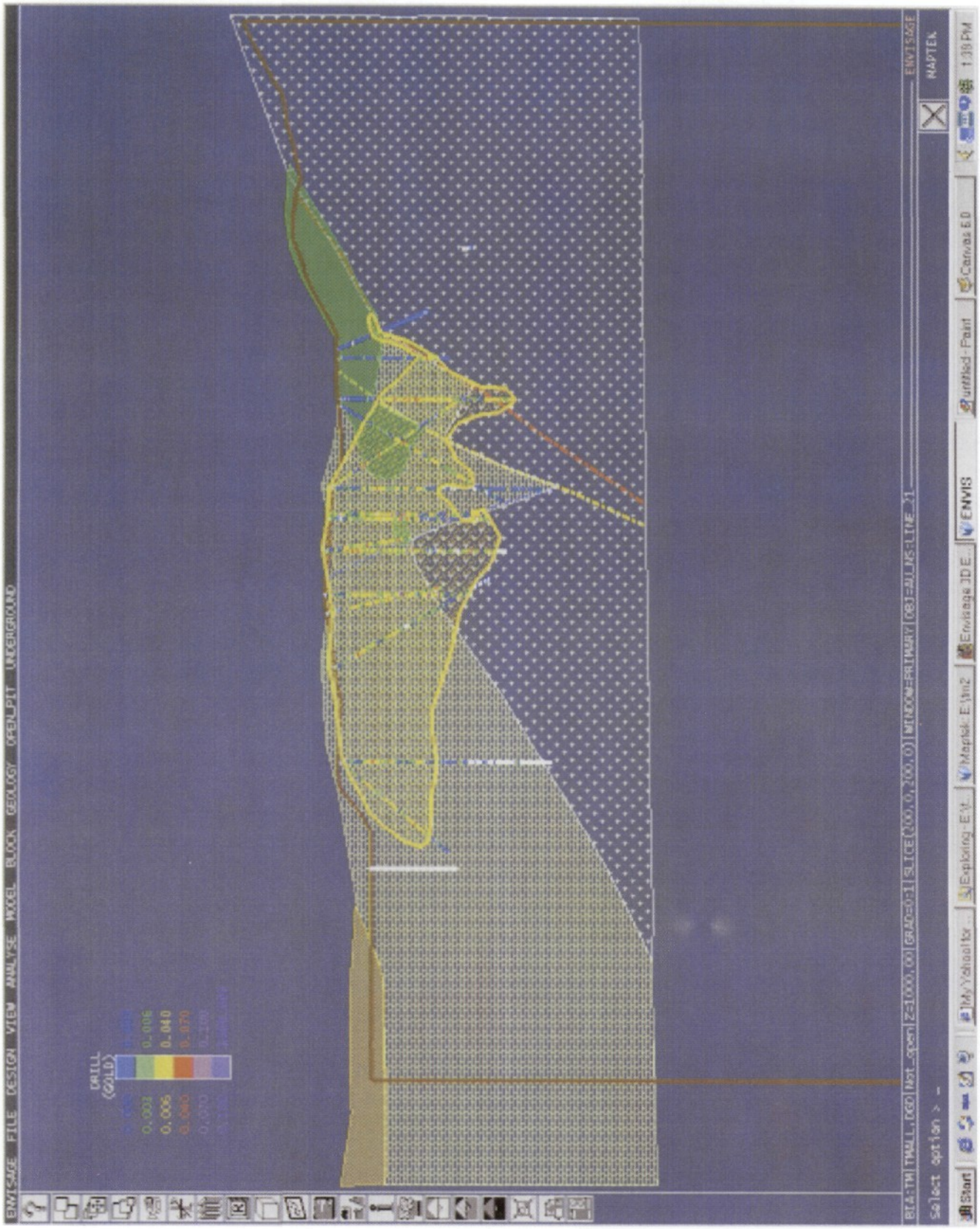

Figure 4 – North-south cross-section through the main part of the Cahuilla gold deposit.

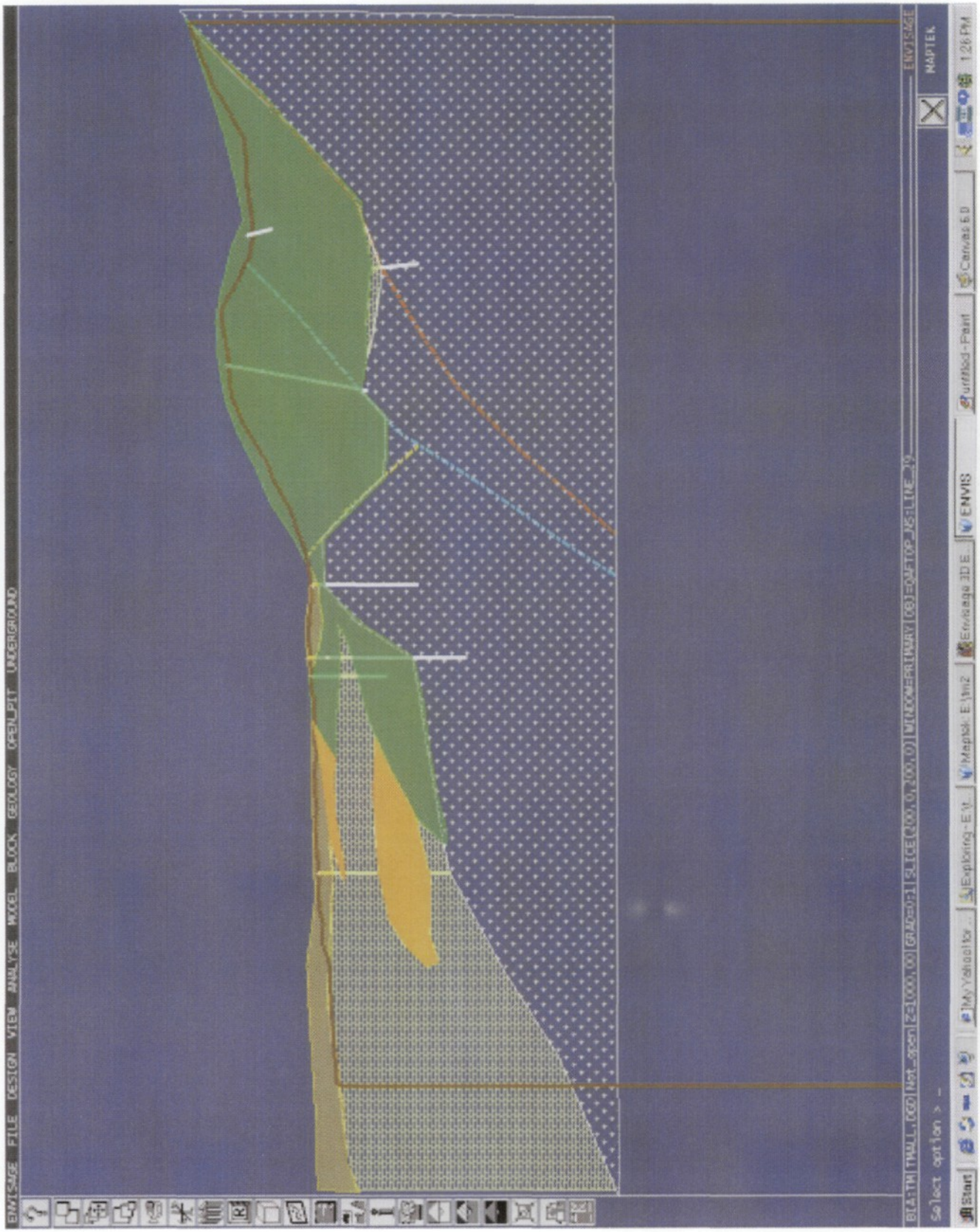

Figure 5 – North-south cross-section showing logged and modeled lithologies.

calculates all associated costs for mining and processing a given block. Then, it relates all blocks and defines a cone or optimal mineable zones at a given gold price. The cone outline is imported back into Vulcan and is used as a guideline in the pit design phase.

In Vulcan, ore and waste tonnages can be calculated and a mine plan can be designed. NPV and scheduling are also calculated using Vulcan.

Although this introduction only deals with the open pit and precious metal side of mining, Vulcan can be applied to modeling and design of underground and non-metallic, tabular ores. The final product from Vulcan and Whittle could be used in establishing the potential value of mineral deposits which in turn could be used as well as the basis for the agreement negotiation between the Tribe and the mining companies.

Conclusions

The Bureau of Indian Affairs (BIA), through the Division of Energy and Mineral Resources (DEMR), is providing technical support to Indian Reservations interested in evaluating their mineral resource potential. DEMR is taking responsibility for making available to Tribes, geologists and engineers in addition to updated mining software. The Cahuilla Gold deposit located in the Torres Martinez Reservation is the first deposit to undergo modeling and prefeasibility assessment by DEMR. Other Reservations will follow.

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Gypsum on the Wind River Indian Reservation

John Zeise[1] and Lynne Chastain[2]

Introduction

The Shoshone and Arapaho Tribes of the Wind River Indian Reservation are interested in exploiting their industrial minerals. The Tribes requested technical assistance in the evaluation of their gypsum resources from the Bureau of Indian Affairs, Division of Energy and Mineral Resources (DEMR) in the summer of 1997.

The Bureau of Indian Affairs Division of Energy and Mineral Resources (DEMR), is providing technical support to the Shoshone and Arapaho Tribes of the Wind River Indian Reservation. The Tribes do not need or can afford full time geologists and engineers to support their programs. The DEMR is taking responsibility for making such scientific expertise available tob both the Tribal Council and Natural Resources Department, in conducting an assessment of the Reservation's gypsum resource potential.

As part of an ongoing project assisting the Tribes with their industrial minerals resources, the Tribes requested a drilling plan to evaluate the Sweetwater Basin gypsum resources located on the north slope of the Owl Creek Mountains near Thermopolis, WY (Figure 1). Gypsum drilling was carried out in April 1999. Drilling allowed for better sample collection and geometric understanding of the deposits.

General Setting

The Wind River Indian Reservation, located in west central Wyoming, contains about 3500 square miles of land (Figure 1). The reservation stretches from the northern part of the Owl Creek Mountains to the crest of the Wind River Mountains. To the east the reservation boundary begins just west of the town of Shoshone and extends westward to the town of Dubois. There are approximately 2,500 Shoshone and approximately 5,000 Arapaho on the reservation.

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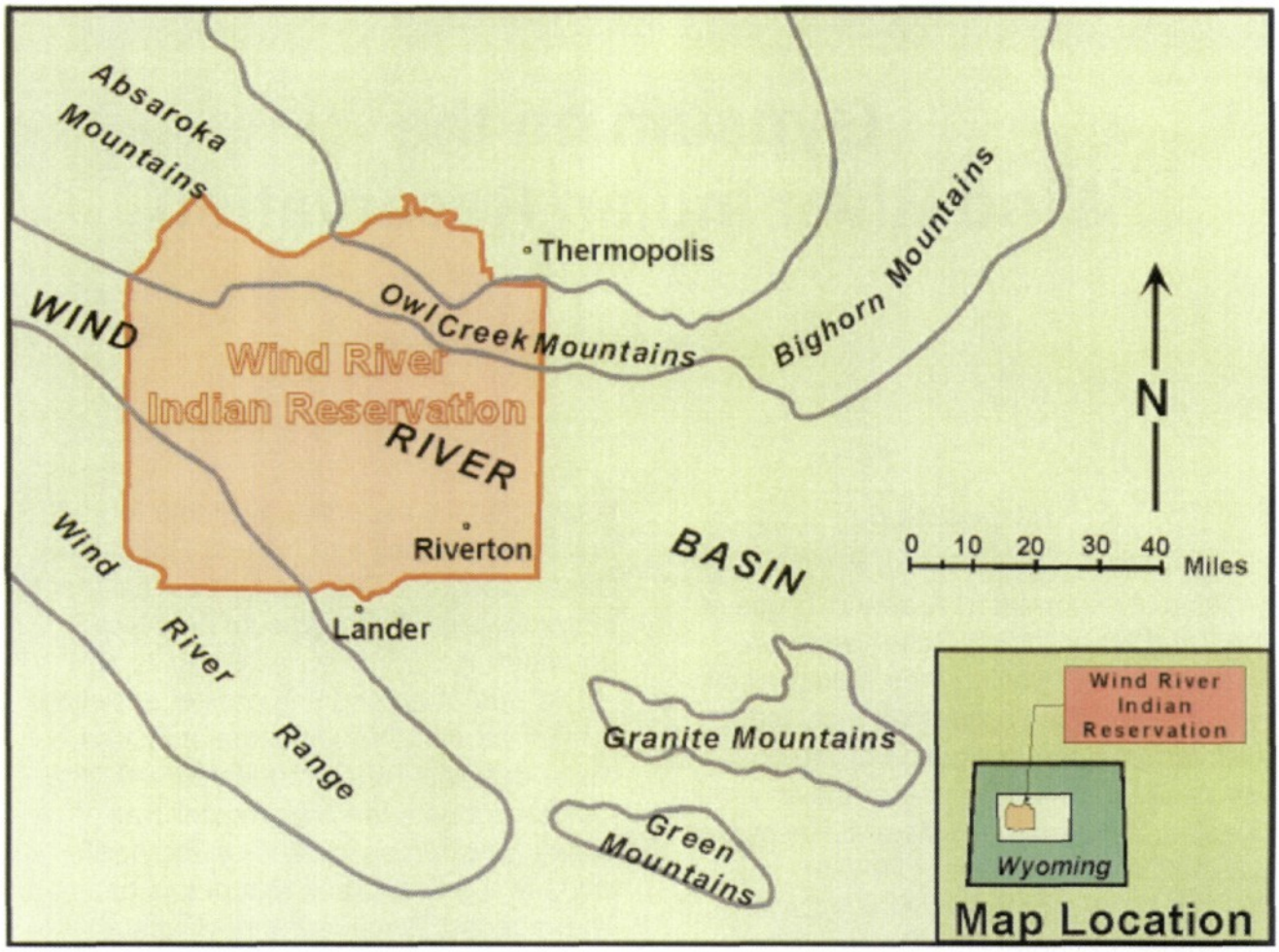

Figure 1. Wind River Indian Reservation location and physiography

Geology of the Wind River Indian Reservation

The Wind River Indian Reservation lies in the western half of the Wind River Basin, which is flanked on the southwest by the Wind River Range and on the north by the Owl Creek, Washakie, and Absaroka Mountains. The northeast corner of the reservation lies in southernmost Big Horn Basin. The Wind River and Big Horn Basins are large, structurally complex sedimentary as well as topographic basins (Figure 2). Margins of the basins are delineated by groups of complexly folded and faulted Precambrian, Paleozoic, and Mesozoic rocks that are exposed in the surrounding ranges and uplifts. The interior of the basins contains less disturbed rocks of Cenozoic age.

Gypsum resources discussed in this report outcrop primarily along basin margins, on the slopes of the Wind River and Owl Creek Ranges. Gypsum deposits also crop out along anticlines within the Wind River Basin. In five areas on the Reservation, relatively small amounts of overburden overlie apparently large gypsum resources. These deposits can be readily mined using conventional surface mining techniques. Listed in order of proximity to the nearest railroad by the best existing routes these are 1) the Sweetwater Basin, 2) the southeast end of the Sage Creek anticline, 3) the central part of Maverick Springs anticline, 4)

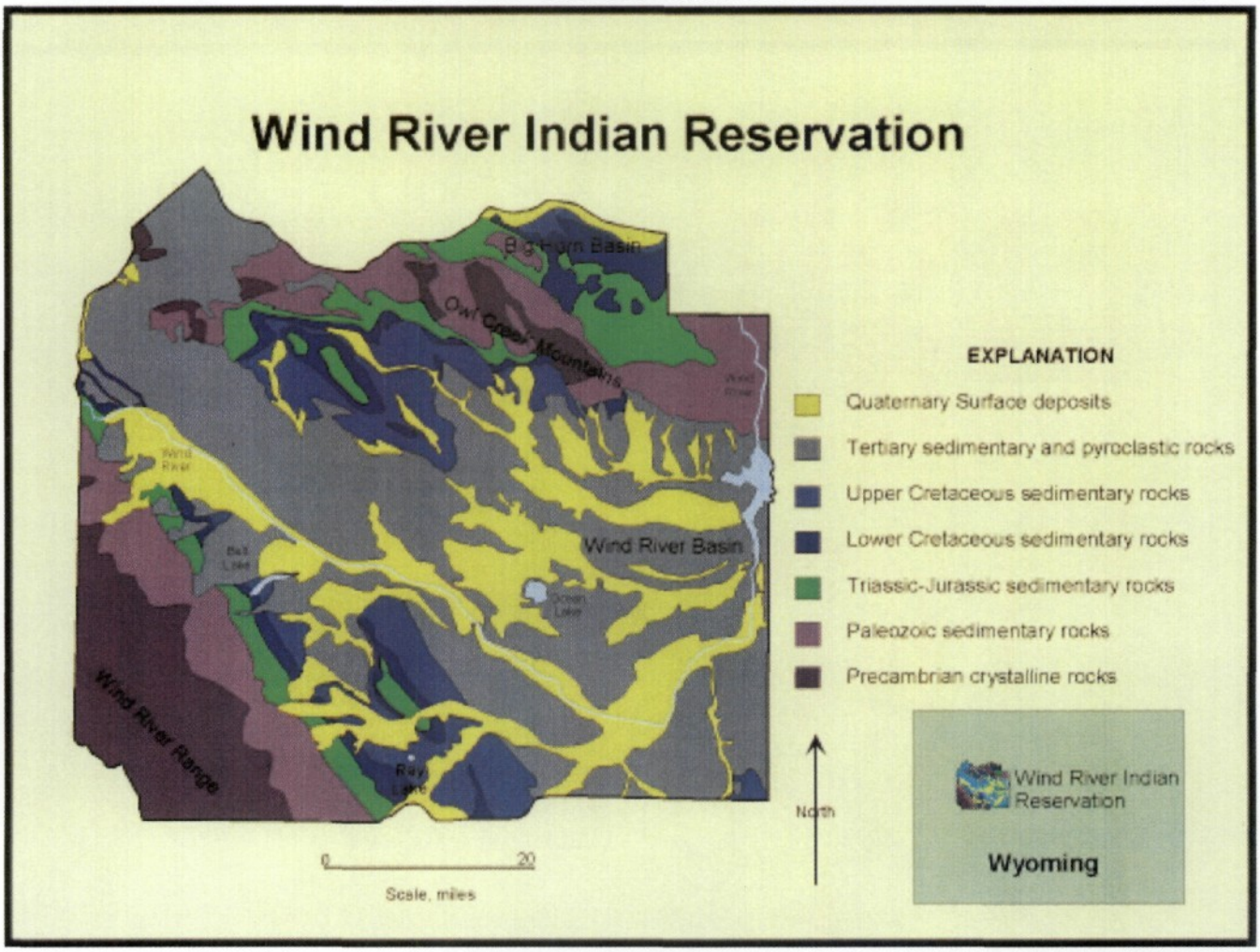

Figure 2. Geology of the Wind River Indian Reservation

the ridge just northwest of the Bradford Ranch, and 5) the ridge between Antelope basin and Sagwup Draw.

Industrial Minerals are sensitive to economic factors such as shipping distances; for this reason, the study area for this project was limited to the Sweetwater Basin for gypsum (Figures 3, 4).

Project History

The Shoshone and Arapaho Tribes of the Wind River Indian Reservation in Wyoming requested that DEMR produce a report on the industrial minerals bentonite, gypsum, and phosphate rock on the reservation. Personnel from DEMR condensed existing NIEMR database information about these products into a report complete with geologic maps, sample location maps, and references. This report was reproduced and sent to Wind River Tribal and BIA personnel; Tribal personnel then distributed the report to industry.

The Tribes requested that DEMR personnel come up to give a field trip to Tribal and local BIA personnel, which occurred October 1997. DEMR personnel assisted as Tribal personnel presented a poster outlining their industrial minerals at the 1997 and 1998 Northwest Mining Association Annual Conference in Spokane Washington; the Tribe will also be presenting a

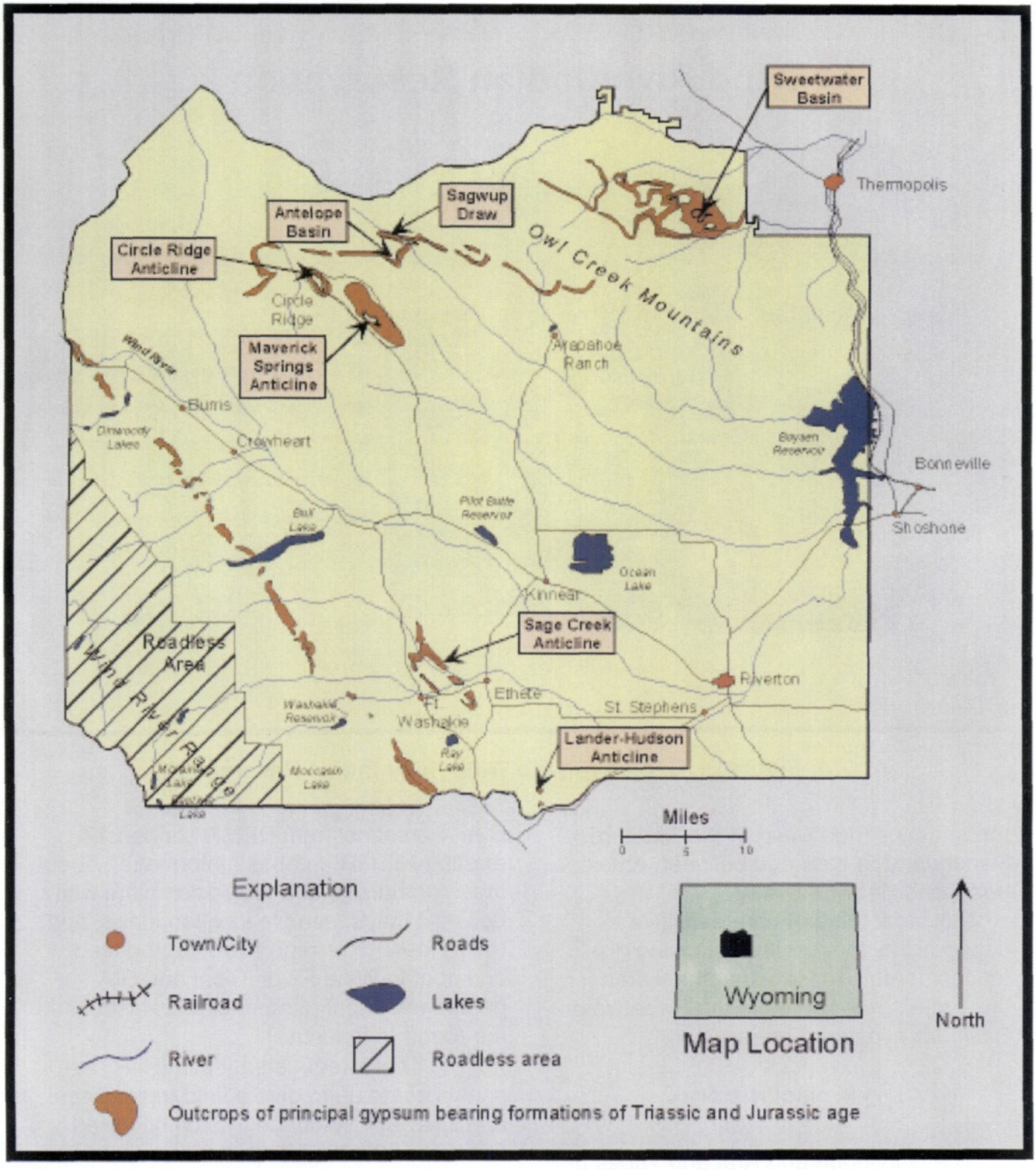

Figure 3. Gypsum-bearing formation outcrops on the Wind River Indian Reservation

poster and giving a talk at the 1999 Industrial Minerals Conference in Salt Lake City.

In the summer of 1998, DEMR personnel performed field verification, including mapping and surface sampling, of the gypsum deposits on the north flank of the Owl Creek Mountains in the Bighorn Basin. BIA personnel collected digital orthophotoquads and integrated these into ArcView and ArcInfo to assist in mapping and modeling the deposits.

In October 1998 DEMR personnel mapped and sampled the gypsum from this area. Thirty-eight samples from the Sweetwater Basin were analyzed in November 1998. In the Fall of 1998, DEMR personnel submitted a proposal for further evaluation of the gypsum deposits via drilling. Gypsum drilling occurred in April 1999. DEMR personnel drilled and collected 195 feet of core from the gypsum deposit, and analyzed 45 samples and 5 duplicate samples.

Gypsum-Bearing Formations

Occurrence

Gypsum-bearing formations crop out for more than 100 miles distance along the northeast flank of the Wind River Range, along both flanks of the Owl Creek Mountains, and along the flanks of the Lander-Hudson, Sage Creek, Maverick Spring, and Circle Ridge anticlines (Figure 3). Large quantities of gypsum reportedly occur in the Chugwater and Dinwoody Formations of Triassic age, but the Gypsum Springs Formation of Jurassic age contains the most extensive and potentially valuable gypsum resources in the area. Gypsum has been mined in Wyoming and on the Reservation intermittently since 1890.

On the reservation, the basal portion of the Gypsum Springs Formation consists of a massive bed of gypsum. This bed ranges from 35 to 90 feet in thickness. The massive gypsum bed can contain thin lenses of mud, clay or silt.

Gypsum Quality

In October, 1998, DEMR personnel mapped and sampled in detail a gypsum deposit in the Sweetwater Basin (Figure 4). The gypsum beds were tested in April 1999, with five core holes drilled (Figure 5) totaling 195 feet. From this core, 45 samples and 5 duplicate samples to Chemex for analyses.

On the surface, the gypsum was typically fractured and had silt from the shale layers above in it. Red siltstone layers occur throughout the massive gypsum bed. However, upon drilling, very little red silt was found within the gypsum and the red siltstone beds were discrete from the gypsum layers.

Sample Method

Surface samples were collected by removing any loose dirt or topsoil in order to collecting the sample. At least 3 pounds of sample were taken to ensure a representative sample. In the October 1998 filed trip, 38 samples were collected from 9 trenches around the outside of the butte.

Drill core samples were taken as small 1 to 5 inch representative sections of drill core. In the April 1999 drilling program, 45 samples were recovered. Samples were selected approximately every 3.5 feet of gypsum (Figure 6).

Analytical Procedures

Gypsum samples were analyzed for free and combined water, and for the elements aluminum, calcium, chromium, iron, potassium, magnesium, manganese, sodium, phosphorous, sulfur, silica, and titanium by Chemex Laboratories, Sparks, Nevada. The results were recalculated according to

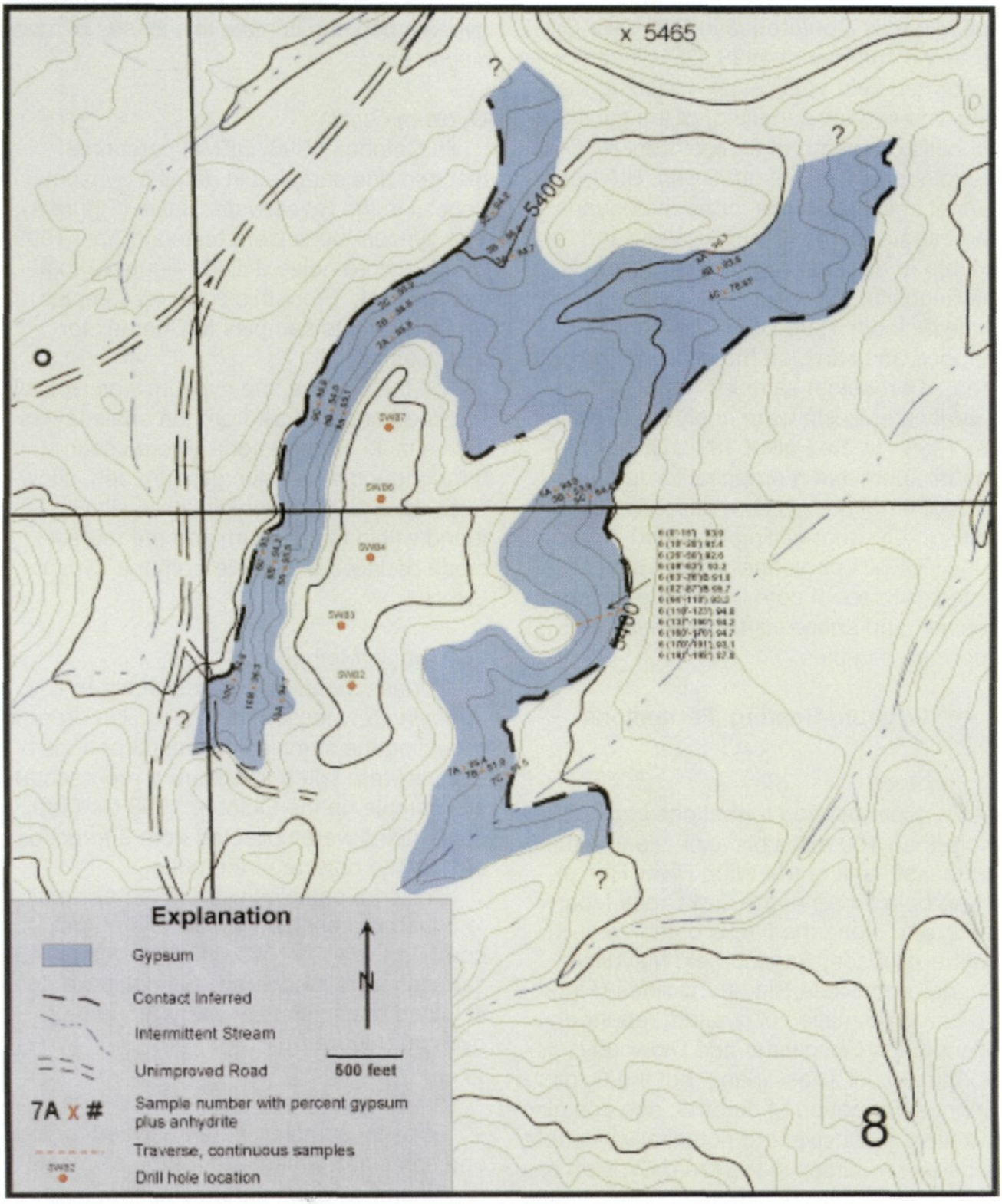

Figure 4. Sweetwater Basin gypsum deposit

Figure 5. Drill Rig at the Sweetwater Basin on the Wind River Reservation

Figure 6. John Zeise overseeing drilling operations at the Sweetwater Basin

Figure 7. John Zeise logging the core at the Sweetwater Basin.

the American Society for Testing and Materials Test C 471-76, 1997.

Results

Gypsum Analyses

From the October 1998 surface samples, all but 2 samples had total gypsum plus anhydrite at 87.8% or higher, with all but four samples having total percentage gypsum plus anhydrite at 91.0% or higher (Figure 8). Results from the April 1999 drilling are not yet available.

Conclusions

The Bureau of Indian Affairs Division of Energy and Mineral Resources is assisting the Arapaho and Shoshone Tribes in the evaluation of their gypsum deposits. Results from this study are encouraging. The gypsum market is strong, primarily due to the strength of the building market. Two gypsum mines are in operation in Wyoming, and are at capacity. Ore grade varies from 85 to 90% gypsum plus anhydrite in these two mines. The gypsum in the Sweetwater basin is above these state ore grade values.

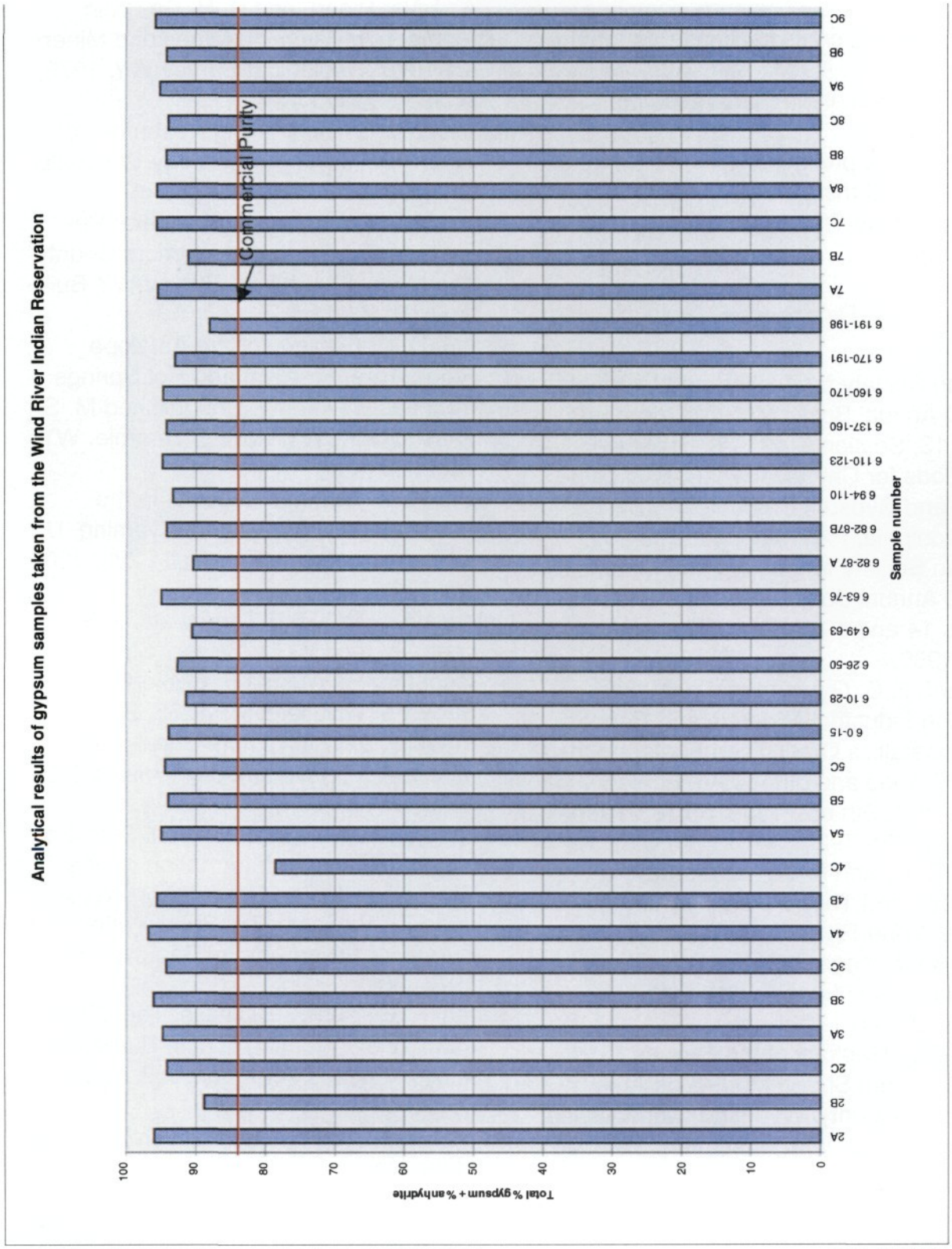

Figure 8. Table of Gypsum Analyses

With the data collected in the past few months, the Division will achieve the following results:

1) Produce a geologic model of the Sweetwater Basin Gypsum, complete with map and cross sections through the butte.
2) Perform a preliminary resource calculation.
3) Design a preliminary mine plan for a hypothetical mine.
4) Assist the Tribes in marketing the gypsum.

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