CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

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James Doyle Sell Mining Collection

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ASARCO Southwestern Exploration Division

WLK

June 1, 1989

W.D. Gay
H.G. Kreis
M.A. Miller
J.J. Malusa
J.D. Rasmussen

Drill Project Paperwork

Overall the drilling project flowsheet seems to work well and, to date, the estimates made by the individual project geologists are sufficiently close that we have been able to keep close control on expenditure levels. However, there are two things on the flowsheet which were perhaps not clear.

First, at the end of each month, as soon as you have made your monthly cost estimates, please copy the monthly sheet #3031 which you have filled out and attach the driller's shift reports to the copied 3031 for filing.

Second, prepare your drilling cost summaries as soon as the accounting department has all the official data, usually a month after drilling or cleanup road or site work is completed. There is a tendency to wait several months for geologic data and include the drilling cost summaries with the geologic report. This is not necessary. Cost summaries should be completed as soon as the data are available so that this information can be used for Supplemental Exploration Authorization requests. This can be pulled monthly from the accounting sheets, then totalled at the last month. The cost summaries should contain the following:

	Total	Cost/Ft.
Drilling	$	$
Road, Site Work		
Assaying		
Geology		
Field Supervision		
General Administration		
Other Categories you wish to include		
	$	$

If rotary or air hammer and diamond drilling are done in the same hole, those direct drilling costs (contractor invoices) should be tabulated

separately. A paragraph of comments should include the contractor, the size of drill used, and other pertinent information such as major problems and major unusual costs (mud, casing lost or left in the hole, moving costs, etc.). A notation of the impact of the unusual items on a cost/ft. basis is particularly useful. Please mark Mr. Sell for a copy of all cost summaries. Cost summaries can be prepared on a hole-by-hole basis for particularly deep tests or for aggregate programs which run continuously, such as Buckskin or Santa Cruz. In the latter case, summaries are often best prepared after the authorization is expended.

I emphasize that the above are not just exercises in paperwork. Shift reports are used to acquaint prospective contractors with drilling conditions and can result in reduced bids. Cost summaries are extensively used to prepare new authorizations and annual budgets, so I would appreciate your cooperation on the above items.

James D. Sell

James D. Sell

JDS:mek
attachments

cc: W.L. Kurtz

ATTACHMENT A

Drilling Project Flowsheet

I resubmit a previous report compiled by various people involved in drilling projects which has proven to be of help in keeping the project drilling thoughts and data under control during management of a drilling project. The steps are self-explanatory, but please review them and bring any questions you might have to my attention. Those who have not made a monthly cost estimate, checked contractor invoices, or written a monthly or final report should review various examples in the files if there are any problems on how to proceed.

The flowsheet is set up to remind you of the daily details in all our drilling projects which are logically handled by the project geologist and the field technicians. You might use it as a check list and cross off steps as they are completed, making it easy for someone to pick up a project at some interim stage and carry it to completion.

James D. Sell

James D. Sell
June 1, 1989

DRILLING PROJECT FLOWSHEET

The various steps in a drilling project are listed below in approximate sequential order; not all steps may be applicable to a specific project. The project geologist (with J.D. Sell) is responsible for obtaining drill contractors; W.D. Gay and the geologist are responsible for all road permits and land owner notifications; the project geologist is responsible for the remainder, including tabulating progress by himself and others on the flowsheet, and keeping everyone informed. Stay organized and flexible.

1. Land status reviewed with geologist, J.D. Sell, and W.D. Gay; timing established for permits and road work (at least 2 months before drilling when possible).

2. Bids solicited by project geologist and J.D. Sell.

   a) Contractor needs location (state), minimum footage, drilling requirements (hole size, etc.), water source, and starting date.

   b) Rotary casing inventory and diamond bit for rotary spot cores maintained by geologist, and filed with Mary.

   c) Sample material inventory maintained by D.A. Melhado as monitored and requested by geologists-technicians.

3. Drill contractor selected by J.D. Sell/geologist; purchase order written by geologist; drill authorization request written by geologist with cover/final by J.D. Sell.

4. Drill site located on ground and roads flagged by geologist.

5. Road permit applications filed by W.D. Gay/geologist.

6. Road contractor obtained by geologist; may need different contractor for rotary vs. diamond drill sites.

   a) Purchase order number for construction/reclamation obtained by geologist.

7. Road and drill site reviewed with U.S.F.S., state/Federal government, patent landowner (where necessary), road contractor, and geologists; permission to build gates, separate disposal of drilling mud, sanitations arranged.

DRILLING PROJECT FLOWSHEET

8. Road permit permission received by W.D. Gay.

9. Road contractor mobilized to build site and road.

10. Water source and cost confirmed by geologist.

11. Sample materials (trailer if required) moved on site by geologist (see attached list).

12. Rotary casing moved to site (arranged by geologist, consult with J.D. Sell).

13. Diamond bit for rotary spot cores obtained from storage and moved on site by geologist.

14. Fire-fighting equipment in working order and on site (geologist), but should also be included in drilling contractor proposal as part of their responsbility.

15. Name and phone number of project geologist given to drill contractor.

16. Drill moved on site by geologist with letter of personnel authorized to see the core.

17. Sample procedures clearly outlined to driller with initial close supervision.

18. Drill core and shift reports collected weekly; reports checked on site for accuracy/legibility.

    a) Spot checks on core recovery, proper handling of core made on site.

19. Monthly cost estimate made by geologist.

    a) Drill costs calculated from shift reports and contract.

    b) Cost estimate to Mary by 22nd of month (see attached forms).

    c) Submittal of completed Form 3031 and shift reports to Mary.

    d) Monthly contractor invoices carefully checked and signed by geologist, forwarded to J.D. Sell/Mary.

20. Monthly report of drilling progress, assays, etc. by geologist (by 27th of month).

DRILLING PROJECT FLOWSHEET

21. Quarterly reports, if needed, to landowner, by geologist via J.D. Sell (by end of quarter).

22. Down-the-hole survey scheduled by geologist before hole terminated (if required, allow several weeks).

23. Hole terminated by geologist; contractor headquarters notified.

    a) Site cleaned by drill crew.

    b) Hole plugged/capped/concealed/abandoned (whichever necessary).

    c) Survey of collar location (may be done anytime after rig on site).

24. All equipment cleaned, stored.

    a) List of all sample materials and rotary casing used compiled by geologist and given to Mary for filing.

    b) Rotary diamond bit returned to storage.

    c) Fire-fighting equipment reconditioned, if necessary.

25. Final report on drilling by geologist; should include cost summary.

26. Final drill hole record sheet completed (see attached form).

27. Geologist to notify W.D. Gay when drilling complete - all property owners notified where required.

28. Site reclaimed; road contractor notified by geologist; seeded by geologist if advisable or required.

EA #_____

SOUTHWESTERN EXPLORATION DIVISION

26th _____ thru
25th _____, 198__

MONTHLY COST SUMMARY

_____ Project, _____, _____
(County) (State)

A. DIRECT DRILLING (Acct. 521-)

CONTRACTORS' CHARGES

Invoiced during month covering prior month's work

Contractors' Services

_____ (Invoice Amt.) _____
_____ (Prior month's estimate) _____ _____

_____ (Invoice Amt.) _____
_____ (Prior month's estimate) _____ _____

Invoiced during month covering current month's work

Contractors' Services	Statement Amt.	

Estimated balance of contractors' charges covering work through 25th of current month

Contractors' Services	Statement Amt.	

Supplies and Freight

Field Trailer Rental		
Water Purchases (Drilling)		
Surveying of Drill Holes		

B. SITE PREPARATION (Acct. 580-)

CONTRACTORS' CHARGES

Invoiced during month covering prior month's work

Contractor's Services

_____ (Invoice Amt.) _____
_____ (Prior month's estimate) _____ _____

Invoiced during month covering current month's work

Contractor's Services	Statement Amt.	

Estimated balance of contractor's charges covering work through end of current month

Contractor's Services	Estimated Cost	

Supplies and Freight

C. FIELD ADMINISTRATION (Accts. 530-, 540-, 550-, 570-, 610-)

Salaries

Name	No. Days Allocated to Project During Month (show as ratio to total working days in month, i.e., 24/26)	

Wages

Name	No. of Straight Time Hours During Month	No. of Overtime Hours During Month	

Traveling and Living Expenses - ASARCO Salaried Personnel

Name	Estimated or Actual Traveling Expenses Incurred During Month	

Supplies - Itemize individual purchases of $25.00 or more - group small purchases under Misc.

Item	Cost	

Assaying

Assayer	Charge or Estimated Expense for Assaying Performed During Month	

Freight

Carrier	Charge	

C. FIELD ADMINISTRATION - Continued

Field Administration Expenses

Item	Cost	
Office or Core Shed Rental		
Electrical Service		
Gas Service		
Water Service		
Telephone Service		

D. GENERAL ADMINISTRATION (Accts. 620-, 641-)

Salaries

Name	No. Days Allocated To Project During Month (show as ratio to total working days in month, i.e., 24/26)	

Transportation - Company Vehicles

Vehicle License	Miles Driven Chargeable to Project During Month	

Drafting Dept. Expense

Salaries & Wages		
Supplies		

E. MINERAL PROPERTY (Accts. 501- thru 507-)
Includes legal fees & taxes; claim staking & validation;
State Land rental payments

Description	Amount	
	TOTAL	

Form completed by: _____

DRILLING PROJECT CHECK LIST

Equipment & Supplies

Trailer . . . . . _____
SEPOR Splitters . . . . . _____
Wash Tubs . . . . . _____
Cloth Sample Bags . . . . . _____
Plastic Sample Bags . . . . . _____
Wire Ties . . . . . _____
Markers (Waterproof) . . . . . _____
Markers (Sharpies) . . . . . _____
Tags (White) . . . . . _____
Tags (Yellow) . . . . . _____
Stamp (Hole No. & Depths) . . . . . _____
Stamp (American Analytical...) . . . . . _____
Burlap Bags . . . . . _____
Gold Pans . . . . . _____
Scales . . . . . _____
Bailing Wire . . . . . _____
Pliers w/Wire Cutters . . . . . _____
Pallets . . . . . _____
Plastic Vials . . . . . _____
BX Core Boxes . . . . . _____
Ball-point Pens . . . . . _____
Carbon Paper . . . . . _____
White Envelopes . . . . . _____
Manila Envelopes (Large) . . . . . _____

Forms

a) Drill Hole Summary . . . . . _____
b) ASARCO Rotary Drill Shift . . . . . _____
c) Monthly Cost Summary . . . . . _____
d) Drilling Time-Hrs.-Per Diem-Assay Charges . . . . . _____
e) ASARCO Sample Shipments . . . . . _____
f) American Analytical Assay Forms . . . . . _____
g) List of Holes, Depths, etc. . . . . _____

Plastic Containers (Pails) . . . . . _____
Flagging . . . . . _____
Lath . . . . . _____
Grade Stakes . . . . . _____

HOLE _____ PROJECT _____ 26th: _____ THRU 25th _____, 19 ____ CONTRACTOR _____

DESCRIPTION: _____

	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL	PRICE	AMOUNT
FEET DRILLED																																		
																																SUB TOTAL		
CEMENTING																																		
CONDITIONING																																		
CASING																																		
																																SUB TOTAL		
MATERIALS																																		
																																SUB TOTAL		
TRUCK RENTAL																																		
MILEAGE																																		
LOADS OF WATER																																		
																																SUB TOTAL		
MISC.																																		
																																SUB TOTAL		

TOTAL _____

mn 3031

DRILL HOLE RECORD

HOLE NUMBER _____

HOLE DESIGNATION: _____ RECORD DATE: _____ 19____ BY _____

LOCATION: PROJECT (?) _____

COUNTY _____ STATE _____

HOLE DESCRIPTION:

FINAL T.D. _____ FT.

	MODE		DEPTHS
a.)	ROTARY ☐		FROM _____ TO _____ FT.
b.)	DIAMOND ☐		FROM _____ TO _____ FT.
c.)	VERTICAL ☐		
d.)	ANGLE ☐	BEARING _____	INCLINATION _____

DRILLING HISTORY:

a.) ROTARY: CONTRACTOR _____

OPEN ☐	CASED ☐	SIZE (ID)
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.

TERMINATED ☐. LOST ☐ REASON _____

DATES _____ 19____ TO _____ 19____

b.) DIAMOND: CONTRACTOR _____

FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____

TERMINATED ☐. LOST ☐ REASON _____

DATES _____ 19____ TO _____ 19____

c.) HARDWARE LEFT IN HOLE (CASING, TOOLS, ETC.):

FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____

OTHER _____

d.) DIRECTIONAL SURVEY YES ☐ NO ☐ _____

e.) NATURAL WATER ENCOUNTERED _____ IF SO, DEPTH(S) _____ AND NATURE IF KNOWN _____

REMARKS: _____

ASARCO

Exploration Department
Southwestern United States Division

James D. Sell
Manager

May 15, 1989

Mr. A.J. Torquato
Torquato Drilling Accessories
215 Susquehanna Street
Old Forge, Pennsylvania 18518

Drilling Accessories

Dear Mr. Torquato:

Thank you for your letter and drilling accessories packet.

At the present time the exploration group contracts out all the drilling services.

I appreciate knowing of your products for discussion with our contractors.

Sincerely,

James D. Sell

JDS:mek

cc: W.L. Kurtz

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue (602) 792-3010

ASARCO

RECEIVED
APR 21 1989
EXPLORATION DEPARTMENT

Rocky Mountain
Exploration Division

April 18, 1989

TO: Exploration Managers

FROM: P.J. Bartos & D.I. Fletcher

Wet/dry splitter and
sampling device for
reverse circulation drilling

The splitting and sampling device manufactured by Sampling Devices Inc. (SDI) appears to be a good sampler/splitter for reverse circulation drilling. This unit was examined by PJB and DIF at the SDI manufacturing plant in Denver. It is of simple construction, has no moving parts, and is light-weight (approx. 140 lbs. fully constructed; individual parts are no heavier than about 45 lbs.). The device appears to be fairly rugged and is constructed of welded steel, 1/8" or thicker. It can be assembled from simple parts in 5-10 minutes and disassembled in 5 minutes. It is necessary only to eyeball-level the device on its 3 adjustable legs, and can be so leveled on fairly steep ground (e.g. for track-mounted RC on slopes without level ground or cut roads).

COST: $1800 + tax
Lead-time to order: Approx. 3 weeks

This device was developed by Francis Pitard for AMAX, in conjunction with Ken Lovstrom, and is now being manufactured independently by SDI (Pitard's company). Ken Lovstrom is a sales representative for SDI and has been promoting this device as the best-available wet or dry RC sample splitter. These units are currently in use by AMAX, Battle Mountain Gold, INCO, and Bond International (St. Joe).

The sample device is set up underneath the drill cyclone. Cuttings (wet or dry) feed into the upper feed cone and are split radially into the collection funnels and reject gaps. Each collected sample split contains 1/8 of the total interval discharge. For holes with severe water flows, multiple buckets of water + sample can be collected for each split, flocculant added, and the water decanted. As each split funnel receives only 1/8 of the cyclone discharge, the collection person therefore deals with only 1/8 of the total water discharged for the interval. This splitter supposedly works well for dry or wet samples, but not for sticky-mud-type samples. No sampler/splitter works well on sticky-muddy samples. These usually have to be manually homogenized and split with a shovel.

We recommend each office acquire one of these samplers; they appear well suited for our reverse circulation sampling needs.

PJB.

Paul J. Bartos

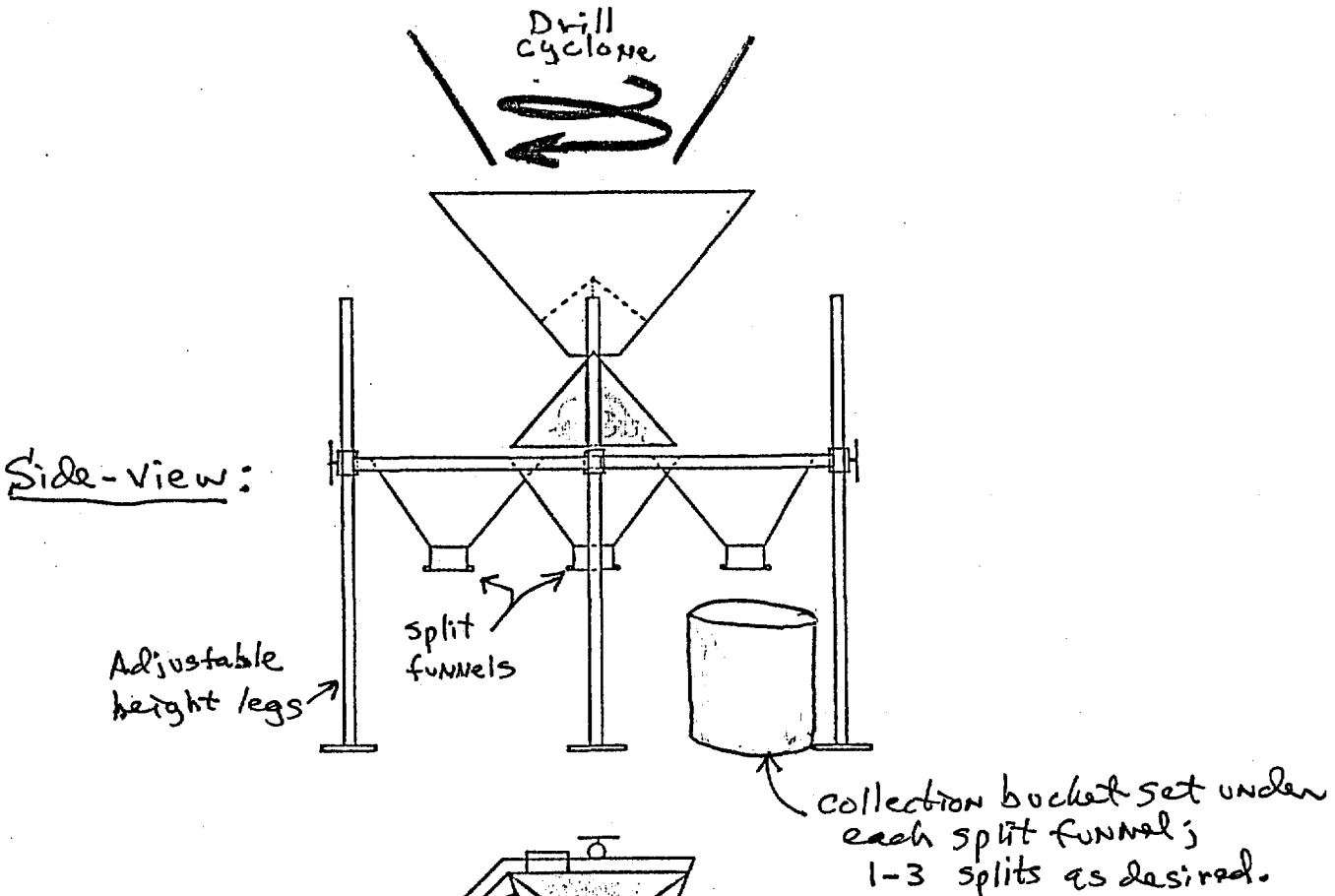
D.I.F.

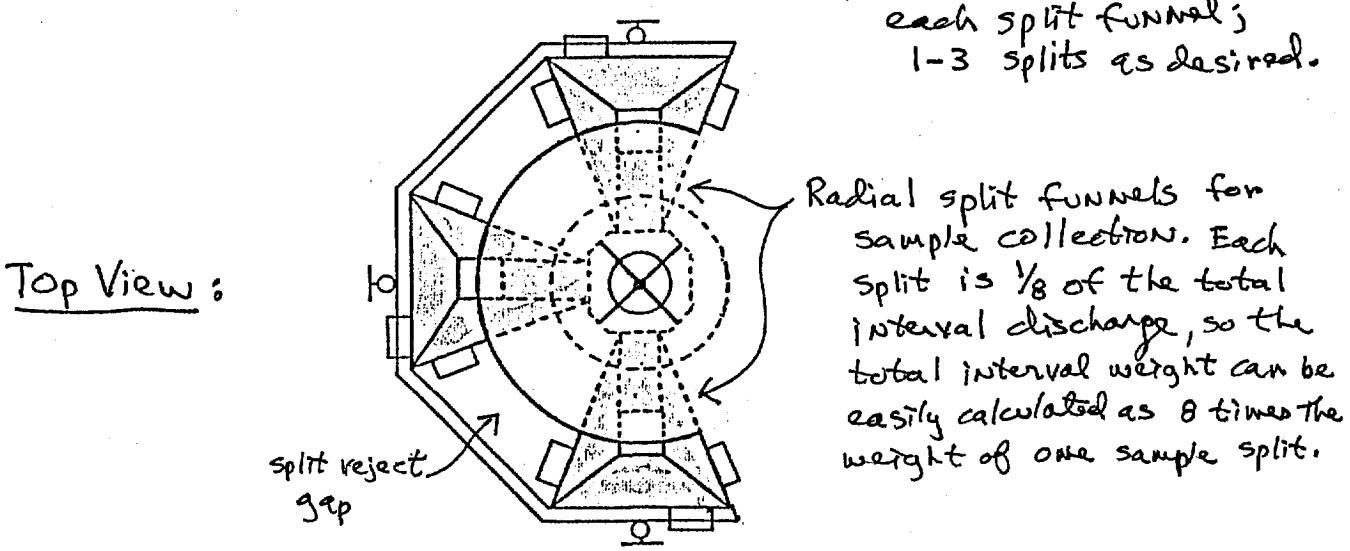
Darby I. Fletcher

DIF/PJB:lb
Atts.

SDI Brochure

ILLUSTRATION OF A CORRECT SAMPLER FOR CUTTINGS
OR PULPS FOR REVERSE CIRCULATION DRILLING.
SDI SYSTEM # CU 101 SD.
THE DEVICE MUST BE PLACED UNDER THE CYCLONE DISCHARGE.





SDI Brochure

SAMPLING DEVICES, INC.
13131 West Cedar Dr.
Lakewood, Colorado 80228
(303) 989-1939 or (303) 451-7893

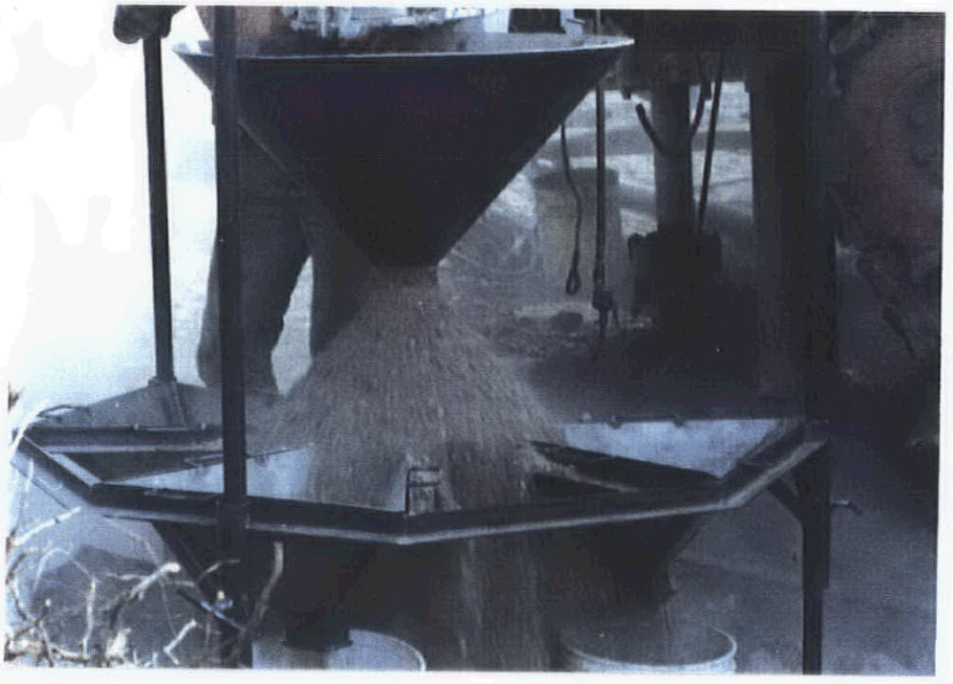
THE SDI CU-101-SD SAMPLER

OBJECTIVES OF THE CU-101-SD SAMPLER

* Provide maximum information to the geologist at an early stage of property evaluation. As soon as mineralized areas are identified, it is a must to optimize sampling protocols. This optimization can be achieved by collecting 50 to 100 replicate **correct** samples using opposite buckets available on the CU-101-SD sampler. The exact procedure to follow in order to optimize sampling protocols can be provided by SDI.
* Provide **unbiased** split samples that can be relied upon. The sampler is designed to split either dry material or pulp. When large amounts of water are expected, the CU-101-SD sampler is the best and cheapest tool available to perform a quick and correct sample size reduction.

ADVANTAGES OF THE CU-101-SD SAMPLER

* Compact, modular, and there are no moving parts. Particularly adapted to split cuttings from reverse circulation drillings.
* **Delimitation** of increment boundaries is correct, therefore it gives exactly the same sampling probability to all fragments, fine or coarse, regardless of their composition, shape, density, etc... In other words, the sampler does not introduce a delimitation bias which is often a problem with other existing devices. It should be emphasized that grab samples, shovel samples, etc... are always introducing a delimitation bias that deprives the sample of any practical value.
* **Extraction** of increments is correct, therefore it respects the first important rule of extraction correctness: all fragments with their center of gravity inside one bucket should be part of the sample. If their center of gravity is outside the bucket they should be part of the rejects.
* It also respects the second rule of extraction correctness: no part of any receiving bucket should be more narrow than three times the size of the largest fragments to be sampled. This is often a problem with riffle splitters used on the field. An extraction error always leads to a bias.
* Can provide a sampling ratio of 1/8, 1/4, 3/8, or 1/2 in a single operation that involves no handling, which can save a lot of manpower.
* All parts are easily accessible, and none are enclosed, therefore the sampler is easy to clean.
* The sampler is set in such a way that there is only one way to use it. It is not as dependent on well trained operators as other devices are.
* It is light, easy to move, and easy to integrate to the drilling machine when installed under the cyclone.
* It does not interfere with production as the riffle splitter. When large amounts of water are coming, it can be used continuously as the drilling progresses. Bags under buckets can be changed within seconds.
* The funnel provided to fit under the cyclone is adapted to most existing drilling machines.
* The frame holding the buckets can be adjusted to any height and leveled.
* It is not fragile and can be submitted to most rough field conditions.
* The sampler is proportional, therefore drilling recovery can be calculated from sample weight.



This is a photocopy of a picture of the SDI sampling device. Here the sampler is splitting cuttings into 3 collected splits, each collected in a 5-gallon plastic bucket set under the split funnels. The device is set directly underneath the cyclone and slides up/down on the 3 upright legs. The legs can be easily adjusted to eyeball-level the splitter on uneven ground. Each collected split is 1/8 of the total drill interval.

DIF

Copy for Balla - Sell ✓ (sent 3/15/89 mak)

Likewise for you-all!

Kurt 3/15/89

March 10, 1989

TO: Messrs. D. M. Smith, Jr.
P. G. Vikre

RECEIVED

MAR 1 5 1989

EXPLORATION DEPARTMENT

Drill Proposals

Properties proposed for drilling should be reviewed in the field by either myself, Mr. Kurtz or Mr. Brown before they are drilled as there is always the possibility of disagreement as to whether drilling is justified. Therefore, if one of us has not been on the ground, please have a geologic report with recommendation in our hands sufficiently far in advance of drilling so that an on-site review can be made if it is considered necessary.

It will be your responsibility either to get one of us on the ground or obtain agreement that you may proceed based on the geologic report.

F. T. Graybeal

F. T. Graybeal

FTG:mc

cc: W. L. Kurtz

ASARCO

Exploration Department
Southwestern United States Division

James D. Sell
Manager

February 3, 1989

Mr. Robley E. Berry
Secretary/Treasurer
Hard Rock Mineral Drilling Co., Inc.
1300 Robertson St.
Ft. Collins, CO 80524

Drilling Contractors

Dear Rob:

Your letter to Mr. Graybeal, with copy to me, has been sent back to me -- with discussion.

Your lead-off sentence is a true assessment, and "...the less than sterling impression..." is indeed what Asarco feels after the long delays and longer summer's expenditure of time.

Asarco certainly knows that the problems encountered with the drill, and its upkeep, during the Ochre Springs drilling was not normal. Eight holes (±500' depth) in forty-five days, oh my!

Drilling at Gold Hill in similar sequences of units and to similar depths (±500') indicated that Hard Rock Drilling could do it, i.e., four holes completed in just nine days including moves up and down steep terrain. Such a turn-around is what exploration groups desire, and from the manager's point of view"...makes the sampler earn his pay..." and, of course time-wise, makes for successful drilling projects.

With your recent modifications to the rig and your renewed goal of minimizing downtime and delays, it should provide Hard Rock Drilling with a successful input to exploration programs.

Asarco Exploration will have continued drilling projects and look forward to future bids from Hard Rock Mineral Drilling Co., Inc.

Sincerely,

James D. Sell

James D. Sell

JDS:mek

cc: F.T. Graybeal, W.L. Kurtz (w/HRMDCo. ltr.)

ASARCO Incorporated P. O. Box 5747 Tucson, Az 85703-0747
1150 North 7th Avenue (602) 792-3010

W L Kurtz

HARD ROCK MINERAL DRILLING CO. INC.

(303) 221-0762

1300 Robertson St.
Ft. Collins, CO 80524

December 27, 1988

RECEIVED

JAN 3 1989

EXPLORATION DEPARTMENT

F.T. Graybeal, Chief Geologist
ASARCO Incorporated
180 Maiden Lane
New York, NY 10038

Dear Mr. Graybeal:

I am painfully aware of the less than sterling impression Hard Rock Mineral Drilling Company left with Asarco on the Gold Hill project this summer. Please be assured that Kenneth Huey, Guy Moses, and I were not happy with initial performance either. At the time, it seemed as though nothing we could do would satisfy our rig's insatiable desire to burst hoses, brake pumps, eat compressors, and generally refuse to perform the task it was designed for, "drilling." In 25 years of drilling, Kenneth could not recall a more disastrous period. At times it was as though the Gods were conspiring against us.

Hard Rock Mineral Drilling Company was founded to provide a quality drilling service for the mining industry and to be an economic entity in that endeavor. Initially, our performance was neither quality nor economic. The principals of Hard Rock Mineral have spent considerable time, money, and effort to improve our operation and equipment. We have replaced the old vane compressor with a new screw type. We have installed a carousal to facilitate rod changing and have replaced several troublesome pumps and motors as well as hoses and fittings. In January, we will be installing a rod handling system to enable us to angle drill. We feel the expense and effort is well worth it. We can only become economic by drilling and the steps taken to correct the problems have enabled us to reach that goal. Towards the end of the season and on our last contract, we were able to realize a minimum of down time and a substantial increase in footage drilled.

Hard Rock Mineral Drilling Company cannot promise a trouble-free drilling program; however, we can and do promise that we have done everything we can to insure a normal season and will continue to perform our duties in a manner to minimize down time and delays due to equipment failure. We thank you for your patience and understanding during our start-up. We hope you will consider us in future drilling programs.

Very truly yours,

Robley E. Berry

Robley E. Berry
Secretary/Treasurer
Hard Rock Mineral Drilling Company

cc: Jim Sell
Asarco Inc.
Western Exploration Div.
P.O. Box 5747
Tucson, AZ 87503

DDS — general info

ASARCO

Rocky Mountain
Exploration Division

April 11, 1983

TO: W. L. Kurtz

FROM: D. M. Smith, Jr.

Diamond Drilling
Bid Comparison

Attached is a compilation of the bids received for diamond drilling at Ark (800 ft., vertical, NX) and Alta (1000 ft., -55°, NX), as well as the estimated costs for each hole. Although Joy was not the low bidder that firm was chosen because of their past performance and first-hand knowledge of the Ark drilling conditions.

D. M. Smith, Jr.

Douglas M. Smith, Jr.

DMS:lb

cc: DIFletcher

RECEIVED

APR 13 1983

EXPLORATION DEPARTMENT

1983 Combined Bid Totals For Hypothetical Holes

	Ark	Alta	Total
Boyles	$14,132	$20,201	$34,333
Connors	12,649	16,756	29,405
Finley	28,380	35,866	64,246
Jex & Miller	17,210	24,891	42,101
Joy	15,608	19,165	34,773
Lake City	16,545	24,650	41,195
Longyear	14,474	22,948	37,422
Resource	28,704	42,324	71,028
XL	17,450	22,166	39,616

Low Bidders

1. Connors 29,405
2. Boyles 34,333
3. Joy 34,773
4. Longyear 37,422
5. XL 39,616

4-8-83 DMS, Jr.

1983 DIAMOND DRILLING BIDS

Drilling Company	Rig	Crews/hrs/days	Mob. - Demob.	Collar or overburden drilling	Coring	Special drilling cementing, etc.	Standby	Subsistence
Boyles Bros., Ark	LY-44	2/16/5	$800 hywy, $55/hr. other	$55/hr.	0-500 NX $15.40 500-1000 NX $16.75	$55/hr.	$55/hr.	-
Boyles Bros., Alta	LY-44	2/20/5	$1,000 hywy, $55/hr. other	$55/hr.	0-500 NX $18.45 500-1000 NX $20.00	$55/hr.	$55/hr.	-
Connors, Ark	-	X/10/6	$1,000 hywy, $55/hr. other	$55/hr.	0-500 NX $12.60 500-1000 NX $13.60	$55/hr.	$55/hr.	-
Connors, Alta	-	X/10/6	$1,000 hywy, $55/hr. other	$55/hr.	0-500 NX $13.60 500-1000 NX $14.90	$55/hr.	$55/hr.	-
Finley, Ark	-	-	$2,500	$100/hr.	0-800 $32.00	$100/hr.	$80/hr.	-
Finley, Alta	-	-	$2,500	$100/hr.	0-1000 $33.00	$100/hr.	$80/hr.	-
Jex & Miller, Ark	-	-	$1,750	0-500 HQ $21.00 500-1000 HQ $24.00	0-500 NQ $18.00 500-1000 NQ $21.00	$55/hr.	$55/hr.	-
Jex & Miller, Alta	-	-	$1,750	0-500 HQ $23.75 500-1000 HQ $26.75	0-500 NQ $22.00 500-1000 NQ $25.00	$55/hr.	$55/hr.	-
Joy, Ark & Alta	J-22	2/8/5	$4,750	$55/hr.	0-500 NX $15.70 500-1000 NX $16.70	$45/hr.	$30/hr.	$15/man/day
Lake City, Ark	-	-	none	$67.50/hr.	0-500 NX $17.50 501-750 NX $20.00 751-1000 NX $22.50	$67.50/hr.	$67.50/hr.	$20/man/day
Lake City, Alta	-	-	none	$67.50/hr.	0-500 NX $22.50 501-750 NX $25.00 751-1000 NX $27.50 1001-1250 NX $30.00	$67.50/hr.	$67.50/hr.	$20/man/day
Longyear, Ark	LY-44	2/10/5	$1,000 + $49/hr. to next hole	$13.80/ft.	0-1000 NQ $13.80	$60.50/hr.	$49.00/hr.	$20/man/day
Longyear, Alta	LY-44	2/10/5	$1,000	$18.75/ft.	0-1000 NQ $18.75	$60.50/hr.	$49.00/hr.	$20/man/day
Resource, Ark & Alta	LY-44	-	$2.50/mi. + $75/hr. between holes	$115.00/hr.	$115.00/hr.	$115.00/hr.	$75.00/hr.	$40/man/day
XL, Ark	LY-44	-	$800	$70.00/hr.	0-800 NQ $18.00	$70.00/hr.	$50.00/hr.	$25/man/day
XL, Alta	LY-44	-	$400	$70.00/hr.	0-500 NQ $18.00 500-1000 NQ $21.00	$70.00/hr.	$50.00/hr.	$25/man/day

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Ark DDH-2 (Hypothetical)

Drilling Company	10 hrs. or 50 ft. of overburden drilling	160 ft.* of special drilling @ highest ate	20 hours of standby	590 ft. of normal drilling	25 days of subsistence	Mob. - Demob.	Total
Boyles	$ 550	$2,420	$1,100	$ 9,207.50	$ -	$ 855	$14,132
Connors	550	2,420	1,100	7,524	-	1,055	12,649
Finley	1,000	4,400	1,600	18,880	-	2,500	28,380
Jex & Miller	1,050	2,420	1,100	10,890	-	1,750	17,210
Joy	550	1,980	600	9,353	750	2,375	15,608
Lake City	675	2,970	1,350	10,550	1,000	none	16,545
Longyear	690	2,662	980	8,142	1,000	1,000	14,474
Resource	1,150	5,060	1,500	18,794.45	2,000	80 mi x 2.50/mi = 200	28,704
XL	700	3,080	1,000	10,620	1,250	800	17,450

*3.61 ft./hr. drilling rate in 1981
160 ft. of drilling @ 3.61 ft/hr = 44 hrs.

Alta DDH-1 (Hypothetical)

Drilling Company	20 hrs. or 100 ft. of overburden drilling	200 ft.* of special drilling @ highest rate	20 hours of standby	700 ft. of normal drilling	30 days of subsistence	Mob. - Demob.	Total
Boyles	$1,100	$3,666	$1,100	$13,225	$ -	$1,110	$20,201
Connors	1,100	3,666	1,100	9,780	-	1,110	16,756
Finley	2,000	6,666	1,600	23,100	-	2,500	35,866
Jex & Miller	2,375	3,666	1,100	16,000	-	1,750	24,891
Joy	1,100	3,000	600	11,190	900	2,375	19,165
Lake City	1,350	4,500	1,350	16,250	1,200	-	24,650
Longyear	1,875	4,033	980	13,125	1,200	1,735	22,948
Resource	2,300	7,666	1,500	26,833	2,400	1,625	42,324
XL	1,400	4,666	1,000	13,200	1,500	400	22,166

*Use 3.0 ft./hr. drilling rate

File Drilling; Drilling Procedures

ASARCO

Southwestern Exploration Division

August 15, 1980

TO: W. L. Kurtz

FROM: J. D. Sell

Treatment of Sanded Dolomite
Drilling Problem Solution

A report which is available through the University of Utah Research Institute (UURI) concerning the "Treatment of Sanded Dolomite" is attached. This report covers a process to stabilize sloughing drill holes where sanded dolomite is encountered. The method was developed for completion of drill holes in geothermal exploration and may also have application in the mineral industry as well, especially in the areas of limestone replacement deposits such as Leadville, Tintic, etc.

The report is Open-File Report #UT/CFS/UOC-5, Union Oil Company, Cove Fort/Sulphurdale, Utah; report "Treatment of Sanded Dolomite" and patent description of "Consolidation of Caving," 13 p. It is available for reproduction costs ($0.90) from:

UURI, Earth Science Laboratory
Publications
420 Chipeta Way, Suite 120
Salt Lake City, Utah 84108

James D. Sell

James D. Sell

JDS:lb
Att.

cc: NPWhaley - w/att.

TREATMENT OF SANDED DOLOMITE

Sanded dolomite was encountered at 560' in Forminco #1, and was at least 491' thick, although the total section was not penetrated. This sloughing formation caused the premature abandonment of this well, and resulted in a research effort to develop a method of treating this interval.

The sanded dolomite is believed to occur randomly in the dolomitized sections in the area due to acid gas leaching. Consequently, it is not a lithologic structure that can be mapped, and we must be prepared to combat this problem whenever we encounter it.

For example, sanded dolomite was not encountered in well #42-7, but it may have been encountered in well #31-33. An 85' interval of unconsolidated sloughing material was encountered in well #31-33 at 4785', but due to lost circulation problems, no material was circulated back to the surface. However, the interval was treated with a modification of the procedure described below (due to the depth and temperature, acid was not used), and successfully stopped the sloughing and allowed the hole to be completed.

Appendices 1 and 2 give a detailed procedure for conducting this patented* process. As can be seen from the Appendices and the detail given in the patent, this procedure requires a significant amount of extra equipment, as well as stockpiling enough chemicals to do the treatments. These costs are reflected in the higher cost of drilling wells in this area.

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* Patent 4,120,369 - copy attached

DSP:rmw
Att.

OFR
50,90 UT/CES/-OC-5 Union Oil Company, Cooper Fed/Sabedoumolo, Colo, report

APPENDIX 1

PROCEDURE FOR PERFORMING A CONSOLIDATION TREATMENT

	Volumes for Hole Size (Gallons)			
	8 3/4 in (22.2 cm)		12 1/4 in (31.1 cm)	
	gallons	cu.meters	gallons	cu.meters
1. Fresh water preflush (Pump fluid with the bit on the bottom.)	140	(0.52)	320	(1.21)
2. Chemical Preflush: 0.2% surfactant -5% calcium chloride-2% hydrochloric acid (Pump while raising the bit to fill about 60 feet (18.4 m) of hole.)	200	(0.757)	370	(1.4)
3. Close the annulus and pump water to displace the chemical preflush, but keep the pressure below fracturing pressure	100*	(0.378)	180*	(0.68)
4. Open the annulus and lower the bit to the bottom. Pump water to circulate the preflush up into the annulus	230	(0.87)	370	(1.4)
5. 50% 41° Bé "N" sodium silicate) 50% water) (Pump while raising the bit to fill about 60 feet (18.4 meters) of hole.)	200	(0.757)	370	(1.4)
6. Close the annulus and pump water to displace silicate. Keep the pressure below fracturing pressure.	100*	(0.378)	180*	(0.68)
7. Open the annulus, lower the bit to the bottom and pump water to circulate the excess sodium silicate stage up into the annulus	230	(0.87)	530	(2.0)
8. 5% calcium chloride flush solution. (Pump while raising the bit to fill about 60 feet (18.4 meters of hole.)	200	(0.757)	370	(1.4)
9. Close the annulus and pump water to displace calcium chloride flush solution. Keep the pressure below fracturing pressure.	100*	(0.378)	180*	(0.68)
10. Open the annulus and lower the bit to the bottom; pump water to circulate the excess calcium chloride water up into the annulus	140	(0.52)	320	(1.21)
11. Resume normal mud circulation and drilling				

* A time constraint of 30 minutes should be applied to these steps. If all the indicated volume is not pumped within 30 minutes, the treatment step should be terminated, and the remaining volume should be added to the next (displacement) step.

APPENDIX 2

TOTAL VOLUMES AND CHEMICAL REQUIREMENTS PER 30 FEET

	Hole Diameter			
	8 2/4 In. (22.2 cm) Hole		12 1/4 In. (31.1 cm) Hole	
Water	1540 gal.	(5.82 m^3)	3165 gal.	(12.0 m^3)
Calcium Chloride	167 lb.	(76 Kg)	308 lb.	(140 Kg)
Surfactant	0.40 gal.	(1.51 liters)	0.74 gal.	(2.8 liters)
Concentrated Hydrochloric Acid (37%)	9.1 gal.	(34.4 liters)	16.8 gal.	(63.6 liters)
41° Bé "N" Sodium Silicate Solution	100 gal.	(0.378 m^3)	185 gal.	(0.700 m^3)

Makeup of 10-Barrel Batches Each Stage

Stage 1		
Water	9.56 bbl	(6.51 m^3)
Calcium Chloride	175 lb	(79.4 Kg)
37% Hydrochloric Acid	19 gal.	(71.9 liters)
Surfactant	0.85 gal.	(3.18 liters)
Stage 2		
Water	5.0 bbl	(0.80 m^3)
41° Bé "N" Sodium Silicate	5.0 bbl.	(0.80 m^3)
Stage 3		
Water	10.0 bbl	(1.59 m^3)
Calcium Chloride	175 lb	(79.4 Kg)

United States Patent [19]

Fischer et al.

[11] 4,120,369

[45] Oct. 17, 1978

[54] METHOD FOR DRILLING A WELL THROUGH UNCONSOLIDATED DOLOMITE FORMATIONS

[75] Inventors: Paul W. Fischer, Whittier; David S. Pye, Brea; Julius P. Gallus, Anaheim, all of Calif.

[73] Assignee: Union Oil Company of California, Brea, Calif.

[21] Appl. No.: 838,895

[22] Filed: Oct. 3, 1977

[51] Int. Cl.² E21B 33/138

[52] U.S. Cl. 175/72; 166/292

[58] Field of Search ..... 166/285, 292, 294; 175/57, 65, 66, 72; 252/8.5 LC

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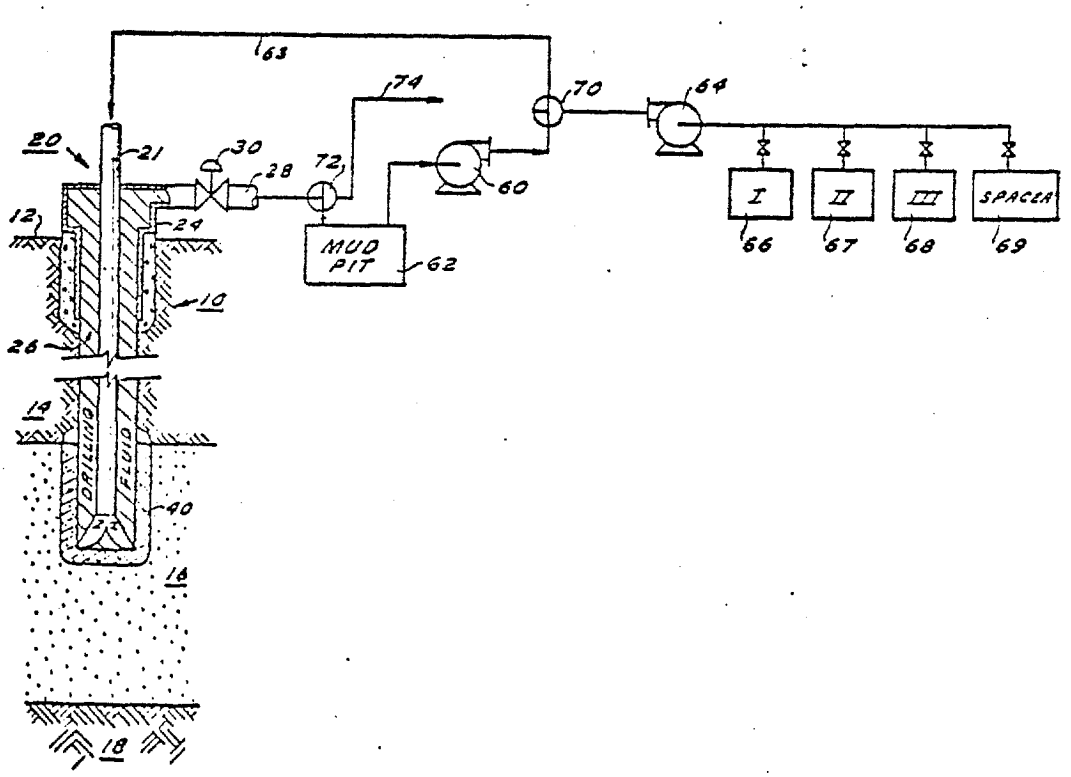
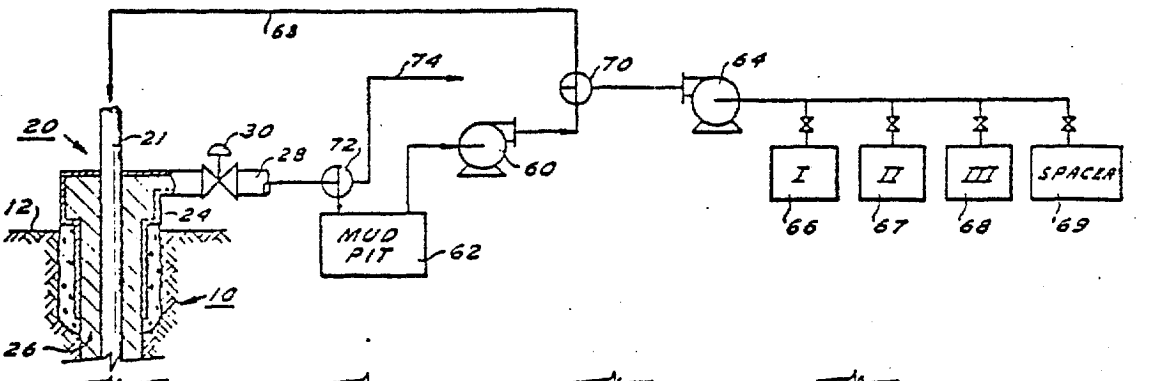
Primary Examiner—Stephen J. Novosad
Assistant Examiner—George A. Suchfield
Attorney, Agent, or Firm—Richard C. Hartman; Dean Sandford; Daniel R. Farrell

[57] ABSTRACT

A method for drilling a well through a subterranean formation containing one or more zones of unconsolidated dolomite, wherein the drilling operation is interrupted periodically to consolidate the newly drilled incompetent dolomite by the injection of a sequence of reactant slugs comprised of (I) an aqueous solution containing an acid, a surface active agent and a precipitating agent for silicates, (II) an aqueous solution containing a water-soluble silicate, and (III) an aqueous solution containing a precipitating agent for silicates.

18 Claims, 11 Drawing Figures





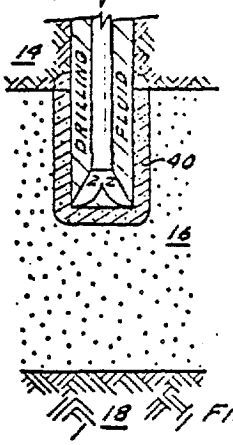


FIG. 1

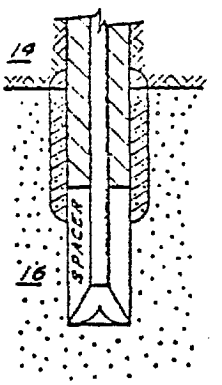


FIG. 2

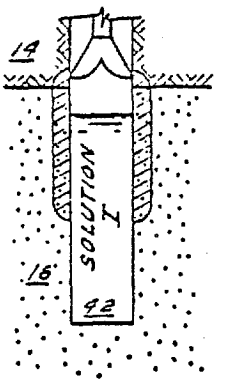


FIG. 3

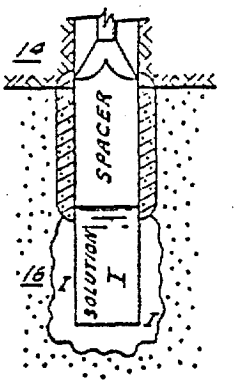
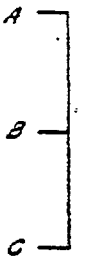


FIG. 4



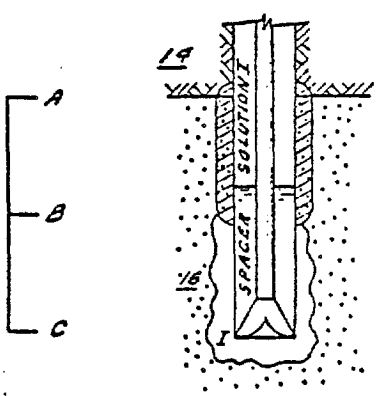


FIG. 5

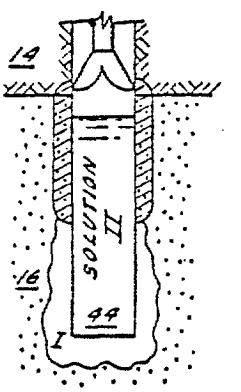


FIG. 6

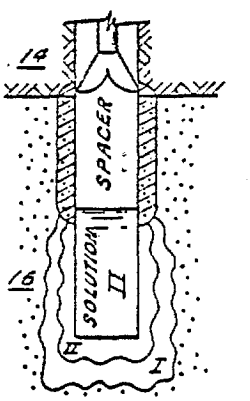


FIG. 7

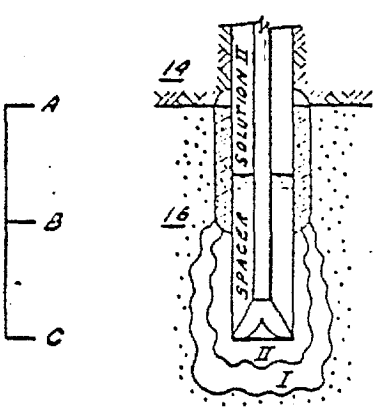


FIG. 8

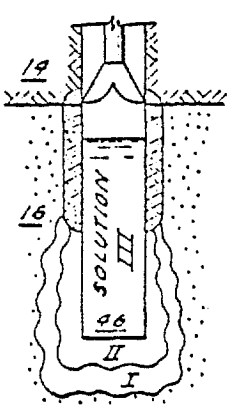


FIG. 9

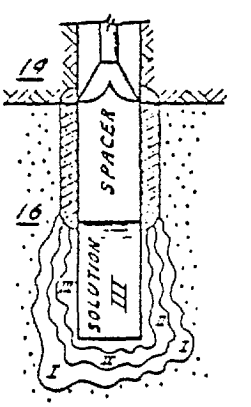


FIG. 10

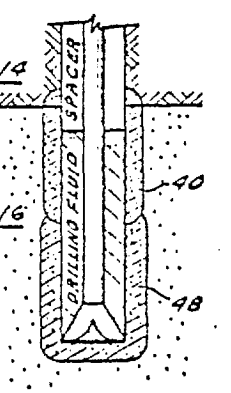


FIG. 11

METHOD FOR DRILLING A WELL THROUGH UNCONSOLIDATED DOLOMITE FORMATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the drilling of wells, and more particularly concerns an improved method for drilling a well through a formation containing unconsolidated dolomite.

2. Description of the Prior Art

Drilling a well through an incompetent subterranean formation has presented many problems. Conventionally, aqueous-base drilling fluids containing water, clay and various additives are circulated through the bore hole during the drilling operation to carry drill cuttings from the bore hole to the surface. These clay-containing drilling fluids form a mud cake on the bore hole walls which reduces the sloughing of the incompetent formation as long as the fluid pressure in the bore hole due to the standing column of drilling fluid, exceeds the pressure of the connate fluid in the incompetent formation. Therefore, drilling through typical incompetent formations per se is not particularly a problem. However, it is commonplace to encounter a lost circulation zone, either in the incompetent formation itself or in an underlying strata, or to lose the column of drilling fluid due to the cumulative effect of individually manageable fluid losses to a plurality of formations. When the lost circulation results in a fluid pressure in the bore hole less than the fluid pressure in the adjacent incompetent formation, the formation will slough into the bore hole. A stuck drill string often results from this sloughing and may lead to abandonment of the drill string and the well.

The incompetent formations normally encountered in drilling oil and gas wells are generally formations which contain quartz sand and/or clay. Accordingly, the prior art methods of consolidating these formations have been directed to injecting one or more chemical solutions to react with the quartz sand or clay to form a consolidated sheath about the well bore. Depending upon whether or not it is desirable to permanently seal the formation from the well bore, the chemical solutions can be selected such that the resulting sheath is either permeable, such as disclosed in U.S. Pat. No. 3,175,611 to Hower, or substantially impermeable, such as disclosed in U.S. Pat. No. b 2,207,759 to Reimers.

Dolomite formations encountered in drilling oil and gas wells are generally competent unless the formation also contains a significant amount of quartz sand or clay. Accordingly, dolomite formations which are substantially free of quartz sand and clay have not required consolidation. However, subterranean formations containing one or more zones of unconsolidated dolomite have been encountered in drilling core holes for minerals exploration, and in drilling wells to explore geothermal prospects. The incompetent dolomite is believed to result when a zone of dolomite crystals dispersed in a calcite matrix is subjected to ground water leaching, such as hydrothermal leaching by a geothermal fluid. The ground water selectively leaches the more soluble calcite matrix materials to leave the unconsolidated, finely divided dolomite crystals. These crystals are relatively free flowing and are prone to sloughing into a void space, such as a bore hole.

Previous attempts to drill through these unconsolidated dolomite formations have been unsuccessful. Numerous core holes and at least one well drilled to explore a geothermal prospect have been abandoned due to this problem. Prior art consolidation methods have been found to be inadequate for the consolidation of the incompetent dolomite formations. Therefore, a need exists for a method for drilling through incompetent dolomite formations.

Accordingly, a principal object of this invention is to provide a method for drilling a well through incompetent dolomite formations.

Another object of this invention is to provide a method for drilling through a hydrothermally-leached formation containing incompetent dolomite.

Yet another object of the invention is to provide a method for consolidating an incompetent dolomite formation during the drilling operation sufficiently to prevent subsequent sloughing of the formation into the bore hole during the drilling operation.

A further object of the invention is to provide an improved drilling method by which a relatively thick incompetent zone of dolomite can be penetrated while avoiding sloughing of the dolomite into the bore hole and while reducing fluid loss to the incompetent formation.

Further objects, advantages and features of the invention will become apparent to those skilled in the art from the following description taken in conjunction with the accompanying drawings.

SUMMARY OF THE INVENTION

The invention provides a method for drilling a well through an incompetent dolomite formation. In the method, the drilling operation is periodically suspended after penetrating a distance into the incompetent formation and the portion of the newly drilled formation adjacent the bore hole is consolidated by the injection of a sequence of discrete slugs comprised of (I) an aqueous solution containing an acid, a surface active agent and a precipitating agent for silicates, (II) an aqueous solution containing a water-soluble silicate capable of reacting with solution I to form a silicate gel, and (III) an aqueous solution of a precipitating agent for silicates. Solutions I, II and III react in the newly drilled portion of the formation to form and set a silicate gel thereby forming a substantially impermeable, consolidated sheath around the bore hole. This sheath serves to prevent sloughing of the incompetent formation during the later stages of the drilling operation and until the well can be completed.

In a preferred embodiment of the method of this invention, formations which contain one or more zones of the incompetent dolomite are drilled by conventional rotary drilling techniques using an aqueous, substantially clay-and oil-free drilling fluid. The well is drilled in a plurality of increments and each newly drilled portion of the formation is consolidated by the aforementioned treatment prior to drilling the next increment.

The invention provides the important advantage of consolidating each portion of the formation as it is encountered, thereby avoiding the possibility of a stuck drill string due to subsequent sloughing of the formation. The consolidation also substantially eliminates fluid loss to the formation adjacent the consolidated annular sheath. Furthermore, the consolidation treatment can be and is preferably conducted without pulling the drill string from the hole and the method does not require the use of a well liner or any special tools.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more readily understood by reference to the drawings wherein like numerals refer to like elements, in which:

FIGS. 1 through 11 are schematic diagrams of a cross section of earth strata which illustrate the series of steps carried out in a preferred embodiment of the method of this invention.

DETAILED DESCRIPTION OF THE INVENTION

The method of this invention is applicable to all drilling operations in which incompetent dolomite formations are to be penetrated, such as core drilling for minerals exploration, rotary drilling in the exploration for oil, gas or a geothermal fluid or in the drilling of wells or shafts to gain access to a subterranean formation. The method of this invention finds particular utility in the rotary drilling of a well through an incompetent dolomite formation overlying a geothermal reservoir.

A preferred embodiment of the method of this invention is illustrated in FIGS. 1 through 11. As shown in FIG. 1, well 10 extends from the earth surface 12 through a first subterranean formation 14 and a short distance (from point A to point B) into a second subterranean formation 16. Formation 14 is fairly competent and therefore does not require consolidation. Formation 16, however, contains unconsolidated dolomite which is prone to sloughing into the bore hole. Below formation 16 is a fluid-bearing reservoir 18 such as a reservoir containing oil, gas, steam or high temperature brine, or other mineral deposits of interest. The objective of the rotary drilling operation is to penetrate into formation 18 to tap the fluid contained therein or to obtain core samples of the mineral deposits.

A drill string, shown generally as 20, is disposed in well 10 in a conventional manner. Drill string 20 includes rigid conduit 21 and drill bit 22 attached to the end of conduit 21. Well casing 24 is disposed in the top of well 10 in a conventional manner to seal off the top strata of formation 14 from the bore hole and to provide a fluid tight pathway from well 10 to blooie line 28. During the drilling operation, drill string 20 is rotated by a prime mover, not shown, and a drilling fluid is circulated by pump 60 from mud pit 62 through line 63, downwardly through drill string 20, upwardly through well annulus 26 and out through blooie line 28 back to mud pit 62. Valve 30 is provided on blooie line 28 to shut in well annulus 26. The circulating drilling fluid carries drill cuttings from the bore hole to mud pit 62.

Chemical injection pump 64 is provided to inject reactant solutions from tanks 66, 67 and 68, and spacer liquid from tank 69 through line 63 and into well 10. Three-way valves 70 and 72 are provided to switch from the drilling fluid circulating system to the chemical injection system. Tank 66 contains solution I which is an aqueous solution of an acid, a surface active agent and a water-soluble precipitating agent. Tank 67 contains solution II which is an aqueous solution of a water-soluble silicate. Tank 68 contains solution III which is an aqueous solution of a water-soluble precipitating agent. And tank 69 contains a spacer liquid which is substantially nonreactive with respect to solutions I, II and III and the drilling fluid. Three-way valve 72 is provided on blooie line 28 to direct any excess of solution I, II and III to a disposal site, not shown, through conduit 74. Preferably the excess reactant slugs are not dumped into mud pit 62 in order to avoid contamination of the drilling fluid.

FIG. 1 illustrates the status of well 10 after the bore hole has been drilled from point A to point B into formation 16 and the newly drilled portion of the formation has been consolidated in accordance with the method described more fully hereinafter. During this consolidation a substantially impermeable sheath, shown generally as 40, was formed around the bore hole, which sheath prevents sloughing of the formation into well 10.

In the method, the bore hole is extended from point B to point C into formation 16 in the conventional manner, i.e., by rotating drill string 20 and circulating a drilling fluid downwardly through conduit 21 and upwardly through annulus 26. Upon reaching point C, the drilling operation is interrupted and the newly drilled portion of formation 16, i.e., from point B to point C, is consolidated by the sequence of steps illustrated in FIGS. 2 through 11. In these steps, a body of each reactant solution is first positioned in the bottom of the bore hole by slowly raising the drill string as the reactant solution is flowed into the well. This raising of the drill string reduces the mixing of the reactant solution with the other fluids in the well and also minimizes the time during which the drill string is immersed in the reactant solution. This latter feature greatly reduces the chances that the drill string will become stuck in the well by premature cementation of the reactant solutions. Next, the well annulus is sealed by one of the methods well known in the art and a spacer slug is injected under pressure to displace the reactant solution into the newly drilled portion of the formation. Although the incompetent formations are normally porous and often drain fluid continuously from the bore hole, the reactant solutions are injected under pressure to ensure placement of a sufficient quantity of the solutions in the formation to form a sizable consolidated sheath. Furthermore, the permeability of the formation is significantly reduced by the injection of solutions I and II, therefore solution III must be displaced into the formation under pressure. Typically, the permeability of the consolidated sheath will be on the order of less than one thousandth of the permeability of the unconsolidated formation.

As shown in FIG. 2, the drilling fluid is displaced upwardly through well annulus 26 by injecting a spacer liquid through conduit 21 while drill string 20 is rested on the bottom of the well. Then, drill string 20 is raised as a discrete slug of solution I is introduced through conduit 21 into the bore hole to provide body 42 of solution I in the bottom of well 10, as shown in FIG. 3. Next, annulus 26 is shut in by means of valve 30 or any other conventional device, such as an expandable packer, not shown, positioned on drill string 20. A spacer liquid is injected under pressure into well 10 through conduit 21 to displace solution I into the newly drilled portion of formation 16, as shown in FIG. 4. The pressure in well 10 is then reduced by opening valve 30; drill string 20 is run to the bottom of well 10; and the excess solution I is displaced out of annulus 26 by a spacer, as shown in FIG. 5.

Solutions II and III are each introduced into the bottom of well 10 and displaced into the newly drilled portion of formation 16 by the same method as described above for the injection of solution I. Briefly, FIG. 6 illustrates body 44 of solution II in the bottom of the bore hole, which was formed by the injection of a

discrete slug of solution II through conduit 21 as drill string 20 was raised; FIG. 7 illustrates the displacement of solution II into the newly drilled portion of formation 16 by a spacer liquid which was injected into the shut-in well under pressure; FIG. 8 illustrates the displacement of the excess solution II upwardly through the well annulus by a spacer; FIG. 9 illustrates body 46 of solution III in the bottom of the bore hole, which was formed by the injection of a discrete slug of solution III through conduit 21 as drill string 20 was raised; and FIG. 10 illustrates the displacement of solution III into the newly drilled portion of formation 16 by a spacer fluid which was injected into the shut-in well under pressure.

It is preferred that the amount of mixing of the reactant solutions with other fluids in the well bore, i.e., connate fluids and spacer slugs, be minimized and that the amount of spacer actually displaced into the formation between the reactant solutions be minimized, in order that the reactant solutions become well mixed at the highest possible concentration of reactant chemicals. Accordingly, it is preferred that the slugs of reactant solutions and spacer be sized such that the excess solution remaining in the bore hole after displacement by the spacer completely fills the bore hole adjacent the newly drilled portion of the formation as illustrated in FIGS. 4, 7 and 10. This procedure reduces the amount of spacer displaced into the formation to the small amount due to the natural fluid loss during the displacement of the excess solution from the bore hole illustrated in FIGS. 5 and 8.

As shown in FIG. 10, a portion of each discrete slug of solutions I, II and III has been displaced into formation 16. Although shown in formation 16 as distinct fluids, it will be understood of course that the three solutions will mix in formation 16 adjacent the bore hole. Solutions I, II and III interact to form a silicate gel which consolidates the formation adjacent the bore hole by forming a substantially impermeable annular sheath about the bore hole. FIG. 11 illustrates the status of well 10 after sheath 48 has set in the newly drilled portion of formation 16. Sheath 40 and sheath 48 together form a substantially continuous sheath which prevents sloughing of formation 16 into the bore hole and substantially eliminates fluid passage between the bore hole and formation 16.

The third and subsequent portions of formation 16 are drilled and treated by repeating these same steps. The formation containing incompetent dolomite will normally be drilled in a plurality of increments of from about 20 to about 100 feet in depth, preferably between about 20 and about 60 feet in depth. Once the unconsolidated formation has been passed or the fluid-bearing reservoir has been penetrated, the consolidation treatment can be suspended and conventional drilling and completion methods can be used to complete the well, such as by running a well liner or production casing and cementing it in place.

From this description of the preferred process steps, it will be apparent that numerous modifications can be made in the method of injection of the reactant solutions into the formation. For example, it is contemplated that the solutions can be injected without the raising and lowering of the drill string, and that one or more of the spacer solutions may be deleted without adversely affecting the consolidation of the formation. However, since the premature mixing of the reactant solutions or some other unforeseen problem could result in the drill string being stuck in the well, the above-described process steps are preferred in order to substantially prohibit this result.

In rotary drilling, the drilling fluid employed to drill through strata overlying the unconsolidated dolomite formation is not deemed critical, but rather will be selected according to methods well known in the art which depend in general upon the type of strata penetrated. However the selection of a drilling fluid for drilling through the unconsolidated dolomite is critical to the success of the method of this invention. Of course, in those drilling methods which do not require drilling fluids, such as cable tool drilling, none will be used.

In rotary drilling through an incompetent formation by the method of this invention, it is desirable to use a clay-free drilling fluid. Clay tends to invade the relatively porous incompetent formations and causes plugging problems. In addition, when high temperatures are encountered, a corrosion inhibitor is usually required in the drilling fluid in order to combat the corrosive effects of oxygencontaining gases or carbon dioxide in either the drilling fluid, such as an aerated drilling fluid, or in the connate fluid. However, clay tends to absorb these corrosion inhibitors so they are not available for corrosion protection. Furthermore, while clay-containing drilling fluids normally form a mud cake on the walls of the bore hole which serves to temporarily seal off incompetent formations, this mud cake is usually not adequate to prevent the subsequent sloughing of the incompetent formation when the well goes dry due to lost circulation. However, the mud cake is difficult to remove by chemical treatment and therefore effectively seals off the incompetent formation from any fluids which are injected into the bore hole to consolidate this formation. Therefore, in drilling through incompetent formations by the method of this invention, clay-containing drilling fluids and other drilling fluids which form a relatively impermeable and difficult to remove cake on the walls of the bore hole are to be avoided. To the contrary, drilling fluids which form easily removed cakes are preferred.

Similarly, oil-containing fluids are to be avoided when drilling through incompetent formations by the method of this invention. The use of oil-containing fluids often results in rendering oil-wet the formation immediately adjacent the bore hole with a resulting lower mobility to aqueous fluids. This lower mobility undesirably reduces the injectivity of the aqueous treatment solutions. It is critical to the success of the consolidation treatment that the reactant solutions I, II and III penetrate into the unconsolidated formation in an amount sufficient to consolidate a sizable sheath about the bore hole, such as an annular sheath having a differential radius of at least 3 inches and preferably at least 6 inches. In order to consolidate a sheath this large, a fairly substantial quantity of the reactant solutions must be displaced into the unconsolidated formation. Accordingly, any fluid which reduces the permeability of the formation, such as clay- or oil-containing drilling fluid, should be avoided. In particular, cakeforming conventional drilling fluid additives such as clay, lignite, lignin and lost circulation materials which form cakes which are difficult to remove should be avoided, if possible, while drilling through the sloughing dolomite formation.

Aqueous drilling fluids which are substantially free of oil and clay are preferred for use in drilling through

incompetent dolomite formations. Suitable drilling fluids can consist essentially of water or a sodium chloride brine, however these fluids are often not suitable in a particular well due to a high fluid loss or low density. As is known, a water-soluble polymer can be added to increase the viscosity of the drilling fluid and to improve the fluid loss properties of the drilling fluid. While a high fluid loss is to be avoided, a very low fluid loss is also undesirable since this indicates that the formation has been rendered relatively impermeable to water. Preferably the polymer is selected to reduce the fluid loss to an acceptable level without adversely affecting the permeability of the formation to the consolidation solutions. Slightly crosslinked polymers, such as slightly-crosslinked acrylic and hydroxyethylcellulose polymers, have been found to be effective. On the other hand, heavily crosslinked heteropolysaccharides and polyacrylamide polymers have been found to detrimentally affect the consolidation treatment. Preferred polymers included the hydroxyethylcellulose polymers marketed by Hercules, Inc. under the trademark Natrasol. Particularly preferred polymers are the sodium polyacrylates marketed by American Cyanamid Company under the trademark Cypan and those polymer additives marketed by Rotary Drilling Services and X-L Laboratories under the trademark Ben-EX and by Pal-Mix under the trademark Super-X.

Conventionally, a weighting agent such as calcium carbonate is added to an aqueous based drilling fluid to adjust the fluid density and to improve fluid loss control. A calcium carbonate weighting agent marketed by Brinadd Company under the trademark Sluggit has been found to be suitable.

One suitable drilling fluid is an aqueous solution containing about 1 pound per barrel of Cypan sodium polyacrylate and about 10 pounds per barrel of Sluggit weighting agent.

Although drilling fluids which form easily removed cakes are preferred, it is contemplated that under some well conditions the only suitable drilling fluid will be a clay-containing fluid. The method of this invention can still be used to consolidate the incompetent dolomite adjacent the bore hole but appropriate steps must be taken to remove the mud cake before solutions I, II and III are introduced into the formation. It may be necessary to remove the mud cake by an acid treatment, such as a flush of hydrofluoric acid, or by means of a mechanical scraper.

Solution I is an aqueous solution containing an acid, a surface active agent and a precipitating agent for silicates. The acid is selected from the water-soluble inorganic and organic acids which form water-soluble salts with the surface active agent and the multivalent cation of the precipitating agent. Depending on the particular precipitating agent, suitable inorganic acids include hydrochloric, nitric, hydroiodic, hydrofluoric and hydrobromic acids. Suitable organic acids include formic, acetic, propionic and citric acids. Hydrochloric acid is particularly preferred. Solution I will normally contain between about 0.5 and about 20 weight percent of acid, with good results being obtained with between 1 and 10 weight percent, and particularly between 2 and 5 weight percent of acid.

The surface active agents useful in Solution I include anionic, nonionic, cationic and amphoteric agents. (cf. Detergents and Emulsifiers, 1975 Annual, John W. McCutcheon, Inc.) A wide variety of surfactants are useful, but the preferred surfactant will depend upon the type of acid and precipitating agent contained in the solution. In general, the surfactant must be soluble in an aqueous acidic solution containing multivalent cations. Accordingly, surface active sulfates and phosphates which form precipitates with multivalent cations are not suitable. Additionally, viscous soaps, such as sodium and potassium salts of processed or modified rosins, as well as other viscosity increasing agents, such as polyacrylamides, are to be avoided since these reagents adversely reduce the mobility of the solution. If the viscosity of solution I is increased, the quantity of the reactive solutions displaced into the incompetent formation will be less, thereby reducing the effectiveness of the consolidation treatment.

Surface active amines, alkyl sarcosines, n-alkyl trimethyl ammonium chlorides and sorbitan monolaurates have been found to be useful in the method of this invention. An ethylene oxide condensation product of the primary fatty amines marketed by Armak Company under the trademark Ethomeen C/15 is an example of the cationic surfactants found to be useful in this invention. Also useful are the cocoyl sarcosines marketed by Ciba-Geigy Corporation under the trademark Sarkasyl LC (anionic), the n-alkyl trimethyl ammonium chlorides marketed by Armour Industrial Chemical Company under the trademark Arquad T-50 (cationic) and the sorbitan monolaurates marketed by Atlas Chemical Industries under the trademark Tween 20 (nonionic).

The most preferred surface active agents are those surface active amines which exhibit corrosion inhibiting properties. Most corrosion inhibitors have surface active properties and, if compatible with the aqueous acid solution containing multivalent cations, are preferred for use in the method of this invention. Suitable corrosion inhibitors which can be used either alone or in addition to the afore-mentioned surfactants in Solution I include a corrosion inhibitor marketed by the Halliburton Company under the trademark HAI-75 and an amine corrosion inhibitor marketed by The Dow Chemical Company under the trademark Dowell-A-130.

Solution I will contain between about 0.005 and about 5 weight percent of the surface active agent, with good results obtained when the solution contains between 0.05 and 3 weight percent of the surface active agent, more particularly between about 0.1 and 0.5 weight percent. The concentration of the surface active agent should never be enough to cause a significant increase in the viscosity of the solution or to otherwise reduce the mobility of the solution in the dolomite formation.

The precipitating agents suitable for use in the method of the invention include the water-soluble salts of multivalent cations which react with silicates to form and set a silicate gel. Suitable multivalent cations include the alkaline earth metals, such as magnesium, calcium, strontium and barium, and certain of the transition metals, such as zinc, manganese, iron, nickel and cobalt. Iron and calcium are the preferred multivalent cations due to their availability and low cost. Suitable precipitating agents include the multivalent cation salts of inorganic acids, such as hydrochloric, hydrobromic, hydroiodic and nitric acids, and the multivalent cation salts of organic acids, such as formic, acetic, propionic and citric acids. Chloride salts are preferred due to their low cost, with iron and calcium chlorides being particularly preferred. Solution I should contain between about 1 and about 20 weight percent of the precipitating agent. Good results are obtained when the concentration of the precipitating agent is between about 2 and 10

weight percent, more particularly about 5 weight percent.

Solution I comprises an aqueous solution containing from about 0.5 to about 20 weight percent of a water-soluble acid, from about 0.005 to about 5 weight percent of a surface active agent, and from about 1 to about 20 weight percent of a water-soluble precipitating agent for silicates. Particularly preferred compositions for use as Solution I include aqueous solutions comprised of fresh water containing from about 2 to 5 weight percent hydrochloric acid, from about 2 to 10 weight percent of iron or calcium chloride, and from about 0.1 to about 0.5 weight percent of either HAI-75 corrosion inhibitor or Ethomeen C/15 surfactant or mixtures thereof.

Solution II is an aqueous solution containing a water-soluble silicate which is capable of reacting with the precipitating agent of Solution I to form and set a silicate gel. Suitable silicates include organic silicates, such as ethyl-ortho silicate, and inorganic silicates, such as the alkali metal and ammonium silicates. The alkali metal and ammonium silicates are preferred and sodium silicate is particularly preferred. Sodium silicate is a relatively complex inorganic substance, available in various grades from Na_2SiO_3 to $Na_2O.4SiO_2$ and any of these grades may be suitable for the purposes of the invention. A sodium silicate marketed by the Philadelphia Quartz Company as a 37% concentrate under the trade name Sodium "N" Silicate is particularly preferred. The concentration of the silicate in Solution II should be at least about 7 weight percent. The concentration of silicate should not however be so large as to render Solution II difficult to pump.

Preferably, Solution II comprises an aqueous solution containing between about 5 and about 40 percent of an alkali metal or ammonium silicate. One suitable silicate solution is made by diluting the sodium "N" silicate concentrate in a one to one ratio with fresh water to yield a 18.5 weight percent solution of sodium silicate.

Solution III is an aqueous solution containing a precipitating agent for silicates. The precipitating agents disclosed above as a constituent of Solution I are also preferred for use in Solution III, and the precipitating agents employed in these solutions can be the same or different precipitating agents selected from the aforementioned precipitating agents. Iron and calcium chlorides are preferred precipitating agents. Solution III should contain between about 1 and 20 weight percent of the precipitating agent, with good results being obtained when the concentration of the precipitating agent is between 2 and 10 weight percent, particularly about 5 weight percent.

The spacer liquid is an aqueous solution which is non-reactive with the drilling fluid and solutions I, II and III. Suitable liquids include fresh water and dilute solutions of alkali metal and ammonium salts, such as a 3 weight percent solution of NaCl.

Solutions I, II and III, and the spacer liquid should be substantially oil-free. Any oil injected into the unconsolidated formation will adversely affect the consolidation treatment by reducing the quantity of reactive solutions injected and by causing the consolidated sheath to be more permeable.

The volumes of the reactant solutions employed to consolidate each newly drilled portion of the incompetent formation will depend, of course, on the diameter of the bore hole, the concentrations of reactants used, the length of the newly drilled portion of the bore hole, and the desired thickness of the consolidated annular sheath. Although the volumes can vary widely, the following volumes are presented as exemplary for the treatment of 30 feet of newly drilled formation for the indicated size of bore hole by the method illustrated in FIGS. 1-11.

Treatment Slug	Composition	Volume of Treatment Slug, Gal. Bore Diam. 8.5-inch	Bore Diam. 12-inch
1) Spacer	3% NaCl	140	320
2) Solution I	5% $CaCl_2$ 2% HCl 0.2% HAI-75	200	370
3) Spacer	3% NaCl	100[a] 230[b]	180[a] 370[b]
4) Solution II	18.5% Na_2SiO_3	200	370
5) Spacer	3% NaCl	100[a] 230[b]	180[a] 530[b]
6) Solution III	5% $CaCl_2$	200	370
7) Spacer	3% NaCl	100[a] 140[b]	180[a] 320[b]

[a] Spacer injected under pressure to displace a like volume of reactant solution into the formation.
[b] Spacer introduced to displace excess reactant solution from the bore hole.

The suitability of a particular combination of reactant solutions for consolidating incompetent dolomite can be determined by a Dolomite Consolidation Procedure, as follows:

Dolomite crystals from a hydrothermally-leached formation are placed into a 1.5-inch glass tube on a wire screen supported by a rubber stopper, so as to form a loosely packed, 1-inch thick cake on the screen. The rubber stopper is provided with a ¼-inch tubing which provides fluid tight communication between the glass tube and a vacuum flask.

The dolomite cake is saturated with a 3 weight percent sodium chloride solution and then sequentially contacted with each of solutions I, II, III by placing 40 milliliters of the prepared solution on top of the dolomite cake and drawing a slight vacuum through the filter cake. Any excess solution which remains on top of the dolomite cake after 30 minutes is carefully poured off and measured prior to treatment with the next solution. Subsequently the rubber stopper and wire screen are removed from the glass tube and, if the dolomite cake does not fall out the glass tube, the tube and cake are immersed in a beaker of water. After several minutes, the dolomite cake is qualitatively judged for consolidation and rated as follows:

CONSOLIDATION INDEX

0 — Cake falls out of the tube prior to immersion in water.
1 — Cake remains in tube but has a mush consistency.
2 — Cake has a hard top or bottom surface but the other surface is soft.
3 — Cake has a hard top or bottom surface with the other surface being semi-hard.
4 — Cake has a hard top and bottom but had a small quantity of loose pieces on the top.
5 — Cake is solid and hard. Based on this test, the combinations of reactant solutions selected should have a Consolidation Index of at least 3 and preferably should have a Consolidation Index of 4 or 5.

The invention is further illustrated by the following examples which are illustrative of specific modes of practicing the invention and are not intended as limiting the scope of the invention as defined by the appended claims.

EXAMPLES 1-9

The suitability of various conbinations of reactant solutions for use in the method of this invention is determined by the Dolomite Consolidation Procedure described above. Solution I of Examples 1-6 lack one or more of the essential ingredients of the solutions of this invention and are run for comparison with Examples 7-9 which are within the scope of this invention.

The compositions of the various solutions and their corresponding Consolidation Index are presented in Table 1. The compositions of Examples 7-9 which are within the scope of this invention have Consolidation Indices of 3 or above. And the compositions of Examples 1-6, which are outside the scope of this invention, have Consolidation Indices less than 3 and are not suitable for the purposes of this invention.

TABLE 1

Example No.	1	2	3	4	5	6	7	8	9
Solution I									
ml/30 min	40	33.5	40	40	8	23	11	40	40
$CaCl_2$	5%	5%	5%	5%	5%	—	5%	5%	5%
HCl	—	—	—	—	—	2%	2%	2%	2%
Surfactant type	—	0.1% Ethomeen C/15	—	0.1% Ethomeen C/15	0.2% Sarkosyl LC	0.1% Ethomeen C/15	0.2% Ethomeen C/15	0.2% Sarkosyl LC	0.2% Tween 20
Solution II									
ml/30 min	6	4	12	8.5	7	13	10	16	22
sodium silicate	37%	37%	18.5%	18.5%	18.5%	18.5%	18.5%	18.5%	18.5%
Solution III									
ml/30 min 5% $CaCl_2$	<1	6	2	1	10	9	8	3	3
Consolidation Index	1	2	2	2	2	0	5	5	4

Examples 10-16

Similarly, the suitability of various aqueous drilling fluids for use in the method of this invention is determined by a modification of the Dolomite Consolidation Procedure. After the dolomite cake is saturated with the 3 weight percent sodium chloride solution, a 100 milliliter column of drilling fluid is poured onto the top of the dolomite cake and a vacuum is drawn on the bottom of the cake for 16 hours. If the drilling fluid drains quickly, another measured quantity of drilling fluid is added. At the end of 16 hours, any excess drilling fluid is carefully poured off and measured. Then the dolomite cake is contacted with the reactant solutions per the Dolomite Consolidation Procedure.

The compositions of the various aqueous drilling fluids and solutions I, II and III, and the corresponding Consolidation Indices, are presented in Table 2. The drilling fluids of Examples 10-14 are suitable for the method of this invention. However, the drilling fluids of Examples 15 and 16 are clearly unacceptable since they reduce the permeability of the dolomite to the subsequently injected reactant solutions.

TABLE 2

Example No.	10	11	12	13	14	15	16
Drilling Fluid							
Polymer	—	Super-X	Ben-EX	Natrasol HR250	CYPAN	XC-AL	SC-Polymer
lb/Bbl		1	0.5	1.5	2	1	1
Sluggit, lb/Bbl	10	10	10	10	10	10	10
ml/16 hr.	130	26	230	42	50	31	30
Solution I							
ml/30 min	6	13	40	40	40	<1	<1
$CaCl_2$	5%	5%	5%	5%	5%	5%	5%
HCl	2%	2%	2%	2%	2%	2%	2%
Surfactant	0.25%	0.2%	0.2%	0.25%	0.25%	0.25%	0.25%
type	HAI-75	HAI-75	HAI-75	HAI-75	HAI-75	HAI-75	HAI-75
Solution II							
ml/30 min 18.5% sodium silicate	9	5	11	10	22	3	3
Solution III							
ml/30 min 5% $CaCl_2$	4	<1	1	1	2	<1	2
Consolidation Index	4	4	5	5	4	0	0

XC-AL is a highly crosslinked heteropolysaccharide marketed by Xanco Oil Field Products
XC-polymer is a high molecular weight heteropolysaccharide marketed by Xanco Oil Field Products

While particular embodiments of the invention have been described, it will be understood, of course, that the invention is not limited thereto since many obvious modifications can be made, and it is intended to include within this invention any such modification as will fall within the scope of the appended claims.

Having now described the invention, we claim:

1. In a method for drilling a bore hole through a subterranean formation containing one or more zones of unconsolidated dolomite, the improvement which comprises the steps of:

(a) drilling a distance through said subterranean formation, thereby exposing a newly drilled portion of said formation;

(b) interrupting said drilling;

(c) introducing into said bore hole a sequence of discrete reactant slugs of substantially oil-free solutions comprised of (I) an aqueous solution containing a water-soluble acid, a water-soluble surface

active agent and a first water-soluble precipitating agent for silicates; (II) an aqueous solution containing a water-soluble silicate; and (III) an aqueous solution containing a second water-soluble precipitating agent for silicates;

(d) displacing each of said reactant slugs from said bore hole and into said newly drilled portion of said formation, wherein said reactant slugs become mixed;

(e) allowing said reactant slugs to react in said newly drilled portion of the formation, thereby forming a substantially impermeable, consolidated annular sheath about said bore hole; and

(f) resuming said drilling.

2. The method defined in claim 1 wherein said bore hole is drilled through said formation in a plurality of increments, each of said increments being drilled and consolidated by said steps (a) through (f).

3. The method defined in claim 1 wherein said zones containing unconsolidated dolomite are hydrothermally leached zones which are substantially free of quartz sand and clay.

4. The method defined in claim 1 wherein said first and second precipitating agents for silicate are water-soluble salts of multivalent cations which react with silicate to form a silicate gel.

5. The method defined in claim 1 wherein said first and second precipitating agents are selected from the group consisting of calcium chloride and iron chloride.

6. The method defined in claim 1 wherein said surface active agent is selected from the group consisting of surface active amines, alkyl sarcosines, n-alkyl trimethyl ammonium chlorides, sorbitan monolaurates, and mixtures thereof.

7. The method defined in claim 1 wherein said surface active agent is a corrosion inhibiting composition.

8. The method defined in claim 1 wherein said water-soluble acid is selected from the group consisting of organic and inorganic acids which form water-soluble salts with said first precipitating agent.

9. The method defined in claim 1 wherein said water-soluble acid is selected from the group consisting of hydrochloric, hydrofluoric, acetic and citric acids.

10. The method defined in claim 1 wherein a drilling fluid is circulated through said bore hole during the drilling step and wherein said reactant slugs are separated from each other and from said drilling fluid by slugs of an inert spacer liquid.

11. The method defined in claim 10 wherein said drilling fluid is circulated downwardly through a drill string disposed in said bore hole and upwardly through the annular space between said drill string and the walls of said bore hole, and wherein each of said reactant slugs are individually introduced into said bore hole and displaced into said newly drilled portion of said formation by the consecutive steps comprised of flowing said reactant slug downwardly through said drill string as said drill string is raised to a predetermined position, thereby forming a body of said reactant slug in the bottom of said bore hole; temporarily sealing said annular space; injecting a fluid spacer into said drill string while said drill string is maintained in said predetermined position, thereby displacing at least a portion of said reactant slug into said newly drilled portion of said formation; opening said annular space; lowering said drill string to a point near the bottom of said bore hole; and circulating a fluid spacer downwardly through said drill string to displace the remainder of said reactant slug upwardly through said annular space.

12. The method defined in claim 1 wherein said solutions I, II, and III are selected such that their Consolidation Index is at least 3.

13. In a method for drilling a bore hole through a subterranean formation containing one or more hydrothermally leached zones of unconsolidated dolomite overlying a geothermal reservoir, wherein a substantially oil- and clay-free drilling fluid is passed through the bore hole during the drilling operation, the improvement comprising the steps of:

(a) drilling a short distance through said subterranean formation, thereby exposing a newly drilled portion of the formation;

(b) interrupting said drilling operation;

(c) introducing into said bore hole a sequence of discrete reactant slugs of substantially oil-free solutions comprised of (I) an aqueous solution containing from 1 to 10 weight percent of a water-soluble acid selected from the group consisting of hydrochloric acid, hydrofluoric acid, acetic acid and citric acid, from 0.05 to 3 weight percent of a surface active agent selected from the group consisting of surface active amines, alkyl sarcosines, n-alkyl trimethyl ammonium chlorides, sorbitan monolaurates and mixtures thereof, and from 2 to 10 weight percent of a first precipitating agent selected from the group consisting of water-soluble multivalent cation salts of hydrochloric acid, hydrofluoric acid, acetic acid and citric acid; (II) an aqueous solution containing from 5 to 40 percent of a water-soluble, inorganic silicate selected from the group consisting of alkali metal and ammonium silicates; and (III) an aqueous solution containing from 2 to 10 weight percent of a second precipitating agent selected from the group consisting of the water-soluble multivalent cation salts of hydrochloric acid, hydrofluoric acid, acetic acid and citric acid, said sequence of said reactant slugs having a Consolidation Index of at least 4, and each of said reactant slugs being separated from each other and from said drilling fluid by slugs of an inert spacer liquid;

(d) sequentially displacing each of said reactant slugs from said bore hole into said newly drilled portion of the formation, wherein said slugs become mixed;

(e) allowing said reactant slugs to react in said newly drilled portion of the formation thereby forming a substantially impermeable, consolidated annular sheath about said bore hole; and

(f) repeating said steps a) through e).

14. The method defined in claim 13 wherein said short distance comprises between about 20 to about 100 feet.

15. The method defined in claim 13 wherein said first and second precipitating agents are selected from the group consisting of iron chloride and calcium chloride.

16. The method defined in claim 13 wherein said surface active agent is a corrosion inhibiting composition.

17. The method defined in claim 13 wherein said solution I comprises an aqueous solution containing about 5 weight percent calcium chloride, about 2 weight percent hydrochloric acid and between about 0.1 and 0.5 weight percent of an ethylene oxide condensation product of the primary fatty amines.

18. The method defined in claim 13 wherein said drilling fluid is circulated downwardly through a drill string disposed in said bore hole and upwardly through the annular space between said drill string and the walls of said bore hole, and wherein each of said reactant slugs are individually introduced into said bore hole and displaced into said newly drilled portion of said formation by the consecutive steps comprised of flowing said reactant slug downwardly through said drill string as said drill string is raised to a predetermined position, thereby forming a body of said reactant slug in the bottom of said bore hole; temporarily sealing said annular space; injecting a fluid spacer into said drill string while said drill string is maintained in said predetermined position, thereby displacing at least a portion of said reactant slug into said newly drilled portion of said formation; opening said annular space; lowering said drill string to a point near the bottom of said bore hole; and circulating a fluid spacer downwardly through said drill string to displace the remainder of said reactant slug upwardly through said annular space.

* * * * *

Russ Osborne - 303-986-5563
Mining Corporation, Inc.
part of Noranda group
12981
West Colfax
Lakewood, Co 80228
wants to quote on stabilizing

Mr. Strindberg
brought this
down for you...
11/18/80

JRS -

I don't think we would want part of the Noranda group butting on our exploration projects.

We are looking for some one on the could do 3,000 feet of tunnel work that might be 2x diamond drill costs — say total tunnel costs - 3,000 x 80/ft - $240,000
Can you import some Mexican miners to us?

Kurt

Cell file Dullos

ASARCO

RECEIVED

NOV 30 1979

EXPLORATION DEPARTMENT

Northwestern Exploration Division
John C. Balla
Manager

November 27, 1979

Mr. W.L. Kurtz, Manager
Western U.S.A.
ASARCO Incorporated
P.O. Box 5747
Tucson, AZ 85703

Hydra-Wink Drill
Rock Creek Project
Sanders County, Montana

Dear Sir:

We have decided that the initial drilling in the east fork of the Bull River area (behind the north outcrop of the Rock Creek deposit) should be done with a hydra wink drill. To those who might not be familiar with it, I am attaching a brochure on the drill, and a similar one on Exploration Services Corporation, a Spokane based company owned by John Erfurth and a former ASARCO geologist (northwest division, 1969-1973). Mr. Erfurth would be the likely candidate for the job.

Very truly yours,

John C Balla

John C. Balla

JCB/dt
Enclosure

cc: T.C. Osborne with enclosure
D.M. Smith " "

Note to WLK: Bill, pass this on to Fred Graybeal.

WINK INTERNATIONAL EXPLORATION DRILLING LTD.

ARE PLEASED TO INTRODUCE THE ALL NEW

'HYDRA-WINK'

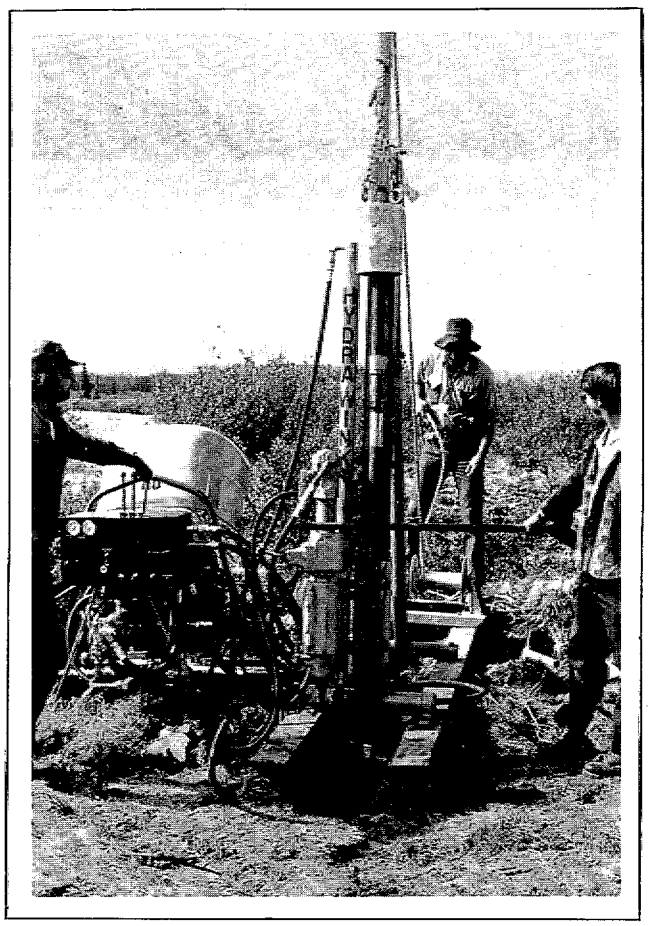
CANADA'S NEWEST DRILLING MACHINE
"Made by Drillers for the Drillers, in the Drilling Industry"

Wink International Exploration Drilling Ltd.

CONTRACTORS—CONSULTANTS
Manufacturer of the HYDRA-WINK DRILLS

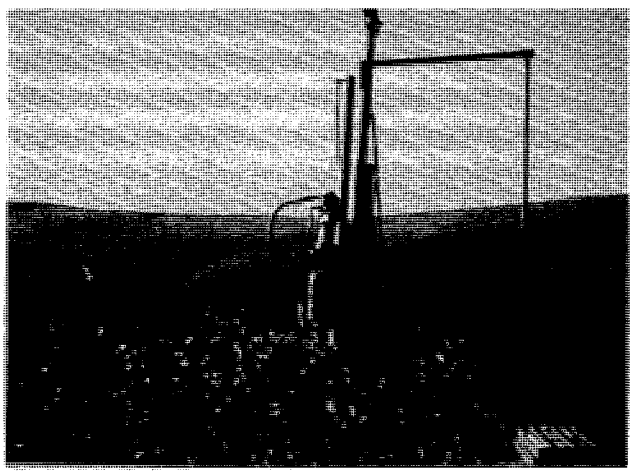
12511 #2 Road,
Richmond, British Columbia
Canada
Postal Code V7E 2G3

Telephone (Area Code 604) 271-7117
(Cable) "Winkie"



Soil Testing with a Hydra-Wink

Loading Hydra-Wink into Otter Aircraft



Hydra-Wink at work in Alaska

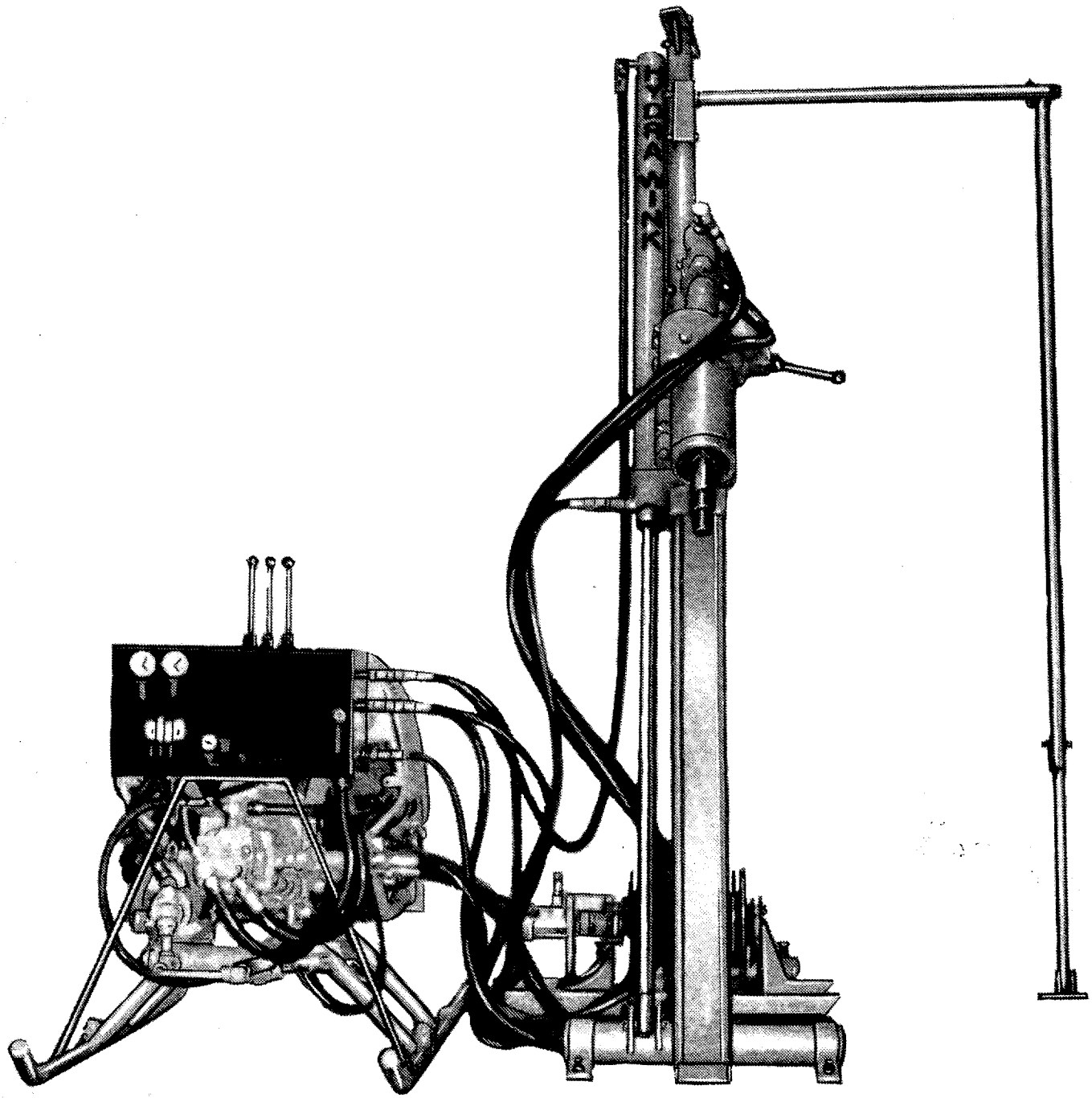
Wink International Exploration Drilling Ltd. are pleased to introduce the all new "Hydra-Wink" — Canada's newest drilling machine.

"Made by Drillers, for Drillers,
in the Drilling Industry."

The design is the key to outstanding core drill performance. The "Hydra-Wink" **three in one drill** is designed for surface and underground wire line drilling and soil testing.

Optional Powers include Gasoline or Diesel Engines, Air or Electric Motors.

The Hydra-Wink requires less spare parts; no sprockets, no drive chains, no chuck and no clutch. All of the troublesome parts were eliminated to give you a simple and trouble free drilling unit.



HYDRA-WINK SPECIFICATIONS

Engine:
Volkswagen Industrial air cooled with magneto hand crank start (12 Volt electric start available).Horsepower rating: 53 SAE—47 DIN.

Hydraulic Motor:
Piston type, Torque, 60 ft./lbs. at 2500 P.S.I.

Hydraulic Pumps — Series 18 Sundstrand:
Variable volume piston pump, 2.3 cu.in. per rev.

The Series 18 sundstrand variable volume pump and the Series 18 Sundstrand motor make up the hydrostatic drive that provides infinite speed control of the drill head.

— Series 15 Sundstrand:
The Series 15 Sundstrand pump is variable volume and pressure compensated. This pump provides power to operate the feed cylinder and hydraulic winch.

Transmission:
Industrial type, 4 forward speeds, one reverse.

Gear	Ratio	R.P.M.
1st	6.8:1	0-500
2nd	3.3:1	1-1640
3rd	1.8:1	0-1900
4th	1:1.05	0-3500

Reversible in all gears.

Drill Mast:
Square tubing with round tubing cross member. All welded construction. Single telescopic support leg. Top mounted wire line sheave wheel.

Drill Head:
Hinged pinned, spindle drive, two roller bearings, each capable of 48,000 lb. load. Complete head, 7" diameter, 12" long.

Integral Water Swivel:
Chevron packing.

Feed Cylinder:

Bore:	2½"
Stroke:	70"
Pull:	12,250 lbs.
Thrust:	6,250 lbs. at 2500 P.S.I.

Hydra-Wink Drill Dimensions:

Width:	2 ft.
Length:	7 ft. 11 in.
Weight approx.:	650 lbs.

Hydraulic Control Panel Dimensions:

Width:	33"
Length:	73"
Height:	40"
Weight approx.:	545 lbs.

Rod Puller:
Ball type rod puller, fits into head.

Rod Holder:
Ball type, sits on top of casing T.

Wireline Winch:
Reversible hydraulic motor driven.
Drum capacity: 1,000 ft., 3/16" wire rope.
R.P.M. 0-180 at 15 gal. per min.
Weight: 109 lbs.

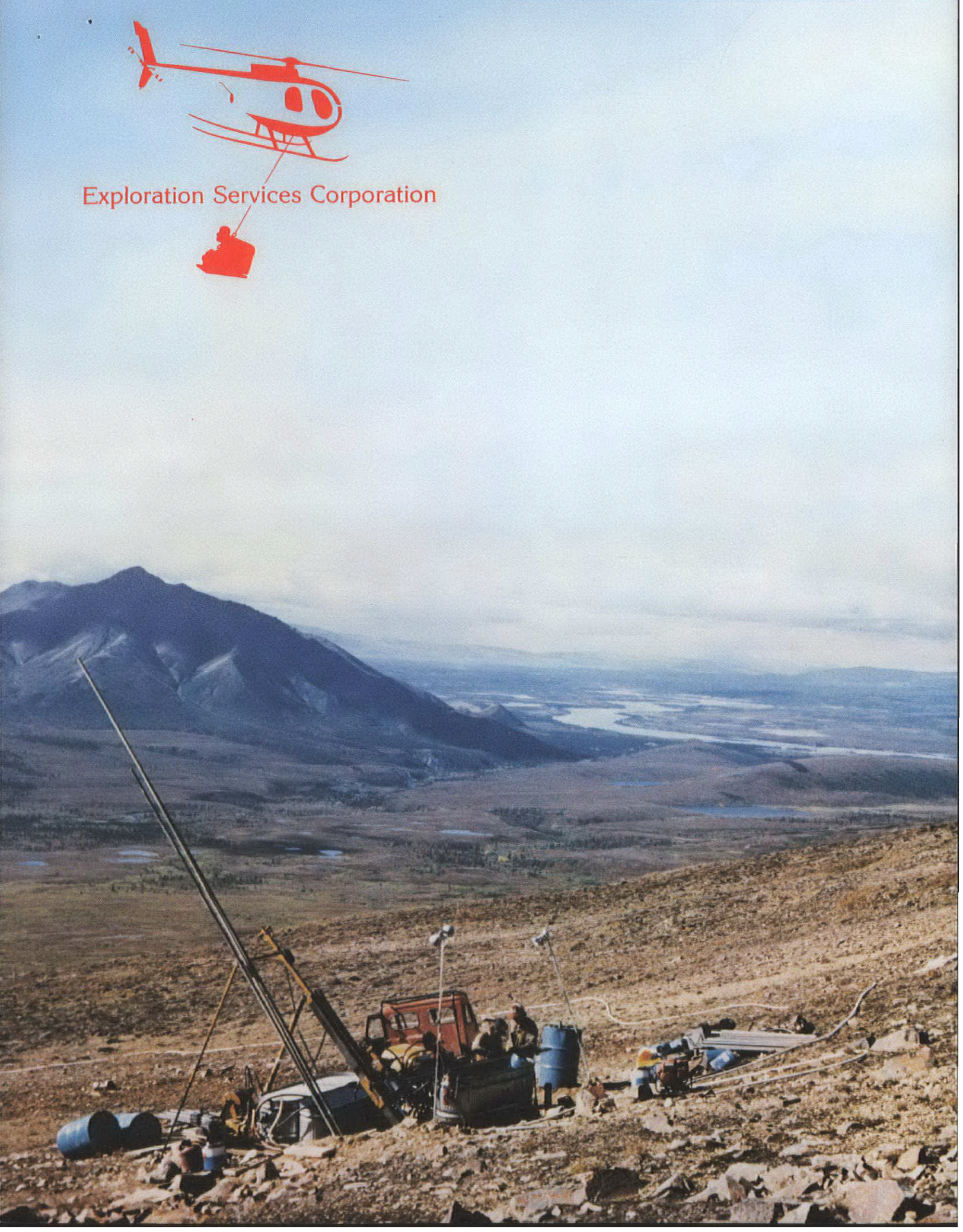
Rated Drilling Capacities:

Size	Core Diameter	Hole Diameter	Depth
AQ	1-1/16"	1-57/64"	1000 ft.
BQ	1-7/16"	2-23/64"	550 ft. -700'
NQ	1-7/8"	2-63/64"	300 ft.

Augering Capacity:
3" diameter hole 250 ft.
6" diameter hole 100 ft.

PRINTED IN CANADA

Exploration Services Corporation



Exploration Services Corporation

Providing Exploration Support to the Mining Industry

DIAMOND CORE DRILLING
Utilizing The Hydra-Wink Diamond Core Drill

1. Surface and underground wireline drilling
2. Soil sampling
3. Helicopter supported difficult and remote access programs
4. Fast set up and tear down
5. Minimal environmental impact for drill site
6. Low down time, reliable hydraulic power
7. Equipment portable by 3/4 T. 4 x 4 truck
8. Projects supplied by aerial support

Helicopter portable

High altitude drill site

Winter operation

GEOLOGICAL CONSULTING
Registered Professional Geologists

1. Mineral property evaluation and management
2. Detail and reconnaissance mapping - report and map preparation.
3. Geophysical, radiometric and geochemical sampling programs
4. Environmental impact statements

CLAIM STAKING

1. Property acquisition and searches
2. State and federal compliances
3. State leases
4. Assessment work

Remote program logistics

Complete camp and logistical support

'HYDRA-WINK' Specifications:

The Hydra-Wink diamond core drill has incorporated features and capabilities of larger drills at the same time allowing the ease of portability by light truck or helicopter. The hydraulic power system commands a wide range of speeds and head pressures for variable geologic conditions and changes in diamond bit types. The elimination of gears, sprockets, chucks and clutches has lessened chance of breakdown and greatly lowered down time for maintenance. Surface and underground wireline drilling is accomplished from positive, negative or horizontal angles, delivering N, B and A size core to 1000 feet.

Engine:

Volkswagen Industrial air cooled with magneto hand crank start (12 Volt electric start available). Horsepower rating: 53 DAE—47 DIN.

Hydraulic Motor:

Piston type, Torque, 60 ft.1lbs. at 2500 P.S.I.

Hydraulic Pumps—Series 18 Sundstrand:

Variable volume piston pump, 2.3 cu.in. per rev.
The Series 18 Sundstrand variable volume pump and the Series 18 Sundstrand motor make up the hydrostatic that provide infinite speed control of the drill head.

—Series 15 Sundstrand:

The Series 15 Sundstrand pump is variable volume and pressure compensated. This pump provides power to operate the feed cylinder and hydraulic winch.

Transmission:

Industrial type, 4 forward speeds, one reverse.

Gear	Ratio	R.P.M.
1st	6.8.1	0-500
2nd	3.3.1	1-1640
3rd	1.8.1	0-1900
4th	1:1.05	0-3500

Reversible in all gears.

Drill Mast:

Square tubing with round tubing cross member.
All welded construction. Single telescopic support leg. Top mounted wire line sheave wheel.

Drill Head:

Hinged pinned, spindle drive, two roller bearings, each capable of 48,000 lb. load. Complete head, 7"diameter, 12" long.

Water Pumps:

Bean EO4,104 AMD
AOE Series pumps

Integral Water Swivel:

Chevron packing.

Feed Cylinder:

Bore: 2 1/2"
Stroke: 70"
Pull: 12.250 lbs.
Thrust: 6,250 lbs. at 2500 P.S.I.

Hydra-Wink Drill Dimensions:

Width: 2 ft.
Length: 7 ft. 11in.
Weight approx.: 650 lbs.

Hydraulic Control Panel Dimensions:

Width: 33"
Length: 73"
Height: 40"
Weight approx.: 545 lbs.

Rod Puller:

Ball type rod puller, fits into head.

Rod Holder:

Ball type, sits on top of casing T.

Wireline Winch:

Reversible hydraulic motor driven.
Drum capacity: 1,000 ft., 3/16" wire rope.
R.P.M. 0-180 at 15 gal. per min.
Weight: 109 lbs.

Rated Drilling Capacities:

Size	Core Diameter	Hole Diameter	Depth
AQ	1-1/16"	1-57/64"	1000 ft.
BQ	1-7/16"	2-23/64	700 ft.
NQ	1-7/8"	2-63/64"	300 ft.

Augering Capacity:

3" diameter hole 250 ft.
6" diameter hole 100 ft.

Designed and Printed by
KROMA INTERNATIONAL GRAPHICS CENTER, SPOKANE, WASHINGTON, USA

ASARCO RECEIVED OCT 31 1979

Exploration Department
Western USA

October 29, 1979

J. C. B.
NOV 2 1979

RECEIVED
NOV 2 1979
SPOKANE

Jo NPW 11/9/79

D. M. Smith, Jr.
Denver Office

I am circulating the attached report on plugging abandoned drill holes by Baroid for your general information.

Please forward to John Balla, who should return it to Tucson for permanent filing.

W. L. Kurtz/lb

W. L. Kurtz

WLK:lb
Att.

cc: JCBalla
NPWhaley
HGKreis

C.J.: Please mail to J.C.B. in Spokane

D.M.S. Jr.
10/31/79

RECEIVED
NOV 15 1979
EXPLORATION DEPARTMENT

ASARCO

Southwestern Exploration Division

January 24, 1979

file?

TO: J. D. Sell
R. B. Crist
B. J. Devere
G. W. Pickard
G. J. Stathis
H. G. Kreis
S. R. Davis
N. P. Whaley
P. G. Vikre
T. C. Benavidez
H. M. Stone

Drilling Project Flowsheet

Mr. N. P. Whaley and I have prepared the attached outline of steps to be taken during management of a drilling project. The steps are self-explanatory, but please review them and any questions you might have may be brought up during an in-house meeting I am planning in early February. Those who have not made a monthly cost estimate, checked contractor invoices, or written a monthly or final report should first check with Lois and review various examples in the files if there are any problems on how to proceed.

The flow sheet is set up to free Mr. Whaley from the dozens of daily details in all our various drilling projects which are more logically handled by the project geologist. You might use it as a check list and cross off steps as they are completed, making it easy for someone to pick up a project at somé interim stage and carry it to completion. Several of the steps can be easily handled by Messrs. Stone, Benavidez, or Wood but geologists should see me first to determine whether additional help will be available.

F. T. Graybeal

F. T. Graybeal

FTG:lb
Atts.

cc: WLKurtz - w/atts.

DRILLING PROJECT FLOWSHEET

The various steps in a drilling project are listed below in approximate sequential order and not all steps may be applicable to a specific project. N.P.Whaley is responsible for obtaining drill contractors; R.B.Crist is responsible for all road permits and land owner notifications; the project geologist is responsible for the remainder, including tabulating progress by himself and others on the flowsheet, and keeping everyone informed. F.T. Graybeal will assign geological technicians who can expedite certain steps with instructions from the geologist. Stay organized and flexible.

1. Land status reviewed with geologist, F.T.Graybeal, and R.B.Crist; timing established for permits and road work (at least 2 months before drilling when possible).

2. Bids solicited by N.P.Whaley
   a) contractor needs location (state), minimum footage, drilling requirements (hole size, etc.), water source, and starting date
   b) rotary casing inventory and diamond bit for rotary spot cores maintained by N.P.Whaley
   c) sample material inventory maintained by N.P.Whaley and monitored by geologists.

3. Drill contractor selected by F.T.Graybeal-N.P.Whaley; purchase order written by N.P.Whaley; drill authorization request written by F.T.Graybeal.

4. Drill site located on ground and roads flagged by geologist.

5. Road permit applications filed by R.B.Crist.

6. Road contractor obtained by geologist; may need different contractor for rotary vs. diamond drill sites
   a) purchase order number for construction/reclamation obtained by geologist.

7. Road and drill site reviewed with U.S.F.S., state/federal government, patent land owner (where necessary), road contractor, and geologist; permission to build gates, separate disposal of drilling mud, sanitations arranged.

8. Road permit permission received by R.B.Crist.

9. Road contractor mobilized to build site and road.

10. Water source and cost confirmed by geologist.

11. Sample materials (trailer if required) moved on site by geologist (see attached list).

12. Rotary casing moved to site (arranged by geologist, consult with N.P.Whaley).

13. Diamond bit for rotary spot cores obtained from N.P.Whaley and moved on site by geologist.

14. Fire-fighting equipment in working order and on site (geologist).

15. Name and phone of project geologist given to drill contractor.

16. Drill moved on site by geologist with letter of personnel authorized to see the core.

17. Sample procedures clearly outlined to driller with initial close supervision.

18. Drill core and shift reports collected weekly; reports checked for accuracy/legibility on site
    a) spot checks on core recovery, proper handling of core made on site.

19. Monthly cost estimate made by geologist
    a) drill costs calculated from shift reports and contract (two summary forms attached; take your pick)
    b) cost estimate to Lois Bormolini by 27th of month (see attached forms)
    c) monthly contractor invoices carefully checked and signed by geologist, forwarded to F.T.Graybeal.

20. Monthly report of drilling progress, assays, etc. by geologist (by 27th of month).

21. Down-the-hole survey scheduled by geologist before hole terminated (if required, allow several weeks).

22. Hole terminated by geologist; contractor headquarters notified
    a) site cleaned by drill crew
    b) hole plugged/capped/concealed/abandoned (whichever necessary)
    c) survey of collar location.

23. All equipment cleaned, stored
    a) list of <u>all sample materials</u> and rotary casing used compiled by geologist and given to N.P.Whaley
    b) rotary diamond bit returned to N.P.Whaley
    c) fire-fighting equipment reconditioned if necessary.

24. Final report on drilling by geologist; should include cost summary.

25. Drill hole record sheet completed (see attached form); shift reports filed.

26. Geologist notify R.B.Crist when drilling complete -- all property owners notified where required.

27. Site reclaimed; road contractor notified by geologist; seeded by technician if advisable or required.

SOUTHWESTERN EXPLORATION DIVISION

26th _____ thru
25th _____, 197___

MONTHLY COST SUMMARY

_____ Project, _____, _____.
(County) (State)

A. DIRECT DRILLING (Acct. 521-)

CONTRACTORS' CHARGES

Invoiced during month covering current month's work

Contractors' Services	Statement Amt.	

Estimated balance of contractors' charges covering work through end of current month

Contractors' Services	Estimated Cost	

Supplies and Freight

Field Trailer Rental _____

Water Purchases (Drilling) _____

B. SITE PREPARATION (Acct. 580-)

CONTRACTORS' CHARGES

Invoiced during month covering current month's work

Contractors' Services	Statement Amt.	

Estimated balance of contractors' charges covering work through end of current month

Contractors' Services	Estimated Cost	

Supplies and Freight

C. SAMPLERS, SAMPLING, SAMPLE PREPARATION, ASSAYING (Acct. 540-)

Wages (Temporary Help)

Name	No. of Straight Time Hours During Month	No. of Overtime Hours During Month	

Assaying

Assayer	Charge or Estimated Expense for Assaying Performed During Month	

D. CLAIM STAKING, VALIDATION (Acct. 507-)

Invoiced during month covering current month's work

Contractors' Services	Statement Amt.	

Estimated balance of contractors' charges covering work through end of current month

Contractors' Services	Estimated Cost	

Wages

Name	No. of Straight Time Hours During Month	No. of Overtime Hours During Month	

E. OTHER (Itemize any other major expenses not covered above or by invoice.)

Item	Cost	

26th _____ thru
25th _____ 197__

PROJECT _____

HOLE NO._____ CONTRACTOR _____

I. Footage:

_____ $ _____
_____ $ _____
_____ $ _____
_____ $ _____

Sub-Total = $

II. Rig Time:

a) Cementing _____ $ _____
b) Conditioning _____ $ _____
c) _____ $ _____
d) _____ $ _____

Sub-Total = $

III. Materials:

_____ @ $ _____ $ _____
_____ @ $ _____ $ _____
_____ @ $ _____ $ _____
_____ @ $ _____ $ _____
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_____ @ $ _____ $ _____
_____ @ $ _____ $ _____

Sub-Total = $

IV. Water:

a) Truck Rental _____ $ _____
b) Mileage _____ $ _____
c) Water _____ $ _____

Sub-Total = $

V. Miscellaneous:

a) _____ $ _____
b) _____ $ _____
c) _____ $ _____

Sub-Total = $

Total for Period = $ _____

HOLE _____ PROJECT _____ 26th: _____ THRU 25th _____, 19 ____ CONTRACTOR _____

DESCRIPTION: _____

	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	TOTAL	PRICE	AMOUNT
FEET DRILLED																																		
																																SUB TOTAL		
CEMENTING																																		
CONDITIONING																																		
CASING																																		
																																SUB TOTAL		
MATERIALS																																		
																																SUB TOTAL		
TRUCK RENTAL																																		
MILEAGE																																		
LOADS OF WATER																																		
																																SUB TOTAL		
MISC.																																		
																																SUB TOTAL		

TOTAL _____

mc 3031

DRILLING PROJECT CHECK LIST

Equipment - Supplies:

Trailer . . . . . _____
SEPOR splitters . . . . . _____
Wash tubs . . . . . _____
Cloth sample bags . . . . . _____
Plastic sample bags . . . . . _____
Wire ties . . . . . _____
Markers (water proof) . . . . . _____
Markers (Sharpies). . . . . _____
Tags (white). . . . . _____
Tags (yellow) . . . . . _____
Stamp (hole No. & depths) . . . . . _____
Stamp (American Analytical...). . . . . _____
Burlap bags . . . . . _____
Gold pans . . . . . _____
Scales. . . . . _____
Bailing wire. . . . . _____
Pliers w/wire cutters . . . . . _____
Pallets . . . . . _____
Plastic vials . . . . . _____
BX core boxes . . . . . _____
Ball point pens . . . . . _____
Carbon paper. . . . . _____
White envelopes . . . . . _____
Manila envelopes (large). . . . . _____
Forms:
a) Drill Hole Summary. . . . . _____
b) Asarco Rotary Drill Shift . . . . . _____
c) Monthly Cost Summary. . . . . _____
d) Drilling Time-Hrs.-Per Diem-Assay Chgs. . . . . _____
e) Asarco Sample Shipments . . . . . _____
f) American Analytical Assay Forms . . . . . _____
g) List of holes, depths, etc. . . . . _____
Plastic containers (Pails). . . . . _____
Flagging. . . . . _____
Lath. . . . . _____
Grade Stakes. . . . . _____
. . . . . _____
. . . . . _____
. . . . . _____
. . . . . _____
. . . . . _____

DRILL HOLE RECORD

HOLE NUMBER _____

HOLE DESIGNATION: _____ RECORD DATE: _____ 19 _____ BY _____

LOCATION: PROJECT (?) _____

COUNTY _____ STATE _____

HOLE DESCRIPTION:

FINAL T.D. _____ FT.

MODE		DEPTHS
a.) ROTARY	☐	FROM _____ TO _____ FT.
b.) DIAMOND	☐	FROM _____ TO _____ FT.
c.) VERTICAL	☐	
d.) ANGLE	☐	BEARING _____ INCLINATION _____

DRILLING HISTORY:

a.) ROTARY: CONTRACTOR _____

OPEN ☐	CASED ☐	SIZE (ID)
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.
FROM _____ TO _____ FT.	FROM _____ TO _____ FT.	_____ INS.

TERMINATED ☐. LOST ☐ REASON _____

DATES _____ 19 _____ TO _____ 19 _____

b.) DIAMOND: CONTRACTOR _____

FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____

TERMINATED ☐. LOST ☐ REASON _____

DATES _____ 19 _____ TO _____ 19 _____

c.) HARDWARE LEFT IN HOLE (CASING, TOOLS, ETC.):

FROM _____ TO _____ FT.	SIZE _____
FROM _____ TO _____ FT.	SIZE _____

OTHER _____

d.) DIRECTIONAL SURVEY YES ☐ NO ☐ _____

e.) NATURAL WATER ENCOUNTERED _____ IF SO, DEPTH(S) _____ AND NATURE IF KNOWN _____

REMARKS: _____

copy FTG 8/29/79

ASARCO

Southwestern Exploration Division

August 23, 1979

TO: W. L. Kurtz

FROM: N. P. Whaley

Down-Hole Hammer Drill with
Angle-Hole Capabilities, Formerly
Owned by Hank Avery Drilling Company

H. C. Avery, Jr. is no longer in the drilling business, and the crawler-mounted BEETLE drill has been sold.

It is now owned and operated by Polar Resources of Elko, Nevada [(702)-738-8712]. C. Warren Hunt is president of Polar Resources and states that the drill is operating and, when not on a job, available for contract drilling services.

It should complete the job it is now on ca. the end of October. This is their first year with this drill in contract work, and Hunt states that their rates are "very competitive" to develop a clientele.

You may know of Polar Resources; I do not. They appear to be involved in mining-promotional and geoscience service operations. Would a conflict-of-interests question be in order?

N. P. Whaley

N. P. Whaley

NPW:lb

Good idea

ASARCO

Southwestern Exploration Division

August 14, 1979

TO: N. P. Whaley

FROM: F. T. Graybeal

Spot core capability of air hammer rigs

Please investigate the possibility of obtaining short (2'-5') spot core samples using our various air hammer drill contractors. Problems at LAU and Portland led both G.J.Stathis and S.R.Davis to consider the possibility of extensive sample dilution caused by the heavy flow of water washing material from shallower portions of the hole. Both have suggested that several short spot core samples from wet zones would provide a better indication of dilution than visual estimates of rock type mixing as seen in vials. I realize this will require a pump and possibly some type of water tank (preferable to a standby mud pit) and that Asarco might be required to furnish the bit and the barrel. It would be useful to determine which air hammer contractors now provide all the required equipment.

F. T. Graybeal

F. T. Graybeal

FTG:lb

cc: WLKurtz ✓
GJStathis
SRDavis
PGVikre

~~DTS~~/ DPC
9-14-78
NPW

Air Mail

September 12, 1978

Mr. J. Middlin
General Manager
Mount Isa Mines Limited
Mount Isa, Queensland 4825, Australia

Dear Mr. Middlin:

During my visit to Mount Isa last April I recall that someone on your geological staff mentioned that you had been using Dynadrill equipment with considerable success in controlling and intentionally deflecting deep surface diamond drill holes.

We plan some deep drilling next year in the U.S., and would like to consider use of the Dynadrill for planned deflections. We are more or less aware of its capabilities as claimed, but we have no direct experience with it. It would therefore be much appreciated if someone on your staff familiar with your use of it could write me with some details of MIM's experience in deflecting drill holes with the device. Please don't have anyone go to too much trouble or prepare anything elaborate, we will be happy with some basic data and an opinion.

With best regards,

Very truly yours,

Original Signed By
T. C. Osborne

T. C. Osborne

cc: Mr. E. M. Bennett
Carpentaria Exploration Company Pty. Ltd.

bcc: RLHennebach
WLKurtz

RECEIVED
SEP 14 1978
EXPLORATION DEPT.

:M

S. J. (STAN) BALDWIN
MECHANICAL SUPERINTENDENT – DIAMOND DRILLING
CANADIAN MINE SERVICES LTD.

bsidiary Companies:
NADIAN MINE ENTERPRISES LTD.
MERON McMYNN CONTRACTING LTD.
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8020 - 128th Street
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Canada V3W 4E9
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Telex: 043-51188
Res: 584-7552

1977 Apr 25/77.

EXPL. DIV.

WK file
Drilling

Finally got the brochures together & time to send them. Hope they are of some help to you to explain the Super Drill. Have a new brochure on the company coming out soon.

Regards.
Stan Baldwin

→ 1/LK –

As shown on page 4 of the white brochure, they have been very successful at Lakeshore & Miami East underground. Earl Anderson, geologist M-E, has nothing but good words for these people. I understand from J. Kelly that he is pleased with their work from the decline underground the Twin Cities pit.

Possible use UG at Lacaster?

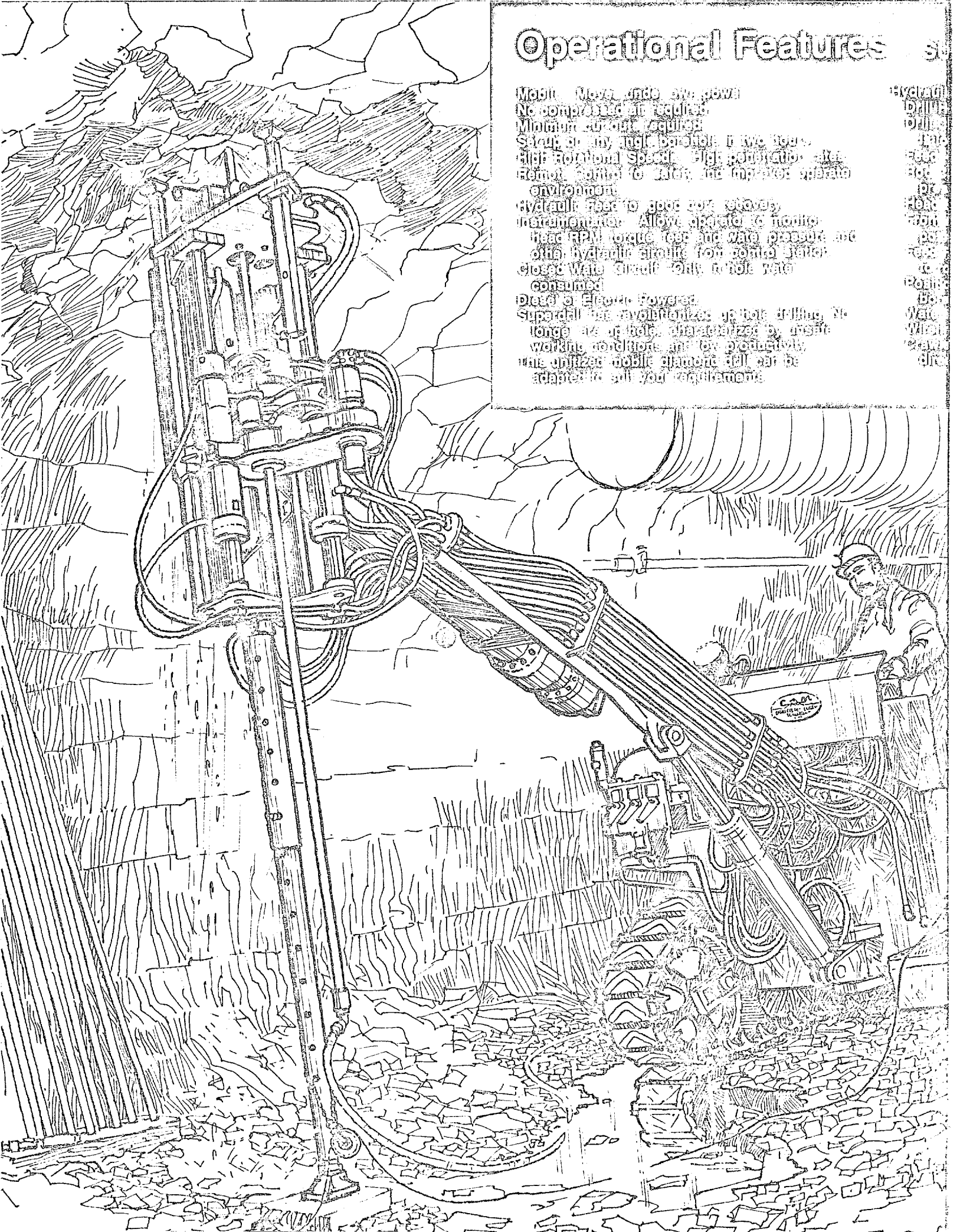
Jim

Copy to [illegible]

SUPERDRILL
MARK II

MOBILITY & MECHANIZATION
CONTRIBUTE TO :

Increased production
Reduced moving time
Easier setting
Centralized remote control
Reduced operator fatigue
Greater safety
More efficient power utilization



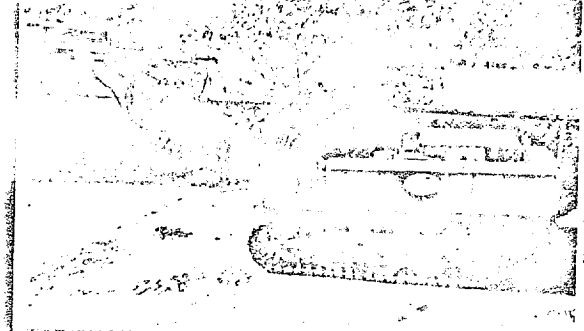
Operational Features

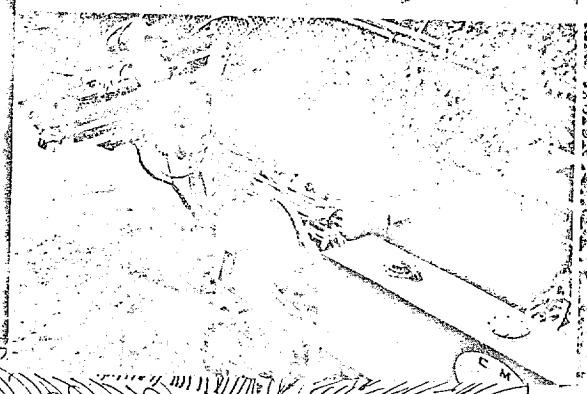
Mobil - Move and set down
No compressed air required
Minimum set-out equipment
Single or two man bandit, two boys
High rotational speed - High penetration rate
Remote control to keep the operator separate environment
Hydraulic feed to pipe and shaver
Instrumentation - Allows operator to monitor feed RPM, torque, rod and water pressure and other hydraulic circuits from control panel
Stores water circuit only to hole with consumed
Diesel or Electric Powered
Superdrill has revolutionized uphole drilling. No longer are uphole characterized by unsafe working conditions and low productivity.
The utilized mobil diamond drill can be adapted to all your requirements

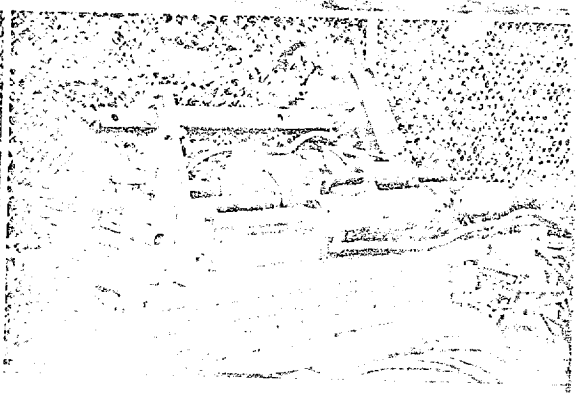
PERDRILL MODEL [illegible]

Power [illegible] following [illegible]
[illegible] Infinite RPM control
[illegible] Rotating grip [illegible] hydraulic [illegible]

[illegible] variable [illegible] control
[illegible] Rotating [illegible] hydraulic
[illegible] lost
[illegible] adjustable [illegible]
[illegible] Rear Stabilizers [illegible]
[illegible]
[illegible] Extension [illegible]
[illegible]
[illegible] Boom [illegible]
[illegible]
[illegible] Infinite control [illegible]
[illegible] Variable speed
[illegible] Variable speed [illegible]
[illegible]







High-Speed Drill Head
Hydraulic Chuck
Rod Clamp
Positioner Boom
Feed Frame
Front Stabilizers
Rear Stabilizer
Water Pump
Wire Line Winch
Crawler Vehicle
Control Station
Outrigger
Double Truck Chassis
Chassis Separation Point
Hydraulic Pump Group
75 h.p. Electric Motor
Power Cable
Water Line

SUPERDI

A product of Cana

DOMESTIC AND FOREIGN PATENTS APPLIED FOR

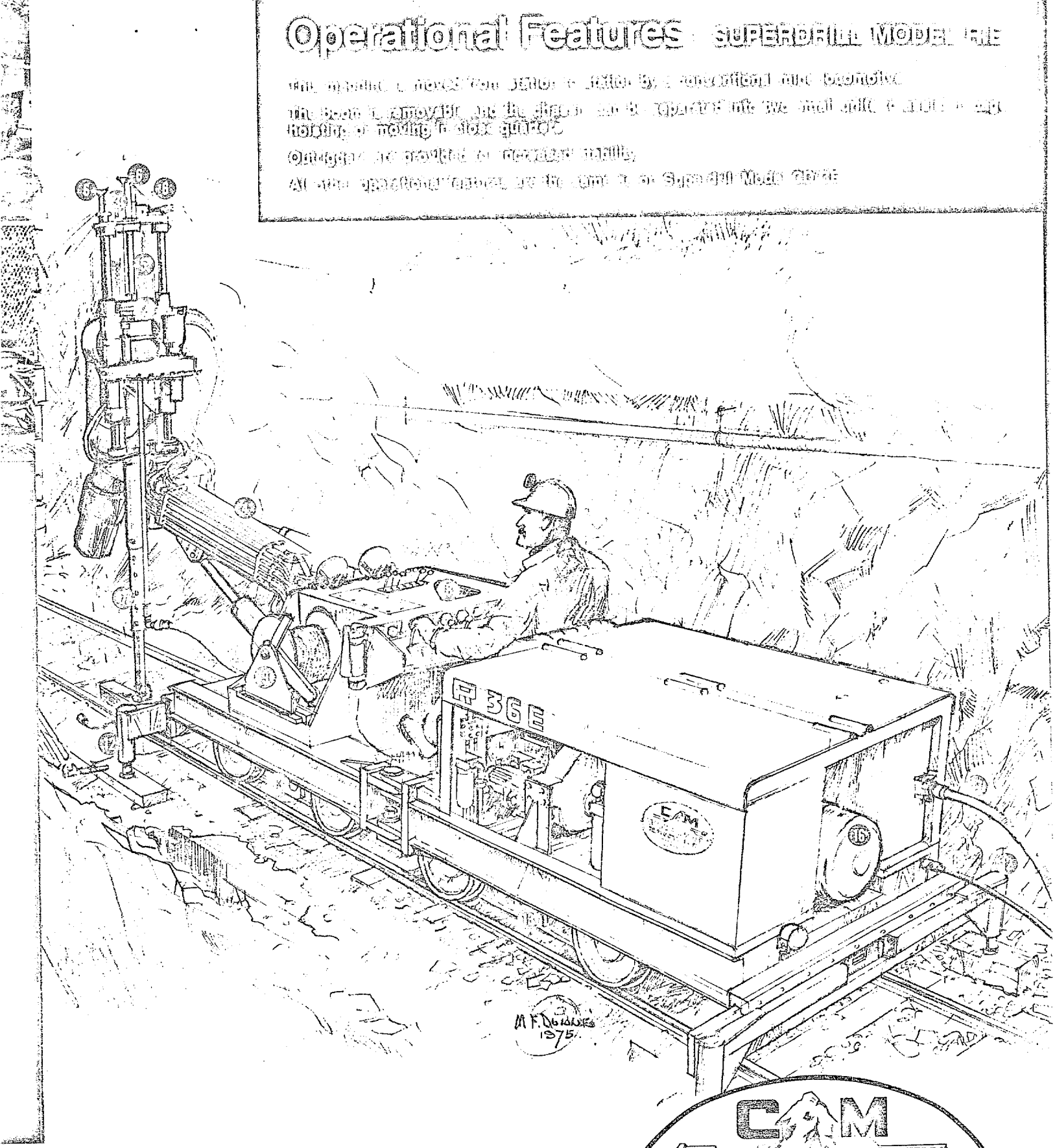
Operational Features SUPERDRILL MODEL [illegible]

[illegible] more [illegible] by [illegible] locomotive.

[illegible] operate [illegible] and [illegible] hoisting or moving [illegible] gantry.

Outriggers are provided to increase stability.

All other operational features are the same as Superdrill Model [illegible]

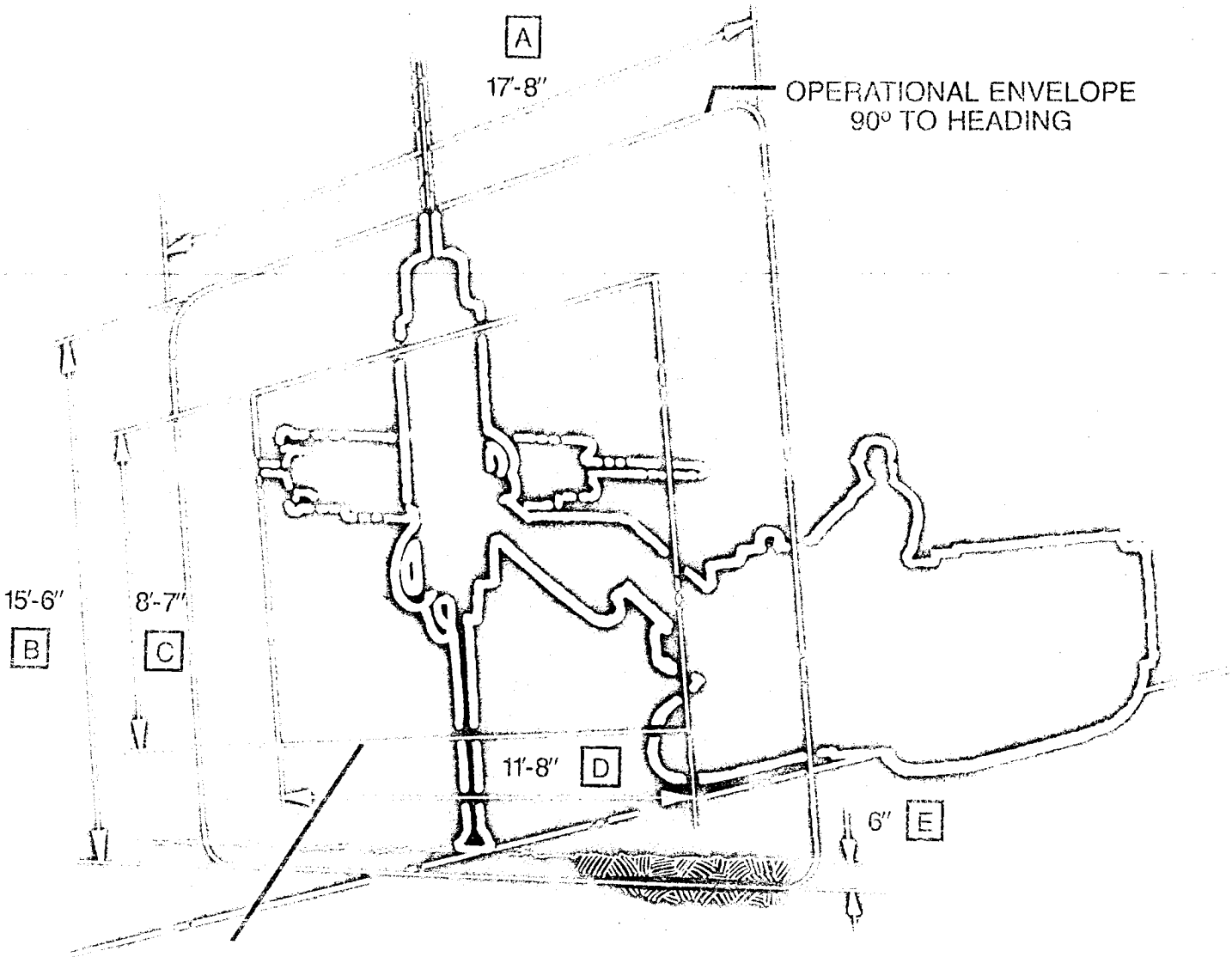


DRILL MARK II

nadian Mine Services Ltd.

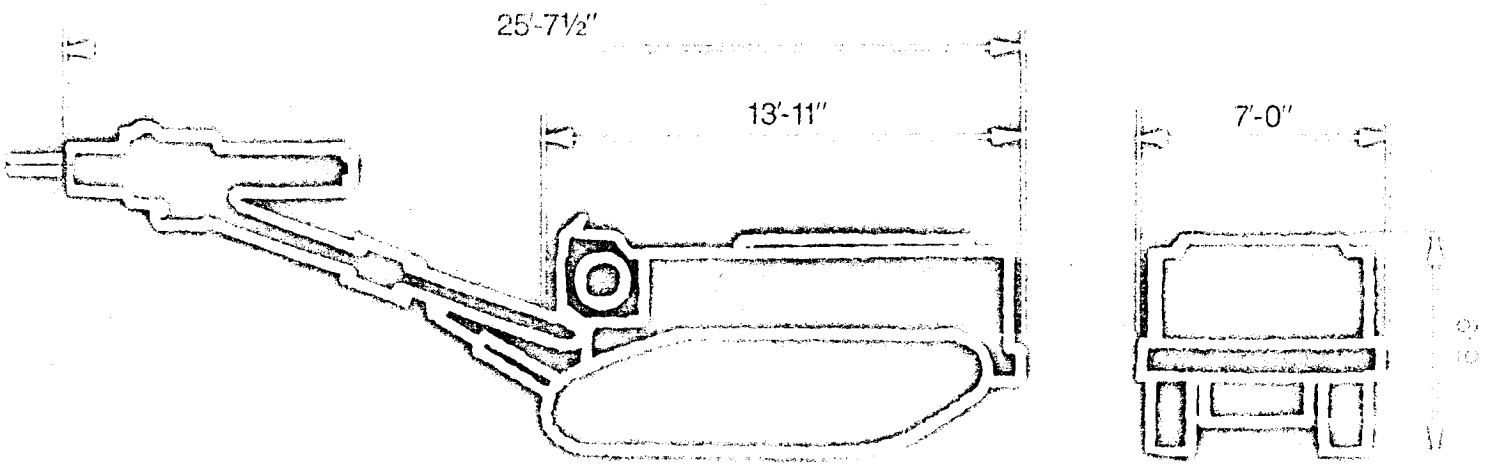
D FOR

CAM
CANADIAN MINE SERVICES LTD.

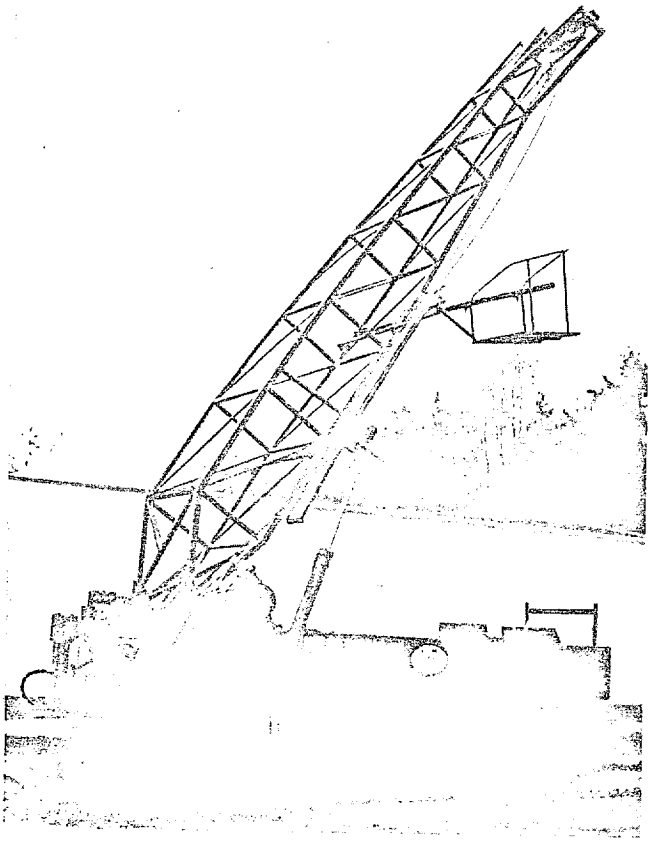


DIMENSIONS FOR MODEL R.E.
RAIL MOUNTED SUPERDRILL

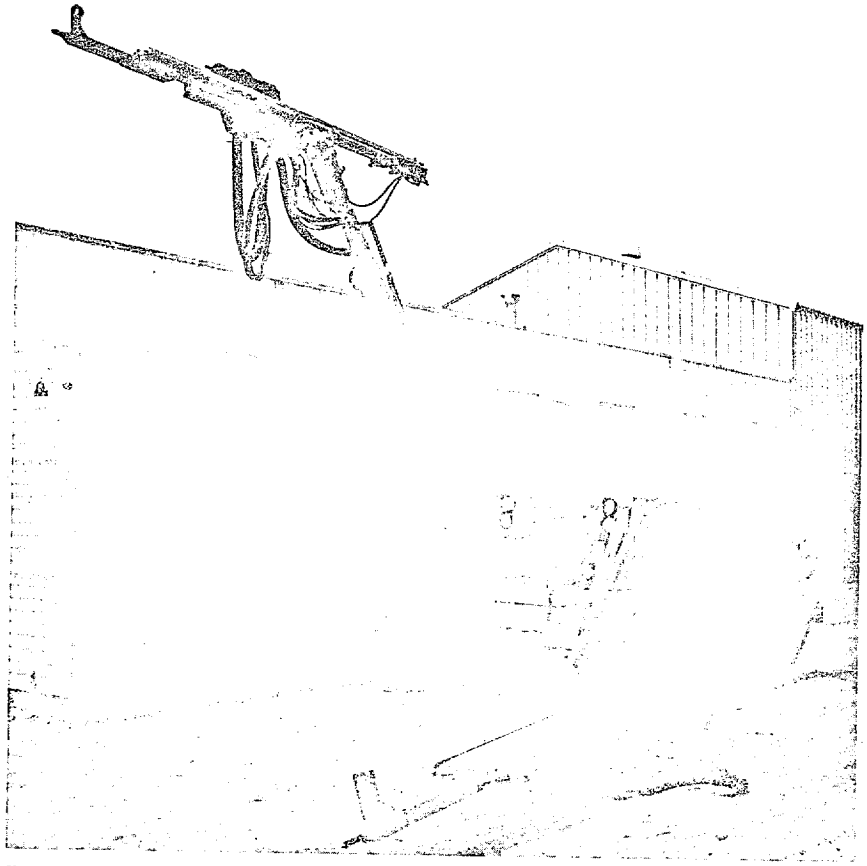
A	B	C	D	E
16'-8"	14'-3"	7'-8"	10'-0"	6"



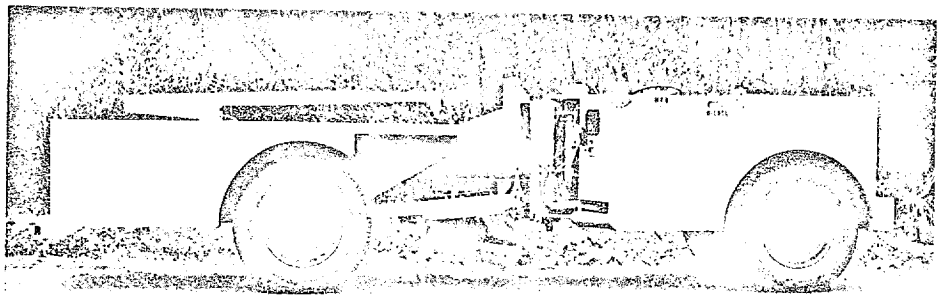
Other Products by Canadian Mine Services Ltd



Mobile Diamond Drill

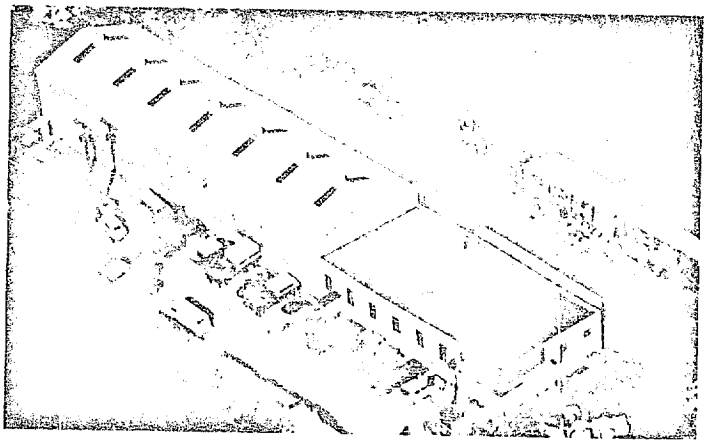


Rock Drill Jumbo



King Nipper Service Vehicle

Hy-Grader



Canadian Mine Services Ltd.

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DIAMOND DRILLING

CUSTOM EQUIPMENT

DESIGN AND MANUFACTURE

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LITHO'D IN CANADA

A Modern Approach To Underground Core Drilling

By C. D. MacDonald
Manager Diamond Drilling
Canadian Mine Services Ltd.

November 5th, 1976

Abstract

The rapid advancement of mining technology has resulted in highly mechanized mining operations. The underground environments associated with these mining operations have changed greatly from those of the past. This article outlines our approach to providing core drilling services which are compatible with modern mining methods. The development of our hydraulic core drill (Superdrill) will be discussed and some of our achievements with the drill will be presented.

Introduction

With one possible exception, the basic design of underground diamond drills has not changed since the late 1930's. Drills designed for short boreholes, to approximately 500 feet in depth, are generally bar mounted screw feed air powered drills. For drilling deeper boreholes underground, the industry has relied on modified surface drills. Both of these drill types are severely handicapped when drilling steeply inclined up-holes. These drills also require large, costly excavations because of their physicial dimensions and operational characteristics. In order to make the best use of underground excavations, a large number of ore bodies are presently being examined from exploration drifts located below these potential ore bodies. If the ore bodies prove economical, these exploration drifts become part of the production facility. This preference has resulted in a great need for core drills that can efficiently drill steeply inclined up-holes.

The Evolution of Superdrill

By 1970 we had experienced all the usual problems of drilling with compressed air behind mining crews in large trackless headings. Low air, no air, conflicts with mining crews, all demanded a solution.

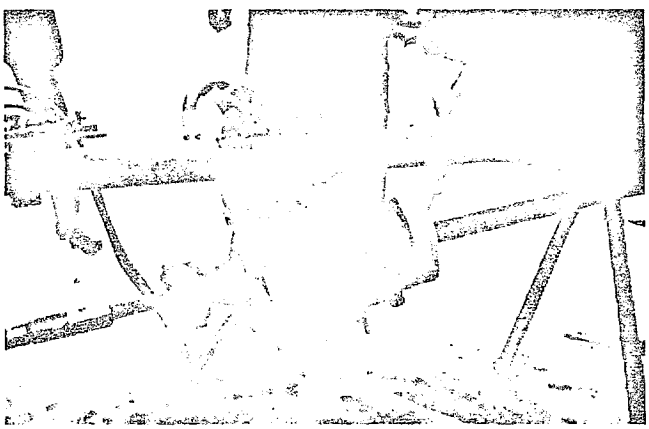


FIGURE 1
Screw feed drill with hydraulic motor.

Also, we were becoming concerned with the inefficient compressed air power system. Therefore our initial project was to decrease costs and to increase productivity by converting an existing air powered diamond drill to a diesel hydraulic powered drill. The prototype drill was tested at Alwin Mine in British Columbia. It became obvious, after initial testing, that the performance of the drill was much superior to the equivalent air

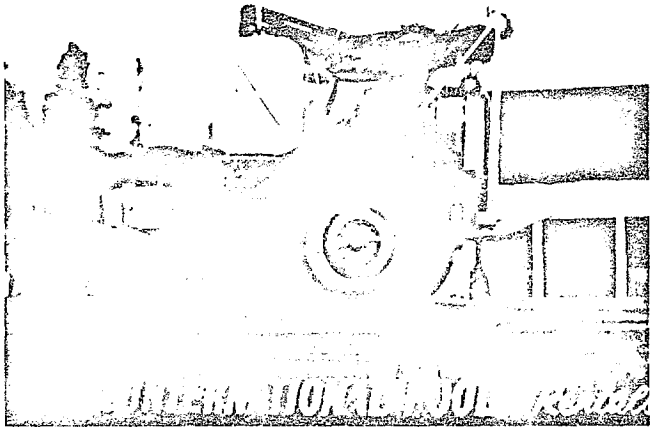


FIGURE 2
Diesel hydraulic power plant for screw feed head.

powered drill, but unfortunately the drill head failed repeatedly. The screwfeed hydraulic drill is presented as Figures 1 and 2.

After initial testing we decided to design and construct a drill that would be highly productive at core drilling in a trackless underground mine. The drill was to have the following characteristics:

1. SELF PROPELLED—TO ELIMINATE THE USE OF LHD EQUIPMENT DURING MOVES.
2. PHYSICALLY DESIGNED TO ACCOMMODATE THE DRILLING OF STEEPLY INCLINED UP-HOLES.
3. SHORT DRIVE TUBE TO REDUCE STATION CUT-OUT REQUIREMENTS.
4. HIGHLY PRODUCTIVE WHEN DRILLING.

Consideration was given to the utilization of existing drill components in the new drill. However, after examing the drill heads available, we decided to design and construct a drill head to our own specifications. The prototype drill, which became known as Superdrill, was completed in July, 1972. Superdrill was tested and placed on a contract coring program. After overcoming many obstacles we redesigned the drill. Completed on May 29th, 1974, the new Superdrill was the first of our present model 100 series.

Since May, 1974, we have examined operational environments for various large underground programs and customized equipment using the basic Model 100 Superdrill head. We have discussed the different configurations elsewhere in the text.

We have recently produced a smaller diamond drill model TD 20 Superdrill, and are presently working on a high torque drill head which will be known as Model 200.

Design Features of Superdrill

Superdrill was designed with the following hydraulic features:—

1. ROTATION
2. FEED
3. ROD CLAMP
4. CHUCK
5. WATER PUMP
6. WIRELINE HOIST
7. DRILL HEAD POSITIONING
8. CARRIER DRIVE
9. ANCHORAGE SYSTEM

Customizing for Adaptability

In the past we examined the operational environments of specific large core drilling programs and customized our Superdrills accordingly. As a result we have developed core drills which are very effective for use in conjunction with the three general types of mine development. Minor modifications are usually necessary to accommodate unique property conditions.

A. Trackless Mines

For the trackless underground mines, we primarily use a track laying mobile carrier shown in Figure 3. The drill can be completely diesel

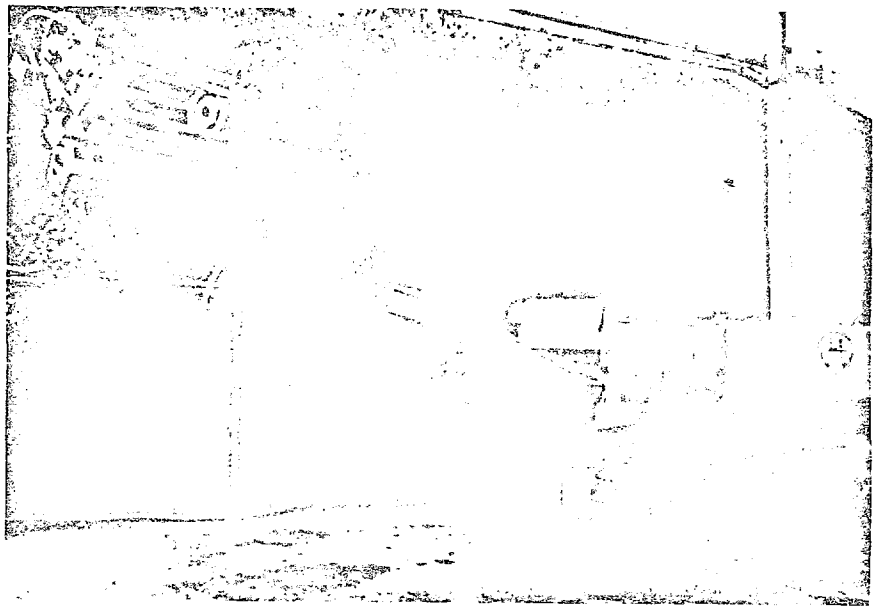


FIGURE 3
Diesel powered track laying Model 100 Superdrill.

powered, which requires the least amount of back up support, or can be diesel powered for mobility and electrically powered for the drilling process. This basic unit was designed for holes of approximately 500 feet in depth but it has drilled AQ boreholes over 1,400 feet in depth.

The necessity for drilling short boreholes to 100 feet depth in very hard rock has led to the development of our Model 20 Superdrill which is mounted on a farm tractor. The drilling functions of this drill shown in Figure 4, are powered by an electric motor which is compatable with the mine development plan of utilizing electric hydraulic development jumbos.

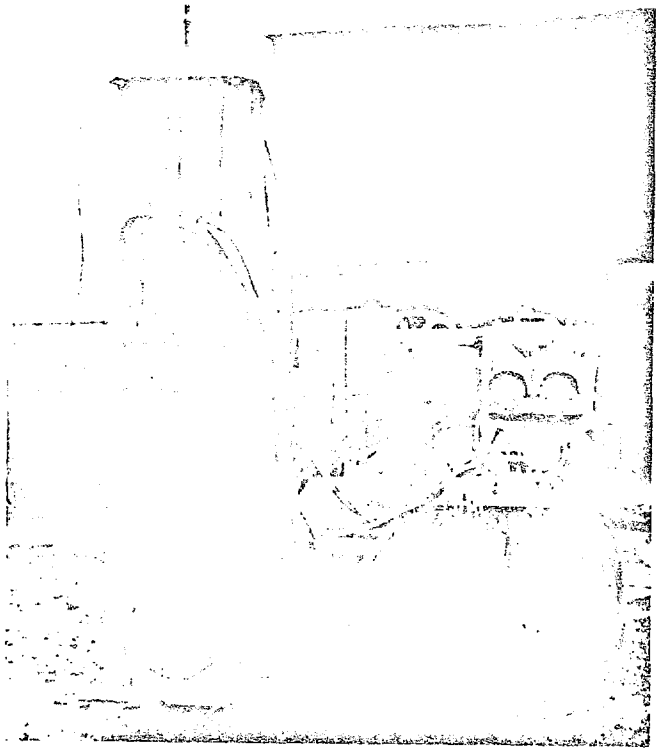


FIGURE 4
Electric TD 20 Superdrill on tractor.

B. Wide Gauge Track

A number of the large ore bodies being extracted by block caving methods rely on track haulage drifts for underground transportation. For operating in these mines we have developed our Rail Electric drill shown in Figure 5. All drilling functions of this unit are powered by an electric motor.

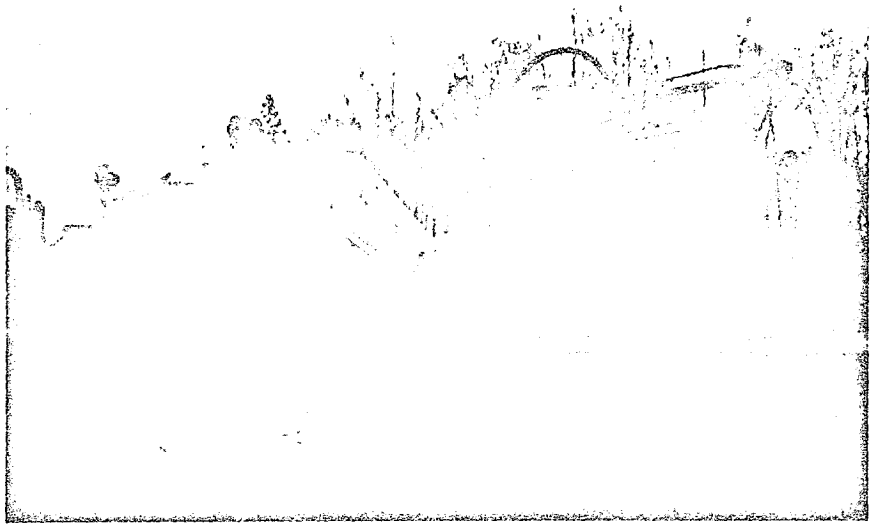


FIGURE 5
Rail electric Model 100 Superdrill.

C. Narrow Gauge Track

Narrow vein ore bodies continue to be developed by small headings and small internal shafts serviced by narrow gauge rail. For these operations, we developed a skid mounted electric drill consisting of a power package, a skid mounted feed frame, and an operator's panel. Figure 6 shows this unit in operation.

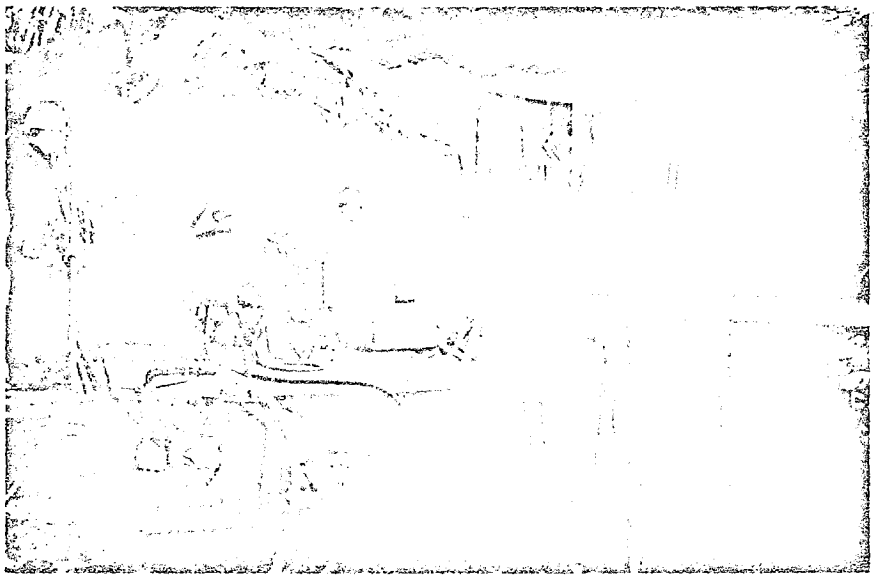


FIGURE 6
Electric Model 100 Superdrill skid-mounted.

Advantages of Superdrill

A. Productivity

Perhaps the biggest advantage of our Superdrills over conventional drills is the increase in productivity. The increase in productivity is achieved through the introduction of new systems and the increase in horsepower used in the drilling process. We have been successful in coring most formations at penetration rates in excess of 12 inches per minute and in some instances penetration rates have been as high as 30 inches per minute.

The following table shows the location of properties on which Superdrills have been used and the productivity ratio when compared with conventional drills. It should be pointed out that productivity records have been established on all properties on which these drills have operated.

Mine	Location	Productivity Ratio
Agnew Lake Mine	Ontario	N.R.C.
Canadian Tungsten Mine	N.W.T.	1.41
Climax Mine	Colorado	1.73
Grum Project	Y.T.	1.48
Henderson Mine	Colorado	N.F.P.
Homestake Mine	S. Dakota	1.69
Lakeshore Mine	Arizona	2.28
Miami East Mine	Arizona	1.63
Wesfrob Mine	B.C.	1.75
White Pine Copper Mine	Michigan	1.60

Productivity Ratio = Feet per shift Superdrill divided by feet per shift conventional drills.

N.R.C. — No reliable comparison due to lack of information on conventional drills.

N.F.P. — Not for print.

Some of our productivity highlights to date have been:

ONE MACHINE MONTH	6488 FEET
ONE DAY	410 FEET
10 HOUR SHIFT	261 FEET
8 HOUR SHIFT	240 FEET
8 HOUR SHIFT (vertical up-hole)	180 FEET

Besides the obvious advantage of obtaining information quickly for decision making, high productivity can also greatly reduce support costs. The reduced support costs can come in the form of a reduction in labour force, or a rapid completion of a drill program.

B. Flexibility of Sequences

The mobility of our drills and the ability to set up and drill upholes at ease has introduced a new dimension to the scheduling of boreholes. This flexibility of scheduling enables the geologist to drill some boreholes which were not economically justified in the past. Figure 7 shows a typical set-up on a nearly vertical up-hole. This set-up can be achieved in 2 man hours; whereas the staging required for a conventional drill might take in excess of 30 man hours.

FIGURE 7
Typical set-up for steep up-hole.

C. Power Options

Superdrills can be powered by air, diesel, or electrical power. To date, most applicators have been in the diesel and electrical power systems. The best working environment is achieved through the use of the electrical power system.

D. Straighter Boreholes

By rotating the rods at up to three times conventional speed, we have experienced less deviation than boreholes drilled with conventional drills. This phenomenon is evident on the two properties where significant records are available for comparative purposes. Figure 8 shows a plot of borehole deflection versus borehole depth for both a Superdrill and an air powered drill.

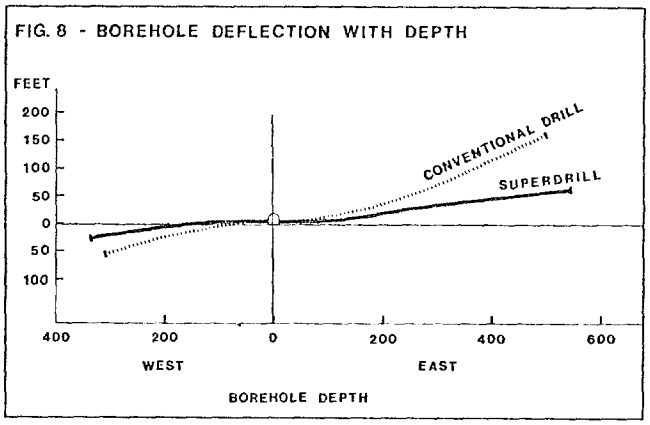


FIGURE 8
Borehole deflection with depth.

E. Longer Bit Life

Much experimental work has been done recently on the performance of diamond core bits. Both K. Spink and C. Marx have published good articles on the subject. The conclusions derived in these papers indicate, that by utilizing our systems, we should obtain optimum bit life. By having infinite control of both rotational speed and bit pressure, we achieve 10% to 20% better bit performance than conventional drills. We have found resonant vibrations in the drill string when approaching the upper limit of rotational speeds for conventional drills. By increasing our rotational speed considerably above this level, vibrations are reduced and better core bit performance results.

Conclusion

We have developed a line of hydraulic core drills for use in a highly competitive contracting business. These drills have been designed to operate effectively in modern underground environments. To date we are encouraged with the increases in productivity that have been achieved. The interest and support of the mining companies with whom we have been associated, have contributed greatly to the development of our Superdrill.

ASARCO

Southwestern Exploration Division

December 1, 1976

TO: F. T. Graybeal

FROM: N. P. Whaley

Superior East Project
Pinal County, Arizona
Directionally Controlled
Re-drill of a Section:
Hole A-8

I. Basic Factors and Assumptions:

a) BX wedge (1-1/2°): $400.00
b) Joy Mfg. Co. rig time charge: 24.00/hr. ($576.00/24 hr.dy.)
c) Dyna-Drill:
   1) Rental (2 dy. min.) $300.00/dy.
   2) To-Fr/Longbeach Calif. 10.00/dy.
   3) Service fee (operator) 200.00/dy.
   $510.00/dy.
   4) Bits (w/40'-60'-100'/bit) $200.00-$300.00
   5) Advance: 3 ft./hr.±
d) Interval to be redrilled: 3,800' to 4,500' (700'± drilling).
e) Joy Mfg. Co. average advance/24 hr. dy. during initial drilling of the intercept from 3,800' to 4,366' was 33.4'/dy. (say 30'/dy).

II. Using these factors and assumptions, cost estimates for three re-drill options are presented below.

a) Wedging out of the original hole with a single, 1-1/2° unoriented wedge and re-coring a 750 ft. to 800 ft. intercept:

1) Cost of wedge		= $ 400.00
2) Rig time to set (est'd. 4 dys. @ $576.00/dy.)		= $ 2,304.00
3) Coring from 3,750 ft. to 4,500 ft. (750 ft. @ $24.00/ft.)		= $18,000.00
	Sub-total	$20,704.00
4) Assaying		= $ 200.00
5) Overhead		= $ 1,000.00
	Overall Total	$21,904.00

b) Wedging out of the original hole with an oriented, 1-1/2° wedge, coring, and setting additional oriented, 1-1/2° wedges every 75 ft. (minimum interval suggested by Joy Mfg. Co.) throughout the 750 ft. to 800 ft. intercept:

1) Overall total for the first option described above		= $21,904.00
2) Cost of eight additional wedging operations, including orientation fees. 8 x $3,000		= $24,000.00
	Overall Total	$45,900.00

(This is obviously untenable, both economically and mechanically. The technique could be used only with a limited number of oriented wedges.)

c) Wedging out of the original hole with an oriented, 1-1/2° wedge and using the Dyna-Drill to establish a drift and bearing for the re-coring of a 750 ft. to 800 ft. intercept:

Questa dyna drill are costs $100 foot

1) Original wedging operation with orientation		= $ 3,000.00
2) Use of Dyna-Drill for drilling 100 ft.± intercept above re-core zone to establish drift and bearing:		
2.5 dys. @ $510.00/dy		= $ 1,275.00
2 bits @ $250.00 ea.		= $ 500.00
Orientation charges		= $ 500.00
3) Drilling contractor rig time during operation of Dyna-Drill 2.5 dys. @ $576.00/dy.		= $ 1,440.00
4) Coring 700' @ $24.00/ft.		= $16,800.00
	Sub-total	$23,515.00
5) Assaying		= $ 200.00
6) Overhead		= $ 1,000.00
	Overall Total	$24,715.00

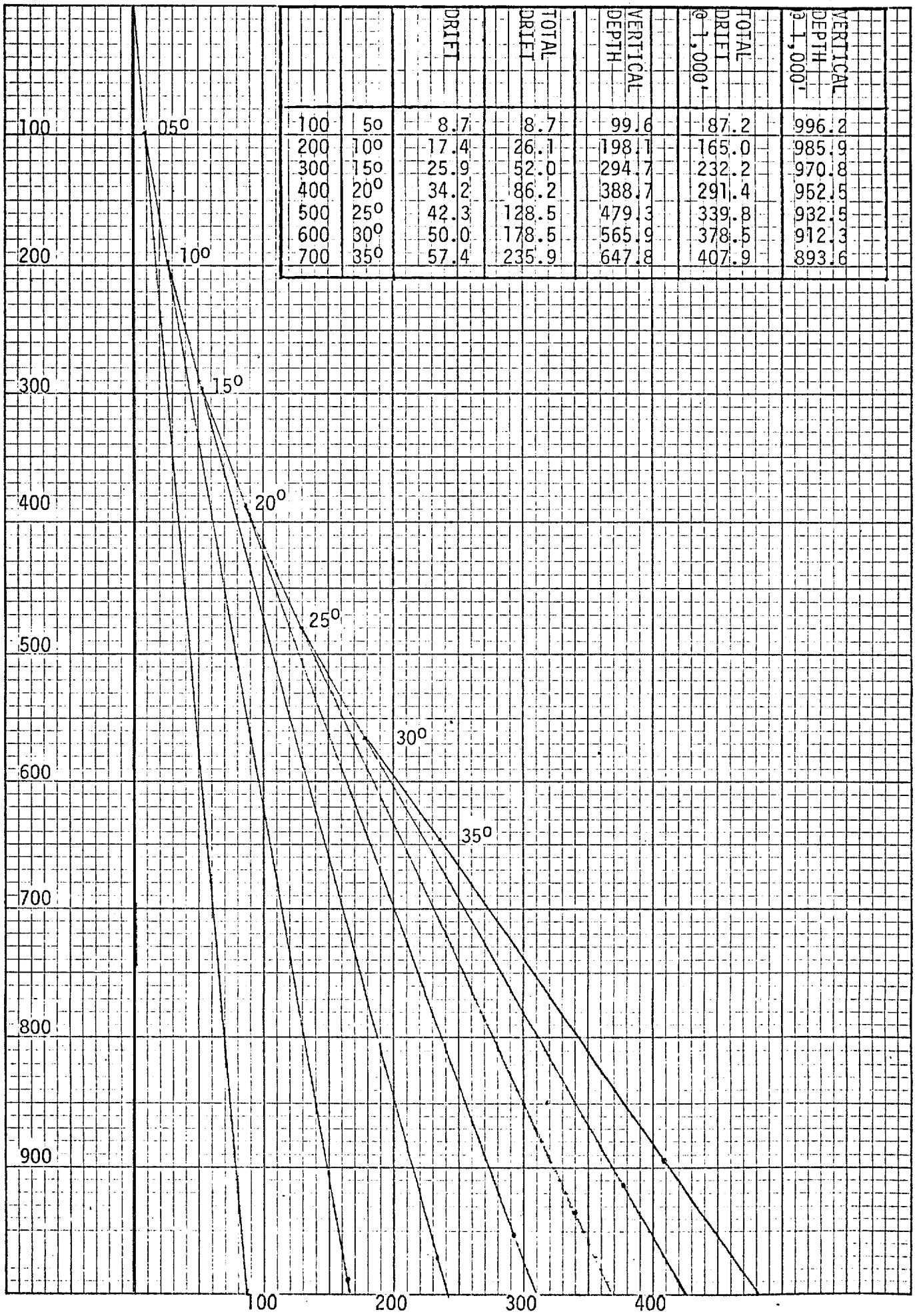
The second and third options contain so many variables that it is rather difficult to assign a reliability factor to them. Any technical or mechanical problems could escalate costs greatly.

N. P. Whaley

N. P. Whaley

NPW:lb

5% BUILD-UP CURVE



		DRIFT	TOTAL DRIFT	VERTICAL DEPTH	TOTAL DRIFT @ 1,000'	VERTICAL DEPTH @ 1,000'
100	5°	8.7	8.7	99.6	87.2	996.2
200	10°	17.4	26.1	198.1	165.0	985.9
300	15°	25.9	52.0	294.7	232.2	970.8
400	20°	34.2	86.2	388.7	291.4	952.5
500	25°	42.3	128.5	479.3	339.8	932.5
600	30°	50.0	178.5	565.9	378.5	912.3
700	35°	57.4	235.9	647.8	407.9	893.6

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ASARCO

RECEIVED
MAR 14 1977
EXPLORATION DEPARTMENT

Rocky Mountain Exploration Division
Stephen Von Fay
Exploration Manager

March 10, 1977

Mr. Norm Whaley
Exploration Department
ASARCO Incorporated
P.O. Box 5747
Tucson, Arizona 85703

Diamond Drillers

Dear Norm,

As you know, Bear Creek has had a large drilling project (up to 12 rigs) going at Questa. You will be interested in Heinemeyer's opinions on companies and personnel.

It is amusing to read that Boyles Bros. still doesn't understand cement, and therefore presumably still doesn't understand mud chemistry. I expect their little job for us in Texas will be startling to them, when they wind up using a salt based drill fluid, and see Halliburton perform.

Very truly yours,

Stephen Von Fay

SVF:slr
Enclosures
cc: WLKurtz

Note: I asked Gary to compare the three companies in their major effort at Questa! CEB

Bear Creek Mining Company
P.O. Box 277 / Questa, New Mexico 87556 / Tel. 505 586-0323

Questa Office

March 8, 1977

Mr. Charles E. Beverly
ASARCO
1805 So. Bellaire Street, Suite 301
Denver, Colorado 80222

Dear Chuck:

The following are a few comments regarding the strength and weaknesses of the drilling companies we have engaged here at Questa.

LONGYEAR COMPANY

308 E. Pima Street
Phoenix, Arizona 85004

Tel. 602 258-6543

Roy Muncy (Manager on leave)
Russ Beddows (Acting Manager)
Gil Speaker (Asst. Manager)

Comments

We have found that Longyear has the guts when it comes to tackling seemingly very difficult jobs. They will, usually at your expense, attempt unusual techniques and use often unorthodox practices to get the hole going (they have a high success rate, by the way). Their equipment is often in poorer shape than Boyles or Joy rigs and their drilling crews aren't as production oriented as the other companies. Longyear has equipment to drill rotary holes, vertical as well as angle diamond drill-holes and they do a good job of underground drilling. Longyear seems to have a good success ratio with cementing but this depends a great deal on the drilling foremen.

Personnel

The best Longyear diamond drill-hole foreman in our minds is G. I. Hayes. He tends to fix things before they break and has an eye for potential trouble. He is able to improvise exceptionally well. In addition he is fair in his charges to the client. The best rotary drill foreman and driller (if you decide to rotary the top portion of your hole) is Dwane Wilson. Gil Speaker and Russ Beddows are both good people in the Phoenix office. Roy Muncy will be returning soon to manage the Phoenix office.

Equipment

I doubt that you would want a Longyear 44 rig for your purposes. Longyear has two bigger drills which would fit your needs nicely. The smaller of the two is an HC-44 which has a depth capability of 6000 feet - it has a 30-foot pull.

The biggest of the two is the DH-8 which is good for 8000 feet - it has a 60-foot pull. The DH-8 would be a faster drilling rig but may be too much rig for what you want. The HC-44 could do the job but may not have the reserve if you want to go deeper. You should get the specs. from Longyear to compare with other companies' equipment.

The best rotary drill they have is a Gardner Denver 2000 (?) which will drill 1000-2000 foot holes on air, foam or with mud. It is a real nifty rig and it puts holes down at a rapid rate (up to 400 feet per 12 hour shift, depending on conditions).

BOYLES BROS. DRILLING CO.

10801 N. 21st Avenue
Phoenix, Arizona 85029

Bud Mathews (Manager)

Tel. 602 944-1731

Comments

Boyles Bros. has the best drilling equipment in the best repair of the three drilling companies discussed. They use Longyear 44 and CP-50 drill rigs. We have found that they also have consistently the best crews due to the fact that Boyles has a low turnover rate and drillers have usually worked for the company for many years. The drillers are production oriented. However, Boyles in general is reluctant to take any chances and they often try to convince one that the hole cannot be continued when in reality it could with a little gambling. In essence they like to give up too easily. Although Boyles supposedly does have angle rigs and underground rigs they only like to drill vertical holes. They do have a convertible rotary-core rig which could come in handy for you. Boyles generally does not have good luck with cementing. This is probably due to hesitancy and being too cautious. Good cement jobs require getting the lead out and a knowledge of just how to put the cement charge in the correct place.

Personnel

One of Boyles' better drill foremen is Mark Church. He knows his business but is all for Boyles. Sometimes you have to argue pretty strongly to get your own way. Bud Mathews is the manager in Tucson and Art Beatty is the Assistant District Manager located in Las Cruces, N.M.

Equipment

As mentioned above, Boyles uses Longyear 44 rigs and CP-50's. The CP-50 would be ideal for what you want although the round trip pulling time is longer than for a '44'. The CP-50 is the rig Inspiration used at Alum Creek last summer.

The CP-50 has a 40 or 50-foot pull.

JOY MANUFACTURING COMPANY

750 E. Evans Boulevard
Tucson, Arizona 85713

Jack Lloyd (Manager)

Tel. 602 294-2931

Comments

Joy has the best equipment after Boyles. They also have excellent crews and the Joy drill-sites are kept spotless. Joy's hourly charges are usually somewhat less than Boyles or Longyear, but Joy drills the slowest of the three. Joy is also very timid about attempting chancy operations; however, they will try things with less coaxing than Boyles. Joy is very good at getting stuck drill strings unstuck. They have left hand drill rods which enable them to spud into the top of twisted off pipe and back off sections of the drill string. They are also fairly good at cementing. One bad factor is the depth rating of their drills. The standard drill is a Joy 22 which has slightly less depth capability than a Longyear 44. Joy drilled to 3800 feet for us but that was near their limit with BX pipe.

Personnel

Lonnie Guordin is one of their best foremen. He has excellent judgment and lots of experience. Jack Lloyd is the manager in Tucson.

Equipment

Normal vertical rigs are Joy 22's. Joy can and will also drill angle holes to +3000 feet. Joy supposedly has a lot bigger rig but I think most of them are overseas - you should check anyway on a bigger drill.

MUD PROGRAM

We use a very expensive mud program here but we get the holes down. I suspect you will have many of the same problems we have had with swelling clays. We use a great deal of salt in our program to dehydrate these clays. Our mud is a combination of "LoLoss", "Dextrid" and "Impramix". These are Baroid muds. The best thing for you to do is to get in touch with

Maurice Stelzer
Sales Engineer
Baroid Division, NL Industries
Grants, N.M. 87020

Res. Phone 505 287-8135
Bus. Phone 505 287-4433

Mobile Tel. 505 287-2923 #942

He will come to the property and make sure you have just the right mix. This is a free service if you buy Baroid muds.

SURVEYING

If you want to survey the hole when you're done (it's worthwhile on a deep hole with lots of possible drift), I've found Mo Mollenhauer to be the best. He will charge about $1,000 for the survey and it's well worth it. His address and 'phone:

P.O. Box 17376
Tucson, Arizona 85731

Tel. 602 298-2779

Sincerely,

G. R. Heinemeyer
Project Geologist

GRH/jh

ASARCO

Please copy for
JC Bailey
SWOrey
DPCrawford
FTomyhead

look file Drilling

Exploration Department

March 10th, 1977.

FILE MEMO

DRILLING-PERCUSSION
FOAMING and DE-FOAMING AGENTS

With sufficient air compressor capacity an accurate sample can be obtained in firm, fairly dry ground by percussion drilling; however, in wet and/or friable, caving ground, a foaming agent must be introduced to inhibit caving and to obtain full recovery of the heavy mineral fraction. The problem of handling large frothy samples has recently been overcome by the development of a de-foaming agent which is injected into the sample discharge pipe. This system should be applicable to sampling various mineral occurrences that require special techniques, particularly the colluvial cassiterite deposits of Spain.

Attached is Mr. Whaley's discussion with data obtained from a Baroid engineer.

J. H. Courtright

J. H. Courtright

JHC:jlh
attmt
c.c. T.C.Osborne, w/encls
R.B.Sprague, w/encls
J.J.Merz, w/encls
W.L.Kurtz, w/encls
N.P.Whaley, w/o

ASARCO

Southwestern Exploration Division

March 9, 1977

TO: J. H. Courtright

FROM: N. P. Whaley

Drilling - Percussion
Foaming and De-foaming Agents

The following memorandum will hopefully provide a convenient summary of our discussion with Dwaine Hussey, Drilling Fluids Engineer of Baroid Division, N L Industries, Inc. on February 25.

The problem presented was one of prospecting for placer cassiterite by a method which would provide a valid sample at an economically practicable cost for a large area. One such method to be considered would be the drilling of 5-inch to 6-1/2-inch holes with a pneumatically-operated, bottom-hole hammer utilizing a foam or foam slurry to facilitate the lifting of the high specific gravity materials (i.e., cassiterite).

Introducing or injecting a pre-mixed solution of water and a foaming agent into a formerly dry air-drilling system actually represents only one of a number of possibilities in a series of lifting media which, except for the energy requirements, can be considered as a de facto continuum ranging from what is commonly termed water mist ... through mud mist, and stiff foam ... into aerated mud, each stage characterized by an increased cuttings-carrying capability. Thus for any given hole it is theoretically possible to select an optimum medium within this continuum to effectively lift and discharge all cuttings. Modification of an initially selected medium or system can be made as down-hole conditions change (e.g., rate of penetration, change in water production from the formation, etc.). Rather than attempt a description of each of these systems, I am attaching copies of a few pages from a paper by Kinder Chambers (Attachment A), where each is briefly discussed. Quantitative statements in this paper often refer to large diameter, oil field holes. Our interest should be confined to the techniques and methodologies described.

Dwaine Hussey felt that for our drilling a good starting point in this continuum of systems would probably lie somewhere between water misting and stiff foam, utilizing a Baroid injection slurry known as Trol-Foam, containing a mixture of Quik-Trol and Quik-Foam (both are Baroid products). Attachment B is a copy of a table showing the mixing ratio for this and other slurries, foam concentration in 100 gallons of water for various quantitites of foam added, and average injection rates commonly used. A paper by James R. Youell, describing an application of a variation on the Trol-Foam slurry could also be of interest, and a copy is included as Attachment C.

Until a specific drilling system is adopted, it is impossible to prescribe or know exactly what the character of the discharge or sample will be, but if the assumption is made that this discharge will resemble something

between a concentrated froth and a stiff foam the consistency of an aerosol-can shaving cream, the probable need of a defoaming agent to kill the foam volume and facilitate the containerizing of the sample is suggested. A number of these agents are available, and a list of Baroid products is given below.

DEFOAMING AGENTS

Product	Composition	Application
Aluminum Stearate	Aluminum Stearate	Fresh Water Hard Water Mixed with oil
FROBAN	Detergent	Fresh Water
DEFOAMER 23	Alkylaryl Sulfonate	Salt Water
Monosulph	Sulfonated Castor Oil	Salt Water
Octyl Alcohol	Long Chain Alcohol	Fresh Water
SURFLO W300	Sulfonated Castor Oil and Long Chain Alcohol	Fresh Water or Salt Water

In practice, small quantities of these defoaming agents are put into solution in water or diesel oil (which also acts as a defoamer) and injected as a high-pressure mist into the discharge line ahead of the sample collection system.

Again, in considering our drilling, Dwaine Hussey felt that the most effective of these agents would probably be Aluminum Stearate if we could tolerate the diesel oil in which it has to be mixed. If the diesel should not be acceptable in the sample, his alternate recommendation was the W300 which can be mixed with water.

Baroid Division does have both sales and engineering representatives in Spain, and should we be interested in considering any of these systems it would certainly be wise to establish contact with them to discuss our requirements, assess available equipment and technology, and develop cost estimates.

The following names and telephone numbers were provided by Dwaine Hussey:

Sales Representative:
Kenneth Fread
Apt. 534
Tarragona, Spain
Tel. 2-07640
2-07744
TELEX 56485 (DRXL)

Sales Engineering Representative:
Gordon Skinner
c/o Prodipesa Fernandez
de La Hoz 40
Madrid 10, Spain

Gordon Skinner - Continued
Tel. 011-341-0700
0704
0708
TELEX 22672

Kenneth Fread was recommended as the initial contact.

N. P. Whaley

N. P. Whaley

NPW:lb
Atts.

ROTARY DRILLING SYSTEMS

AIR DRILLING	DUSTING WATER MISTING FOAM DRILLING MUD MISTING	HIGH up hole VELOCITY
	GEL FOAM	LOW up hole VELOCITY
MUD DRILLING	AERATED MUD MUD	

Injection Slurry	Water (gallons)	QUIK-GEL (pounds)	QUIK-TROL (pounds)	QUIK-FOAM (% by vol.)	
'A' - QUIK-FOAM	100	—	—	0.02 - 3.0	Increase as required to compensate for down hole water dilution etc.
'B' - TROL-FOAM	100	—	½-1	0.1 - 2.0	Mix well
'C' - MUD-MIST	100	25	—	0.3 - 1.0	Mix well Viscosity 32-40 sec/qt.
'D' - GEL-FOAM	100	12-15	1	0.3 - 1.0	Mix well Viscosity 32-40 sec/qt.

NOTE: Mix only in this sequence.

BAROID DIVISION
NL INDUSTRIES
P.O. BOX 1675 HOUSTON, TEXAS 77001

FOAM CONCENTRATION

(In 100 gallons U.S. water)

%	Pints	OZ.
2.5	20	
1.25	10	
1.0	8	
0.75	6	
0.50	4	
0.25	2	32
0.125	1	16
0.096	¾	12
0.064	½	8
0.032	¼	4
0.016	⅛	2

INJECTION RATES (Av.)

Overburden (unconsolidated)	- 7 - 10 g.p.m.
Rock (broken)	- 5 - 7 g.p.m.
Rock (solid)	- 3 - 5 g.p.m.
Dust control/water	- ¼ - 2 g.p.m.

BAROID DIVISION

NL INDUSTRIES

NEW TECHNIQUES IN FOAM DRILLING

by

JAMES R. YOUELL

The Arizona Highway Department had a need for subsurface soil information on the proposed route of the elevated Papago Freeway.

To get the information, it necessitated sampling a boulder and cobble bed that contained loose, dry, runny sand and silt lenses. Several methods were proposed: rotary drilling and casing holes, airtrack and mist, a Becker Hammerdrill (pile driver using reverse circulation air system). We chose a small diameter 3 1/2" bit on a Halco DD 325 Hammerdrill, operated from our Mobile Drill Model B-50.

To add to this combination, a Gel-Foam drilling fluid was metered into the air line at the rate of 7 to 10 gallons for every 15 lineal foot of 3 1/2" hole. Hole stability, penetration rate and sample recovery results were excellent. Penetration was at 20 to 30 feet per hour.

WHAT WAS OUR GEL-FOAM?

The Gel-Foam was a take-off from an old Baroid receipe:

Into a 50 gallon barrel of soft water, mix 25 lbs. of Quik-Gel thoroughly until smooth with a Jet mixer.

Blend in 1/2 to 3/4 lbs. of Quik-Trol, increasing the quantity in caving ground to achieve a higher Marsh funnel viscosity. The viscosity should be kept near 30 seconds per quart under normal ground conditions, increasing the viscosity between 40 - 50 for bad caving ground conditions.

After the desired viscosity is obtained in the batch, gently

fold in 1 pint of Quik-Foam until mixture is uniform.

Place in the air lift system for 10 - 12 seconds. Out of the hole will come the best transporting and cuttings moving device in the modern world.

Let stand for 90-180 minutes and the bubbles will disappear, leaving a crunchy pile of dry cuttings ready for sample sacking.

WHY IS THE QUIK-GEL AND QUIK-TROL USED?

The two additives increase the strength and transporting power of the bubble. They also promote the building of a very low water loss wall cake, that promotes hole stability.

WHAT METHOD OR TECHNIQUE WAS USED TO INJECT THE GEL-FOAM INTO THE AIR SYSTEM?

A parallel receiver tank filled with Gel-Foam was placed so that pressure would be placed ahead of a fine needle valve. The small metered quantity of fluid was then drawn into the main air line by a Venturi. Quick shut-off valves were used at connection time as normal operating procedure. Liberal use of ball check valves to protect equipment is recommended; one above the Hammerdrill, one on each side of the Gel-Foam tank to guard the compressor from foam damage. See flow sheets for details.

ARE THERE OTHER METHODS OF GETTING FOAM INTO THE SYSTEM?

Yes, a positive displacement mud pump is often used at a very low gallonage. Calibration is necessary to achieve proper output. An alternate and ancient device known as a bucket is also used. It is filled to a predetermined mark and carefully poured down the drill pipe at connection time; this practice is known as sluging.

WHY DID WE USE THIS PARTICULAR EQUIPMENT SYSTEM?

The adaptability of the Mobile B-50s' all hydraulic speed and feed control allowed the flexibility necessary at low rotation speeds of 10 - 12 R.P.M. The 78" feed ram afforded 150 to 200 lbs. of smooth operation, one chuck change between 10 foot rod sections. The hydraulic control on this rig gave infinite adjustment which is necessary to put the Halco DD 325 Hammerdrill at optimum footage output. This appeared to be between 20 - 30 feet per hour in this ravely ground.

The Halco Hammerdrill was selected for its small size. It is able to drill through our Mobile hollow stem auger; another thought was that small, 3 1/2" holes are more economical to drill than larger Hammerdrills, made by other manufacturers.

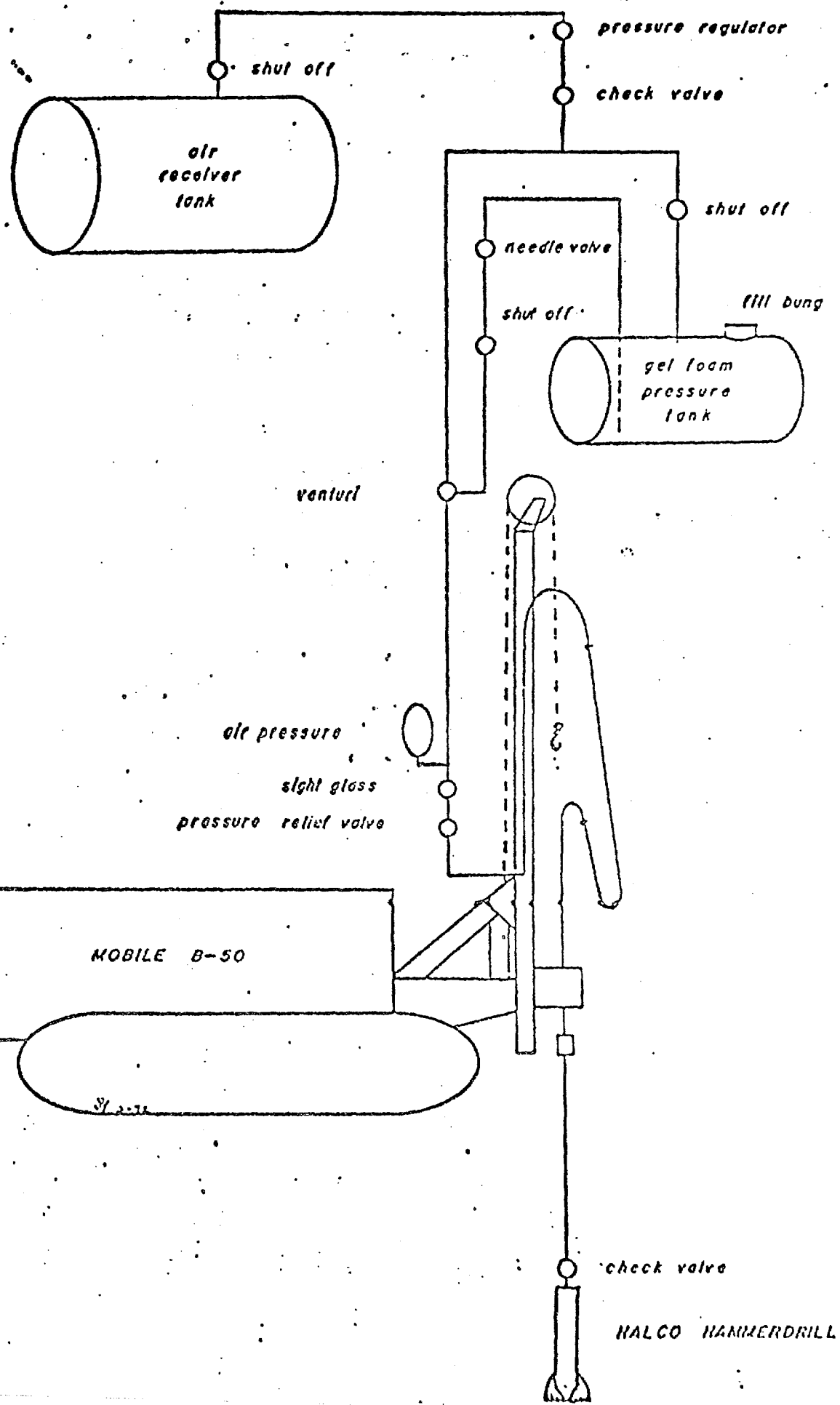
HAVE WE USED GEL-FOAM IN APPLICATIONS OTHER THAN HAMMER DRILLING?

We have and are, quite impressed with the quality job provided in long hole rotary boring as well as vertical drilling. We held 180 foot horizontal 5 1/8" diameter bore holes using Gel-Foam in a weathered, steeply dipping slate. A control section was run without Gel-Foam; results: hole caved, re-drill required - no re-drill was necessary where Gel-Foam was used in the slate.

HOW DID WE DISCOVER GEL-FOAM AS A DRILLING SYSTEM?

Benjamin Franklin answered a similar question, "How did you achieve such greatness?" His reply, "I'm standing on the shoulders of great men." This must be our reply also. Baroid's engineer, Lloyd Hill, was the prime mover in mud chemical adaptation, while Doug Linsay, Halco Western Hemisphere Manager and "Hank" Davis, Vice-president of Mobile Drill Company and the organizations behind these men, deserve much credit for our successful use of Gel-Foam. It would be negligent to forget the drill crew of the Arizona Highway Department, headed by Lavone Prince, who put these theories into practice.

##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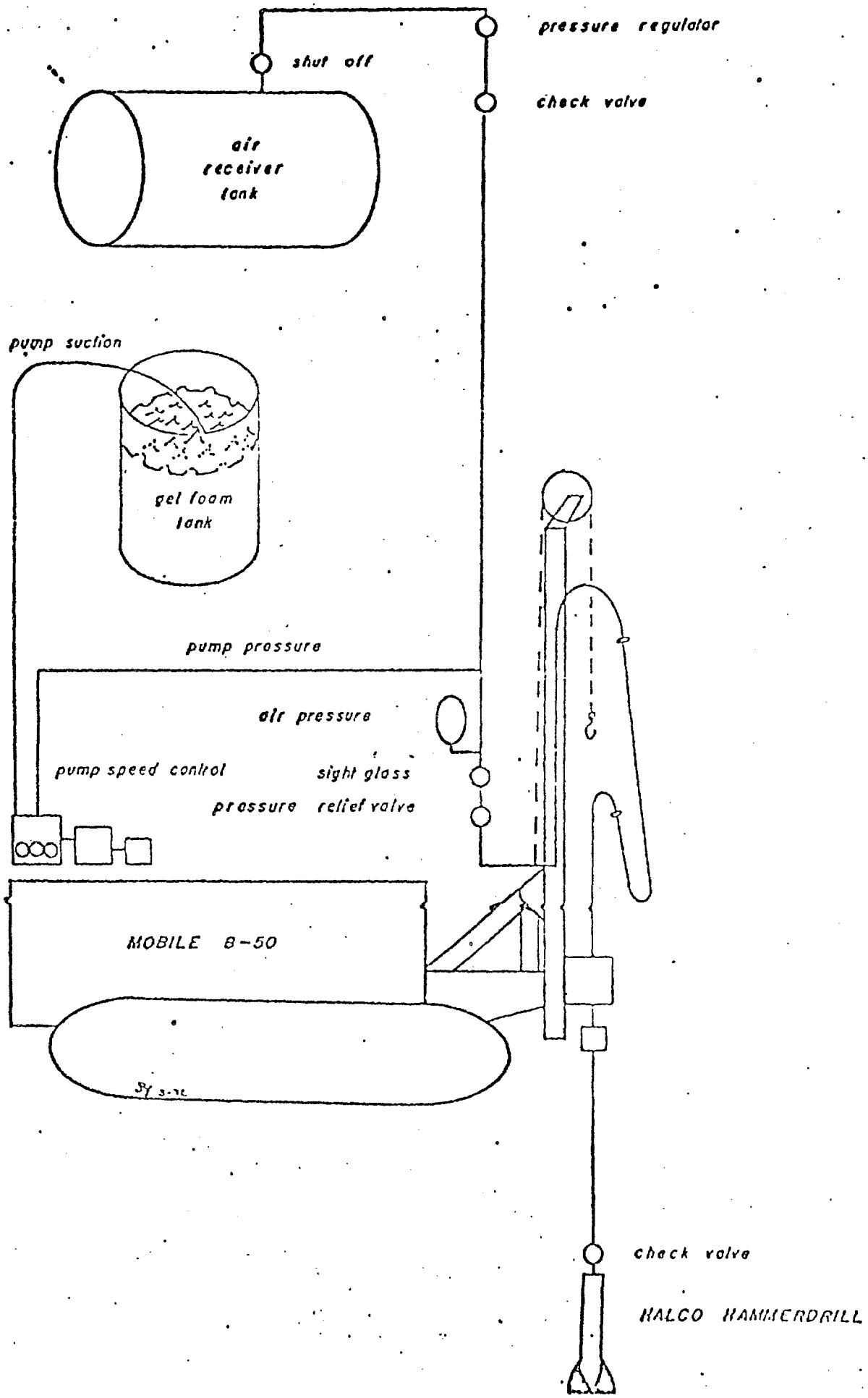
MOBILE B-50
check valve
HALCO HAMMERDRILL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air receiver tank
pump suction
gel foam tank
pump pressure
air pressure
pump speed control
sight glass
pressure relief valve
MOBILE B-50
check valve
HALCO HAMMERDRILL

GLOSSARY

Baroid: Division of National Lead Company. P. O. Box 1675, Houston, Texas 77001 Rep: Lloyd Hill. (602) 934-2004

***Quik-Foam:** A biodegradable foaming agent producing a relatively uniform size bubble; used in foam drilling by itself or with other drilling agents.

***Quik-Gel:** A high yield Bentonite. A 50 lb. bag will produce 200 gallons of 15 centipoise drilling mud.

***Quik-Trol:** A nonfermenting organic compound used to stabilize swelling formation clay and to make a non-clay drilling fluid. Mix 1 lb. in 1 gallon Diesel, then stir into 50 gallons of water. It will produce a Marsh viscosity of 40 - 50 seconds.

Halco Hammerdrill: D. W. Jaquays Company 1219 S. 19th Avenue, Phoenix, Arizona Rep: Doug Linsay (602) 254-6494 The drill we operate is a DD 325, 2 7/8 O.D., 2' 10" long. Uses 125 C.F.M., at 80 p.s.i. Weight w/o bit, 43 lbs. Bit sizes 3 1/4", 3 3/8", 3 1/2". This Hammerdrill is adapted to either NW or AQ drill rods.

Mist drilling: Conventional air drilling in which very small quantities of water are injected to provide dust control. A light application of Quik-Foam is sometimes used. .03% - .06%.

Mobile Drill B-50: Mobile Drill Company, Indianapolis, Indiana. Rep: "Hank" Davis, Aptos, Calif. (408) 688-6387. The B-50 we operate in Arizona is a crawler mounted full hydraulic combination auger, Hammerdrill and soil drive sampler that is capable of 1400 feet of AQ wire line core drilling, 800' of NQ wire line, as well as conventional rotary mud and Gel-Foam drilling.

* Trademark of Baroid, Division of National Lead Company.

ASARCO

Exploration Department
Western USA

February 1, 1977

Mr. F. T. Graybeal
Tucson Office

Dyna-Drill

Last Saturday J. H. Courtright, J. C. Balla, and I interviewed Gary Heinemeyer who indicated good success with the dyna-drill at Questa. They have used the dyna-drill to obtain a 15° deviation -- continuing the hole with standard coring equipment.

Joy has proved the best contractor -- especially so because they have left-handed rods to take care of the twist-off problems.

Longest section drilled with dyna-drill was 300 feet.
Cost averages about $100 per foot.
A sufficient capacity mud pump is available to adequately run the dyna-drill.
Kerr-McGee has used the dyna-drill at Red Mountain.
Suggest N. P. Whaley thoroughly check into the presently demonstrated capabilities of the dyna-drill.

The dyna-drill might be capable of providing two or more penetrations at a sufficient horizontal distance from A-8 and A-9 to qualify as equivalent to a new hole drilled from surface. I believe Sell said he calculated the true width of the A-8 zone as 350 to 400 feet; therefore, a large horizontal offset is not needed to make an effective test.

W. L. Kurtz

WLK:lb

cc: TCOsborne
JHCourtright
JDSell
NPWhaley

ASARCO

cent file

JDS → file drill contractor

F. T.

Southwestern Exploration Division

MAY 24 1976

May 24, 1976

TO: F. T. Graybeal

FROM: N. P. Whaley

Diamond Drilling.
Depth Capacities of Drills
Most Commonly Used.

The following depth figures, quoted to me recently by the southwestern supervisors of Joy Manufacturing Company and Longyear Company, represent the nominal, safe depth capacities of some of the more popular models of drills when operating under optimum-to-normal, down-hole conditions in nominally vertical holes.

Drill	Core Size			
	NCWL	NXWL	BXWL	AXWL
Joy 12	400-500	1,200	1,700-1,800	2,000(+)
Joy 22HD	2,200	3,200	5,600-5,700	6,000(+)
Joy 36	2,500(±)	5,000	6,000-6,500	---
	HQWL	NQWL	BQWL	AQWL
Longyear 38	800	1,500	2,200(+)	2,800(±)
Longyear 44HD	2,500	5,000	5,000	---

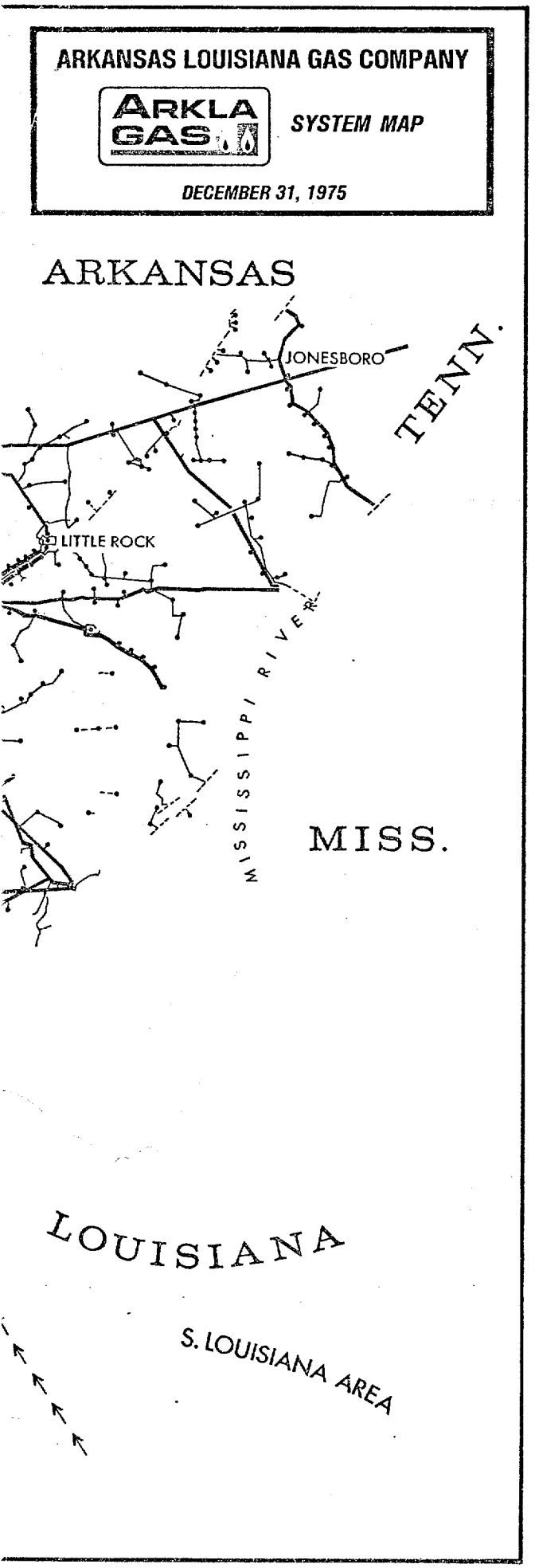
Again, may I emphasize that these are realm-of-magnitude figures.

N. P. Whaley

NPW:lb

cc: WLKurtz ✓

N. P. Whaley



Deeper Wells Illustrate Rising Cost of Search For New Gas Supplies

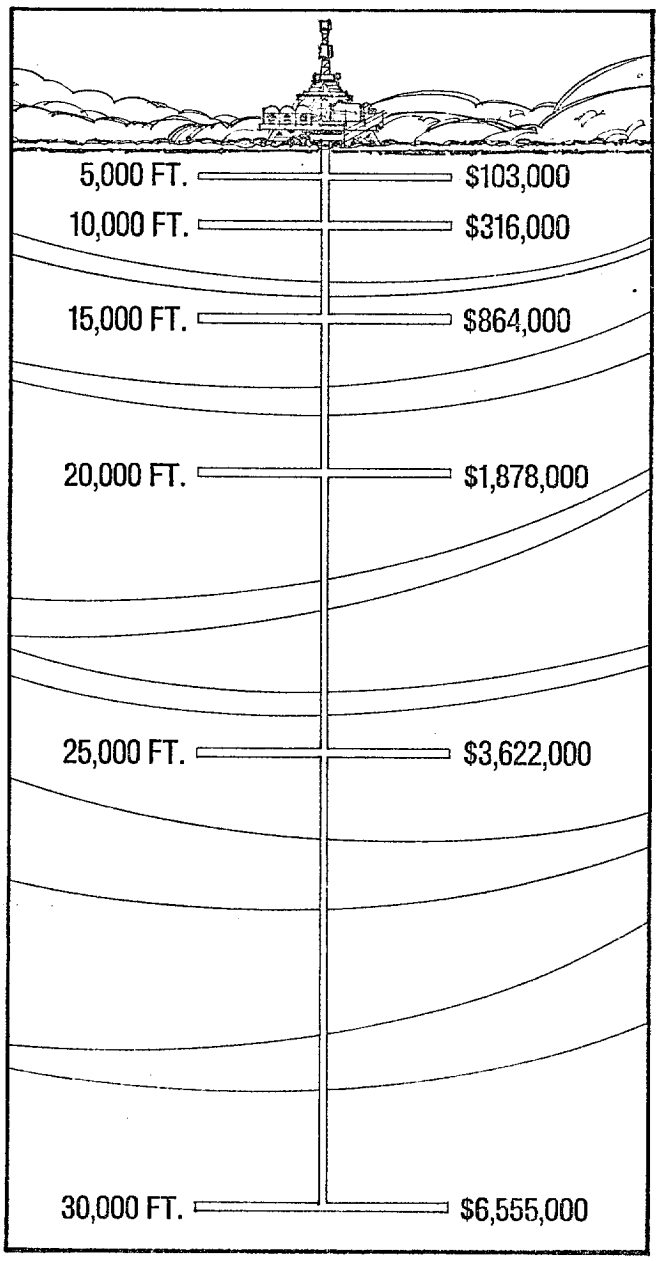
The symbolic drawing below shows dramatically the rising cost of finding gas in western Oklahoma and the Texas Panhandle—the Deep Anadarko Basin:

Twenty 10,000-foot wells can be drilled for the cost of ONE 30,000-foot well.

The "last 5,000" feet costs almost as much as the first 25,000.

Based on data compiled by the American Petroleum Institute, the International Association of Drilling Contractors and the Petroleum Engineering Magazine Deep Well report.

COST OF DRILLING



ASARCO

Southwestern Exploration Division

November 19, 1976

F. T. G.

NOV 22 1976

TO: G. J. Stathis

FROM: N. P. Whaley

Hayden Hill Project
Lassen County, California
1976 Drilling -- Basic
Performance and Cost Data

The following material represents a tabulated summary of basic performance and cost data which might be of some help in the preparation of a more comprehensive and interpretive report on the 1976 summer drilling program which you supervised.

I. Dates:

a) Period encompassed:	35 dys.	8-19-76 thru 9-22-76
b) Drilling Periods:	13 dys.	8-19-76 thru 8-31-76
	9 dys.	9-6-76 thru 9-14-76
c) Time-off Periods:	5 dys.	9-1-76 thru 9-5-76
	5 dys.	9-15-76 thru 9-19-76

II. Performance:

Hole No.	TD (Ft.)	Hrs.	Ft./Hr.
HH-1	300	12	25.0
HH-2	450	20	22.5
HH-3	120	7	17.1
HH-4	80	5	16.0
HH-5	242	16	15.1
HH-6	450	30	15.0
HH-7	255	20.5	12.4
HH-8	545	38	14.3
HH-9	425	22.5	18.9
HH-10	145	18.5	7.8
Totals (10) and/or overall average	3,012	189.5	15.9

Footage per day for period encompassed
(3,012 ft.) ÷ 35 days = 86.1 ft./dy.

Footage per day for drilling periods
(3,012 ft.) ÷ 22 days = 136.9 ft./dy.

III. Direct Drilling Costs:

Item	Cost	Cost/Ft.
a) Rds. & Sites	$ 1,201.75	$0.40
b) Drilling (Aug.)	7,603.17	
(Sept.)	8,925.57	
Total	$16,528.74	$5.49
c) Overall (a+b)	$17,730.49	$5.89

If you would find a reordered format of greater value, or if you need additional information, please let me know.

N. P. Whaley

N. P. Whaley

NPW:lb

cc: FTGraybeal

Copy to all geol. + WLK
HMS, TCB

ASARCO

Southwestern Exploration Division

F. T. G.
AUG 23 1976

August 23, 1976

cc to file. Diamond drill

TO: F. T. Graybeal

FROM: N. P. Whaley

Diamond Coring Bits and
Related Drill Hole Sizes

In response to your recent request for specifications of diamond coring bits and the nominal diameters of diamond drill holes, I'm attaching three sheets of dimension information: one for Longyear Company, one for Joy Manufacturing Company, and one for Boyles Bros. Drilling Company.

N. P. Whaley

N. P. Whaley

NPW:lb
Atts.

LONGYEAR — DIAMOND CORING BITS

SERIES "Q" WIRE LINE DIAMOND BITS

SIZE	CORE DIAMETER (inches)		HOLE DIAMETER (inches)		HOLE VOLUME (gal. per 100 ft.)
	Decimal	Fractional	Decimal	Fractional	
AQ, AQ-U	1.062	1-1/16	1.890	1-57/64	14.6
BQ, BQ-U	1.432	1-7/16	2.360	2-23/64	22.7
NQ, NQ-U	1.875	1-7/8	2.980	2-63/64	36.3
HQ	2.500	2-1/2	3.782	3-25/32	58.3
PQ	3.345	3-11/32	4.827	4-53/64	95.05
RWG*	.735	47/64	1.175	1-11/64	5.6
EWG, EWM, EWL*	.845	27/32	1.485	1-31/64	9.0
AWG, AWM, AWL*	1.185	1-3/16	1.890	1-57/64	14.6
BWG, BWM, BWL*	1.655	1-21/32	2.360	2-23/64	22.7
NWG, NWM, NWL*	2.155	2-5/32	2.980	2-63/64	36.3
HWG*	3.000	3	3.907	3-29/32	62.3
2-3/4 x 3-7/8	2.690	2-11/16	3.875	3-7/8	61.2
4 x 5-1/2	3.970	3-31/32	5.495	5-1/2	123.4
6 x 7-3/4	5.970	5-31/32	7.750	7-3/4	245.1

*DCDMA "W" sizes were formerly designated "X".
All dimensions, weights and volumes shown are nominal approximations in inches, pounds and U.S. Gallons

JOY WIRELINE CORE BARREL & DRILL ROD SPECIFICATIONS

	AX	BX	NX	NC
Hole Diameter (Approx.)	1-7/8"	2-3/8"	3"	3-11/16"
Core Diameter (Approx.)	1-1/64"	1-7/16"	2"	2-13/32"
Reaming Shell - Set O.D.	1-55/64"	2-3/8"	2-63/64"	3-43/64"
Bit - Set O.D.	1-27/32"	2-23/64"	2-31/32"	3-21/32"
Bit - Set I.D.	1-1/64"	1-7/16"	2"	2-13/32"
Outer Tube - O.D.	1-3/4"	2-9/32"	2-27/32"	3-1/2"
Outer Tube - I.D.	1-27/32"	1-29/32"	2-15/32"	3-1/16"
Inner Tube - O.D.	1-1/4"	1-3/4"	2-5/16"	2-29/32"
Inner Tube - I.D.	1-1/16"	1-1/2"	2-5/64"	2-9/16"
Rod - O.D.	1-3/4"	2-1/4"	2-13/16"	3-1/2"
Rod - I.D.	1-11/32"	1-7/8"	2-7/16"	3-1/16"
Threads Per Inch	4"	4"	4"	3"

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DIMENSION TABLES
COREBARRELS, CORE BITS, CASING BITS & SHOES, REAMING SHELLS

INCH DIMENSIONS ARE NOMINAL APPROXIMATIONS — MILLIMETRE EQUIVALENTS SHOWN IN PARENTHESIS

HOLE SIZE	COREBARREL DESIGN					APPROX. HOLE DIAMETER	APPROX. CORE DIAMETER	CORE BIT		COREBARREL REAMING SHELL	CASING SIZE & DESIGN	CASING BIT		CASING SHOE		CASING REAMING SHELL
	WF	WG	WM	WT	WL			O.D. SET	I.D. SET	O.D. SET		O.D. SET	I.D. SET	O.D. SET	I.D. SET	O.D. SET
R				RWT		1-3/16 (30.2)	23/32 (18.3)	1.160 (29.5)	0.735 (18.7)	1.175 (29.8)	RX or RW	1.485 (37.7)	1.000 (25.4)	1.485 (37.7)	1.186 (30.1)	—
E		EWG	EWM			1-1/2 (38.1)	13/16 (20.6)	1.470 (37.3)	0.845 (21.5)	1.485 (37.7)	EX or EW	1.875 (47.6)	1.405 (35.7)	1.875 (47.6)	1.495 (38.0)	1.890 (48.0)
				EWT			7/8 (22.2)		0.905 (23.0)							
A		AWG	AWM			1-15/16 (49.2)	1-3/16 (30.1)	1.875 (47.6)	1.185 (30.1)	1.890 (48.0)	AX or AW	2.345 (59.6)	1.780 (45.2)	2.345 (59.6)	1.900 (48.3)	2.360 (59.9)
				AWT			1-9/32 (32.5)		1.281 (32.5)							
					AWL		1-1/16 (26.9)		1.062 (27.0)							
B		BWG	BWM			2-3/8 (60.3)	1-5/8 (41.3)	2.345 (59.6)	1.655 (42.0)	2.360 (59.9)	BX or BW	2.965 (75.3)	2.215 (56.3)	2.965 (75.3)	2.370 (60.2)	2.980 (75.7)
				BWT			1-3/4 (44.4)		1.750 (44.5)							
					BWL		1-7/16 (36.4)		1.433 (36.4)							
N		NWG	NWM			3 (76.2)	2-1/8 (54.0)	2.965 (75.3)	2.155 (54.7)	2.980 (75.7)	NX or NW	3.615 (91.8)	2.840 (72.1)	3.615 (91.8)	2.992 (76.0)	3.630 (92.2)
				NWT			2-5/16 (58.7)		2.313 (58.8)							
					NWL		1-7/8 (47.6)		1.875 (47.6)							
H	HWF	HWG				3-15/16 (100.0)	3 (76.2)	3.890 (98.8)	3.000 (76.2)	3.906 (99.2)	HX or HW	4.625 (117.5)	3.777 (95.9)	4.625 (117.5)	3.925 (99.7)	—
				HWT			3-3/16 (80.9)		3.187 (80.9)							
					HWL	3-51/64 (96.4)	2-1/2 (63.5)	3.762 (95.6)	2.500 (63.5)	3.782 (96.1)						
P	PWF					4-3/4 (120.6)	3-5/8 (92.1)	4.725 (120.0)	3.627 (92.1)	4.748 (120.6)	PX or PW	5.650 (143.5)	4.633 (117.7)	5.650 (143.5)	4.776 (121.4)	—
S	SWF					5-3/4 (146.0)	4-7/16 (112.7)	5.725 (145.4)	4.439 (112.8)	5.748 (146.0)	SX or SW	6.790 (172.5)	5.633 (143.1)	6.790 (172.5)	5.778 (146.8)	—
U	UWF					6-7/8 (174.6)	5-1/2 (139.7)	6.840 (173.7)	5.505 (139.8)	6.870 (174.5)	UX or UW	7.800 (198.1)	6.755 (171.6)	7.800 (198.1)	6.905 (175.4)	—
Z	ZWF					7-7/8 (200.0)	6-1/2 (165.1)	7.840 (199.1)	6.505 (165.2)	7.870 (199.9)	ZX or ZW	8.810 (223.8)	7.755 (197.0)	8.810 (223.8)	7.905 (200.8)	—

Note: Above table is for current international standards. Boyles also offers diamond products for previous standards such as AXT, AWX & AX, etc.

LONGYEAR CORE [illegible] FILE [illegible]

DIAMOND CORE DRILLING DIMENSIONS, WEIGHTS and VOLUMES

925 Delaware Street S.E.
Minneapolis, Minnesota 55414 U.S.A.
Cable: LONGCO

CANADA: North Bay, Ontario
[illegible]

COSTA RICA: Apartado 5235 San Jose, Costa Rica

INDIA: P. O. Box 278 Bombay, I. India

AUSTRALIA: 819-929 Marion Road Mitchell Park, South Australia 5043
87 Old Pittwater Road Brookvale, New South Wales

MEXICO: Guillermo Barroso No. 18-F Fracc. Industrial Las Armas Tlalnepantla, Mexico

JAPAN: No. 7, 3 Chome, Kohimachi Chiyoda-ku, Tokyo, Japan

FRANCE: Place de la Gare 78 La Verriere

GERMANY: Braunschweiger Heerstrasse 61 3100 Celle

NETHERLANDS: Nijverheidsweg 47 Elten Luer

KOREA: I P.O. 1065 Seoul, Korea

PHILIPPINES: P. O. Box 306 Makati, Rizal, Philippines

INCHES

DRILL RODS AND CASING

DRILL RODS

SIZE	O.D. (inches)	I.D. (inches)	WT. (lbs. per 10 ft.)	COUPLING I.D. (in.)	THREADS per inch	CONTENT (gal. per 100 feet)
E*	1-5/16	27/32	28	7/16	3	2.9
A*	1-5/8	1-1/8	38	9/16	3	5.2
B	1-29/32	1-13/32	46	5/8	5	8.1
N	2-3/8	2	49	1	4	16.3
RW*	1-3/32	23/32	19	13/32	4	2.1
EW*	1-3/8	7/8	31	1/2	3	3.1
AW*	1-3/4	1-7/32	44	5/8	3	6.1
BW	2-1/8	1-3/4	42	3/4	3	12.5
NW	2-5/8	2-1/4	54	1-3/8	3	20.7
HW	3-1/2	3-1/16	85	2-3/8	3	38.3

*Parallel Wall

FLUSH-COUPLED CASING

SIZE	O.D. (inches)	I.D. (inches)	WT. (lbs. per 10 ft.)	COUPLING I.D. (in.)	THREADS per inch	CONTENT (gal. per 100 feet)
RX**	1-7/16	1-3/16	18	1-3/16	8	5.7
EX	1-13/16	1-5/8	18	1-1/2	8	10.8
AX	2-1/4	2	29	1-29/32	8	16.3
BX	2-7/8	2-9/16	47	2-3/8	8	26.7
NX	3-1/2	3-3/16	60	3	8	41.4
HX	4-1/2	4-1/8	90	3-15/16	5	69.4

**Formerly XRT

FLUSH-JOINT CASING

SIZE	O.D. (inches)	I.D. (inches)	WEIGHT (lbs. per 10 ft.)	THREADS per inch	CONTENT (gal. per 100 feet)
RW	1-7/16	1-3/16	18	5	5.7
EW	1-13/16	1-1/2	28	4	9.2
AW	2-1/4	1-29/32	38	4	14.8
BW	2-7/8	2-3/8	70	4	23.0
NW	3-1/2	3	86	4	36.7
HW	4-1/2	4	113	4	65.2

All dimensions, weights and volumes shown are nominal approximations in inches, pounds and U.S. gallons.

WIRE LINE DRILL RODS

SERIES "Q" WIRE LINE "WEDG-LOK" DRILL RODS

SIZE	O. D. (inches)	I. D. (inches)	WT. (lbs. per 10 ft.)	THREADS per inch	CONTENT (gal. per 100 feet)
AQ	1-3/4	1-3/8	31	4	7.7
BQ	2-3/16	1-13/16	40	3	13.4
NQ	2-3/4	2-3/8	51	3	23.0
HQ	3-1/2	3-1/16	77	3	38.2
PQ	4-5/8*	4-1/16	103**	3	67.4

*Coupling O.D. **With Coupling

DIAMOND CORING BITS

SERIES "Q" WIRE LINE DIAMOND BITS

SIZE	CORE DIAMETER (inches)		HOLE DIAMETER (inches)		HOLE VOLUME (gal. per 100 ft.)
	Decimal	Fractional	Decimal	Fractional	
AQ, AQ-U	1.062	1-1/16	1.890	1-57/64	14.6
BQ, BQ-U	1.432	1-7/16	2.360	2-23/64	22.7
NQ, NQ-U	1.875	1-7/8	2.980	2-63/64	36.3
HQ	2.500	2-1/2	3.782	3-25/32	58.3
PQ	3.345	3-11/32	4.827	4-53/64	95.05

SIZE*	CORE DIAMETER (inches)		HOLE DIAMETER (inches)		HOLE VOLUME (gal. per 100 ft.)
	Decimal	Fractional	Decimal	Fractional	
RWG	.735	47/64	1.175	1-11/64	5.6
EWG,EWM,EWL	.845	27/32	1.485	1-31/64	9.0
AWG,AWM,AWL	1.185	1-3/16	1.890	1-57/64	14.6
BWG,BWM,BWL	1.655	1-21/32	2.360	2-23/64	22.7
NWG,NWM,NWL	2.155	2-5/32	2.980	2-63/64	36.3
HWG	3.000	3	3.907	3-29/32	62.3
2-3/4 x 3-7/8	2.690	2-11/16	3.875	3-7/8	61.2
4 x 5-1/2	3.970	3-31/32	5.495	5-1/2	123.4
6 x 7-3/4	5.970	5-31/32	7.750	7-3/4	245.1

*DCDMA "W" sizes were formerly designated "X".
All dimensions, weights and volumes shown are nominal approximations in inches, pounds and U. S. Gallons

millimeters

DRILL RODS AND CASING

DRILL RODS

SIZE	O.D. (mm)	I.D. (mm)	WT. (kg per 10 ft.)	COUPLING I.D. (mm)	THREADS per inch	CONTENT (liters per 100 feet)
E*	33.3	21.4	12.7	11.1	3	11.0
A*	41.3	28.6	17.2	14.3	3	19.5
B	48.4	35.7	20.8	15.9	5	30.5
N	60.3	50.8	22.2	25.4	4	61.7
RW*	27.8	18.2	8.6	10.3	4	7.9
EW*	34.9	22.2	14.0	12.7	3	11.7
AW*	44.4	30.9	19.9	15.9	3	22.9
BW	54.0	44.5	19.0	19.0	3	47.3
NW	66.7	57.2	24.5	34.9	3	78.3
HW	88.9	77.8	38.6	60.3	3	145.0

*Parallel Wall

FLUSH-COUPLED CASING

SIZE	O.D. (mm)	I.D. (mm)	WT. (kg per 10 ft.)	COUPLING I.D. (mm)	THREADS per inch	CONTENT (liters per 100 feet)
RX**	36.5	30.2	8.2	30.2	8	21.6
EX	46.0	41.3	8.2	38.1	8	40.9
AX	57.1	50.8	13.1	48.4	8	61.7
BX	73.0	65.1	21.3	60.3	8	101.1
NX	88.9	80.9	27.2	76.2	8	156.7
HX	114.3	104.8	40.8	100.0	5	262.7

**Formerly XRT

FLUSH-JOINT CASING

SIZE	O.D. (mm)	I.D. (mm)	WEIGHT (kg per 10 ft.)	THREADS per inch	CONTENT (liters per 100 feet)
RW	36.5	30.2	8.2	5	21.6
EW	46.0	38.1	12.7	4	34.7
AW	57.1	48.4	17.2	4	56.1
BW	73.0	60.3	31.8	4	87.1
NW	88.9	76.2	39.0	4	138.9
HW	114.3	101.6	51.3	4	247.0

All dimensions, weights and volumes are nominal approximations.

WIRE LINE DRILL RODS

SERIES "Q" WIRE LINE "WEDG-LOK" DRILL RODS

SIZE	O. D. (millimeters)	I. D. (millimeters)	WT. (kg. per 10 ft.)	THREADS per inch	CONTENT (liters per 100 ft.)
AQ	44.5	34.9	14.1	4	29.2
BQ	55.6	46.0	18.2	3	50.7
NQ	69.9	60.3	23.1	3	87.1
HQ	88.9	77.8	34.9	3	144.6
PQ	117.5*	103.2	46.5**	3	255.0

*Coupling O.D. **With Coupling

DIAMOND CORING BITS

SERIES "Q" WIRE LINE DIAMOND BITS

SIZE	CORE DIAMETER (millimeters)	HOLE DIAMETER (millimeters)	HOLE VOLUME (liters per 100 ft.)
AQ, AQ-U	27.0	48.0	55.2
BQ, BQ-U	36.5	60.0	86.0
NQ, NQ-U	47.6	75.7	137.5
HQ	63.5	96.0	220.8
PQ	85.0	122.6	359.8

OTHER DIAMOND CORING BITS

SIZE*	CORE DIAMETER (millimeters)	HOLE DIAMETER (millimeters)	HOLE VOLUME (liters per 100 ft.)
RWG	18.7	29.8	21.2
EWG, EWM, EWL	21.5	37.7	34.0
AWG, AWM, AWL	30.1	48.0	55.2
BWG, BWM, BWL	42.0	60.0	86.0
NWG, NWM, NWL	54.7	75.7	137.5
HWG	76.2	99.2	235.8
2-3/4 x 3-7/8	68.3	98.4	231.8
4 x 5-1/2	100.8	139.6	467.0
6 x 7-3/4	151.6	196.9	927.6

*DCDMA "W" sizes were formerly designated "X"
All dimensions, weights and volumes are nominal approximations

CONVERSION TABLE

Multiply known value by factor to obtain answer

Inches	x 25.400	=	Millimeters
Feet	x 0.305	=	Meters
Cubic Inches	x 16.387	=	Cubic Centimeters
Cubic Feet	x 0.028	=	Cubic Meters
Pounds	x 0.454	=	Kilograms
Gallons (U.S.)	x 0.833	=	Imperial Gallons
Gallons (U.S.)	x 3.785	=	Liters
PSI	x 0.070	=	Kilograms per sq. cm.
GPM (U.S.)	x 3.785	=	Liters per minute

DECIMAL EQUIVALENTS

Inches		Millimeters	Inches		Millimeters
1/64	.0156	.397	33/64	.5156	13.097
1/32	.0312	.794	17/32	.5312	13.494
3/64	.0469	1.191	35/64	.5469	13.891
1/16	.0625	1.587	9/16	.5625	14.287
5/64	.0781	1.984	37/64	.5781	14.684
3/32	.0937	2.381	19/32	.5937	15.081
7/64	.1094	2.778	39/64	.6094	15.478
1/8	.1250	3.175	5/8	.6250	15.875
9/64	.1406	3.572	41/64	.6406	16.272
5/32	.1562	3.969	21/32	.6562	16.669
11/64	.1719	4.366	43/64	.6719	17.066
3/16	.1875	4.762	11/16	.6875	17.462
13/64	.2031	5.159	45/64	.7031	17.859
7/32	.2187	5.556	23/32	.7187	18.256
15/64	.2344	5.953	47/64	.7344	18.653
1/4	.2500	6.350	3/4	.7500	19.050
17/64	.2656	6.747	49/64	.7656	19.447
9/32	.2812	7.144	25/32	.7812	19.844
19/64	.2969	7.541	51/64	.7969	20.241
5/16	.3125	7.937	13/16	.8125	20.637
21/64	.3281	8.334	53/64	.8281	21.034
11/32	.3437	8.731	27/32	.8437	21.431
23/64	.3594	9.128	55/64	.8594	21.828
3/8	.3750	9.525	7/8	.8750	22.225
25/64	.3906	9.922	57/64	.8906	22.622
13/32	.4062	10.319	29/32	.9062	23.019
27/64	.4219	10.716	59/64	.9219	23.416
7/16	.4375	11.112	15/16	.9375	23.812
29/64	.4531	11.509	61/64	.9531	24.209
15/32	.4687	11.906	31/32	.9687	24.606
31/64	.4844	12.303	63/64	.9844	25.003
1/2	.5000	12.700	1	1.0000	25.400

LONGYEAR Co.
5-'75

DIAMOND CORE DRILLING
DIMENSIONS, WEIGHTS and VOLUMES

925 Delaware Street S.E.
Minneapolis, Minnesota 55414 U.S.A.
Cable: LONGCO

Troy, Pennsylvania
Cookeville, Tennessee
Salt Lake City, Utah
Sun Meadows, Virginia
Phoenix, Arizona

CANADA:
North Bay, Ontario
Moncton, N. Brunswick
Montreal, Quebec
Toronto, Ontario
Winnipeg, Manitoba
Vancouver, B.C.

COSTA RICA: Apartado 5235
San Jose, Costa Rica

INDIA: P. O. Box 278
Bombay, I. India

AUSTRALIA: 919-929 Mainton Road
Mitchell Park, South Australia 5043
87 Old Pittwater Road
Brookvale, New South Wales

MEXICO: Guillermo Barroso No. 18-F
Fracc. Industrial Las Armas
Tlalnepantla, Mexico

JAPAN: No. 7, 3 Chome, Kohinacli
Chiyoda-ku, Tokyo, Japan

FRANCE: Place de la Gare
76 La Verrière

GERMANY: Braunschweiger Heerstrasse 61
3100 Celle

NETHERLANDS: Nijverheidsweg 47
Elten Liver

KOREA: P.O. 1065
Seoul, Korea

PHILIPPINES: P. O. Box 308
Makati, Rizal, Philippines

WIRE LINE DRILL RODS
SERIES "Q" WIRE LINE "WEDG-LOK" DRILL RODS

SIZE	O. D. (inches)	I. D. (inches)	WT. (lbs. per 10 ft.)	THREADS per inch	CONTENT (gal. per 100 feet)
AQ	1-3/4	1-3/8	31	4	7.7
BQ	2-3/16	1-13/16	40	3	13.4
NQ	2-3/4	2-3/8	51	3	23.0
HQ	3-1/2	3-1/16	77	3	38.2
PQ	4-5/8*	4-1/16	103**	3	67.4

*Coupling O.D. **With Coupling

DIAMOND CORING BITS
SERIES "Q" WIRE LINE DIAMOND BITS

SIZE	CORE DIAMETER (inches)		HOLE DIAMETER (inches)		HOLE VOLUME (gal. per 100 ft.)
	Decimal	Fractional	Decimal	Fractional	
AQ, AQ-U	1.062	1-1/16	1.890	1-57/64	14.6
BQ, BQ-U	1.432	1-7/16	2.360	2-23/64	22.7
NQ, NQ-U	1.875	1-7/8	2.980	2-63/64	36.3
HQ	2.500	2-1/2	3.782	3-25/32	58.3
PQ	3.345	3-11/32	4.827	4-53/64	95.05

SIZE*	CORE DIAMETER (inches)		HOLE DIAMETER (inches)		HOLE VOLUME (gal. per 100 ft.)
	Decimal	Fractional	Decimal	Fractional	
RWG	.735	47/64	1.175	1-11/64	5.6
EWG,EWM,EWL	.845	27/32	1.485	1-31/64	9.0
AWG,AWM,AWL	1.185	1-3/16	1.890	1-57/64	14.6
BWG,BWM,BWL	1.655	1-21/32	2.360	2-23/64	22.7
NWG,NWM,NWL	2.155	2-5/32	2.980	2-63/64	36.3
HWG	3.000	3	3.907	3-29/32	62.3
2-3/4 x 3-7/8	2.690	2-11/16	3.875	3-7/8	61.2
4 x 5-1/2	3.970	3-31/32	5.495	5-1/2	123.4
6 x 7-3/4	5.970	5-31/32	7.750	7-3/4	245.1

*DCDMA "W" sizes were formerly designated "X"
All dimensions, weights and volumes shown are nominal approximations in inches, pounds and U. S. Gallons

DRILL RODS & CASING

Inch dimensions and weights are nominal approximations

DRILL RODS					CASING — FLUSH COUPLED					CASING — FLUSH JOINTED				
Size	Rod O.D.	Coupling* I.D.	Threads per inch	Weight lbs/10 ft	Size	Casing O.D.	Coupling I.D.	Threads per inch	Weight lbs/10 ft	Size	Casing O.D.	Casing I.D.	Threads per inch	Weight lbs/10 ft
RW**	1-3/32	13/32	4	20	RX**	1-7/16	1-3/16	8	18	RW**	1-7/16	1-3/16	5	18
EW	1-3/8	7/16	3	30	EX	1-13/16	1-1/2	8	19	EW	1-13/16	1-1/2	4	29
AW	1-23/32	5/8	3	38	AX	2-1/4	1-29/32	8	31	AW	2-1/4	1-29/32	4	40
BW	2-1/8	3/4	3	50	BX	2-7/8	2-3/8	8	62	BW	2-7/8	2-3/8	4	70
NW	2-5/8	1-3/8	3	55	NX	3-1/2	3	8	80	NW	3-1/2	3	4	87
HW	3-1/2	2-3/8	3	96	HX	4-1/2	3-15/16	5	92	HW	4-1/2	4	4	114
AWL†	1-3/4	1-3/8	3	31	PX	5-1/2	4-7/8	5	125	PW	5-1/2	4-7/8	3	153
BWL†	2-3/16	1-13/16	3	40	SX	6-5/8	5-7/8	5	167	SW	6-5/8	5-15/16	3	195
NWL†	2-3/4	2-3/8	3	51	UX	7-5/8	6-15/16	4	197	UW	7-5/8	6-15/16	2	235
HWL†	3-1/2	3-1/16	3	79	ZX	8-5/8	7-15/16	4	236	ZW	8-5/8	8	2	276

*Rod I.D. in the case of WL Series Wireline Rods **Formerly XRT †Boyles WL Series Wireline Rods

Metric dimensions and weights are nominal approximations

DRILL RODS					CASING — FLUSH COUPLED					CASING — FLUSH JOINTED				
Size	Rod O.D. (mm)	Coupling* I.D. (mm)	Threads per 2.5mm	Weight kg/3m	Size	Casing O.D. (mm)	Coupling I.D. (mm)	Threads per 2.5mm	Weight kg/3m	Size	Casing O.D. (mm)	Casing I.D. (mm)	Threads per 2.5mm	Weight kg/3m
RW**	27.8	10.3	4	8.9	RX**	36.5	30.2	8	8.0	RW**	36.5	30.2	5	8.0
EW	34.9	11.1	3	13.4	EX	46.0	38.1	8	8.5	EW	46.0	38.1	4	13.0
AW	43.7	15.9	3	17.0	AX	57.2	48.4	8	13.8	AW	57.2	48.4	4	17.9
BW	54.0	19.0	3	22.3	BX	73.0	60.3	8	27.7	BW	73.0	60.3	4	31.3
NW	66.7	34.9	3	24.6	NX	88.9	76.2	8	35.7	NW	88.9	76.2	4	38.8
HW	88.9	60.3	3	42.8	HX	114.3	100.0	5	41.1	HW	114.3	101.6	4	50.9
AWL†	44.5	34.9	3	13.8	PX	139.7	123.8	5	55.8	PW	139.7	123.8	3	68.3
BWL†	55.6	46.0	3	17.9	SX	168.3	149.2	5	74.6	SW	168.3	150.8	3	87.1
NWL†	69.9	60.3	3	22.8	UX	193.7	176.2	4	87.9	UW	193.7	176.2	2	104.9
HWL†	88.9	77.8	3	35.3	ZX	219.1	201.6	4	105.4	ZW	219.1	203.2	2	123.2

*Rod I.D. in the case of WL Series Wireline Rods. **Formerly XRT †Boyles WL Series Wireline Rods

COREBARRELS, BITS & REAMING SHELLS

Inch dimensions and imperial gallon volumes are nominal approximations

COREBARREL DESIGN					CORE BIT		REAMING SHELL	HOLE DIAMETER	CORE DIAMETER	HOLE VOLUME
WF	WG*	WM	WT	WL†	O.D. Set	I.D. Set	O.D. Set			gal/100 ft
			RWT**		1.160	0.735	1.175	1-3/16	23/32	4.8
	EWG	EWM			1.470	0.845	1.485	1-1/2	13/16	7.6
			EWT			0.905			7/8	
	AWG	AWM			1.875	1.185	1.890	1-15/16	1-3/16	12.0
			AWT			1.281			1-9/32	
				AWL		1.062			1-1/16	
	BWG	BWM			2.345	1.655	2.360	2-3/8	1-5/8	19.1
			BWT			1.750			1-3/4	
				BWL		1.433			1-7/16	
	NWG	NWM			2.965	2.155	2.980	3	2-1/8	30.4
			NWT			2.313			2-5/16	
				NWL		1.875			1-7/8	
HWF	HWG				3.890	3.000	3.906	3-15/16	3	52.5
			HWT			3.187			3-3/16	
				HWL	3.762	2.500	3.782	3-51/64	2-1/2	48.3
PWF					4.725	3.627	4.748	4-3/4	3-5/8	76
SWF					5.725	4.439	5.748	5-3/4	4-7/16	112
UWF					6.840	5.505	6.870	6-7/8	5-1/2	160
ZWF					7.840	6.505	7.870	7-7/8	6-1/2	210

*Formerly X Series **Formerly XRT †Boyles WL Series Wireline Corebarrels

Metric dimensions and litre volumes are nominal approximations

COREBARREL DESIGN					CORE BIT		REAMING SHELL	HOLE DIAMETER	CORE DIAMETER	HOLE VOLUME
WF	WG*	WM	WT	WL†	O.D. Set (mm)	I.D. Set (mm)	O.D. Set (mm)	(mm)	(mm)	litres/30m
			RWT**		29.46	18.67	29.84	30.2	18.3	22
	EWG	EWM			37.34	21.46	37.72	38.1	20.6	34
			EWT			22.99			22.2	
	AWG	AWM			47.62	30.10	48.01	49.2	30.1	54
			AWT			32.54			32.5	
				AWL		26.97			26.9	
	BWG	BWM			59.56	42.04	59.94	60.3	41.3	86
			BWT			44.45			44.4	
				BWL		36.40			36.4	
	NWG	NWM			75.31	54.74	75.69	76.2	54.0	136
			NWT			58.75			58.7	
				NWL		47.62			47.6	
HWF	HWG				98.81	76.20	99.21	100.0	76.2	235
			HWT			80.95			80.9	
				HWL	95.55	63.50	96.06	96.4	63.5	216
PWF					120.01	92.13	120.60	120.6	92.1	340
SWF					145.42	112.75	146.00	146.0	112.7	501
UWF					173.74	139.83	174.50	174.6	139.7	716
ZWF					199.14	165.23	199.90	200.0	165.1	939

*Formerly X Series **Formerly XRT †Boyles WL Series Wireline Corebarrels

Boyles Bros.
5-'75

Joy Mfg. Co.
5-'75

JOY WIRELINE CORE BARREL & DRILL ROD SPECIFICATIONS

	AX	BX	NX	NC
Hole Diameter (Approx.)	1-7/8"	2-3/8"	3"	3-11/16"
Core Diameter (Approx.)	1-1/64"	1-7/16"	2"	2-13/32"
Reaming Shell - Set O.D.	1-55/64"	2-3/8"	2-63/64"	3-43/64"
Bit - Set O.D.	1-27/32"	2-23/64"	2-31/32"	3-21/32"
Bit - Set I.D.	1-1/64"	1-7/16"	2"	2-13/32"
Outer Tube - O.D.	1-3/4"	2-9/32"	2-27/32"	3-1/2"
Outer Tube - I.D.	1-27/32"	1-29/32"	2-15/32"	3-1/16"
Inner Tube - O.D.	1-1/4"	1-3/4"	2-5/16"	2-29/32"
Inner Tube - I.D.	1-1/16"	1-1/2"	2-5/64"	2-9/16"
Rod - O.D.	1-3/4"	2-1/4"	2-13/16"	3-1/2"
Rod - I.D.	1-11/32"	1-7/8"	2-7/16"	3-1/16"
Threads Per Inch	4"	4"	4"	3"

****

Footage	JOY NC	JOY NX	JOY BX	BOYLES NC	BOYLES NX	BOYLES BX	JOY	BOYLES
0 - 500	8.30	7.30	7.10	10.00 ?			4150	5,000
500 - 1000	8.80	7.70	7.50	10.80 ?			4400	5400
1000 - 1500	9.60	8.60	8.40	11.60	10.35		4800	5800
1500 - 2000		9.40		12.10	10.85		(9.05) 18,050 4700	(10.81) 21,625 5425
2000 - 2500		10.40		12.85	11.60		5200	5800
2500 - 3000		11.60		14.10	12.85		5800	6425
3000 - 3500		13.10		15.60	14.35		(11.70) 17,550 6550	(12.93) 19,400 7175
3500 - 4000			14.90	16.10		15.90	7450	7950
4000 - 4500			17.40	18.60		18.40	8700	9200
4500 - 5000			19.90	21.85		21.65	9950	10,825
5000 - 5500			22.90	26.35		26.15	(18.78) 37,550 11450	(20.53) 41,050 13,075
5500 - 6000				30.85		30.36		
6000 - 6500				36.85		36.65	73,150	82,075
6500 - 7000							(13.30)	(14.92)

2,000 - 5500 55,000 (15.74) 60,450 (17.27)

0 - 5000 = 61,700

+ 2/ft 10,000

71,700

TR-10 Aug - Sep - Oct - Nov

4 months

Selection

Mole 300

0 - 500	5.50	2750			
500 - 1000	6.50	3250			
1000 - 1500	8.00	4000	10,000	= 6.67/ft	+ 2.25 cost casing, cementing
1500 - 2000	9.50	4750	14,750	7.38/ft	+ 2.25 cost casing, cementing

Hourly 38.00 x 24 = 912.00 @ 5.50/ft = 166'

@ 6.50/ft = 140'

@ 8.00 ft = 114'

@ 9.50 ft = 96'

1973 - 1974 DRILLING REQUIREMENTS

		TOTAL DEPTH	METHOD	SUGGESTED ROTARY	CONTRACTOR DD
RED HILLS	1	3500 - 5000	ROTARY CASE DD		JOY
CHARLESTON	1	3500 - 5000	DD		JOY
	2	3500 - 5000	DD		JOY
	3	~~#~~ 2,400 hole	DD or Rotary		JOY ?
3R	1	deepen TR-10 to 5000 from 4105	DD move rig from TR-8		JOY
	2	new hole 3500-5000	Use rig from TR-10		JOY
SUPERIOR EAST	1	deepen A-7 ±3100 to ±6000	DD - move rig from AI-1		BOYCES
	2	new hole 3500 - 4500	Rotary and DD	Rotary to 1500' ?	JOY ? ?
	3	deepen two holes on State 4, 5	currently open holes at ___ ? ___		
Bohme	1	AH-4 1500	Rotary spot core		
	2	AH-5 3000	Rotary core DD		JOY
	3	AH-6 3000 - 5000	Rotary core core		
Hardshell		~~#~~ 14,000 of diamond drilling in two holes needs to be over Aug 31 for 2 yrs assessment work			
Geologic Drill		Rotary mist/air capable + 1500' depths			

DRILLING

3R PROJECT

JOY TM-80 Rig

↓

TR-10 (deepen 4105-5000)
Dec - Jan - Feb

↓

TR-11 (0-5000)
Feb - Mar - April - May

↓

SUPERIOR EAST

FROM BOHME ← RDH ±1500' JOY OCCUPY CASED HOLE (1500-5000)
June-July-Aug

STATE SECTIONS 5 - $12,000 finish by may 30 A-3 open hole 1445 ⟩ how drill?
4 - $12,000 " " June 29 A-6 open hole 1358

A-7 deepen by Boyles
rig from AF-1
then to Bohme?

Red Hills

~~Dec~~ Jan RDH → 1500' →

JOY DD - Jan-Feb-Mar
(1500-3500-5000)

↓

CHARLESTON

MAR-APRL-MAY
(0-3500-5000)

JUN-JULY-AUG-SEPT
(like to go into Spot for new assessment year)
(0-3500-5000)

BOHME

RDH from Red Hills
① 0-1500 spot core
② 0-1500 to Sup East
~~③ 1500 to Sup East~~

~~BOYLES DD ? ②~~
~~② RDH 1500 after~~
~~DD ② ? DD ③~~

Boyles (?) occupy
site ② DD (1500-5000)

RDH after complete
DD site ② 0-1500
then DD 1500-4000

HARDSHELL

AUG-SEPT
$7,000 $7,000
diamond drill

Rotary — Harness
Shelton

Rotary holes to 1500' or greater

in order of drilling - 4" casing

	# holes
Red Hills	1
Bohme	2 (3rd after DD)
Sup East	1

↓

onto Geologic Drill Program
0-1500 foot holes

Superior East
Bohme

Boyles Diamond [illegible]

	Depth	Interval	Direct	Site	Sample	Supers.	Total
DCA-1 Boyles	4002'-5813'	1811'	40.50	0.88	0.24	3.05	44.77
A-4 Boyles	3593-6664	3071'	31.14	0.03	0.51	1.67	33.35
M-1A Boyles	[illegible] - [illegible]	2920	29.36	0.22	1.03	2.26	32.86
A-2 Langwell	4076 - 4521	445	46.75	0.27	12.07	8.85	67.94
A-2W Langwell	4230 - 4940	710	18.02	0.23	5.66	2.23	26.27
AH-1	1690 - 3863		20.77				
AH-2	1995 - 3781		20.14				
	Rotary						
A-4 Boyles Shelton	0 - 3593	3593	18.88	0.80	1.05	1.42	22.55
A-2 Coffey	0-4076	4076	17.20	0.99	0.44	0.47	19.10
AT-1 Barnes							
A-7 Barnes							
A-5 Shelton	0 - 3145	3145	14.64	1.87	[illegible]	[illegible]	17.10
AH-1 Whatley	0 - [illegible]		[illegible]				
AH-2 Whatley	0 - 1998		[illegible]				
AH-3 Harris							

CO PO 1
ED 1/1/58

Rawhide

PURCHASE ORDER

AMERICAN SMELTING AND REFINING CO.
Tucson Office 1150 North 7th Avenue
P. O. Box 5747 Tucson, Arizona 85703

DATE: July 18, 1973
ORDER NO.: T-73-364
REQUISITION NO.:

PLANT JOB NO.:
APPROPRIATION NO.:

TO:
J. O. Barnes Drilling Service, Inc.
P. O. Box 141
Casa Grande, Arizona 85222

FINAL DESTINATION — PLEASE NOTE CONSIGNMENT BELOW

DATE REQUIRED AT DESTINATION:

CONSIGNMENT — SELLER WILL SHIP TO

W. L. K.
AUG 13 1973

SHIPPING INTERVAL PROMISED | SELLER WILL SHIP BEFORE:

POINT OF SHIPMENT | TERMS

— RENDER BILLS AS PER ATTACHED SHIPPING INSTRUCTIONS —

F. O. B. POINT

SHIP VIA

QUANTITY	UNIT	SPECIFICATIONS	ITEM NO.	UNIT PRICE
		J. O. BARNES DRILLING SERVICE, INC., hereinafter referred to as CONTRACTOR, will drill exploration holes on ASARCO's drilling projects near Superior, Arizona, the locations and depths of which will be specified by ASARCO's representatives at the jobsite. Payment for this work will be made on an hourly basis and in accordance with CONTRACTOR's letter of proposal dated July 13, 1973, a copy of which is attached to and made a part of this order. Two drill crews consisting of three men each will be provided. In addition, a full-time tool-pusher will be provided. It is understood by both parties to this order that ASARCO will not be charged for delays caused by failure of CONTRACTOR's equipment or personnel. CONTRACTOR's particular attention is called to Clause Eleven (11) on the reverse of this order. The insurance certificates filed in connection with our Purchase Order T-73-45 will suffice if still in force; otherwise, we will require new certificates.		
		Orig: J. O. Barnes Drilling Service, Inc. cc: J. O. Barnes Drilling Service, Inc., for acceptance WLKurtz JDSell HLCrittendon Acctg. Dept. File		

ACCEPTED FOR J. O. BARNES DRILLING SERVICE, INC.

By: _____ Title _____

IMPORTANT

Attached Acknowledgment Card must be completed and returned promptly.

PLEASE ENTER OUR ORDER FOR THE ITEMS SPECIFIED ABOVE, SUBJECT TO ALL INSTRUCTIONS AND PROVISIONS ON REVERSE SIDE.

/s/ Robert B. Crist
for Manager of Exploration

DRILL ANY SIZE HOLE
MUD, AIR AND AIR HAMMER
DRILLING

711 E. LAUREL DRIVE
PHONE 836-8061

J.O. Barnes Drilling Service, Inc.
Licensed and Insured Contractor
P. O. BOX 141
CASA GRANDE, ARIZONA 85222

July 13, 1973

American Smelting & Refining Co.

Att. Howard Crichton.

On your Miami-Superior exploratoy location, we will furnish drilling crew, drill pipe 4½" & 2 & 7/8", fuel and oil for rig, necessary insurance, water truck, water tank, storage tank and a rig-up truck. Of course we will furnish rig.

Will loan your Company H-D500 I R hammers - one new and one used.

We will move in and rig up for 2500.00 for first hole; after that we charge 1000.00 for moving from hole to hole.

Rig time is 60.00 per hr.

Standby time is 30.00 per hr. for first 24 hrs. due to air compressor failure. If standby extends more than 24 hrs, you pay my labor cost.

If drill rig is down more than 2 hrs. there is no cost to you

Bits, supplies, fuel etc. for use on your job will be cost to me plus 10% FOB location.

All billing subject to Arizona Sales Tax.

Sincerely

J.O.BARNES DRILLING SERVICE INC.

J.O. Barnes

J.O.Barnes, President

Items I would question on J.O. Barnes Billing
See penciled yellow sheets on back of Barnes Billing.

Fishing problem is theirs? 54 hours

On 8-21. Mr Hammer came again & they were pulling pipe & getting ready to "fish" the last 8 hours of the shift.
On 8-22 Fished & redressed tools all day.
On 8-23 Found they still had metal in hole - went fishing again.

Excessive time due to not having equip & not doing job right the 1st time. 22 hours

On 8-28. Cement got down @ 6:15 PM - what happened next thing?
On 8-29 A number of hours (15?) lost waiting on welder & working on some after it got on location. Had to repair weld they made earlier - so had to do it twice - more lost hours. (3?)
On 8-30 Approx 8 hours lost in getting drilling head aligned etc.

Possibly part of this on Stanley? 7 hrs?

On 9-5 Booster needs to be shut down - drill waiting on orders during day shift - evening tower pulled 35 stands.

On 9-7 Hole fell in but they got loose & off bottom by 4:45 PM. Next 7 hours spent in changing out drilling lines & spooling old cable up. (Apparently not changed for)

Prob. 9 hours of excess charge?

On 9-8 Continued work on belly lines & rotary table & only 8 hours ± on mixing mud.
On 9-9 Mix & pumping mud.
On 9-10 Mix & pumping mud - finally got pulled up & washed & reamed to fill & down some. 1½ hrs working on mud pump.

Prob. 12 hours excess charge in equip failure etc on them.

On 9-11 Only 2 hours on drilling - rest waiting on repairs of mud pump.

On 9-12 No charge on waiting for parts & repair etc.
Seems to be ~~bilted~~ billed OK — ie 10 hrs running pipe
& mixing mud.

Poor performance On 9-13 Mixing bait mud & working down all day 24 hrs for 31 ft ± ! ~~[illegible]~~.

On 9-14 Next 7 hrs got ± 133 feet ! ; drilled ahead 17 feet
& laying down pipe preparing to case.

Recap:

Possibly deduct: 56

22
7
9

12

106 ~~[illegible]~~ @ 60.00/hr from rig time

Add: 7 hrs @ 30.00/hr to standby time.

Hanna

heath & sherwood drilling

6-8 hudson bay avenue, kirkland lake, ontario, canada
p.o. box 998, phone 705-567-9311, telex 027-76120

July 6th, 1972.

Mr. H. L. Crittendon,
American Smelting & Refining Co.,
South West Exploration Division,
P.O. Box 5747,
1150 North 7th Avenue,
Tucson, Arizona.
U.S.A.

Dear Howard:

I would like to apologize for the length of time it has taken me to get this quotation to you. We have decided to use a rig a little smaller than our HS-150 rig. I have just now received prices and delivery date on a new rig. This rig would be capable of drilling 6-1/4" holes to 4,000 ft. using air, water or mud, drilling to 6,000 ft. with our 3-1/2" rods and 8,000 ft. plus using 2-3/4" rods.

This rig is skid base mounted and can be broken down into pieces of 3500 lbs. if it is required for moving by 204 Bell Helicopter.

I have put the mobilization and demobilization charges in at a fixed cost from Denver, Colorado.

The compressor rental, fuel for compressors, mud and additives, and casing would be for Asarco account. I estimated that 200 ft. of casing would be left in each hole. The reason for this is, I would suggest that the bottom 150 to 200 ft. of the 4-1/2" casing be cemented. We would run a casing cutter at the completion of each hole and recover the top 1,800 ft. of casing from each hole drilled. This casing could then be used in the next hole.

The footage prices of $10.90 ft. for the air drilling to 2,000 ft. and $17.70 ft. for core drilling from 2,000 to 4,000 ft. includes fuel and lubes for the drill rig. Water supply including a water truck and driver on an 8 hour per day basis. If the water truck was required more than 8 hours per day, an additional $7.50 per hour would be charged to cover driver and fuel costs.

continued.....

If the rig is used by Asarco on a day rate basis, the rate stated includes fuel and lubricants for the rig, water supply pump or water truck and driver on an 8 hour day basis. Also included in the footage price is the cost of tricone and core bits.

When you have had a chance to evaluate our proposal, I would be pleased to visit you and discuss it with you. This proposal is one way we are suggesting for your drilling program. We would be willing to look at ways of bidding this contract. One other way, we may suggest, is going on a 75% of machine day rate and a certain price per foot with Asarco supplying the bits. I am estimating that we will drill 280 ft. per 24 hour day on the air tricone drilling to 2,000 ft. and 105 ft. per day on the core drilling from 2,000 ft. to 4,000 ft. This may be on the conservative side, but we will have a better idea what the footage production will be, if and when, we drill a couple of holes.

We would be able to start the drilling about 60 days after we have received a letter of intent, or a signed contract from Asarco.

We would like to thank you for the opportunity of bidding on your drilling program. If you have any questions, do not hesitate to call me in Kirkland Lake, Ontario, Canada. Our telephone number is 705-567-9311.

If I am not in Kirkland Lake, our receptionist will contact me and I will call you back.

Yours very truly,

HEATH & SHERWOOD DRILLING,

W. L. Hokanson

W. L. Hokanson.

WLH:mfc
attachment.

July 6th, 1972.

American Smelting & Refining Co.,
Tucson, Arizona.

Mobilization from Denver, Colorado	3,740.00
Drill Proposal - 3 holes to 4,000 ft.	
Price to drill 6-1/4" hole from 0 - 2,000 ft. including installing casing and cement	10.90 ft.
Asarco to provide casing. A suitable compressor to drill with air to 2,000 ft. and all necessary additives such as stiff foam etc. estimated drilling time to 2,000 ft. would be 8-1/2 days.	
Heath & Sherwood Drilling to provide bits and all necessary drill collars and drill pipe, including rotating head and bowl assembly.	
Core drill from 2,000 ft. to 4,000 ft. Hole size 3-7/8. Core size 1-7/8.	
Price per foot	17.70 ft.
Asarco to supply all muds and additives, core boxes, reaming and casing costs, if necessary.	
Machine rates for day work operations standby with crews.	
Standby with crew, includes 72 man hours	1,110.00 per day
Moving including 72 man hours	1,110.00 per day
Moving time will apply if moves exceed one day.	
Day work for reaming, cementing or other special operations, includes 72 man hours, fuel and lubricants.	1,290.00 per day
Price stated is for 3 holes to 4,000 ft.	
Demobilization back to Denver, Colorado	3,740.00

Drilling time

6-1/4 hole	=	8-1/2 days
3-7/8 hole	=	20 days

Estimated cost to Asarco -

Compressor - exact cost not available

Casing recovery estimate - cutting pulling casing cost $600.00

Muds including soluble oil,- estimated mud consumption 280 barrels per hole at $3.00/bbl. 840.00

Soluble Oil - 35 gallons day x 20 days x 1.35/gal. 945.00

Estimated compressor cost $350.00 per day x 8-1/2 days 2,975.00

Total estimated cost to Asarco for three 4,000 ft. holes

Mud	840.00 x 3	2,520.00
Soluble Oil	945.00 x 3	2,835.00
Compressor	2975.00 x 3	8,925.00
* Casing estimated	3.00 ft. x 2,400 ft.	7,200.00
Mob and demob.		7,480.00
Drilling 12,000 ft. at average 14.31 ft.		171,600.00
Casing recovery cost 600.00 x 3		1,800.00
Estimated total drilling cost		$202,360.00 or,
		$16.86 ft.

Plus core boxes and surveys.

* 1,800 ft. of 4-1/2 casing may be recovered from last hole.

Casing Program

Drill 8-3/4" hole to 30 ft. set and cement 7" O.D. H-40 17 lbs. at 30 ft. cement required - 9 sacks.

Drill 6-1/4" hole to 2,000 ft. run in 4-1/2" O.D. 9.5 lbs. 3.965 drift diameter casing.

Cement bottom 200 ft. of casing using 15 sacks cement.

Bottom 200 ft. of casing to be thread locked with Baker Lok or Halco weld.

Casing to be hung in casing slips, at top of 7" pipe. Weight to be determined when casing is set.

Hanna

East 905 Third Avenue, Spokane, Washington SHAFT DRILLERS 99202 Phone (509) 535-3587

June 13, 1972

Mr. Howard Crittendon
American Smelting & Refining Company
P. O. Box 5747
Tucson, Arizona 85703

Dear Howard:

Sorry to be so late getting back to you and glad on the other hand to learn that the road cut was Gila conglomerate rather than Whitetail.

In a real cursory-type cost estimate, it looks like the average costs would run as follows:

1) Rotary in Gila conglomerate, Dacite, Whitetail conglomerate 0-3000 LF $7.50/LF.

2) Diamond coring (wireline) in Whitetail conglomerate and grab bag 3000-4500 LF $12.50/LF to absolute maximum of $20.00/LF.

This is all based on holes 4000 to 4500 LF each.

If you have an 8000 LF program for three holes, as mentioned in your letter, you must be contemplating shallower depths. In that case, you can still apply the footage costs as noted. The sliding scale of $12.50 - $20.00/LF is to adjust against the quartz in the schist. Assuming we encounter the quartz in quantity (say 50% of coring), the average price of coring would be $16.25/LF. If there was no quartz, then we would probably be on an average @ $12.50 - $14.00/LF coring.

All our operations would be on a seven-day week, three (3) shift basis, with a full-time foreman or superintendent.

For rig space, we would require about the same area as the Mayhew 3000 of Coffee's. (Same on access roads, which should include a turn-around.)

As to mobilization, we have yet to arrive at a realistic figure, particularly on 8000 feet--it would help to have more holes or more footage. We will sharpen our pencils on this, but at this point it looks like $5000.00.

Hourly charges would be:

Rotary	$125.00/hour	w/rig running (air included)
	62.50/hour	w/rig on surveys, standby, etc.
Coring	$ 83.50/hour	w/rig running
	55.50/hour	on surveys, standby, etc.

The foregoing figures are not final and we are looking for a lower range. Once you have a firm program (relative), I am sure we will have some firm figures.

Thanks for the trip and review. It was one of the best site reviews I have had.

Sincerely,

Charles K. Presley
For: E. A. Hainze
Manager - Diamond Drill Division

EAH: sh

Howard:
Gene had to go down to the Asarco job near Weed, Calif. so I'm signing HH for him.
Best regards.
Ken Presley

Henne

P. O. Box 14837, Oklahoma City, Oklahoma 73114

SHAFT DRILLERS

Phone (405) 843-5721 Telex 071-310

July 25, 1972

Mr. Howard Crittendon
American Smelting and Refining Company
P. O. Box 5747
Tucson, Arizona 85703

Dear Howard:

This letter will supersede Gene Hainze's letter of June 13, 1972, concerning the diamond core drilling on ASARCO's property northeast of Tucson.

After viewing the property and discussing the drilling program, this letter will firm up the prices and hopefully all of the details that you may have questions on and to reiterate the prices given to you verbally before we left.

It is our understanding that you desire to get started on this program sometime in Ausust or not later than the middle of October to complete your program in the time you have allotted. We plan to furnish a rig of the capacity as described in the attached inventory or a rig of comparable equipment that will equal or exceed the specifications as needed for your work. We will furnish one complete drilling rig including drill pipe and drill collars including three 4-man crews and one rig supervisor working a schedule of 24 hours per day, seven days per week.

ASARCO will guarantee us 8,000 feet of hole or a minimum of three core holes whichever is first reached.

On the first hole we will move in, rig up, and be ready to spud the conductor hole for a flat sum of $7,500.00 which includes labor, supervision, and all trucking necessary to complete this work. On subsequent moves, from location to location, we will furnish the same items as above for a flat sum charge of $2,400.00. Our final demobilization charge at the end of two holes will be $5,000.00. Our final demobilization at the end of four holes or more will be $2,400.00

It is anticipated that the top 1,200 to 2,000 feet of hole can be air drilled by rotary and our price will be $7.50 per foot. This price includes us furnishing three 4-man crews, one rig supervisor, air for air drilling, mist pump, air operator, fuel for air compressors, fuel for rig, repair and maintenance on rig, one complete rig, drill pipe and drill collars, and bits. We will be on our footage price while tripping in or out of the hole, changing the bit, and drilling.

The hole may encounter too much water at which time the hole will either be continued on mud to drill ahead or diamond coring may begin at this point at the Operator's option.

Should rotary drilling be continued, our footage price while drilling with mud will be on a sliding scale. The sliding scale is to be determined by two points on a graph on a straight line relationship with two points being plotted as follows:

1. If the average penetration rate is 150 feet per day or less, the price will be $12.50 per foot.

2. If the average penetration rate is 300 feet per day or more, the price will be $7.50 per foot.

This daily average should not be taken everyday and a price determined for that day, but should be taken daily only for a cummulative average for this entire section of rotary drilled hole with mud to establish one daily average and one price per foot. This then can easily be taken off of the graph. All hourly rate time is not to be considered in this calculation. All of the hours are to be added while on bottom drilling, tripping in and out of the hole and the changing of the bit for a total number of applicable hours. This is to be divided by 24 to give the total days involved for this interval. The total rotary-mud drilled section is then to be divided by this number of days to find the point on the graph in feet per day average; the footage price is then taken from the vertical scale. As you can see your footage price for rotary-mud drilling will not exceed $12.50 per foot, nor will it be less than $7.50 per foot.

The diamond coring portion of the hole will be figured the same way as the rotary-mud drilled hole. The two points to determine the graph are as follows:

1. An average coring rate of 90 feet per day will be at $22.50 per foot.

2. An average coring rate of 252 feet per day will be at $12.50 per foot.

To find the maximum price per foot cored, extend the straight line on the graph to 60 feet per day average to find the maximum rate per foot. By the same token, extend the other end of the line to an average coring rate of 282 feet per day to find the lowest price per foot cored. The average footage cored is to be figured as above and to include only the time to core, retrieve the interbarrel, and trip in and out of hole for bit change, and barrel dumping.

Our hourly rate changes will be as follows:

1. While drilling with and including air, $125.00 per hour.

2. When drilling with the rotary and air is not utilized, our rate will be $62.50 per hour.

3. When coring, our hourly rate will be $83.50 per hour when the rig is in operation.

4. Our other rate for surveys and standby time will be $62.50 per hour when coring.

The only time we anticipate utilizing 1. above at the $125.00 per hour rate will be while surveying or unloading the hole after a bit change and continuing ahead with air, plus running conductor pipe. The Operator will furnish all standby air charges that are charged prior to spud and after the air drilled portion of the hole has been completed. This will have to be negotiated with the air compressor people. ASARCO will also furnish the trucking of the air compressors to each location.

The appropriate hourly rate 1. through 4. above will apply to the following:

Cleaning hole for conductor pipe; cleaning hole to run casing; running conductor pipe; running casing; all cementing time for casing, squeezing, etc.; unloading and cleaning hole; running surveys; standing by for the Operator; and cementing all water.

The Operator is to furnish all mud, all cement, centralizers, conductor pipe, casing, threadlock, float shoe equipment, bloole line, rotating head and rubbers, soap for the ejection pump, all welding on Operator furnished items, plus all water, including the cost for same as well as trucking and transportation of water.

In addition to our equipment, we will furnish a two-pen geolograph recorder and a gin truck with gin poles to stay with the rig; however, the Operator will furnish the fuel for the truck and the maintenance if needed on this truck. Our drilling crews will operate this truck both for our needs as well as the needs of the Operator. The Operator will furnish tractor towage when needed.

The above prices and conditions will also apply on your other property providing the distance does not exceed five miles and that the geology is essentially the same consisting of the Gila conglomerate, Dacite and Whitetail conglomerate and the Shist or Grab Bag, and that the only difference being the differences in thickness of these formations. It is our understanding that our only guarantee is 8,000 feet of hole or a minimum of three holes whichever is first reached, but if our performance is satisfactory, it may be possible to drill two additional 6,500 feet holes on your other property.

We hope we are the successful bidder, and hope that all of your questions have been answered. Enclosed are two charts showing the sliding footage scales. If you have any questions concerning this bid, please advise.

We greatly appreciate the conference and the time you afforded to us and hope that we may be of service to you in the near future.

Very truly yours,

SHAFT DRILLERS, INC.

W. A. Glass

W. A. Glass
Vice President

WAG:dv

Enclosures

Bchme

East 905 Third Avenue, Spokane, Washington SHAFT DRILLERS 99202 Phone (509) 535-3587

August 29, 1972

Mr. Howard Crittendon
American Smelting & Refining Company
Southwestern Exploration Division
P. O. Box 5474
Tucson, Arizona 85703

Dear Howard:

We have reviewed your letter of July 28, 1972, and have the following suggestions in another form than presented in our July 25, 1972 proposal.

First, we do not anticipate any large volume of accumulated hourly charges.

Secondly, we believe that coring progress will be substantially above past experience so that the sliding scale actually would be in your firm's favor. For your convenience, we have provided a single per foot price. All equipment provided to the job by Shaft Drillers will be in good operating condition, which will substantially reduce accumulated delays and costs as experienced in the past.

1) Mobilization $7500

2) Demobilization $2500 if 3 holes - no charge

3) Rotary drilling with air $7.50/LF

4) Rotary drilling with mud (if necessary) $12.50/LF

5) Diamond drilling to 7000 LF ~~$22.00~~/LF 17.50

6) Reaming hole or drilling out cement $9.00/LF

7) Hourly charges:

   a) Rotary drilling with air $125.00/hour on bottom

   b) Rotary drilling without air $62.50/hour on bottom

   c) Core drilling @ $83.50/hour on bottom

   d) Running and pulling casing, standby, surveys, delays (no charge for weather delay) not the fault of Shaft, cementing, lost circulation, unloading and conditioning hole $62.50/hour

8) All drilling mud, drilling mud additives, cement and cement admixtures, foams, casing, casing shoes, water, conductor pipe, centralizers, casing threadlock, float shoe and blooie line will be charged @ list price F.O.B. jobsite if provided by Shaft.

9) All drill sites and access will be safely constructed and maintained at no cost to Shaft. Should road grades exceed 10%, ASARCO will provide a cat for assistance.

10) Moves between holes, teardown and set up will be charged @ $2400 each hole.

11) Five holes will be guaranteed of 4000 - 4500 LF each unless Shaft's performance does not meet the expectations of either party. Two additional holes of 6000 - 6500 feet each will be included as a continuation of the contract if Shaft's performance remains acceptable in progress and costs after completion of the first three 4000 - 4500 LF holes.

12) To provide for the anticipated performance, Shaft will provide the following to the job location:

   a) One National T12 rotary/core drill with pumps, dog house, racks, tanks, light plants, etc.

   b) One gin truck with poles

c) One welder each acetylene and arc

d) Crew transportation

e) Full-time superintendent

f) 3 shifts of 4 men each 7 days/week

g) Two pen geodograph

h) Air compressors

i) Mist pump

j) Air comp. operator

k) All bits, collars, drill pipe, core barrels

l) All fuels, lubricants, parts, etc.

13) Core boxes will be provided by ASARCO.

Shaft estimates completion of a 4000-4500 LF hole in about 20 days.

We remain most interested in your work and hope that our thoughts in this letter reflect acceptable frameworks. Should you have any questions regarding the foregoing, please call us at your convenience. We are available to discuss the program in detail with you in Tucson.

Sincerely,

E. A. Hainze
Manager - Diamond Drill Division

EAH: sh

Shaft -	7,500	Mobe	Between Sites	2,400
	2,400	Dense		
AIR -	0 - 1200 to 2,000	7.50		
Mud		7.50 - 12,50		

Heath-Sherwood

AIR	0 - 2,000	10.90	includes casing time & cementing ASARCO supply air.
CUR	2 - 4,000	17.70	

Lois

a copy please of latest:

J.O. Barnes Bill

Air Equip Bill

Burles Bros bill

Jay Bill (guess it will be last years 3R bill)

A.D.C.
SEP 4 1973

J.O. Barnes Drilling Service, Inc.

711 E. LAUREL DR. - PHONE 836-8061 - P.O. BOX 141
CASA GRANDE, ARIZONA 85222

DATE Aug. 30, 1973

TO: American Smelting & Refining Co.
P O Box 5747
Tucson Arizona 85703

Order # T-73-364
July 18, 1973

Hole # 1, Superior.

Move in and rig up		$2500 00
Rig operatin time, 590 hrs. @ 60.00 per hr.		35400 00
Labor to run casing & haul water 124 man hours @ 3.66 per hr.		453.84
Overtime labor cost, 12 hrs. @ 7.32		87 84
One 15" Bit	250.00	
One 9" Bit	240.00	
Two 9" DHD Hammer Bits @ 600.00 each	1200.00	
Sales Tax on one 9" Bit	18.00	
One 6¼" Bit	195.00	
Sales Tax @ 3%	5.85	
Two 6" Reed Bits @ 963.00 each	1926.00	
Three 5 & 5/8" Button Bits @ 450.00 each	1350.00	
Sales Tax @ 3%	40.50	
One 6" M88-39864D	1112.86	
Two invoice, Baroid Division	723.43	
Total		7061 64
Plus 10%		706 16
		46209 48
46209.48		
Less 16584.49 Labor		
29624.99 @ 3% Sales Tax		888 75
		$47098.23

APPROVED FOR PAYMENT

By: _____
(Signature)

APPROVED FOR PAYMENT

By: _____
(Signature)

Air Equipment & Drilling Inc.

Mailing address:
P.O. Box 1664
Bakersfield, Calif. 93302

Phone 805 399-8353

4001 State Road
Bakersfield, California

Portable Compressor
Equipment for:
Air & Gas Drilling,
Industrial use.

American Smelting & Refining
P O Box 5747
Tucson, Arizona 85703

August 10, 1973

P.O. #T-73-339

Job: 1073

W. G. K.

AUG 15 1973

COPY

TO: Invoice you for furnishing labor and equipment to air drill your Corehole AI-1

Compressor Rental (see schedule)	$ 8,170.00
Injection Equipment Rental (see schedule)	385.00
Labor (see schedule)	5,322.00
Transportation - 5 units - 630 mi Ea-3150 mi @ 10/¢/mi	315.00
Transportation - 2 pickups - 630 mi ea - 1260 mi @ 12¢/mi	151.20
	$14,343.20

DAY LABOR RECAP

DATE	LABOR HRS	LABOR AMT	COMPRESSORS #79 HRS	#79 AMT	#81 HRS	#81 AMT	#83 HRS	#83 AMT	INJECTION EQUIPMENT DAYS	INJECTION EQUIPMENT AMT
7/14	20	$200.00								
7/15	22	220.00								
7/16	21	210.00	S	$ 50.00	S	$ 50.00	S	$ 50.00	S	$ -0-
7/17	16	160.00	S	50.00	S	50.00	S	50.00	S	-0-
7/18	18	180.00	9	140.00	S	100.00	S	50.00	S	-0-
7/19	8	80.00	S	50.00	S	50.00	S	50.00	S	-0-
20	24	240.00	14*	180.00	16*	180.00	S	50.00	S	-0-
7/21	24	240.00	17*	180.00	17*	180.00	S	50.00	S	-0-
7/22	29	290.00	22*	180.00	22*	180.00	3	80.00	S	-0-
23	28	280.00	11	160.00	11	160.00	S	50.00	1	35.00
8/24	24	240.00	10	150.00	10.	150.00	2	70.00	1	35.00
7/25	12	120.00	11	160.00	11	160.00	4	90.00	1	35.00
7/26	8	72.00	S	50.00	S	50.00	S	50.00	S	-0-
7/27	8 S	72.00	S	50.00	S	50.00	S	50.00	S	-0-
7/28	16 S	144.00	1	60.00	S	50.00	1	60.00	S	-0-
7/29	24	240.00	17*	180.00	14*	180.00	5	100.00	S	-0-
7/30	24	240.00	4	90.00	21*	180.00	S	50.00	1	35.00
7/31	24	240.00	22*	180.00	17*	180.00	14*	180.00	1	35.00
8/1	24	240.00	16*	180.00	13*	180.00	16*	180.00	1	35.00
8/2	20	200.00	9	140.00	6	110.00	14*	180.00	1	35.00
8/3	25	250.00	11	160.00	18*	180.00	19*	180.00	1	35.00
8/4	24	240.00	16*	180.00	16*	180.00	16*	180.00	1	35.00
8/5	16 S	144.00	S	50.00	S	50.00	S	50.00	S	-0-
8/6	24	240.00	9	140.00	9	140.00	9	140.00	1	35.00
8/7	24	240.00	11	160.00	11	160.00	11	160.00	1	35.00
8	16	160.00	S	50.00	S	50.00	S	50.00	S	-0-
8/9	14	140.00								
		$5322.00		$2970.00		$3000.00		$2200.00		$385.00
				3000.00						
				2200.00						
				$8170.00						

S - standby
*Maximum daily charge

W. G. K.
AUG 15 1973

ROTARY DRILLING
GROUTING
FOUNDATION TESTING
DIAMOND DRILLING EQUIPMENT
DRILLING ADDITIVES

BOYLES BROS.
DRILLING COMPANY
CONTRACTORS-ENGINEERS
General Offices and Plant
1624 Pioneer Road P. O. Box 58 Phone (801) 487-367
SALT LAKE CITY, UTAH 84110
Cable: BOYLESCO
Telex: 388-321

GOLDEN, COLORADO
SPARKS, NEVADA
SPOKANE, WASHINGTON
MURFREESBORO, TENNESSEE
IRONWOOD, MICHIGAN
SANTIAGO, CHILE cable: BOYLESBROS
LIMA, PERU cable: BOYLESCOP
MEXICO CITY, MEXICO telex: 001774546

COPY

INVOICE DATE: July 31, 1973
ORDER NUMBER: T-73-340
INVOICE NUMBER:
CONTRACT: 6-664
TERMS:
LOCATION: Bohme Ranch

Mr. Howard Crittendon
American Smelting & Refining Company
P. O. Box 5747
Tucson, Arizona 85705

W. G. K.
AUG 14 1973

Hole No.	From	To	Footage	Rate	Total
Mobilization				300.00	300.00
Setup Time			28 Hrs.	35.00	980.00
Cement Time			72 Hrs.	35.00	2,520.00
Water Hauler			44 Hrs.	3.65	160.60
Payroll Tax				160.60	51.39
Water Truck Rental			9 Days	325.00	97.47
Water Truck Mileage			54 Mi.	.30	16.20
Materials Used:	Quik Gel (Baroid)		40 Sks.	3.58	143.20
M	Mud No. 2 SG (Wasatch)		25 Sks.	3.18	79.50
	Cellex (Baroid)		2 Sks.	73.95	147.90
	CMC (Wasatch)		1 Sk.	65.90	65.90

ROTARY DRILLING
GROUTING
FOUNDATION TESTING
DIAMOND DRILLING EQUIPMENT
DRILLING ADDITIVES

Boyles Bros.
DRILLING COMPANY
CONTRACTORS-ENGINEERS
General Offices and Plant
1624 Pioneer Road P. O. Box 58 Phone (801) 487-3671
SALT LAKE CITY, UTAH 84110
Cable: BOYLESCO
Telex: 388-321

PHOENIX, ARIZONA
GOLDEN, COLORADO
SPARKS, NEVADA
SPOKANE, WASHINGTON
MURFREESBORO, TENNESSEE
IRONWOOD, MICHIGAN
SANTIAGO, CHILE cable: BOYLESBROS
LIMA, PERU cable: BOYLESCOP
MEXICO CITY, MEXICO telex: 001774546

COPY

INVOICE DATE: July 31, 1973
ORDER NUMBER: T-73-340
INVOICE NUMBER:
CONTRACT: 6-664
TERMS:
LOCATION: Bohme Ranch

Mr. Howard Crittendon
American Smelting & Refining Company
P. O. Box 5747
Tucson, Arizona 85705

W. G. K.

AUG 14 1973

Hole No.	From	To	Footage	Rate	Total
Materials Used:	Caustic Soda (Baroid)		1 Sk.	12.75	12.75
	Soda Ash (Baroid)		1 Sk.	10.60	10.60
	Calseal (Magcobar)		1 Sk.	12.90	12.90
	Lube Kote (Magcobar)		3 Sks.	9.31	27.93
	Rod Lube (Magcobar) - 5 Gal.		3 Cans	14.32	42.96
	Disperse S (Wasatch		1 Sk.	16.90	16.90
			TOTAL BILLING		4,686.20

JOY MANUFACTURING COMPANY

OLIVER BUILDING
PITTSBURGH, PENNSYLVANIA 15222

PLEASE REMIT TO
P. O. BOX 360135M
PITTSBURGH, PA. 15230

CUSTOMER'S ORDER NO.	DATE	REQ. NO.	OUR ORD'R NO.	DATE	AT REC. POINT	B.O.NO.
T-72-521						
CONTRACT	CODE 99 69 05 02 02 209			DATE	AT SHIP POINT	

COPY

02124

SOLD TO
American Smelting & Refining Co.
Southwestern Exploration Dept.
Attention: Mr. Howard Crittenden
P. O. Box 5747
Tucson, Arizona 85703

DEC 18 1972

TERMS NET 30 DAYS
NO CASH DISCOUNT

PLEASE REMIT TO
P.O. BOX 360135M
PITTSBURGH, PA. 15230

INVOICE NO. 05116432

INVOICE DATE 12-7-72

DATE SHIPPED

SHIPPED VIA

SHIPPED TO
Patagonia, Arizona

P. O. ADDRESS

MARKS

REQUESTED ROUTING

SHIPPED FROM Michigan City, Indiana

ORIGINAL QUANTITY ORDERED	PART NUMBER	DESCRIPTION	CODE	UNIT PRICE	QUANTITY BACK ORDERED	QUANTITY SHIPPED	AMOUNT
		To 101' core drilling at Patagonia, Arizona as per agreement.					
	PROSPECT NO.	FROM TO		TOTAL FT.	COST UNIT		TOTAL COST
	TR-10	BX 4004, 4105,		101.	17.00		$1,717.00
	MUD USED UP						
		18 50-lb. bags drilling mud @ $2.60/bag					46.80
	CORE BOXES USED						
		11 Cardboard Core Boxes @ $1.25/ea.					13.75
	CASING LEFT IN PLACE						
	TR-10	1,391 feet NX Casing @ $3.50/ft.					4,872.00
		200 feet BX Casing @ $2.50/ft.					500.00
	SURVEY TIME						
	TR-10	Nov. 29 4 hours @ $16.00/hr.					64.00
	WATER TANK RENTAL						
		Nov. 15 through Nov. 29, 1972.					
		One (1) tank @ $300.00/mo.					40.00

F. O. B. SHIPPING POINT UNLESS OTHERWISE SPECIFIED
NO RETURNS ALLOWED UNLESS AUTHORIZED BY THIS OFFICE
GOODS COVERED BY THIS INVOICE WERE PRODUCED IN COMPLIANCE WITH THE REQUIREMENTS OF THE FAIR LABOR STANDARDS ACT OF 1938, AS AMENDED, INCLUDING SECTION 12(A).

4133-6 4-67
4134-SINGLE 4-67

09007

JOY MANUFACTURING COMPANY

PAGE NO. 2

SOLD TO	OUR ORDER NO.	AT REC. POINT	AT SHIP POINT	B.O. NO.	INVOICE NO.
American Smelting & Refining Company					05115432

ORIGINAL QUANTITY ORDERED	UNIT	PART NUMBER	DESCRIPTION	SALES CODE	UNIT PRICE	QUANTITY BACK ORDERED	QUANTITY SHIPPED	AMOUNT
		DEMOBILIZATION			A.D.C.			
			One (1) Drill Unit		DEC 13 1972			$ 300.00
								$7,553.55

COPY

INVOICE (CONTINUATION)

FORM P138A

ASARCO PD 1
REVISED 1/1/58

PURCHASE ORDER

AMERICAN SMELTING AND REFINING CO.
Tucson Office 1150 North 7th Avenue
P. O. Box 5747 Tucson, Arizona 85703

DATE	September 6, 1973
ORDER NO.	T-73-464
REQUISITION NO.	
PLANT JOB NO.	
APPROPRIATION NO.	

TO:
Joy Manufacturing Company
707 Boyd Boulevard
P. O. Drawer 489
LaPorte, Indiana 46350

FINAL DESTINATION — PLEASE NOTE CONSIGNMENT BELOW

DATE REQUIRED AT DESTINATION:

CONSIGNMENT — SELLER WILL SHIP TO

SHIPPING INTERVAL PROMISED | SELLER WILL SHIP BEFORE:

POINT OF SHIPMENT | TERMS

— RENDER BILLS AS PER ATTACHED SHIPPING INSTRUCTIONS —

F. O. B. POINT

SHIP VIA

QUANTITY	UNIT	SPECIFICATIONS	ITEM NO.	UNIT PRICE
		JOY MANUFACTURING COMPANY, hereinafter referred to as CONTRACTOR, will drill one hole on ASARCO's Thunder Mountain Property near Patagonia, Arizona. Work will be performed and payment will be made in accordance with your letter of proposal dated May 1, 1973. CONTRACTOR's particular attention is called to Clause Eleven (11) on the reverse of this order. The insurance certificates filed in connection with our purchase order T-72-521 will suffice if still in force; otherwise, we will require new certificates. Orig: Joy Manufacturing Co. cc: " " ", for acceptance WLKurtz JDSell RBCrist HLCrittendon Acctg. Dept. File		

IMPORTANT

Attached Acknowledgment Card must be completed and returned promptly.

PLEASE ENTER OUR ORDER FOR THE ITEMS SPECIFIED ABOVE, SUBJECT TO ALL INSTRUCTIONS AND PROVISIONS ON REVERSE SIDE.

/s/ W. L. Kurtz
Manager of Exploration

JOY MANUFACTURING COMPANY
707 BOYD BOULEVARD
P. O. DRAWER 489
LaPORTE, INDIANA 46350

May 1, 1973

American Smelting & Refining Company
Southwestern Exploration Department
Post Office Box 5745
Tucson, Arizona 85703

Attention: Mr. Howard Crittendon

Gentlemen:

Our Southwestern Manager, Mr. Jack Lloyd, informed me that you have planned another project in the vicinity of Patagonia, Arizona. One hole will be drilled 1,000 to 2,000 feet distant from the hole we drilled last year. We understand the hole will extend to a depth of 4,000 feet and may be extended to 5,500 feet.

You will note that our prices have been increased approximately 5% because of increased costs we have had to absorb this past year.

Please consider the following prices for drilling one vertical hole.

Mobilization	$300.00.
Demobilization	$300.00.

	NC Wire Line	NX Wire Line	BX Wire Line
0. to 500. feet	$8.30/ft.	$7.30/ft.	$7.10/ft.
500. to 1000. feet	$8.80/ft.	$7.70/ft.	$7.50/ft.
1000. to 1500. feet	$9.60/ft.	$8.60/ft.	$8.40/ft.
1500. to 2000. feet	- - - - -	$9.40/ft.	$9.20/ft.
2000. to 2500. feet	- - - - -	$10.40/ft.	$10.20/ft.
2500. to 3000. feet	- - - - -	$11.60/ft.	$11.40/ft.
3000. to 3500. feet	- - - - -	$13.10/ft.	$12.90/ft.
3500. to 4000. feet	- - - - -	- - - - -	$14.90/ft.

Sheet No. 2 To: American Smelting & Refining Company

May 1, 1973

	NC Wire Line	NX Wire Line	BX Wire Line
4000. to 4500. feet	- - - - -	- - - - -	$17.40/ft.
4500. to 5000. feet	- - - - -	- - - - -	$19.90/ft.
5000. to 5500. feet	- - - - -	- - - - -	$22.90/ft.
Standby Time for your convenience			$14.00/hr.
Water Truck Rental			$300.00/mo. plus 15¢ per mile.
Water Truck Driver			$950.00/mo.

Hole Surveys, if requested @ $18.00/hr. plus rental and other costs in connection with the rental of Eastman and/or other type survey tools.

Cementing and/or Plugging Drill Holes	$18.00/hr.
Reaming, if necessary	$5.00/ft.
Drilling Mud used	$2.60/50-lb. bag.
Drilling Mud Additives used	At job site cost.
NX Casing lost or ordered left in place	$3.50/ft.
BX Casing lost or ordered left in place	$2.50/ft.
4" Pipe lost or ordered left in place	$3.00/ft.
Setting and Pulling Casing (two-man crew)	$18.00/hr.
Weather-Treated Boxes holding 10' of core	$1.25/ea.

We will make every effort to have a machine and qualified crew available to start this work on August 1. At the present time, all of our qualified crews are assigned to comparatively long term contracts. We will be in a better position to know whether or not we can start the work on August 1 by July 15. If, at that time, we are reasonably sure we will not be able to accommodate you, we will advise you so that other arrangements can be made. Hopefully, we will have adequate machinery available and

Sheet No. 3 To: American Smelting & Refining Company

May 1, 1973

will look forward to working with you on this project.

We trust that our prices will be acceptable to you. Thank you for inviting us to submit a bid on this project.

Yours truly,

JOY MANUFACTURING COMPANY

J. M. Murray, General Manager
Drill Division

JMM:rh

AMERICAN SMELTING AND REFINING COMPANY
SOUTHWESTERN EXPLORATION DIVISION
P. O. BOX 5747, TUCSON, ARIZONA 85703

1150 NORTH 7TH AVENUE
TELEPHONE 602-792-3010

September 6, 1973

Mr. J. M. Murray, General Manager
Drill Division
Joy Manufacturing Company
P. O. Drawer 489
LaPorte, Indiana 46350

Dear Mr. Murray:

It has been called to my attention that we did not issue you a purchase order for the drilling you are currently doing on our Thunder Mountain property near Patagonia, Arizona.

Enclosed is a purchase order for this work.

Very truly yours,

W. L. Kurtz
Manager of Exploration

WLK:lb
Encs.

ARCO PD 1
REVISED 1/1/58

PURCHASE ORDER

AMERICAN SMELTING AND REFINING CO.
Tucson Office 1150 North 7th Avenue
P. O. Box 5747 Tucson, Arizona 85703

DATE: July 3, 1973
ORDER NO.: T-73-339
REQUISITION NO.:

PLANT JOB NO.:
APPROPRIATION NO.:

TO:
Air Equipment & Drilling, Inc.
P. O. Box 1664
Bakersfield, California 93302

Attn: Mr. Joe Clardy

DATE REQUIRED AT DESTINATION:
SHIPPING INTERVAL PROMISED:
SELLER WILL SHIP BEFORE:
POINT OF SHIPMENT:
TERMS:
F. O. B. POINT:

FINAL DESTINATION — PLEASE NOTE CONSIGNMENT BELOW
CONSIGNMENT — SELLER WILL SHIP TO
— RENDER BILLS AS PER ATTACHED SHIPPING INSTRUCTIONS —
SHIP VIA:

QUANTITY	UNIT	SPECIFICATIONS	ITEM NO.	UNIT PRICE
		AIR EQUIPMENT & DRILLING, INC., hereinafter referred to as CONTRACTOR, will provide air equipment and services for ASARCO's drilling projects near Superior, Arizona. Payment for this work will be in accordance with CONTRACTOR's price schedule dated June 1, 1971, a copy of which is attached to and made a part of this order. Equipment will include: two Joy Model WN102 trailer-mounted compressors, each capable of delivering 750 scfm; one trailer-mounted hi-stage "booster" compressor; one Oilwell injection pump; and necessary manifolds, hose, etc., as required. Transportation to the job site is to be arranged by CONTRACTOR, and will be billed to ASARCO as cost. Work will start about July 17, 1973. It is understood by both parties to this order that ASARCO will not be charged for delays caused by failure of CONTRACTOR's equipment or personnel. CONTRACTOR's particular attention is called to Clause Eleven (11) on the reverse of this order. Before entering upon ASARCO's property to perform this work, CONTRACTOR will submit acceptable evidence of compliance with the Workmen's Compensation Laws of the State of Arizona, and, on ASARCO's standard insurance form, acceptable evidence of other required insurance. Orig: Air Equipment & Drilling Inc. cc: " " " " ", for acceptance WLKurtz, JDSell, HLCrittendon, Acctg. Dept., File		

ACCEPTED FOR AIR EQUIPMENT & DRILLING INC.
By: _____ Title

☞ *IMPORTANT*

Attached Acknowledgment Card must be completed and returned promptly.

PLEASE ENTER OUR ORDER FOR THE ITEMS SPECIFIED ABOVE, SUBJECT TO ALL INSTRUCTIONS AND PROVISIONS ON REVERSE SIDE.

/s/ W. L. Kurtz
Manager of Exploration

Air Equipment & Drilling Inc.

Mailing address:
P.O. Box 1664
Bakersfield, Calif. 93302

Phone 805 399-8353

4001 State Road
Bakersfield, California

Portable Compressor Equipment for:
Air & Gas Drilling,
Industrial use.

Distributor:
Weatherford Oil Tools

COMPRESSOR PRICE SCHEDULE JUNE 1, 1971

HIGH & LOW STAGE COMPRESSORS

Daily - $50.00/day plus $10.00/hr. - Maximum $180.00

Weekly - $10.00/hr. - Minimum - $350.00 - Maximum $1,050.00

Monthly - $10.00/hr. - Minimum $1,500.00 - Maximum $3,600.00

FUEL Supplied by Lessee at cost.

LABOR & COMPRESSOR OPERATORS

* NOTE: AS OF JANURARY 1ST. 1973 LABOR WILL BE $10.00 ~~$9.00~~ per man per hour for rig up and operations. Normal operations require 24 man hours per day or $216.00.

INJECTION EQUIPMENT

Pump, tank, manifold for foam and mist drilling, trailer mounted - $35.00 per day. This figure includes fuel.

SEPARATION EQUIPMENT

Centrifugal separator for aerated mud drilling, trailer mounted - $50.00/day, $600.00 maximum each 30 day period.

TRANSPORTATION

Billed directly to Lessee, plus 10¢ per mile for trailer and 12¢ per mile for pickup, if used.

RIG UP

During rig up compressor will be charged out at $50.00 per day plus labor charges as quoted above.

SPECIALIZED EQUIPMENT - AIR DRILLING

Special equipment such as rotating head and circulating subs are to be supplied by Lessee or billed at cost. Blow lines and connections to well head are supplied as part of compressor rental, by Air Equipment & Drilling, Inc.

CREW STANDBY - $72.00 per man per day.

COMPRESSORS WITHOUT COMPRESSOR OPERATOR

Compressors are available under special circumstances without operators. Rates are as quoted above except Lessee will be billed for labor at $9.00 per hour and 12¢ per mile for rig up, start up, and tear out, and routine maintenance checks if done by Air Equipment & Drilling personnel. Lessee also is to provide all running supplies including filters, oils and greases. Other terms and conditions are as set forth in our rental contract. Air Equipment and Drilling reserves the right to make routine maintenance checks at reasonable intervals.

Compressors are not available without operators for oil and gas well work.

SPECIAL CONDITIONS OF RENTAL OR LEASING

(1) Rental of all items is based upon receiving a 2-day minimum for each job; (2) Weekly and monthly rental will be billed in advance; (3) We reserve the right to adjust the above rates (a) If equipment is to be run at sustained high pressures, or (b) if work site is inaccessible, or (c) at a distant point.

LONGYEAR CORE

~~WLK~~
core Fite Drilling

DIAMOND CORE DRILLING DIMENSIONS, WEIGHTS and VOLUMES

Longyear

925 Delaware Street S.E.
Minneapolis, Minnesota 55414 U.S.A.
Cable: LONGCO

Utah, Pennsylvania
Spokane, Washington
Salt Lake City, Utah
West Middlesex, Virginia
Phoenix, Arizona

CANADA:
North Bay, Ontario
Sherbrooke, Quebec
Sturgeon Falls, Ontario
Timmins, Manitoba
Vancouver, B.C.

COSTA RICA: Apartado 5235
San Jose, Costa Rica

INDIA: P. O. Box 276
Bombay, I, India

AUSTRALIA: 919-929 Marion Road
Mitchell Park, South Australia 5043

87 Old Pittwater Road
Brookvale, New South Wales

MEXICO: Guillermo Barroso No. 18-F
Fracc. Industrial Las Armas
Tlalnepantle, Mexico

JAPAN: No. 7, 3 Chome, Kohimachi
Chiyoda-ku, Tokyo, Japan

FRANCE: Place de la Gare
78 La Verriere

GERMANY: Braunschweiger Heerstrasse 61
3100 Celle

NETHERLANDS: Nijverheidsweg 47
Etten Luer

KOREA: I.P.O. 1065
Seoul, Korea

PHILIPPINES: P. O. Box 308
Makati, Rizal, Philippines

INCHES

DRILL RODS AND CASING

DRILL RODS

SIZE	O.D. (inches)	I.D. (inches)	WT. (lbs. per 10 ft.)	COUPLING I.D. (in.)	THREADS per inch	CONTENT (gal. per 100 feet)
E*	1-5/16	27/32	28	7/16	3	2.9
A*	1-5/8	1-1/8	38	9/16	3	5.2
B	1-29/32	1-13/32	46	5/8	5	8.1
N	2-3/8	2	49	1	4	16.3
RW*	1-3/32	23/32	19	13/32	4	2.1
EW*	1-3/8	7/8	31	1/2	3	3.1
AW*	1-3/4	1-7/32	44	5/8	3	6.1
BW	2-1/8	1-3/4	42	3/4	3	12.5
NW	2-5/8	2-1/4	54	1-3/8	3	20.7
HW	3-1/2	3-1/16	85	2-3/8	3	38.3

*Parallel Wall

FLUSH-COUPLED CASING

SIZE	O.D. (inches)	I.D. (inches)	WT. (lbs. per 10 ft.)	COUPLING I.D. (in.)	THREADS per inch	CONTENT (gal. per 100 feet)
RX**	1-7/16	1-3/16	18	1-3/16	8	5.7
EX	1-13/16	1-5/8	18	1-1/2	8	10.8
AX	2-1/4	2	29	1-29/32	8	16.3
BX	2-7/8	2-9/16	47	2-3/8	8	26.7
NX	3-1/2	3-3/16	60	3	8	41.4
HX	4-1/2	4-1/8	90	3-15/16	5	69.4

**Formerly XRT

FLUSH-JOINT CASING

SIZE	O.D. (inches)	I.D. (inches)	WEIGHT (lbs. per 10 ft.)	THREADS per inch	CONTENT (gal. per 100 feet)
RW	1-7/16	1-3/16	18	5	5.7
EW	1-13/16	1-1/2	28	4	9.2
AW	2-1/4	1-29/32	38	4	14.8
BW	2-7/8	2-3/8	70	4	23.0
NW	3-1/2	3	86	4	36.7
HW	4-1/2	4	113	4	65.2

All dimensions, weights and volumes shown are nominal approximations in inches, pounds and U.S. gallons.

WIRE LINE DRILL RODS

SERIES "Q" WIRE LINE "WEDG-LOK" DRILL RODS

SIZE	O. D. (inches)	I. D. (inches)	WT. (lbs. per 10 ft.)	THREADS per inch	CONTENT (gal. per 100 feet)
AQ	1-3/4	1-3/8	31	4	7.7
BQ	2-3/16	1-13/16	40	3	13.4
NQ	2-3/4	2-3/8	51	3	23.0
HQ	3-1/2	3-1/16	77	3	38.2
PQ	4-5/8*	4-1/16	103**	3	67.4

*Coupling O.D. **With Coupling

DIAMOND CORING BITS

SERIES "Q" WIRE LINE DIAMOND BITS

SIZE	CORE DIAMETER (inches)		HOLE DIAMETER (inches)		HOLE VOLUME (gal. per 100 ft.)
	Decimal	Fractional	Decimal	Fractional	
AQ, AQ-U	1.062	1-1/16	1.890	1-57/64	14.6
BQ, BQ-U	1.432	1-7/16	2.360	2-23/64	22.7
NQ, NQ-U	1.875	1-7/8	2.980	2-63/64	36.3
HQ	2.500	2-1/2	3.782	3-25/32	58.3
PQ	3.345	3-11/32	4.827	4-53/64	95.05

SIZE*	CORE DIAMETER (inches)		HOLE DIAMETER (inches)		HOLE VOLUME (gal. per 100 ft.)
	Decimal	Fractional	Decimal	Fractional	
RWG	.735	47/64	1.175	1-11/64	5.6
EWG,EWM,EWL	.845	27/32	1.485	1-31/64	9.0
AWG AWM,AWL	1.185	1-3/16	1.890	1-57/64	14.6
BWG,BWM,BWL	1.655	1-21/32	2.360	2-23/64	22.7
NWG,NWM,NWL	2.155	2-5/32	2.980	2-63/64	36.3
HWG	3.000	3	3.907	3-29/32	62.3
2-3/4 x 3-7/8	2.690	2-11/16	3.875	3-7/8	61.2
4 x 5-1/2	3.970	3-31/32	5.495	5-1/2	123.4
6 x 7-3/4	5.970	5-31/32	7.750	7-3/4	245.1

*DCDMA "W" sizes were formerly designated "X".
All dimensions, weights and volumes shown are nominal approximations in inches, pounds and U. S. Gallons

millimeters

DRILL RODS AND CASING

DRILL RODS

SIZE	O.D. (mm)	I.D. (mm)	WT. (kg per 10 ft.)	COUPLING I.D. (mm)	THREADS per inch	CONTENT (liters per 100 feet)
E*	33.3	21.4	12.7	11.1	3	11.0
A*	41.3	28.6	17.2	14.3	3	19.5
B	48.4	35.7	20.8	15.9	5	30.5
N	60.3	50.8	22.2	25.4	4	61.7
RW*	27.8	18.2	8.6	10.3	4	7.9
EW*	34.9	22.2	14.0	12.7	3	11.7
AW*	44.4	30.9	19.9	15.9	3	22.9
BW	54.0	44.5	19.0	19.0	3	47.3
NW	66.7	57.2	24.5	34.9	3	78.3
HW	88.9	77.8	38.6	60.3	3	145.0

*Parallel Wall

FLUSH-COUPLED CASING

SIZE	O.D. (mm)	I.D. (mm)	WT. (kg per 10 ft.)	COUPLING I.D. (mm)	THREADS per inch	CONTENT (liters per 100 feet)
RX**	36.5	30.2	8.2	30.2	8	21.6
EX	46.0	41.3	8.2	38.1	8	40.9
AX	57.1	50.8	13.1	48.4	8	61.7
BX	73.0	65.1	21.3	60.3	8	101.1
NX	88.9	80.9	27.2	76.2	8	156.7
HX	114.3	104.8	40.8	100.0	5	262.7

**Formerly XRT

FLUSH-JOINT CASING

SIZE	O.D. (mm)	I.D. (mm)	WEIGHT (kg per 10 ft.)	THREADS per inch	CONTENT (liters per 100 feet)
RW	36.5	30.2	8.2	5	21.6
EW	46.0	38.1	12.7	4	34.7
AW	57.1	48.4	17.2	4	56.1
BW	73.0	60.3	31.8	4	87.1
NW	88.9	76.2	39.0	4	138.9
HW	114.3	101.6	51.3	4	247.0

All dimensions, weights and volumes are nominal approximations.

WIRE LINE DRILL RODS

SERIES "Q" WIRE LINE "WEDG-LOK" DRILL RODS

SIZE	O. D. (millimeters)	I. D. (millimeters)	WT. (kg. per 10 ft.)	THREADS per inch	CONTENT (liters per 100 ft.)
AQ	44.5	34.9	14.1	4	29.2
BQ	55.6	46.0	18.2	3	50.7
NQ	69.9	60.3	23.1	3	87.1
HQ	88.9	77.8	34.9	3	144.6
PQ	117.5*	103.2	46.5**	3	255.0

*Coupling O.D. **With Coupling

DIAMOND CORING BITS

SERIES "Q" WIRE LINE DIAMOND BITS

SIZE	CORE DIAMETER (millimeters)	HOLE DIAMETER (millimeters)	HOLE VOLUME (liters per 100 ft.)
AQ, AQ-U	27.0	48.0	55.2
BQ, BQ-U	36.5	60.0	86.0
NQ, NQ-U	47.6	75.7	137.5
HQ	63.5	96.0	220.8
PQ	85.0	122.6	359.8

OTHER DIAMOND CORING BITS

SIZE*	CORE DIAMETER (millimeters)	HOLE DIAMETER (millimeters)	HOLE VOLUME (liters per 100 ft.)
RWG	18.7	29.8	21.2
EWG, EWM, EWL	21.5	37.7	34.0
AWG, AWM, AWL	30.1	48.0	55.2
BWG, BWM, BWL	42.0	60.0	86.0
NWG, NWM, NWL	54.7	75.7	137.5
HWG	76.2	99.2	235.8
2-3/4 x 3-7/8	68.3	98.4	231.8
4 x 5-1/2	100.8	139.6	467.0
6 x 7-3/4	151.6	196.9	927.6

*DCDMA "W" sizes were formerly designated "X"
All dimensions, weights and volumes are nominal approximations

CONVERSION TABLE

Multiply known value by factor to obtain answer

Inches	x	25.400	= Millimeters
Feet	x	0.305	= Meters
Cubic Inches	x	16.387	= Cubic Centimeters
Cubic Feet	x	0.028	= Cubic Meters
Pounds	x	0.454	= Kilograms
Gallons (U.S.)	x	0.833	= Imperial Gallons
Gallons (U.S.)	x	3.785	= Liters
PSI	x	0.070	= Kilograms per sq. cm.
GPM (U.S.)	x	3.785	= Liters per minute

DECIMAL EQUIVALENTS

Inches		Millimeters	Inches		Millimeters
1/64	.0156	.397	33/64	.5156	13.097
1/32	.0312	.794	17/32	.5312	13.494
3/64	.0469	1.191	35/64	.5469	13.891
1/16	.0625	1.587	9/16	.5625	14.287
5/64	.0781	1.984	37/64	.5781	14.684
3/32	.0937	2.381	19/32	.5937	15.081
7/64	.1094	2.778	39/64	.6094	15.478
1/8	.1250	3.175	5/8	.6250	15.875
9/64	.1406	3.572	41/64	.6406	16.272
5/32	.1562	3.969	21/32	.6562	16.669
11/64	.1719	4.366	43/64	.6719	17.066
3/16	.1875	4.762	11/16	.6875	17.462
13/64	.2031	5.159	45/64	.7031	17.859
7/32	.2187	5.556	23/32	.7187	18.256
15/64	.2344	5.953	47/64	.7344	18.653
1/4	.2500	6.350	3/4	.7500	19.050
17/64	.2656	6.747	49/64	.7656	19.447
9/32	.2812	7.144	25/32	.7812	19.844
19/64	.2969	7.541	51/64	.7969	20.241
5/16	.3125	7.937	13/16	.8125	20.637
21/64	.3281	8.334	53/64	.8281	21.034
11/32	.3437	8.731	27/32	.8437	21.431
23/64	.3594	9.128	55/64	.8594	21.828
3/8	.3750	9.525	7/8	.8750	22.225
25/64	.3906	9.922	57/64	.8906	22.622
13/32	.4062	10.319	29/32	.9062	23.019
27/64	.4219	10.716	59/64	.9219	23.416
7/16	.4375	11.112	15/16	.9375	23.812
29/64	.4531	11.509	61/64	.9531	24.209
15/32	.4687	11.906	31/32	.9687	24.606
31/64	.4844	12.303	63/64	.9844	25.003
1/2	.5000	12.700	1	1.0000	25.400

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

April 22, 1975

Memorandum for T. C. Osborne
New York Office

Drilling
General & Rochester

The two attached IBM copies of photographs show a drill that could be used to good advantage at several Asarco properties — Rochester, Hayden Hill, Summitville, Hardshell.

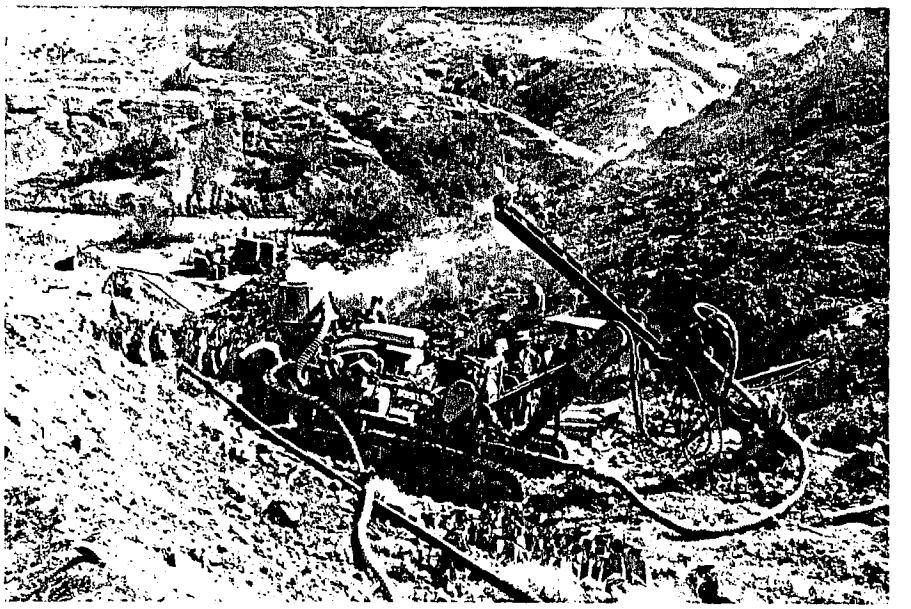
This tractor mounted rig is reported to be capable of drilling air hammer holes 5" in diameter to depths of 500 feet and average 200 feet per shift. The high pressure air — 250 psi @ 600 cfm — is truck mounted and may be located a thousand feet from the drill. The machine can drill angle holes (0-90°) and can swing an 80° horizontal arc from one set up.

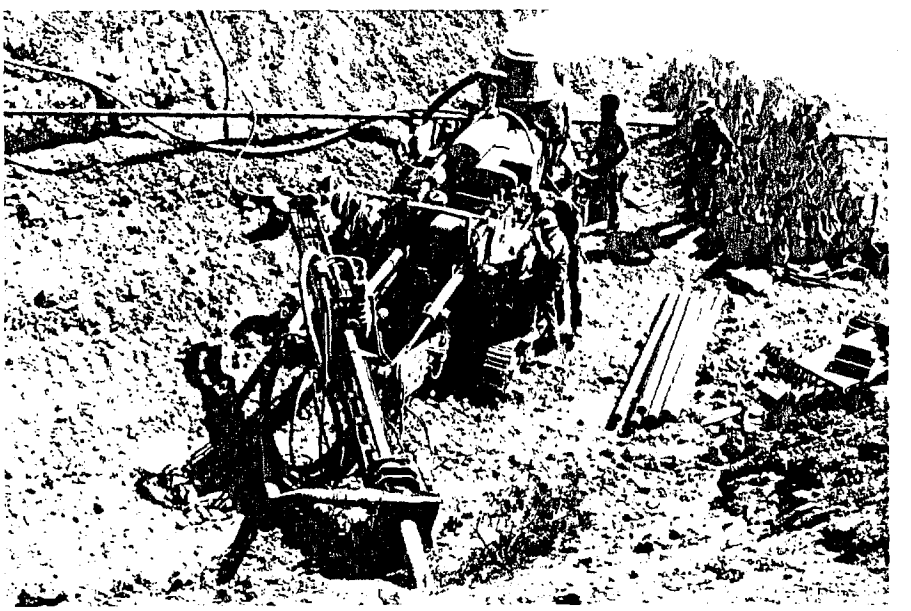
Where drill pads are difficult and expensive to build, such as on the sides of Nenzel Hill at Rochester, and where angle holes are advantageous, such as confirmation drilling in the "high grade" zone at Rochester, I believe this rig has definite applicability. I believe our feasibility studies, to be completed when the SLC Computer Department forwards the Rochester mineral inventory, will show the necessity for this type of drilling.

W.L. Kurtz/lb
W. L. Kurtz

WLK:lb
Atts.

cc: JHCourtright-w/o atts.
NPWhaley - " "
RBCrist - " "





Drilling Contractors

American Smelting & Refining Company
Sacaton Unit
P. O. Box V
Casa Grande, Arizona 85222

CXM Drilling Company
P. O. Box 892
Mammoth, Arizona 85618

July 5, 1974

PROPOSAL: by CXM Drilling Company

For: Drilling Program - Sacaton Mine Area

MOBILIZATION:

$550.00 for each mobilization-demobilization.

FOOTAGE RATES:

0 - 500	$ 5.00 per Foot
500 - 1000	6.50 per Foot
1000 - 1500	7.50 per Foot.

ROADS AND PITS:

Client will furnish necessary locations, roads and pits.

STANDBY:

$37.50 per Hour with Crew,
$27.50 per Hour without Crew.

SURFACE CASING:

Casing charged at cost and an Hourly rate of $50.00 per Hour for reaming, running casing and cementing, plus reaming bit and supplies.

WATER:

Client will furnish water.

CASING:

Client furnishes necessary casing and $50.00 per Hour will be charged for running casing and cementing.

LOST CIRCULATION:

After 4 Hours $50.00 per Hour plus all supplies and materials will be charged client.

EXCESSIVE CHEMICALS AND MUD:

In excess of $25.00 per Day will be charged client.

TO: American Smelting & Refining Company July 5, 1974

HAZARDOUS DRILLING:

In the event of heaving, sloughing or otherwise hazardous conditions or where penetration is consistantly unreasonably low, an hourly rate of $50.00 her Hour plus bits and materials will be charged client. Under Hazardous conditions as agreed by client and contractor, client assumes responsibility for lost pipe and tools.

SAMPLES:

Samples will be caught, washed, bagged and labeled as per clients instructions.

ACCEPTED:

COMPANY_____

By_____

Title_____

Date_____

CXM Drilling Company

By Michael Cole
Partner

FROM: W. L. KURTZ

2-27

TO: MPW

Bryant has requested new rate. Based on the attached what is your opinion of the following

old	new
390	430
37.50	42.50
20.00	25.00

mobilization?

How might this compare w. other contractors?

cc: JDS
FTG
> comments?

RECEIVED
MAY 17 1974
S.W. U.S. EXPL. DIV.

File - Drilling 5/15

From: J. J. Collins

To: Mr Kirby

Apparently we could use a Reverse swing & a photograph to good advantage.

Also record lengths of unbroken core as indicator of fracturing, for caving estimates

Copy to Whaley - 5/20/82

Drilling

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

February 12, 1974

Memo To: W. L. Kurtz

From: J. D. Sell

Area	Casing Requirements 1974-75 3-1/2" I.D.	4" I.D.
Superior East Project		
1) North of Hwy, DCA-2(?) Area	---	2500 ft.
2) South of Hwy, DCA-3 Area	2000 ft.	---
3) South of Hwy, S of A1-1, A2 Area	---	2500-3000 ft. (using DMX type)
4) State Sec. 5 (A-3) Back to back	---	2500-3000(?)
5) State Sec. 4 (A-6) Back to back	---	2500-3000(?)
Bohme Project		
1) New Hole ?	---	2500
Rawhide Project		
1) New Hole South ?	---	2500
Ray West		
1) New Hole, north	---	2500-3000(?)
	2000 ft.	17,500 to 21,000 ft.

Casing on Hand:

±100 ft. of 3-1/2" I.D., black (on Bohme AH-4)
±230 ft. of 4" I.D., black (Bohme Corral)
3,780 ft. of 4" I.D., black (SW Pipe & Supply storage to be moved)
±900 ft. of 7" I.D. oil well (North of Oak Flat)

James D. Sell
J. D. Sell

JDS:lb

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

February 7, 1974

Memorandum for: N. P. Whaley

From: W. L. Kurtz

Drilling Requirements

I have listed below drilling requirements for '74 as I presently view them. As usual, there are a number of question marks.

SUPERIOR EAST

DCA-3 (5-5/8" to current depth of 3,000'): attempt to clean out, case and DD to ±4500' (casing 2-3,000' 3-1/2" ID); Shelton, Boyles.

State 5 - A-3: open hole at 1445' in Whitetail. $12,500 work due by May 30.

State 4 - A-6: open hole at 1358' in dacite. $12,500 work due by June 29.

Decision to be made whether to do work or refile on State 4,5. (If drill holes will need 4" ID casing.)

Assessment work on claims will be fulfilled with drill holes A-7, DCA-3.

CLARK OPTION -- apply work from Rawhide hole AI-1 or else have Cox or Shelton drill shallow hole ($800).

RAWHIDE -- assessment work fulfilled by hole AI-1. No new holes scheduled.

THUNDER MOUNTAIN -- complete hole TM-8; may request additional funds to drill several short (<1000') holes east of TM-8.

MENDOZA OPTION -- $700 in road and drill site work.

3R -- deepen TR-10; drill one new hole (tentatively scheduled for north of TR-10; west of TM-8) by Joy.

CHARLESTON -- DD 10,000' in two holes by Joy.

HARDSHELL -- 2 years assessment work for $15,000 in hammer(?) drilling.

RED HILLS -- complete present hole; decision to be made on $6,300 work due May 29 on section 2.

BOHME -- Boyles DD in the two cased holes.

NW SILVER BELL -- rotary drill 25 location holes; rotary drill 2750' in 3 holes. Shelton? (If premineral bedrock mineralized will case 3-1/2" ID)

RAY WEST -- rotary drill $25,000 in one hole (may have funds to complete one hole to +5,000' by combination rotary-DD). (Case hole 4" ID) Contractor?

SILVER STATE -- air hammer drilling +20,000' (will request funds soon). Ecklund.

SILVER BELL EAST -- apply work from Silver Bell Unit to fulfill assessment work.

COURTLAND-GLEESON -- possible project. Drill 5,000' hole or deepen old hole 1-2000'. Contractor - Joy?

ADDITIONAL DRILLING POSSIBILITIES:
Roskruge -- 1-3 rotary holes; 800-2000'.
Lindsay Canyon -- 1 hole to 5000' combination rotary-DD.
Main Tombstone District -- DD 5,000'.
Geologic Drill Type holes at:
3 areas Papago Reservation (Vaiva Vo, Gu Achi, NE Santa Rosa);
Texas Canyon;
West of Cholla Butte;
Others?

W. L. Kurtz

WLK:lb

cc: JHCourtright
RBCrist
JDSell
FTGraybeal

JHC — lots of ideas but not much effort in implementing them before he left us.

W. L. K.

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

JAN 2 1974

December 28, 1973

the 20' core barrel might be tested into again

J. H. C.

JAN 2 1974

TO: W. L. Kurtz

FROM: H. L. Crittendon

Drilling -- General

I have some thoughts which I think may be helpful for future drilling projects and I thought I would pass them along.

Superior East

Holes No. A-3 and A-6 could probably have casing set more cheaply by a cable tool rig. Since 6-5/8" casing with a .188 wall will probably be set, the bit size passing through the casing will have to be 6.0" or less. If 5-7/8" sealed bearing carbide insert bits can be ordered in advance on special order, I believe that is the size that should be used. The 1/4" difference in annulus could very well mean the difference in being able to set the casing on bottom or not. An ideal rig to complete these two holes would be a Failing "DMX" capable of diamond drilling. The upper part could be drilled with mud or air and completed with diamond drilling equipment.

I believe the following methods are worth considering on future drilling of the Superior East Project.

1) Use of a new mud hammer....available from Dresser Industries or Cherokee Tool Co.

2) Use of aerated mud.

3) Use of new Mission 3-5/8"-4" hi-pressure air hammer to continue drilling through 4" ID casing.

4) Use of quick-set cements and gels for lost circulation and to stop water influx.

5) Packed-hole drill collars to help keep hole straight.

6) Use of specially designed rotating air head for small drill rigs.

7) The use of combination rotary-diamond rigs....Heath & Sherwood, Shaft Drillers, Inc., Boyles.

8) Use of twenty-foot core barrels in Whitetail Conglomerate.

9) Use of 6-5/8"-7" casing to case off the dacite. This method is advantageous in air or mud drilling. There are local severe lost circulation zones in the dacite; e.g., DCA-1, A-1, AH-2, AI-1, the hole Barnes drilled for Inspiration.

General

I believe the most obvious need for improvement in diamond drilling is in cementing procedures. Sophisticated equipment and materials are available from the petroleum industry and elsewhere, the problem is getting diamond drillers to use them. Normally, cementing and hole conditioning is at the expense of the mining company and there is not a great deal of incentive for improvement on the part of the diamond drillers.

Possibly some improvement could be made on combination rotary-diamond drilling rigs. Any sophisticated diamond drilling rig, however, runs the risk of being non-competitive with low overhead diamond drilling rigs such as Joys's 22HD. Some air-hammer work could be done with any diamond drill, however, and the 4" Mission hammer offers good possibilities for some cost reduction in the upper parts of the hole. As casing becomes more expensive, cementing techniques should be improved upon and used more.

Howard Crittendon

H. L. Crittendon

HLC:lb

cy — NPW

File Drilling
W. L. K.

WLK

DEC 20 1973

ASARCO
Salt Lake Exploration Division

December 12, 1973

J. D. Sell
Tucson, Office

Dear Jim:

First of all my apologies for not getting this to you sooner.

Regarding our conversations of November 27-29th, I have reviewed briefly the drilling reports from the Miami-Superior area and my initial impression is that air drilling through the uppermost 1000' of dacite is preferable to mud drilling in order to minimize problems arising from severe lost circulation zones. The advantages of air drilling below the point at which the intermediate casing string is set are debatable and it is my opinion that mud drilling from this point on would be most efficient in the long run. This is with the assumption that the equipment required for the switchover is readily available on location. The price advantage of rotary drilling over core drilling diminishes below 2000' when the cost of the tertiary casing is added to the rotary cost. It seems probable that attempting to continue rotary drilling to predetermined coring depths below 2000' in spite of difficulties may not result in the least overall cost.

We discussed at length contractors and equipment. I highly recommend that you adjust your timetable so as to coincide with the availability of the contractors with the most applicable equipment.

As far as the problem of buying worn drill rods, some contracts contain a statement to the effect that "... this document constitutes the entire agreement between ASARCO and _____ and no liabilities or conditions are inferred or assumed other than those specified herein." ASARCO representatives executing this sort of contract must be careful to specify all of contractor's obligations but this clause would substitute for the other phrases I suggested while in your office.

It has always been my contention that you cannot write superior performance into a contract. Superior performance can only arise from a contractor with the proper equipment, experience and intent.

It has been a pleasant sojourn for me to once again talk drilling and if I can advise further, please don't hesitate to call on me.

Regards to Marnie, Tom & Mark and hope Kappy is hobbling around O. K.

Very truly yours,

Joe

J. R. WOJCIK

JRW/mb

by cementing board File - Drilling 1/1/13

(1) Work performed according to good and acceptable drill practices.

(2) Backfill all bore mud with additives Casing

(3) Equipment left in hole —

JHC, NV, RBM

Drilling

SEP 14 1973

N. V.

W. L. K. SEP 1973

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

September 4, 1973

R. B. M. SEP 7 1973

R. S. H.

SEP 10 1973

J. H. C. SEP 7 1973

Memorandum to: W. L. Kurtz

From: F. T. Graybeal

Venture Drilling Company

On Aug. 31, 1973 R. B. Crist and I were shown the drilling equipment and sampling procedures currently used by Venture Drilling Co. by Mr. Abe Kalaf, the owner. The rig is a more modern version of the CP385 currently in use by the Silver Bell unit and is presently operating on Mr. Kalaf's claims in the North Silver Bell area.

Its depth capacity is said to be around 2000 ft.; however, their experience is limited at the present time to about 1200 ft. using either rotary or air hammer bits. The charges for a 6-1/2 inch diameter hole were verbally quoted by Mr. Kalaf as follows:

depth	cost
0-300 ft.	$5.50/ft.
300-600 ft.	$6.30/ft.
600-800 ft.	$7.30/ft.

No charges are made for cementing or mobilization within 100 miles or so of Tucson for 5000-10000 ft. of drilling and they guarantee the hole to the desired depth. Extra charges are levied for drilling dumps and for setting casing. Their average monthly rate is 3000-4000 ft. of advance.

Of particular interest, and no doubt adding to the drilling cost, was a rather elaborate and efficient-looking sampling arrangement which can handle either a wet or dry hole. In a dry hole the sample over the desired interval is collected in a large enclosed hopper with no dust loss. At the completion of the run the sample is emptied through a 1/16 splitter and collected in bags. Further splitting is done by hand where necessary. In a wet hole the sample is emptied out to the ground from a hose. A small sample pan is automatically passed back and forth under the sample-water stream and this portion of the total (5%?) is collected in several pans which are slightly tilted to allow the water to slowly run off. This sample is then split by hand to the desired size.

The sample consists of flat chips varying from 1/2 inch diameter to very fine-grained material. It appears that these chips are suitable for most geologic purposes except for structural data.

Kalaf would like to get a 2-3 year commitment from ASARCO so he could buy another rig. I suggested a 5000-10000 ft. trial period with one of his present rigs and he thought that would be OK. Use of this rig could be made during the initial drilling which may be proposed to evaluate the low-grade reserves at Silver Bell.

F. T. Graybeal

F. T. Graybeal

FTG:lb

Both Crist + Graybeal agree Kalaf's sampling device is superior to any others currently in use — most of his work is confirmation and additional drilling in the operating mines.

It would be good system for Silver State, Nevada.

I would recommend him for any additional drilling need at Silver Bell, Sacaton, and Miami.

Kurtz

Kalaf would use the information to his own advantage - if you had heard him testify in the claim suit against us you would know he can't be trusted

Bm

DRILLING PERFORMANCE
Rotary and Core Combination

I Total Depth 5660'

Rotary 0-3593
Total Elapsed Time: 66 days

a. Direct Drilling	$67,800	
b. Site Preparation	2,900	
Total	$70,700 = $19.68/ft.	
c. Sampling	$ 3,700	
d. Supervision	5,100	
Total	$ 8,800 = $ 2.45/ft.	
Grand Total		$ 79,500 = $22.13/ft.

Core 3593-5660 (2067')
Total Elapsed Time: 54 days

a. Direct Drilling	$64,300	
b. Site Preparation	200	
Total	$64,500 = $31.20/ft.	
c. Sampling	$ 1,100	
d. Supervision	3,400	
Total	$ 4,500 = $ 2.18/ft.	
Grand Total		$ 69,000 = $33.38/ft.

Rotary and Core $148,500 = $26.24/ft.

DRILLING PERFORMANCE - Cont'd.
Rotary and Core Combination

II Total Depth 5231'

Rotary 0-4076
Total Elapsed Time: 28 days

a. Direct Drilling	$70,100	
b. Site Preparation	4,000	
Total	$74,100 = $18.18/ft.	
c. Sampling	$ 1,800	
d. Supervision	1,900	
Total	$ 3,700 = $ 0.91/ft.	
Grand Total		$77,800 = $19.09/ft.

Core 4076-5231* (1155')
Total Elapsed Time: 85 days

a. Direct Drilling	$33,600	
b. Site Preparation	280	
Total	$33,880 = $29.33/ft.	
c. Sampling	$ 1,000	
d. Supervision	1,900	
Total	$ 2,900 = $ 2.51/ft.	
Grand Total		$36,780 = $31.84/ft.

*Includes wedging off and redrilling

Rotary and Core $114,580 = $21.90/ft.

A number of drill hole summaries have been completed and will be submitted separately. In order to avoid repeating an explanation of the method of cost breakdown, that explanation will be given here.

All costs have been or will be applied toward a particular drill hole or toward the project as a whole. Four cost categories were utilized for each drill hole. They are as follows:

a. Direct Drilling: This figure includes all services and materials in drilling including mud, water, cement, casing, air, bits, etc. Also included are mobilization charges, charges for moving rigs and compressors, and charges for pulling or setting casing. An effort has been made to note costs which do not reflect on drilling performance (eg: pulling existing casing in re-entered hole and excessive transportation costs).

b. Site Preparation: Includes costs of preparing site, building or repairing roads into site, maintaining road and site, and site restoration.

c. Sampling: Includes costs of samplers, sample preparation, sampling materials, sample trailers, assays, photographing core and sample storage in the field office.

d. Supervision: Includes salaries and wages of ASARCO employees, travel and living expenses for employees, and vehicle expenses.

JMC — from Fred Eyde
also will give paper on drilling at Chicago street

COMPARISON OF ROTARY AND DIAMOND DRILLING

Use our working base cost of two
Sup East (Rotary & Core Combination) holes.

	Estimate	Superior Oil Bonanza 1	Superior Bonanza 2	Diamond
		Direct Drilling Costs		
Depth	5,000 ft.	4,707 ft.	5,940 ft.	5,229 ft.
Location	3,000	4,128	2,665	1,000
Transportation	8,500	8,607	8,607	200
Bits-Reamers	25,000	14,360	18,790	--
Mud	10,000	3,314	7,268	900
Water	5,000	1,800	3,177	1,453
Footage	49,200	45,852	44,046	64,254
Day Rate	2,736	8,806	14,563	--
Other Contractors	1,500	7,184	2,000	1,000
Total Cost	104,936	94,051	101,116	68,807
Cost/Ft.	20.98	19.98	17.02	13.15
		Supplemental Services		
Coring	--	3,795	2,288	--
Logging	--	8,800	16,080	--
Cementing	--	1,140	--	--
Total Cost	--	107,786	119,484	--
Cost/Ft.	--	22.89	20.11	13.15

	Estimate	Bonanza 1	Bonanza 2	Diamond
		Indirect Expenses		
Drilling Labor	--	2,871	2,970	--
Other Labor	--	5,158	3,439	5,625
Miscellaneous	--	13,247	8,783	8,109
Personnel Quarters	--	158	162	--
Total Cost	--	129,220	134,838	82,541
Cost/Ft.	--	27.45	22.70	15.78
Time	--	21 days	26 days	4½ months (120 drilling days)

Technical File - Drilling/Drill Performance

Red Mountain

Joy #142

0 — ~~1374~~ 1423 — NC

1423 — 3082 — NX

3082 — 5229 BX

24 x 40 = 960

6.50 x f = 960

f = 960 / 6.50 ≈ 150'

AUG 23 1972

W. L. K.

Joy #142 Red Mtn

80'/day DD 0 to 1374 NC

60'/day DD 1374 — 3083 NX

46'/day DD 3083 — 5229 BX

6.8 x 8 = 480 + pits later

Drilling

Gas Drilling
WLS

Nick — it's a good idea, but
[illegible] !!!

File - Drilling General

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

March 3, 1971

TO: W. E. Saegart

FROM: W. L. Kurtz

Re: Drill Core Photography

Recently I had the opportunity to view 35 mm color slides that Conoco had taken of their drill core from hole 51S at Poston Butte.

I was greatly impressed with the detail, especially fracturing, that can be seen in the color slides. I recommend that we establish the practice of making 35 mm color slides of all our drill core. This will give a ready reference for review at any time and more importantly will give a record of the fracturing and shearing prior to the core being split.

In practice, the core is photographed in the core box. The camera is mounted on a bar so that it does not have to be focused each time; a label is placed beside core box noting hole number and footage; the core is sprayed with water to bring out the texture and color of the rock; and appropriate flood lights used. The whole procedure is simple, quick and will provide us with a permanent, easily storable record.

W. L. Kurtz

WLK:mw
cc: H. L. Crittendon

New file - Drilling General

W. L. K.

OCT 5 1970

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

September 28, 1970

TO: A. Dalla Vista
D. T. Friel
J. R. King
R. H. Luning
R. P. Shannon

FROM: H. L. Crittendon

SUBJECT: Drilling Progress Reports

In the interest of providing a more standardized recording of drilling information, I would very much like to review with each of the project supervisors of current drilling projects their method of record keeping. In this regard, I would recommend that monthly reports contain a tabulation of drilling data which should include, as a minimum, the following items:

1. Footage and hole sizes drilled.

2. Materials used, chargeable and non-chargeable.

3. Time distribution, chargeable and non-chargeable.

4. Size and depth of casing set.

5. A brief description of drilling problems encountered.

It is my opinion that if shift reports are adequately maintained on a daily basis, this information can be tabulated with a minimum of time loss. I would also recommend that each project supervisor make note of difficult or unusual drilling conditions inherent in his project and the procedures taken to overcome or reduce them. This information can be extremely useful in evaluating the feasibility of future drilling projects, keeping in mind that these same properties may be drilled several years later by different project engineers and different drilling contractors, which would otherwise be ignorant of the problems encountered if this information is not recorded.

Final geologic reports usually have a section devoted to drilling costs and procedures. Some particular topics which merit discussion for current drilling projects would be:

1. Silver Bell - Rotary drilling rates in capping.

2. Hardshell - Lost circulation and rock hardness.

3. Santa Rosa - Stuck rods, sloughing formations.

4. Posten Butte - Rotary drilling: lost circulation, sampling methods, method of casing holes; Diamond drilling: length of core runs, footage per shift.

5. GEM - Drilling rates, water table.

6. Silver State - Underground drilling and sampling procedures, drilling rates.

Howard Crittendon

Howard Crittendon

HC:mw
cc: W. E. Saegart
W. L. Kurtz

JHC file
Ray, Arizona

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

December 7, 1962

FILE MEMORANDUM

LARGE DIAMETER CORES
FOR METALLURGICAL SAMPLES

Kennecott recently completed 8 diamond drill holes with 6-inch coring bits in an area east of the Ray pit. The purpose of this program was the provision of a representative metallurgical sample of the diabase ore. Various data on the drilling are summarized below:

Total 6" coring	2200'
Core recovery	88%
Weight of 6" core per ft.	31 lbs.
Total weight of core	30 tons
Maximum hole depth	450'
Average distance cored per 8 hr. shift	14'
Cost per foot of coring	$15.50
Total cost (exclusive of overburden drilling	$34,100.00

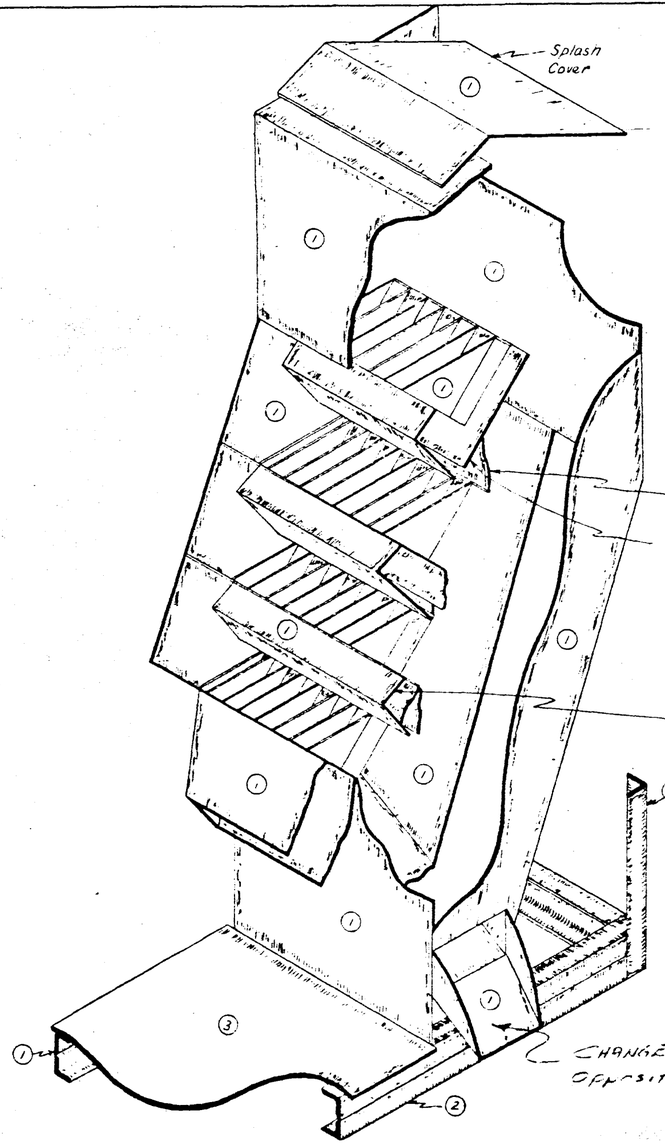
Joy contracted the job for $12.00 per foot plus bit costs which amounted to $3.50 per foot. The drilling was carried out with a Joy 22 heavy duty rig, 10' swivel barrels and mud circulation. Kennecott rotary drilled through the overburden with their own equipment and cased the holes 8" ID.

Art Eklund of Joy stated that in drilling characteristics the diabase would closely approximate a well altered porphyry. He estimated that diamond consumption in formations such as the tactites and hornfels at the Mission would be somewhat higher than in diabase -- possibly 25%, or $4.00 to $5.00 per foot bit cost. The ore bearing formations of the Imperial area at Silver Bell are comparable to those at the Mission, although possibly somewhat less abrasive.

J.H. COURTRIGHT

JHC:kw

cc: CPPollock
DJPope
RBMeen
DRJameson
JEKinnison
JRWojcik



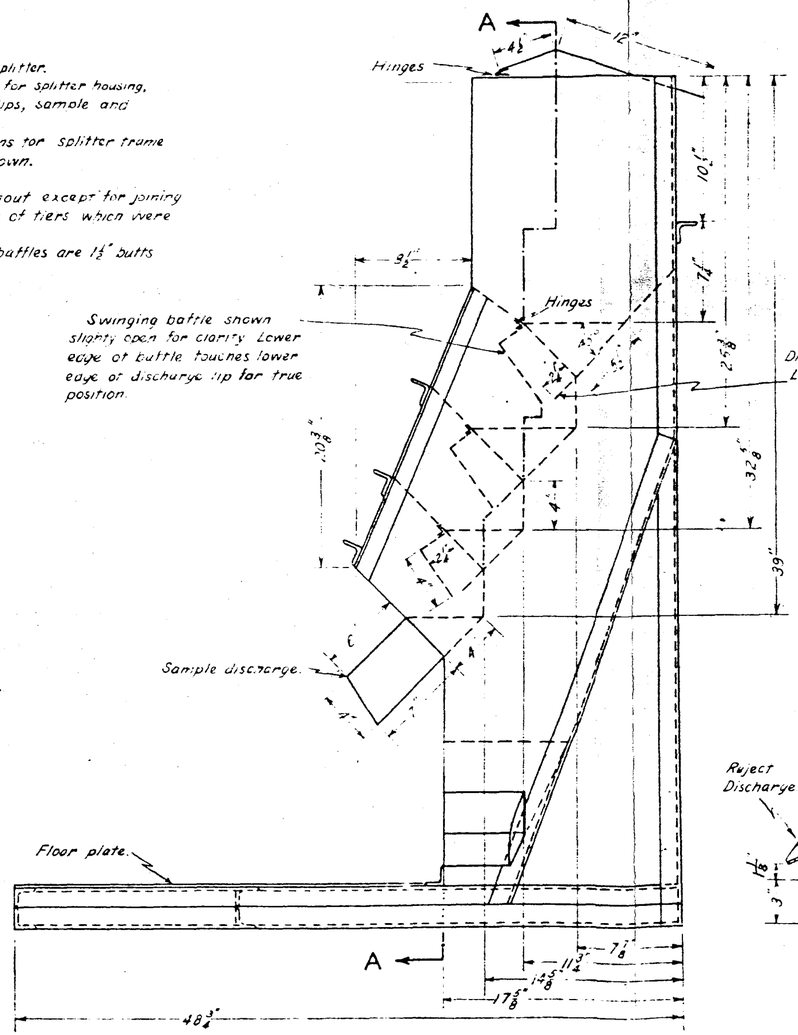
NOTE

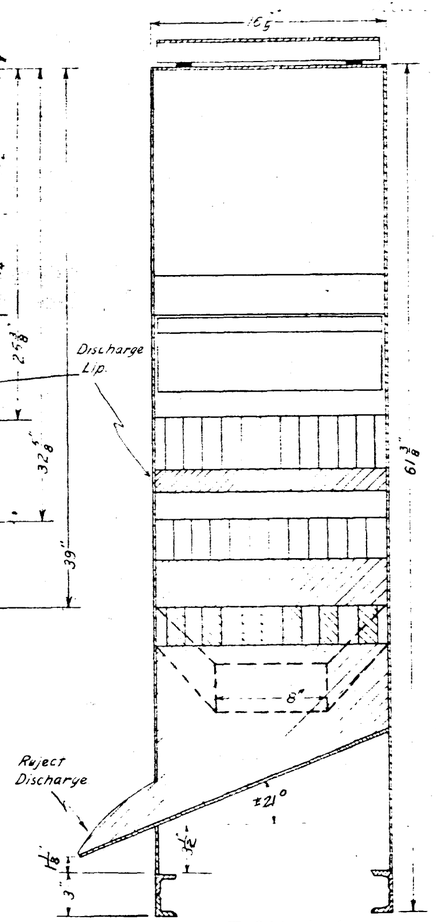
Material used in construction of splitter.

1. 16 gauge black sheet iron for splitter housing, tiers, baffles, discharge lips, sample and reject discharges
2. $1\frac{1}{2}$" equal leg x $\frac{3}{16}$" angle irons for splitter frame and reinforcements as shown.
3. $\frac{1}{8}$" Diamond floor plate.

Welded construction used throughout except for joining of sample and reject dividers of tiers which were solder sweated.

Hinges used for splash cover and baffles are $1\frac{1}{2}$" butts welded in place.





DESIGN OF

CHURN DRILL SLUDGE SPLITTER

American Smelting and Refining Company

Scale 1 ½" = 1' April, 1950

DESIGNED BY J. H. COURTRIGHT AND R. E. MIERITZ

DRAWN BY R. E. MIERITZ

2975

File No. ~~5-214-26~~