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PRINTED: 06/24/2002

ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES AZMILS DATA

PRIMARY NAME: SANTA CRUZ COPPER

ALTERNATE NAMES:
FRANNY GRANNY
SAN FRANCISCO GRANDE

PINAL COUNTY MILS NUMBER: 736

LOCATION: TOWNSHIP 6 S RANGE 4 E SECTION 13 QUARTER C
LATITUDE: N 32DEG 53MIN 50SEC LONGITUDE: W 111DEG 52MIN 33SEC
TOPO MAP NAME: STANFIELD - 7.5 MIN

CURRENT STATUS: EXP PROSPECT

COMMODITY:
COPPER OXIDE
COPPER SULFIDE

BIBLIOGRAPHY:
USBM INSITU RESEARCH PROJECT
ADMMR SANTA CRUZ COPPER FILE
USBM OFR 4(1)-89 - 4(5)-89 "GENERIC IN SITU
COPPER MINE DESIGN MANUAL" [METALLUGY SECT]
USBM IC 9216 IN SITU LEACH MINING

08/18/89

ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES FILE DATA

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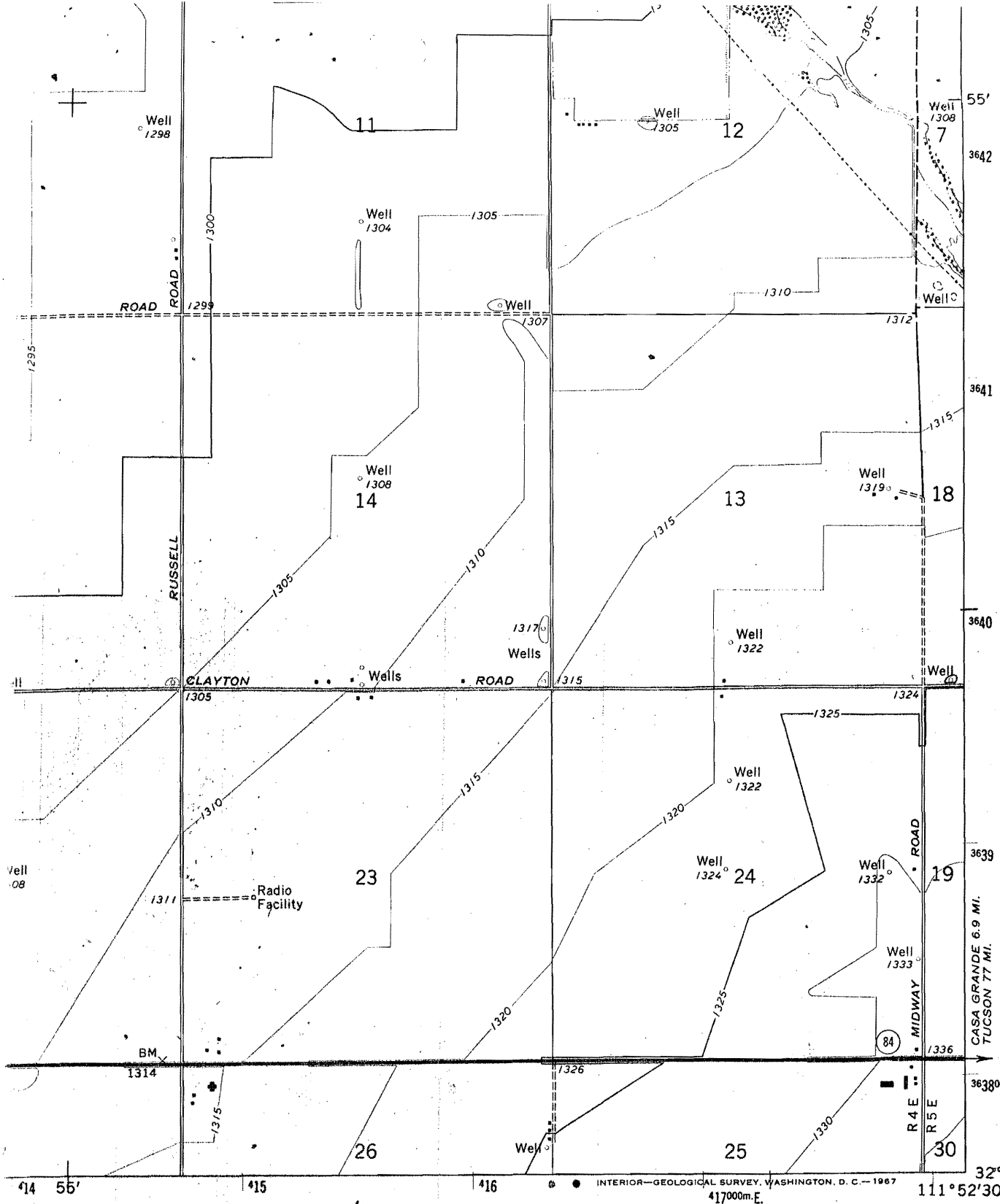
USBM IC 9216 IN SITU LEACH MINING

IN SITU DESIGN MANUALS VOL 1-5 (ADMMR LIBRARY)



Santa Cruz Copper
T6S R4E Sec 13 C

ROAD CLASSIFICATION

Heavy-duty ——— Light-duty ———

Medium-duty ——— Unimproved dirt - - - - - -

State Route

(CHUICHU)
3649 IV SE

ARIZONA

QUADRANGLE LOCATION

STANFIELD, ARIZ.

NW/4 CASA GRANDE 15' QUADRANGLE

N3252.5—W11152.5/7.5

1965

AMS 3649 IV NW—SERIES V898

35-A

PL

0242

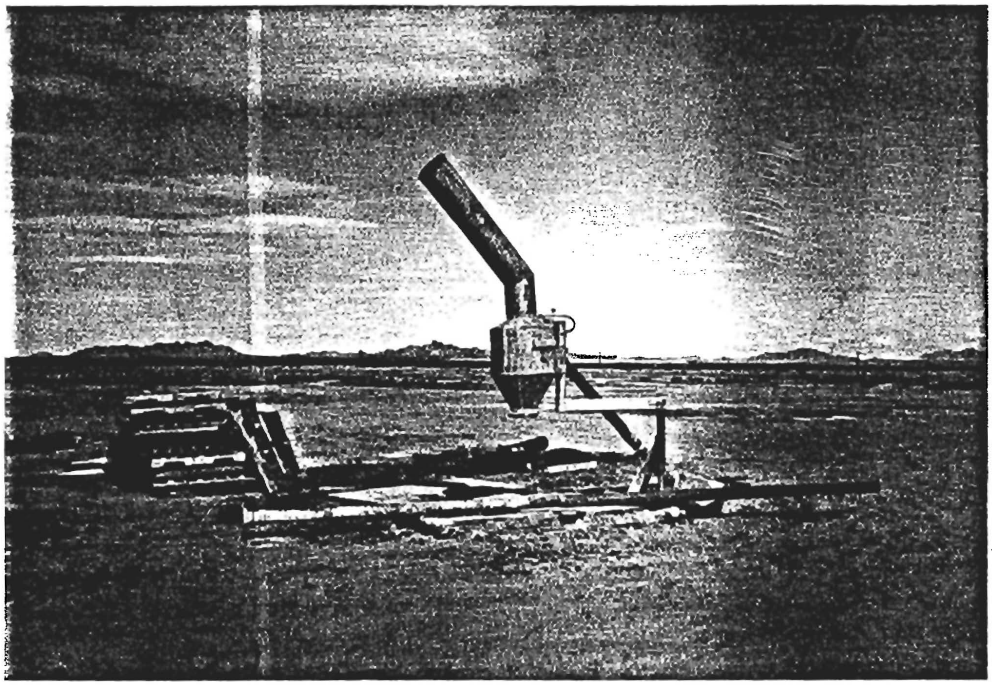
IC 9216

BUREAU OF MINES
INFORMATION CIRCULAR/1989

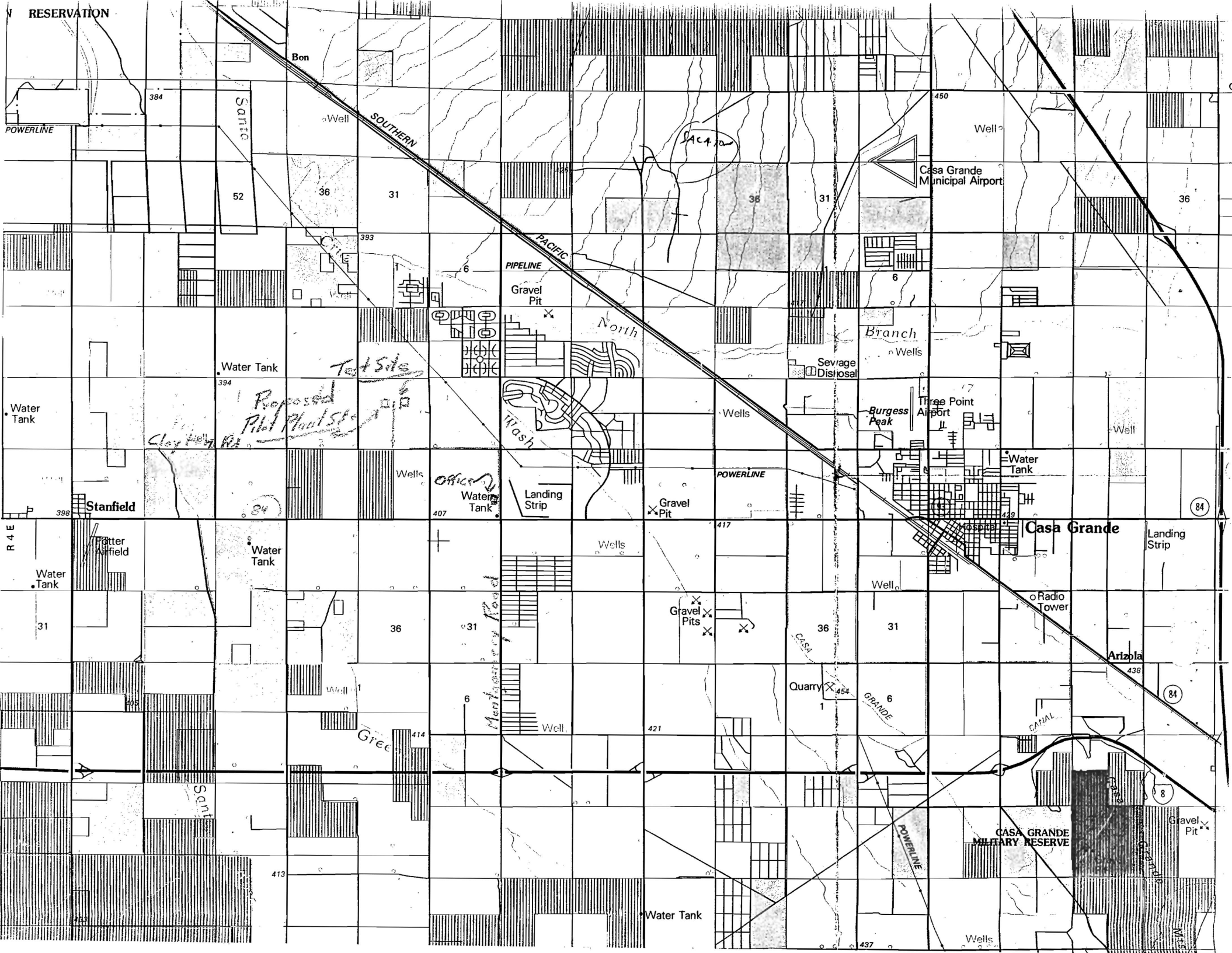
In Situ Leach Mining

Proceedings: Bureau of Mines Technology Transfer Seminars, Phoenix, AZ, April 4, and Salt Lake City, UT, April 6, 1989

UNITED STATES DEPARTMENT OF THE INTERIOR



Santa Cruz Test Site
Sacaton in background
2/2/89
Original in photo file


RESERVATION
Bon
SOUTHERN PACIFIC
PIPELINE
POWERLINE
Well
Gravel Pit
North Branch
Wells
Water Tank
Sewage Disposal
Three Point Airport
Burgess Peak
Casa Grande Municipal Airport
Landing Strip
Stanfield
Potter Airfield
Casa Grande
Hospital
Radio Tower
Gravel Pits
Quarry
Arizola
CASA GRANDE CANAL
CASA GRANDE MILITARY RESERVE
Water Tank
Wells
Gravel Pit
R4E
84
8

Printed from:

Mineral Resource Data System (MRDS)
US Geological Survey Digital Data Series 20
Release 1 June 1996

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RECNO         M030493
REC_TYPE      S
USER_FIELD *U94/6
REP_DATE      83 04
FIL_LINK      CIMRI USBM 0040211072
REP           PETERSON, JOCELYN A.
REP_AFF       USGS
SYN           SANTA CRUZ, FRANNY-GRANNY, FANNY-GRANNY
DIST          FRANCISCO GRANDE AREA
COUNTY        PINAL
STATE_CODE AZ
CTRY_CODE  US
PHYS          12 BASIN AND RANGE
DRAIN         15050303
LAND_ST       01
ELEV          1330 FT
UTM_N         3693900
UTM_E         418000
UTM_Z         +12
TOWNSHIP      006S|006S
RANGE         005E|004E
SECTION       19|13, 24
SECT_FRACT |
MERIDIAN      GILA AND SALT RIVER|GILA AND SALT RIVER
POSITION      HALF WAY BETWEEN CASA GRANDE AND STANFIELD.
LOCATION      INFO FROM LAND.ST :1964
SITE          FRANCISCO GRANDE
LAT           32.8903
LONG          -111.8764
CTRY_NAME  UNITED STATES COMMOD     CU    MO    AU    AG
ORE_MAT       CHALCOPYRITE, MOLYBDENITE, CHALCOCITE, ATACAMITE, PYRITE,
              CHRYSOCOLLA
MAJOR         CU
MINOR         MO
CLH_USE       94/09/12
TRACE         AU    AG
PROD          N
LOC_STRUCT FAULTING
STATUS        3
OWNER         CASA GRANDE COPPER CO
DEP_TYPE      PORPHYRY COPPER
DEPTH_TOP  1600.
D_T_U         M
MAX_LEN       2000.
M_L_U         M
MAX_WID       800.
M_W_U         M
MAX_THICK  1700.
M_T_U         M
```

```
DEP_SIZE      L
DDESC_COM  THE HIGH GRADE OF THE ORE BODY IS DUE TO A SUPERGENE
             ENRICHMENT ZONE COMPOSED OF ATACMITE AND CHRYSOCOLLA IN
             THE OXIDE ZONE.
QUAD250       TUCSON
MIN_AGE       TERT
ORE_CNTL      INTRUSIONS, FAULTING
TECT_SET      BASIN AND RANGE
NAME          PETERSON, JOCELYN A.|ORRIS, GRETA J.
DATE          4/1/83|3/1/94
ED_COM        |
CONT_CODE  NA
GEN_COM       THIS RECORD WAS TAKEN FROM RECORD M030493 OF JAN WILT IN
MOLYBDENU M FILE, CONTACT PERSON T.G. THEODORE, USGS ; INFO.SRC : 1 PUB LIT
REF           GREELEY, 1978, ADMR SPEC REPT NO. 2, P. 83-87.|ULLMER, 1978,
JOUR GEOCHEM EXPL, V.9, NO. 2-3, P. 235-236.|SAWYER, M.B., GURMENDI,
A.C., DALEY, M.R., AND HOWELL, S.B., 1992, PRINCIPAL DEPOSITS OF
STRATEGIC AND CRITICAL MINERALS IN ARIZONA:  U.S. BUREAU OF MINES
SPECIAL PUBLICATION, 334 P.
CONT_NAME  NORTH AMERICA
STATE_NAME ARIZONA
WORK_TYPE  S
AP_COM        NO PRODUCTION AS YET, RESERVES PROVEN FOR FUTURE OPEN PIT
              OPERATIO NS
RPR_ITEM      ORE, OX+SUL
RPR_ACC       EST
RPR_AMT       350000.
RPR_U         TONS
RPR_YEAR      1976
RPR_GRADE  1.0% CU
RPR_SOURCE GREELEY, 1978, P. 83
UPD_DATE      94 03
UPDATER       ORRIS, GRETA J.
COMMOD_TYP M
QUAD24        STANFIELD (1982), CASA GRANDE WEST (1982)
QUAD100       CASA GRANDE
DATE_ISSUE 95/5/18 UPD_AFF    USGS
MODEL         PORPHYRY CU
MODEL_NUM  17
PROF_ID       100
PROF_LOC      100
PF_COMMOD  66 PROF_EXPL  50 PFDESC_DEP 50 PFDESC_WRK 100 PROF_GEOL  35
PROF_REF      100
PPROD_RESV 33
PROF_ALL      70
HR_AGE_MV  TERT HR_TYPE_MV INTRUSIONS OREBODY_NB 1
TYPE          R|U
AFFIL         USGS|USGS
DEP_CODE      10610
HUC           15050303
```

Printed on: 10/13/2000
Record updated: 01/01/1998

Arizona Copper Reseves and Resources

Compiled by the
Arizona Department of Mines and Mineral Resources

Property:

SANTA CRUZ

Operator and/or Owner:

Asarco-Freeport McMoran JV
180 Maiden Lane
New York, NY 10038
212-510-2000
www.asarco.com

Location:

Township 6 S Range 4 E Section 13
County - Pinal AZMILS - 736
Description - 7 miles west of Casa Grande

Mineralization type and reserve/resource:

Acid Soluble - 800 Million tons at 0.43% TCu

Reserve Info.:Geological resource of 1 B tons at 0.55% at 1200 to 3200 deep. Paydirt 4/

Sources:

USBM Data - 1985 - ADMMR Santa Cruz file

Comments:

Joint venture partners are conducting in situ leaching research p
roject with USBM. Partners also own contiguous Casa Grande deposit. Proj
ect and pilot SE-EW closed in 1997. Recovery data still to be published.
New 5 spot being permitted 1998.

Printed on: 10/13/2000
Record updated: 01/01/1994

Arizona Copper Reseves and Resources

Compiled by the
Arizona Department of Mines and Mineral Resources

Property:

CASA GRANDE

Also known as - Fannie Grande, Francisco Grande

Operator and/or Owner:

Asarco-Freeport McMoran JV
180 Maiden Lane
New York, NY 10038
212-510-2000
www.asarco.com

Location:

Township 6 S Range 5 E Section 18
County - Pinal AZMILS - 445
Description - 6 miles west of Casa Grande.

Mineralization type and reserve/resource:

Mixed - 352 Million tons at 1.00% TCu

Reserve Info.:Mixed - (0.5% Cu cutoff) .01% Mo

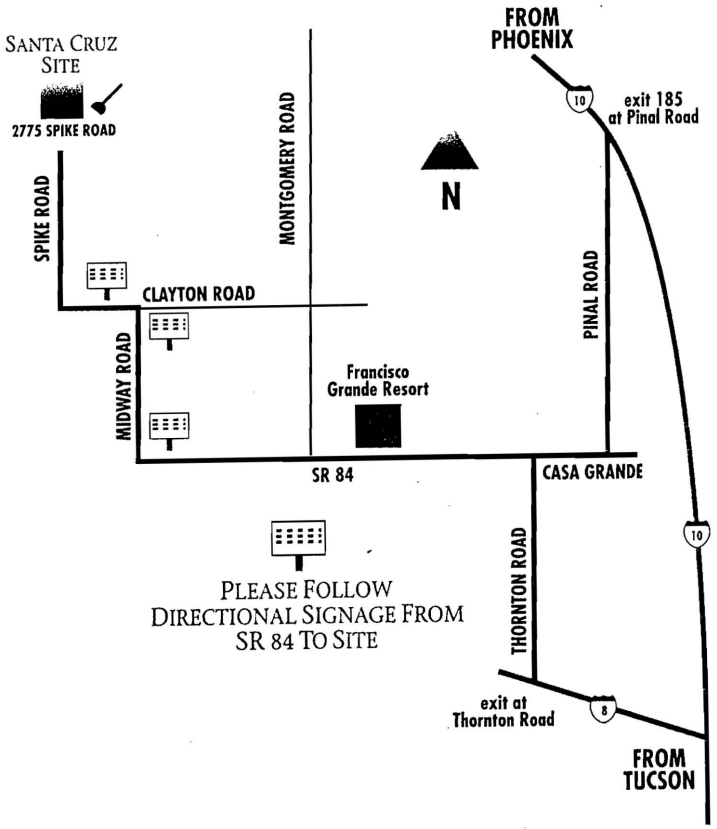
Sources:

Getty Oil Co. Annual Report 1980 - Lowell, J.D. "The Casa Grande West Orebody" AZ State AIME 12/6/82 ADMMR Fannie Grande file

Comments:

Adjacent to Santa Cruz in-situ leach research project and has similar leach potential.

SANTA CRUZ OF PINAL



ASARCO
Santa Cruz, Inc.

Freeport-McMoRan
Copper & Gold Inc.

The Santa Cruz Joint Venture Partners invite you to celebrate the commissioning of the Santa Cruz In Situ Copper Mining Research Project solvent extraction-electrowinning plant. This also marks the beginning of the mining research phase of the project.

The commissioning will include remarks by the Congressional sponsors of the project and the partners-the United States Bureau of Reclamation, ASARCO Santa Cruz, Inc., and Freeport-McMoRan Copper & Gold Inc. There will be tours of the plant and well field.

The Santa Cruz In Situ Copper Mining Research Project is a field test of a new mining technology that holds the promise of mining copper with minimal impact on the land surface from certain deeply buried, low grade deposits. The research phase of the project will provide technical and economic data to evaluate the commercial application of this new technology.

"What we learn here today will help Arizona's mining industry remain strong into the future."
-Congressman J.D. Hayworth

CELEBRATE THE COMMISSIONING OF THE SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

On:
Tuesday, April 1, 1997

At:
1:30 p.m.
2740 N. Spike Road, Casa Grande (see map on back)
Refreshments

2:00 p.m.
Remarks - Tours Following

Special guests will include:
Congressman J.D. Hayworth
Eluid L. Martinez, Commissioner, Bureau of Reclamation

Please R.S.V.P. by Thursday, March 27 to (520)885-9009
In the case of inclement weather, the event will be held at the Francisco Grande Resort.
Casual attire recommended.

Arizona Department of Mines and Mineral Resources
Verbal Information Summary

Mine: Santa Cruz (f) and Fannie Grande (f) **Date: March 1, 1995**
County: Pinal **Engineer: Nyal Niemuth**

Summary from "An update of the Santa Cruz in situ copper mining research project by Jon Alness, Mining Engineer, with the U.S. Bureau of Mines at the U.S. Bureau Mines Copper Industry Briefing held at ADMMR's Office, February 28, 1995.

Draft manual of generic in-situ design criteria was completed in 1988 and is available.

Field Test Goals: 1) Obtain cost data, 2) Determine leach solution grades, and 3) Demonstrate technology is environmentally safe.

USBM funds 75% of the project, while partners Asarco and Freeport McMoran fund 12.5% each.

Field test of the 5 spot well pattern is about to begin. Construction of the pump plant and SX-EW facility is underway and acid injection should begin by November. It will operate between 18 months and 4 years depending on results. Well pattern is 125' corner to corner with the center well being the injection well. Lixivant will be injected at 200-300 psi. The SX-EW plant will be pilot scale, able to produce 1,000 tons of copper per year of commercial size cathode copper product. After leaching is completed a diamond drill hole will be completed to allow examination of core to determine recovery, mineralogical changes, etc.

Site has 4 monitor wells to check near surface (400') ground water.

Reserve estimate is 1 billion tons of 0.55% oxide. (does this include Fannie Grande?)

The project's current status: 1) Geological characterization is complete, 2) Hydrologic characterization is complete, 3) Aquifer Protection permit obtained, and 4) Environmental assessment complete.

An aquifer protection permit was obtained in October, 1994, 29 months after application.

Significanct findings from the tracer element study:: 1) Sufficient solution can be introduced and recovered for in-situ leaching to occur, 2) No communication between leach area and local ground water, 3) Geochemistry indicates deposit can be leached and that all units attenuate acid, and 4) Obtaining the permit indicates such projects can be permitted in Arizona under APP guidelines. A paper on the permitting is forthcoming shortly.

ASARCO Products & Locations

Santa Cruz Project

Telephone: 520-798-7500 **Fax:** 520-798-7783

Address: P.O. Box 5747, Tucson, AZ 85703-0747

Location: 7 miles west of Casa Grande, Arizona

Operations: The Santa Cruz Project is an in-situ copper mining research project conducted 50-50 by the joint venturers, subsidiaries of Asarco and Freeport-McMoRan Copper and Gold Inc., and the United States Department of Interior, Bureau of Reclamation. The research project is designed to determine the feasibility of recovering copper by leaching from a deposit too deep underground to be mined economically by conventional methods.

Size: The Santa Cruz deposit was 1,250 feet to 3,200 feet below the surface and contains 1.0 billion tons of potentially leachable grading 0.55% total copper. The joint venture owns 7,000 surface acres, with the copper mineralization under approximately 250 acres.

Plant facilities: Five-spot injection and recovery wells and a solvent extraction-electrowinning pilot plant. (now on standby)

Products: Copper

Employees: None

Management:

David F. Skidmore, Project Manager
Henry G. Kreis, Site Manager

History:

1974 - Joint Venture formed; copper deposit discovered
1986 - Congressional appropriations obtained by Bureau of Mines to study in-situ copper mining concept
1988 - Santa Cruz selected over other deposits for research site
1988 - Field testing begun
1989 - Construction of test wells
1990 - Secured temporary aquifer protection permit for salt tracer tests
1991 - Conducted salt tracer tests
1994 - Permits received to begin injection of sulfuric acid.
1995 - Pilot plant completed.
1996 - Mining test started.
1997 - Lost funding - closure started
1998 - State required closure activities - final report to Bureau of Reclamation

Return to Top

Products & Locations Index ASARCO Home Page

SANTA CRUZ (A/ PINAL

ASARCO Products & Locations

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SANTA CRUZ (P/ PINAL Co.

U.S. Department of the Interior
Bureau of Mines

TIPSHEET

MINERAL NEWS AND FEATURES
January 1995

For more information on these stories, please call Sandra Cleva at 202/501-9649.

Mining Without the Mine

When the U.S. Bureau of Mines (USBM) and two copper companies start "mining" copper near Casa Grande, Ariz., next year, one thing will be missing–a mine.

Instead, the Arizona experiment (a cooperative government/industry research project) will leach copper from deep within the earth without digging it up.

Known as in-situ mining, this approach uses weak chemical solutions to selectively recover minerals from rock. The rock itself–and the surface–remain basically undisturbed.

In-situ mining produces practically no waste, leaves the land virtually unscarred, and avoids other environmental and safety problems associated with conventional mines. The technique could make it economic to work deposits that are now too low-grade or too deep to be mined.

"The Bureau began studying in-situ mining as an environmentally sound alternative in the mid-1970s, doing basic research and generic work," explained research supervisor William Larson.

USBM scientists have worked with the Santa Cruz Joint Venture (a partnership of ASARCO Santa Cruz Inc. and Freeport Copper Company) on the Casa Grande project since 1988. Wells for injecting and retrieving the leach solution and a groundwater monitoring system have already been installed and extensive tests conducted–both on site and in the lab–to determine how the leach solution will work its way through the rock and ensure protection of the aquifer above the mining zone.

Completion of the environmental permitting process last fall cleared the way for construction of a pilot-scale solvent extraction/electrowinning plant at the site. The plant, which will recover copper from the leach solution, should be ready in about a year; scientists expect to begin "mining" at that time.

Project managers plan to recover copper for at least 18 months, possibly longer. "We want enough time to see if we can maintain the solution flow and quality and to develop the engineering parameters needed for industry to commercialize the technology," Larson said. The test will be the first use of in-situ leaching to recover copper from an undisturbed deposit.

The project already achieved one "first" by obtaining an aquifer protection permit on a site never mined before. "We've set a precedent that should pave the way for others to pursue this technology," Larson said.

"Our work provides an overall technical strategy. Although each deposit is different, much of what we've learned is transferrable," Larson explained. "What is unique about the Casa Grande project is the real partnership between government and industry that's made it possible."

Freezing Fire

Cryogenic firefighting technology developed by the U.S. Bureau of Mines (USBM) promises a safe, effective way to put out fires in coal refuse piles and waste banks at abandoned mines.

The new technique uses a slurry of dry ice and liquid nitrogen to remove heat from the area of the fire and cut off the oxygen it needs to continue burning.

Fires in wastes left at old mining operations can burn for years, even decades, exposing nearby communities to noxious fumes and smoke. But trying to put them out involves spending large amounts of money with no guarantee of success. Techniques now used–which include digging out the burning material–have only about a 50 to 70 percent chance of extinguishing the fire. The work is difficult and dangerous.

"Our slurry technique should be no more expensive, but it is easier to implement and less hazardous to workers since they don't have to expose or move burning material," explained USBM scientist Ann Kim.

The new procedure involves injecting a slurry of solid carbon dioxide and liquid nitrogen into the waste pile; the slurry materials vaporize on injection. The cold gases then expand and move through the waste pile, removing heat and displacing oxygen. This combined process inhibits combustion and lowers the temperature in the waste material, preventing it from reigniting.

The USBM and the Ohio Department of Natural Resources recently demonstrated the cryogenic procedure at a coal refuse pile near Midvale, Ohio. In August, USBM scientists pumped a slurry into the pile, which had been burning for over 10 years.

"We're pleased with the results," Kim reports. "Our monitoring shows that average temperatures have gone down in most of the waste bank. We left one hot spot, which was not unexpected given the limits we worked with." Researchers hope to return in the spring to take care of that area.

The patented slurry procedure and injection equipment, which are available for licensing, might also be applicable to fighting fires in discarded tire heaps, landfills, and underground mines.

Cleaner Way to "Clean Up" Aluminum Scrap

Before aluminum scrap can be recycled into new cast alloys, processors must reduce its magnesium content. "Demagging" aluminum now depends on a procedure that uses chlorine gas and produces chlorine-contaminated wastes.

Scientists at the U.S. Bureau of Mines (USBM) are working on a safer, "cleaner" alternative. In the new process, a special scavenger compound–lithium titanate–collects magnesium ions from molten aluminum scrap.

The scavenger technique, which has been demonstrated in the laboratory, was originally developed to recover lithium from aluminum-lithium scrap.

"We suspected that the same process could work with aluminum-magnesium alloys because magnesium and lithium exhibit similar chemical behavior," explained USBM scientist Bill Riley.

Chlorination effectively removes magnesium from this material, but fugitive emissions of chloride gases are a risk and producers end up with a slag that needs special disposal. The USBM scavenger process avoids these problems without adding a lot of extra processing steps or requiring expensive new equipment.

The scavenger process takes advantage of the fact that lithium titanate has tunnels or open spaces in its structure which can accommodate ions of a specific size and charge.

"It works basically like a battery," Riley said. Melted aluminum-magnesium scrap serves as one electrode, lithium titanate as the other. Magnesium ions flow from the scrap to the scavenger compound.

"We take the charged lithium titanate and electrodeposit the magnesium for recycling. The lithium titanate is then ready to be used again," Riley explained.

The Environmental Protection Agency, which wants to reduce industry use of chlorine, has funded USBM research on the scavenger process under its Environmental Technology Initiative.

"The studies we're doing this year should give us the process parameters and cost data we need to work with industry on a larger-scale demonstration," Riley said.

Moving It With Magnets

Magnets may give us a new way to get goods off the ground and on the go. Researchers at the U.S. Bureau of Mines (USBM) have designed a friction-free freight pipeline system that uses magnetic levitation (maglev for short) to move coal or other materials.

Many underground coal mines now depend on conveyor belts to carry coal to the surface. These haulage systems expose workers to moving parts and respirable dust; friction and overheating are major fire hazards.

"We wanted a safer way to haul coal–one that would avoid these problems and be cost-competitive with a conveyor belt of equivalent capacity," explained USBM engineer John Geraghty. "Our maglev pipeline design could be a solution."

The USBM has developed a one-half commercial-scale prototype to demonstrate its maglev approach. The transport system design calls for an enclosed pipeline paved with permanent magnets and fitted with steel side rails. Haulage containers carry a horizontal positioning system and arrays of permanent magnets mounted underneath.

The containers are suspended by the repulsive force between the two sets of magnets. But that force also pushes the suspended containers to the side.

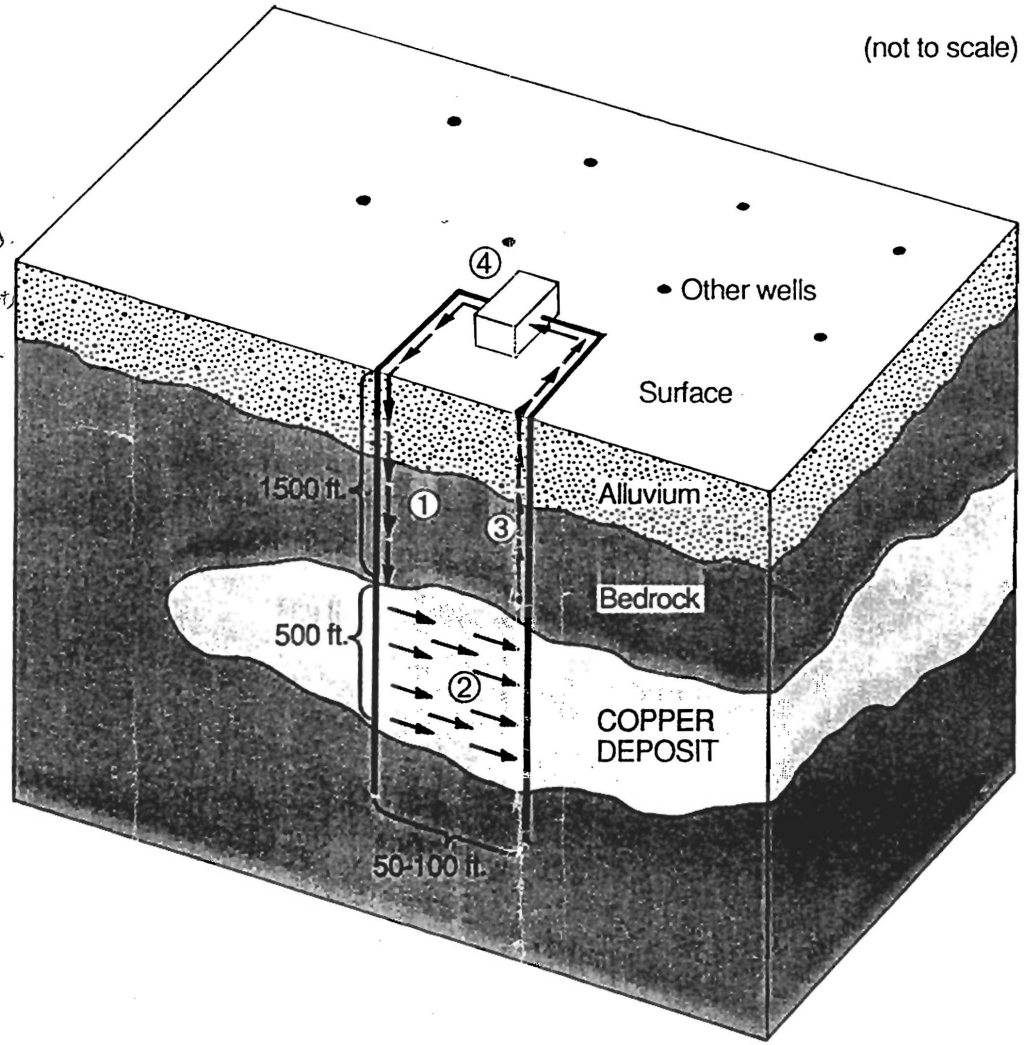
The positioning system on each unit corrects this problem. It uses proximity sensors to "see" if the container is getting too close to the steel rails that line the sides of the pipeline. The sensors activate electromagnets on the container. The activated magnets are attracted to the steel rails, setting up a "pull" that keeps the container centered in the pipeline.

The "noncontact" control provided by the positioning system eliminates mechanical friction, reducing wear and maintenance as well as the amount of energy needed to move material through the pipeline. Possible propulsion systems include pneumatic pressure, linear motors, or hybrid systems that combine the two.

"Our maglev approach is a flexible technology with a variety of potential haulage applications," Geraghty said. Permanent magnet transport systems could move materials in factories, processing plants, clean rooms, and warehouses or provide underground haulage links over short distances.

IN-SITU MINING OPERATION

(not to scale)



locally conq.
steeper contact

Description of process:

① Dilute acid solution is pumped down an injection well to the copper deposit.

② Solution is injected into the copper deposit where copper is dissolved and solution is drawn to a recovery well.

③ Solution is pumped from deposit to the surface.

④ Copper is removed from solution in a surface plant and solution is circulated back to the injection well.

Blue arrows show direction of movement of solution.

ACTUALLY 3 ORE BODIES INC. HANNA CANETH

SC ACTUALLY FAULT DRILLED IN 64 MAINLY ALT. FOUND KEYED BY LOW & FLT BELOW SACATON

NOW CLD 800 MT .43 + HC + 150 MT AT 3rd SMALL ORE BODY

H.C. IN CHALCOCITE ORE BODY

SANTA CRUZ AZ PINAL

SANTA CRUZ

HMC
↓
K Stehl
DE

SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

March 1998

Dear Friend,

As you probably know from newspaper accounts, the Bureau of Reclamation and the Santa Cruz Joint Venture ceased operations at the Santa Cruz well field following President Clinton's line item veto of the project funding in October 1997.

The end of active in situ mining signals the beginning of another process -- closure of the mine. The closure process could last from four to six years depending on requirements by the Arizona Department of Environmental Quality.

Following cessation of injection in December, the Santa Cruz Joint Venture continued pumping from the well field to remove copper bearing leach solutions. This pumping continued until mid-February. As solutions were removed, the fluids remaining in the leach zone become less acidic, causing metals remaining in solution to be redeposited in the ore body through precipitation.

The Bureau of Reclamation, the federal partner in the project, will be involved in developing a closure plan with the private partners. Cost of closure could reach $500,000 and will be shared on the same basis as the project itself, a Federal share of 75% and private share of 25%. Money for the federal share is available from carryover funds from the previous years.

Despite early closure, the environmental and technical goals of the project were met. Thirty-five thousand pounds of copper were recovered, demonstrating that copper can be mined using this technology. Numerous technical problems concerning in situ mining were resolved. No effects were observed in the monitor well system after nearly two years of injection of acid, demonstrating the environmental safety of the process.

The final year of the project was expected to provide data on the economic feasibility of in situ copper mining, the project's final goal. Because of early curtailment, this goal will not be met.

All results of the research will be available to the industry and the public through the Federal Technology Transfer program.

The property and the plant will be maintained during this low cycle in the copper market. A decision to go forward with a commercial scale in situ project at the Santa Cruz site will depend on completing the research on the economics of in situ copper mining.

On behalf of the partners in the Santa Cruz Joint Venture, I want to thank you for your support and interest in the project during its ten year life. The support of the community was an important factor in our success.

David Skidmore
Project Manager

Santa Cruz Joint Venture
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P.O. Box 5747 • Tucson, Arizona 85703-0747
1150 N. 7th Avenue • Tucson, Arizona 85705-6606
(602) 792-3010 • Facsimile (602) 792-3934

SANTA CRUZ COPPER PINAL COUNTY

MG WR 2/7/87: Discussed oxide copper occurrences in Arizona and active smelters/ acid plants in Arizona with Mr. Sterling Cook of the USBM in Mennesota. He is involved in the current in-situ copper leach research program sponsored by the Bureau of Mines. He expects drilling to begin in about one month at the Santa Cruz deposit (file) Pinal County. The first holes will be wideged off of existing holes.

RRB WR 5/1/87: Provided 1986 copper production statistics to S.A. Anzalone, Chief Geologist, Mining Dept., Asarco Inc. He needed them to assist the Bureau of Mines lobby for funds to conduct an in situ leach study at the Santa Cruz Copper (file) deposit near Casa Grande.

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SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

The Santa Cruz Joint Venture, the manager of the Santa Cruz In Situ Copper Mining Research Project, invites you to a briefing on the status of the project.

The briefing will be held on Wednesday, September 7, from 7:30 to 9:00 am at The Property, at 1255 W. Gila Bend Highway.

Research needed to demonstrate protection of groundwater at the Santa Cruz Project has been completed. Results from two and a half years of testing at research project wellfield, located seven miles west of Casa Grande, and extensive research at the United States Bureau of Mines Twin Cities Research Center in Minneapolis MN, have demonstrated that the aquifer used locally for domestic and agricultural purposes will be protected.

The Arizona Department of Environmental Quality has announced its intention to issue an Aquifer Protection Permit to the Santa Cruz Project. This permit is based on research completed at the wellfield and in the laboratory.

The purpose of this briefing is present the research results and to provide an opportunity for members of the community to ask any questions they may have about the environmental safety of the project. We will also bring you up to date on future plans at the Santa Cruz site.

Continental breakfast will be served.

We hope you will be able to attend. Please feel free to bring anyone who might be interested in knowing about the Santa Cruz Project.

Please RSVP to (602) 620-0366 by Friday September 2.

8/26/94

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SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

AQUIFER PROTECTION PERMIT ISSUED

ASSURING GROUNDWATER PROTECTION

The Arizona Department of Environmental Quality has announced its intention to issue an Aquifer Protection Permit for the Santa Cruz In Situ Copper Mining Research Project. The purpose of the Aquifer Protection Permit is to ensure that the proposed facility will protect groundwater for future uses.

The Santa Cruz In Situ Copper Mining Research Project is a test of the technical, economic, and environmental feasibility of a new technology -- in situ mining of copper in a deposit that has not been previously mined. The $22 million project, now in its fifth year, is jointly funded and managed by the U.S. Bureau of Mines and the Santa Cruz Joint Venture, the owner of the mining property.

Results from more than two years of testing at the research project wellfield, located seven miles west from Casa Grande, and extensive research at the U.S. Bureau of Mines Twin Cities Research Center in Minneapolis, MN, have demonstrated that the aquifer used locally for domestic and agricultural purposes will be protected.

The in situ mining process to be tested at the facility will consist of injection of a dilute sulfuric acid solution nearly 1600 feet below land surface into saturated granitic bedrock containing soluble copper oxide minerals. The solution, which will be injected through wells constructed to contain the acidic solution, will dissolve copper from the copper oxide minerals. The copper-bearing solution will be pumped from the copper oxide zone to land surface where the copper will be recovered in a conventional solvent extraction and electrowinning (SX/EW) plant. The in situ mining process involves no excavation of land surface or underlying rock.

Work completed at the Santa Cruz site includes: construction of five wells for the injection and recovery of in situ mining solutions, construction of a groundwater monitoring well system, and extensive testing to define the physical and hydrologic characteristics of the site.

Laboratory research completed at the U.S. Bureau of Mines laboratories includes extensive tests, using rock samples from the Santa Cruz site and in situ mining solutions, to simulate the chemical processes that will occur within the in situ mining zone and adjacent rock during the in situ mining field test. Results from these tests have been integrated into a computer model to project the movement of solutions and their contained chemical constituents over time.

(over, please)

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GROUNDWATER IN LOCAL AQUIFERS USED FOR AGRICULTURAL

AND DOMESTIC PURPOSES WILL BE PROTECTED

* In situ mining solutions will be injected nearly 1000 feet below the aquifer locally used for domestic and agricultural purposes. Tests show that the intervening 1000 feet of granitic bedrock has low permeability and that groundwater moves very slowly through these rock

* The natural neutralizing capacity of the surrounding rock provides a safeguard against migration of acidic solution and harmful chemicals beyond the in situ mining zone. Laboratory tests conducted by the U.S. Bureau of Mines demonstrate that, in the unlikely event that solution would migrate away from the in situ mining zone, the acidic solution would be neutralized and the chemical constituents that were dissolved from the rock would be precipitated from the solution and would again become part of the rock.

* Solutions will be controlled within the in situ mining zone by pumping more solution from the recovery wells than will be injected.

* The injection and recovery wells have been constructed to prevent migration of in situ mining solutions to the overlying aquifer. The wells have two layers of casing, each cemented in place with an acid resistant cement. Extensive tests have demonstrated the integrity of these wells.

* Regular monitoring of groundwater levels and groundwater quality at the four monitor wells has shown no discernible effects in the overlying aquifer from test operations in the injection and recovery wellfield during two and one-half years of testing.

* The groundwater monitor wells will provide a continual check on the operation of the in situ mining test.

In addition to the above, computer modeling, based on the results of field and laboratory research, has been used to project the maximum extent of migration of solutions. The results of this modeling confirm that acidic solutions will not migrate beyond the in situ mining zone because (1) solutions will be controlled through pumping, (2) the acidic solutions will be neutralized by the surrounding rock, and (3) the surrounding rock has very low permeability.

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SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

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Santa Cruz In Situ Copper

The Santa Cruz Joint Venture, (SCJV) a $22 million dollar cooperative demonstration program, has been informed by the Arizona Department of Environmental Quality (DEQ) that they intend to issue an Aquifer Protection Permit for the Santa Cruz Project. The announcement comes after a two and one half year study of the application by the DEQ. The announcement by SCJV was made at a breakfast meeting briefing in Casa Grande on September 7, 1994. The next stage in the process is a public hearing in Casa Grande on September 14 on the draft Environmental Assessment (EA) and closure of written comments before September 26, 1994The project is managed by a joint venture between ASARCO and Freeport Copper Company and the U.S. Bureau of Mines. Funding for the project is shared by the partners.

The deposit was initially discovered by ASARCO geologists in 1964 when they reinterpreted the geology of the Sacaton deposit and found that it was a faulted segment of the main deposit. The main deposit they conjectured was probably located a few hundred yards to the southwest of the Sacaton deposit. Initial drill results indicated a typical Laramide porphyry system that was too deep for open pit and too low grade for underground mining methods. ASARCO then dropped the property which was later acquired by J. David Lowell and Associates for Costal Mining. Coastal drilled the property extensively in the mid 1970's but later sold their interests back to ASARCO and Freeport Copper Company. The Arizona Department of Mines and Mineral Resources list the reserves as 352 million tons at 1.00% copper. Representatives of the joint venture confirmed that the grade of the deposit ranged from 0.5 to 1.5% copper.

CAN CANDE ONLY A PORTION OF DEPOSIT.

The current program will be a pilot plant to determine the technical, economic and environmental feasibility of in situ copper leaching. The pilot plant will consist of one injection well which will introduce a diluted sulfuric acid solution into the copper bearing formation 1500 feet below the surface under a pressure of about 1,000 psi. The solution will be collected by four collection wells located around the induction well on 127 foot centers. Injecting the solutions under this pressure and creating a cone of depression around the collection wells by pumping them in surplus capacity will cause the solutions to flow from the injection well, through the mineralized fissures in the rock and into the collection wells. This will cause some of the copper oxide and carbonate minerals to leach into solution. The injection rate for the current system will be 25 gpm.

The wells, including several monitoring wells, were previously drilled during a program to demonstrate the conductivity of rock and the containment of the solutions. The previous well construction included a triple protection system. The injection and collection wells were drilled into bedrock at the bottom of the aquifer. A steel well casing was then placed and the annulus was grouted with an acid resistant cement. The well was then continued to the zone to be tested. A fiberglass injection pipe was placed to the zone to be leached and the annulus filled with an acid resistant cement. With this quadruple protection system in place the project was tested with a saline solution to determine the

rate at which solutions could be transmitted between the wells. This solution was returned to evaporation ponds.

If the pilot plant is successful and the partners can demonstrate the physical, financial and environmental feasibility of the project will be expanded to a commercial operation.

The ground water will be protected in several ways:

1. The in situ mining operation will be injected nearly 1,000 feet below the productive aquifer in the area.

2. The natural neutralizing capacity of the surrounding rock insures that any acid solutions that escape the designated test area will be neutralized.

3. Solutions will be controlled by over pumping from the recovery wells and there by insuring solution control.

4. Leakage into the fresh water aquifer or the vadose zone from the wells has been prevented by a redundant lining system around the wells.

5. Monitoring wells surrounding the project did not show any communication between the injected solutions and the ground water acquirer.

6. These monitoring wells will provide a continual check on the in situ mining test.

If the project is successful it will demonstrate success of in situ leaching which can have the following benefits over conventional mining:

Production costs are reduced by the elimination of crushing and grinding and handling ore and waste materials. This will also result in reduced energy and labor costs.

The process will use domestically produced materials and energy rather than expensive foreign produced petroleum.

In situ leaching will make some deposits feasible that cannot not currently be mined by other mining methods because they are too deep, too wet, or too low grade.

In situ leaching is safer than conventional mining methods because employees are not exposed to hazards of underground or open pit mining.

The environmental involvement of in situ mining is much smaller than conventional methods and the environmental safe guards are easier to install and monitor.

If this demonstration is successful it will have a tremendous impact on the way we make copper for electrical transmission and use.

The in situ leaching process is covered by the following environmental permits

Underground Injection Control
- Agency: U.S. Environmental Protection Agency
  - Department: Underground Injection Control Program
- Agency: Arizona Department of Environmental Quality
  - Department: Aquifer Protection Permit
- Agency: Arizona Department of Water Resources
  - Department: Pinal Active Management Area
  - Department: Well Driller Certification Program

Air Quality
- Agency: Pinal County
  - Department: Air Quality Control District

Land Use
- Agency: Pinal County
  - Department: Pinal County zoning ordinances

Mine Safety
- Agency: Arizona Mine Inspector
  - Department: Notification of start up

Storm Water Discharge
- Agency: Environmental Protection Agency
  - Department: National Pollutant Discharge Elimination System

Solid Waste
- Agency: Arizona Department of Environmental Quality
  - Department: Solid Waste Facility

Hazardous Substances
- Agency: Emergency Planning
  - Community Right-To-Know Act
  - State Emergency Response Commission
  - Federal Hazardous Materials Transportation and Uniform Safety Act

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- Agency: Arizona Department of Environmental Quality
  - Department: Solid Waste Facility

Hazardous Substances
- Agency: Emergency Planning
  - Community Right-To-Know Act
  - State Emergency Response Commission
  - Federal Hazardous Materials Transportation and Uniform Safety Act

SANTA CRUZ (A) Circulate

United States Department of the Interior

BUREAU OF MINES

TWIN CITIES RESEARCH CENTER
5629 MINNEHAHA AVENUE SOUTH
MINNEAPOLIS, MN 55417-3099

Telex: 362735 BOM TCRC UD

July 2, 1990

Mr. Leroy Kissinger, Director
Department of Mines and Mineral Resources
Mineral Building - Fairgrounds
Phoenix, Arizona 85007

Dear Mr. Kissinger:

In accordance with Section 102(2)(C) of the National Environmental Policy Act (NEPA), please be advised that the Bureau of Mines will hold a public meeting to assist with identifying issues to be included in a draft environmental assessment (DEA) being prepared for the In Situ Copper Mining Research Project. The public meeting is to be held on July 25, 1990, beginning at 7 p.m. and continuing until about 9:30 p.m. at the Holiday Inn, 777 North Pinal Avenue, Casa Grande, AZ. The meeting room will be open at 6:30 p.m. for review of displays and informal discussions with project personnel. The purpose of the meeting is to allow government agencies and the public an opportunity to participate in identifying issues to be included in the DEA. Identification and disclosure of any potential environmental effect of a project is an important part of the NEPA process.

The location selected for conducting the research project is the Santa Cruz site, located approximately seven miles west of the city of Casa Grande, AZ. The proposed action to be evaluated by the DEA is the in situ leach mining of copper from an undisturbed copper oxide ore zone using a pattern of solution injection and recovery wells drilled from the surface, and construction and operation of a pilot-scale, solvent extraction-electrowinning facility to remove copper from recovered solutions. The proposed action is a mining research activity which is intended to evaluate the technical, economic, and environmental feasibility of copper in situ leach mining. The final environmental assessment will provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement (EIS) for the project, or a finding of no significant impact (FONSI). An EIS is prepared if the action is determined to have a significant effect on the human environment. A FONSI briefly presents reasons why an action will not have a significant effect on the human environment and that preparation of an EIS will not be necessary.

In situ leach mining of copper involves the injection of a dilute sulfuric acid solution through a well or wells completed into an otherwise undisturbed ore zone; selective dissolution of copper as the solution moves through natural fractures and pore spaces; collection of copper-bearing solution by recovery wells; removal of the dissolved copper using a conventional solvent extraction-electrowinning plant located on the surface; rejuvenation of solution to its original strength; and solution reinjection back into the ore zone to repeat the cycle.

The In Situ Copper Mining Research Project is a cooperative research effort of the Bureau of Mines and the Santa Cruz Joint Venture (a joint venture formed between ASARCO Santa Cruz, Inc., and Freeport Copper Co.). The surface and subsurface owner of the project site is the Santa Cruz Joint Venture. Wells to be utilized during the term of the project include one injection well together with four recovery wells. These wells are presently in place and were originally installed for use during a site hydrogeologic investigation. The four recovery wells are arranged in a square pattern on the ground surface with side dimensions of 127 ft. The single injection well is located in the center of the square. This arrangement is referred to as "five-spot" well pattern. During the research project, the well pattern may be expanded by installing an additional injection well and two additional recovery wells to form a "double five-spot" with side dimensions of approximately 127 ft by 254 ft. The expanded well pattern, if completed, will bring the total number of injection and recovery wells to eight. Injection of the solution will occur at a rate of 10 to 50 gal/min. The total area of the research project site is about 27 acres. In addition to NEPA criteria, this research project is subject to Federal, State, and local environmental permitting requirements.

Oral and written comments on the environmental issues associated with the proposed action are encouraged. To be most helpful to the Bureau in preparing the DEA, comments are requested by August 8, 1990. The DEA will be released to the public for review and comment before it is made final as an environmental assessment.

A fact sheet describing the principle components of the research project is enclosed. Should you have any questions regarding the research project or the public meeting, please feel free to contact me at the above address, or by telephone at (612) 725-4690.

Sincerely,

William C. Larson

WILLIAM C. LARSON, Research Supervisor
Advanced Mining Division

Enclosure

INFORMATION ON THE
IN SITU COPPER MINING RESEARCH PROJECT

Proposed Action To Be Evaluated In Draft Environmental Assessment: Leaching of copper from an undisturbed oxide ore zone using a pattern of injection and recovery wells completed from the surface, and construction and operation of an adjacent solvent extraction-electrowinning facility to remove copper from recovered solutions.

Objectives of the Research Project: 1) To evaluate the technical, economic, and environmental feasibility of in situ leach mining of copper oxide minerals and 2) provide industry with the means to develop engineering designs for copper in situ leach mining.

Project Location: Seven miles west of Casa Grande, Arizona.

Project Participants: The U.S. Bureau of Mines and the Santa Cruz Joint Venture (SCJV). The SCJV is a joint venture formed between ASARCO Santa Cruz, Inc. and Freeport Copper Co.

Source of Funding: Congressional appropriation to the Bureau of Mines to cover 75 pct of the cost, and the SCJV to cover the remaining 25 pct.

Nature of the Research Project: A weak (one to five pct) solution of sulfuric acid will be pumped via injection wells into that portion of the copper oxide ore zone located at a depth of 1570 ft to 1770 ft below the land surface. The copper is leached from the ore as the solution travels through the fractures which contain the copper mineralization. The solution will be recovered by wells located along the perimeter of the well field. Copper will be removed from the solution using conventional solvent extraction-electrowinning methods. Once stripped of its copper, the barren solution will be recycled back into the ore zone. Movement of all fluids injected into the rock will be controlled through pumping. Approximately one to two percent of the rock in the leach zone will be removed.

Environmental Requirements: Before construction of the surface processing facility and the actual leaching operation may commence, the significance of any environmental effects will need to be evaluated by the Bureau of Mines in accordance with criteria of the National Environmental Policy Act of 1969. The Arizona Department of Environmental Quality will require approval of an aquifer protection permit before acid injection may begin. The Arizona Department of Water Resources will have jurisdiction over well construction activities. The U.S. Environmental Protection Agency will regulate well injection activities under the Underground Injection Control program. Air quality protection permits will need to be obtained from the Pinal County Air Quality Control District.

Surface Facilities: Facilities on the surface include wellheads, pipes, tanks to hold solvent, evaporation and storage ponds, and buildings. Wells to be utilized during the term of the project include one injection well together with four recovery wells. These wells are presently in place and were originally installed for use during a site hydrogeologic investigation. The

four recovery wells are arranged in a square pattern on the ground surface with side dimensions of 127 ft. The single injection well is located in the center of the square. This arrangement is referred to as a "five-spot" well pattern. During the research project, the well pattern may be expanded by installing an additional injection well and two additional recovery wells to form a "double five-spot" with side dimensions of approximately 127 ft by 254 ft. The expanded well pattern, if completed, will bring the total number of injection/recovery wells to eight. Massive pit excavations or tailings piles will not be required. The total area of the research project is about 27 acres.

Water Use: Water use is less than traditional mining because solutions are continuously recycled. Water use is estimated not to exceed 20 acre feet per year during the research project. The Santa Cruz Joint Venture holds non-irrigation Type 1 water rights for 3609 acre feet of groundwater.

Groundwater Protection: Protection of groundwater is a major focus of the engineering design. Elements of this design include:

1. Injection of a tracer solution prior to acid injection to verify the ability to contain and control fluids.

2. Injection and recovery wells to be constructed to prevent the loss of process fluids into the basin-fill deposits aquifer.

3. Injection and recovery wells to be regulated to ensure control of fluids within the mining zone.

4. Monitoring wells in the basin-fill deposits aquifer to be used to detect changes in water quality.

Duration of the Research Project: Approximately five years: at least two years of data collection prior to receiving environmental permits and authorizations, and at least three years of operation and post-leaching evaluation.

Status of the Project: Data collection for environmental permitting and analysis is in progress now.

Opportunities for Public Comment: The public will have an opportunity to comment on the draft EA before it is made final. The Arizona Department of Environmental Quality aquifer protection permit application process will allow for public review and comment before permit approval.

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

FIFE SYMINGTON, GOVERNOR
RANDOLPH WOOD, P.E., DIRECTOR

NOTICE OF ISSUANCE OF A TEMPORARY AQUIFER PROTECTION PERMIT

Pursuant to Arizona Administrative Code, Title 18, Chapter 9, Article 1, the Director of the Arizona Department of Environmental Quality has issued a Temporary Aquifer Protection Permit(s) to the following applicant, valid for a period, not to exceed one (1) year, subject to certain special and general conditions.

Public Notice No. 12-91AZAP — On or about April 11, 1991
Santa Cruz In Situ Copper Research
Santa Cruz Joint Venture/ASARCO
Santa Cruz, Inc.
P.O. Box 5747
Tucson, AZ 85703-0747
Temporary Aquifer Protection Permit No. 10141T

The facility is located approximately seven miles west of Casa Grande, Arizona, in Pinal County, over groundwater of the Pinal Active Management Area, in Township 6 South, Range 4 East, Section 13, of the Gila and Salt River Baseline and Meridian.

The facility is comprised of five injection/recovery wells and an evaporation/solution storage pond. The Temporary Aquifer Protection Permit is written for a tracer test involving the injection of sodium chloride and/or sodium bromide solutions into mineralized bedrock. Hydrologic testing, acid development of wells and hydraulic fracturing are also permitted. Tracer solutions will be injected into a central well and recovered from four surrounding wells. Recovered tracer solutions that are not reinjected will be stored in the pond. The tracer injection tests will last for a maximum of approximately six months. The purpose of the tracer test is to acquire hydrologic data to support further injection experiments using dilute sulfuric acid. The ultimate goal of the research is to determine the economic and enviromental feasibility of in situ mining of copper.

The permit and supporting documents are available for public review Monday through Friday, 8:00 a.m. to 5:00 p.m. at the Arizona Department of Environmental Quality, Water Permits Unit, 2005 North Central Avenue, Phoenix, Arizona 85004.

Persons may submit comments or request a public hearing on the action, in writing, to ADEQ at the above address within thirty (30) days from the date of this notice. Public hearing requests must include the reason for such request.

Santa Cruz File

INJECTION AND RECOVERY WELL CONSTRUCTION SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT

In situ mining consists of injection of dilute acid solution into an ore body and recovery of copper-bearing solution via a system of wells specially constructed for that purpose.

Design of the wells and selection of well construction technology is an important aspect of the Santa Cruz In Situ Copper Mining Research Project (Project). In order to ensure the highest standards of quality, the managers of the Project have assembled a team that includes some of the most experienced drilling companies and well construction specialists in the world.

THE WELL SYSTEM

The injection and recovery well system for the Project consists of five wells. Four of the wells form a square with side dimensions of 127 feet. The fifth well, the injection well, is located at the center of the square about 90 feet from each of the recovery wells. The five wells form a "five-spot" pattern. Three additional wells may be added to form a "double five-spot" pattern. The depth of the injection and recovery wells is about 1,880 feet.

Chemical quality of water is being monitored throughout the Project by four additional wells constructed for the purpose. One of these monitor wells is located on-site at the west side of the five-spot pattern. Two monitoring wells are located down hydraulic gradient (west) and the remaining monitoring well is located up hydraulic gradient (east) from the "five-spot" pattern. The monitoring wells are designed to obtain groundwater samples from the basin-fill deposits aquifer and from the upper part of the underlying conglomerate. Aquifer tests have been conducted at the research site using the on-site monitor well as the pumping well and the three off-site monitor wells as groundwater level observation wells.

CONSTRUCTION

The injection and recovery wells have been constructed to control the location of injection of dilute acid solution in the ore body and to eliminate the possibility of migration of solutions along the well bore to the basin-fill deposits aquifer.

The first step in construction of the well is installation of the surface casing. A borehole 19 inches in diameter is drilled from the surface to a depth of 20 feet. A 16-inch steel casing is installed in the borehole. The space between the borehole and the casing, called the annulus of the well, is filled with cement. The purpose of the surface casing is to prevent contamination of the well and the aquifer by surface water and other material and to provide stability during further drilling.

The second step is construction to the 1,200-foot level. A 14-3/4 inch borehole is drilled to the 1,220-foot level. Blank steel casing, 10-3/4 inches outside diameter, is installed from the land surface to a depth of 1,200 feet and is positioned in the center of the borehole by centralizers. The well annulus is then completely filled with acid-resistant cement from a depth of 1,220 feet to the land surface. Cement is pumped down through the steel casing and into the annulus of the well from the bottom of the borehole. When a predetermined amount of cement is pumped into the casing, a rubber plug is inserted into the casing and water is pumped in above the plug forcing the plug and the cement down the casing. Pumping continues until the rubber plug is lodged against the float valve (see attachment) and the cement completely fills the annular space to the land surface. If the cement does not reach the surface, additional cement is placed in the annulus using a tremie line. That is, a small diameter pipe is inserted down the hole between the casing and the rock formation until it reaches hardened cement. Cement is pumped down this pipe (with the pipe being slowly raised) until the annulus is filled.

In the next step, a 9-7/8 inch borehole is drilled to a depth of 1,870 feet. Seven-inch fiberglass-reinforced plastic casing is installed in the well and the cementing procedures are repeated with acid-resistant cement.

After each well is completed, a cement bond log is obtained to ascertain that the casing is properly cemented, and a pressure test is conducted to document the mechanical integrity of the casing.

In the final step, 200 feet of casing in the ore zone near the bottom of the well is perforated to allow injection and recovery of fluids. The technique used to perforate the well is widely used in the petroleum industry. Small shaped charges are placed in the well and detonated, creating circular openings in the fiberglass-reinforced plastic casing and the cement in the well annulus. The perforations, which are about 1/2 inch in diameter and 1 foot apart, permit injection of fluids into the ore body and recovery of fluids through the recovery wells.

ENVIRONMENTAL SAFEGUARDS

As shown on the attached diagram, the completed well is sealed from the aquifer that supplies local water wells by two separate casings, an outer casing of steel and an inner casing of fiberglass-reinforced plastic. However, based on our present experience, it appears that the outer steel casing may not be required for future wells.

Injection and recovery wells at the Santa Cruz research site are classified as Class V wells under the Underground Injection Control (UIC) program of the federal Safe Drinking Water Act, administered by the EPA. If in situ mining technology is proven to be successful and the Project becomes a commercial operation, the wells would then be classified as Class III wells, the designation used for injection of in situ leaching solutions. The Class III regulations are designed to confine fluids to the leach zone and to prevent migration of fluids to Underground Sources of Drinking Water (USDW's). The rules require cementing of well casings and testing of the mechanical integrity of the casing and of the cement seals. Although EPA rules do not require injection wells constructed for research projects to meet Class III requirements, all injection and recovery wells on the Santa Cruz Project have been constructed to meet these requirements.

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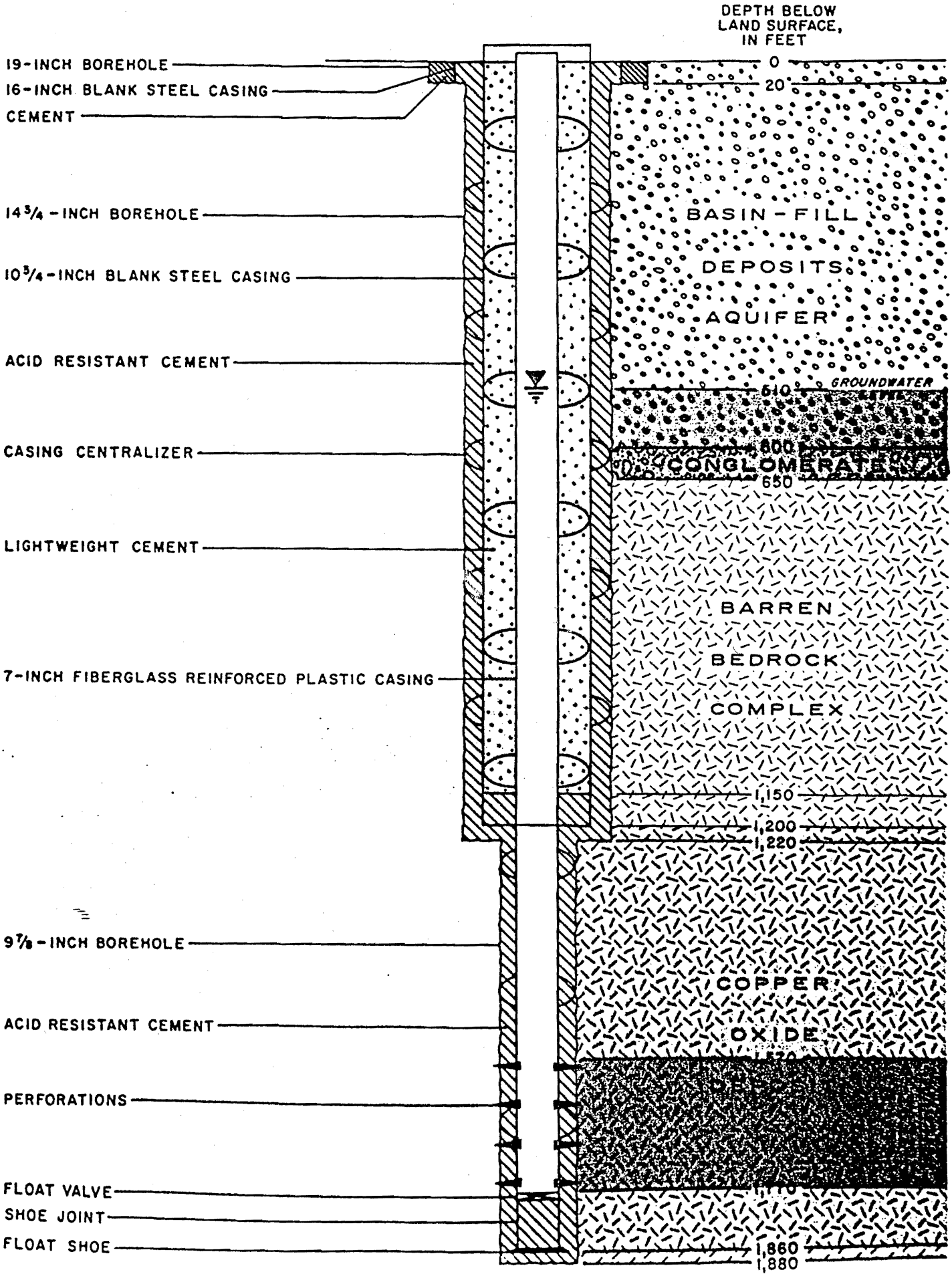
SCHEMATIC DIAGRAM OF TEST WELL AT THE SANTA CRUZ IN SITU COPPER MINING RESEARCH PROJECT



Technology News

From the Bureau of Mines, United States Department of the Interior

Technology News describes tested developments from the Bureau of Mines Research Programs. It is published to encourage the transfer of this information to the minerals industry and its application in commercial practice. Mention of company or product names is for documentation only and does not imply government endorsement of a specific firm or product.

Bureau of Mines research is performed and reported under mandate of the United States Congress. For a free subscription to Technology News, write to: Technology Transfer Group, Bureau of Mines, 2401 E St., NW, Washington, D.C. 20241.

No. 334, June 1989

Procedures for Designing In Situ Leach Mines for Copper

Objective

Provide the U.S. mining industry with technology for designing environmentally sound, low-cost in situ leach mining operations to produce copper from small, deep, and/or low-grade copper oxide deposits.

Approach

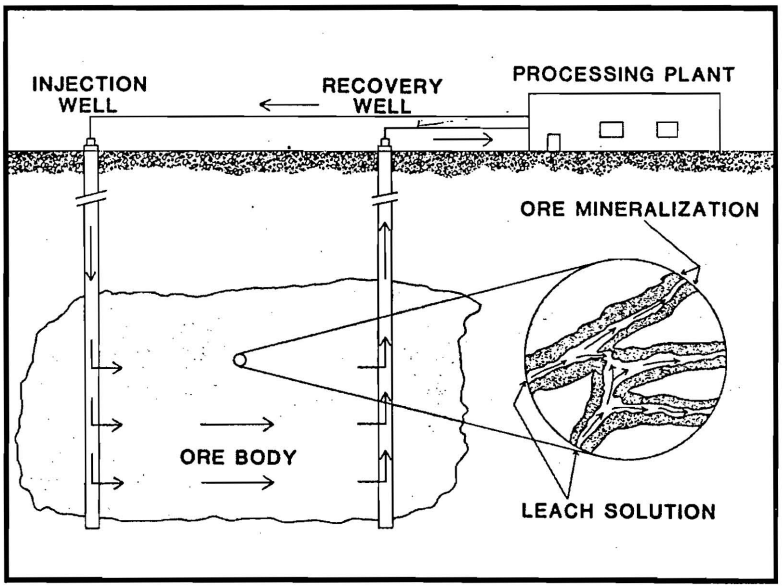
Investigate the feasibility of a new mining method--in situ leach mining--as an alternative to conventional mining for copper. Study fundamental leaching technology that will facilitate future commercial operations. Develop guidelines and procedures that will enable mine operators to design and evaluate in situ leach mining operations for any specific copper oxide deposit.

About In Situ Leach Mining for Copper

In situ leach mining involves the recovery of mineral values from undisturbed ore by circulating solvents, such as dilute sulfuric acid for copper oxide recovery, through the ore in its natural state. In contrast, conventional mining requires mine workers to break the ore and transport it to a processing facility.

An in situ copper mining operation combines surface and subsurface facilities in the following manner:

1. Chemicals used to dissolve and maintain the copper in solution are prepared in the surface facility.
2. The solvent is pumped down a set of injection wells and forced into pores and fractures in the rock by using a pressure exceeding the hydrostatic pressure in the deposit.



In Situ Leach Mining Process

3. As the solvent travels through these flow channels in the rock, it dissolves copper minerals and transports the copper to adjacent production wells.
4. The copper-enriched solutions are

collected in the production wells and then pumped to the surface.

5. Copper is recovered from the enriched solutions in a solvent extraction-electrowinning plant; the acid is regenerated in the plant for recirculation through the ore zone. The solvent will make many trips through the ore zone before the copper in a given well pattern will be depleted.

Design Procedures

During its research on in situ mining technology, the Bureau developed several "tools" that mining companies may use to design operations for copper oxide deposits. A major design tool consisted of a systematic method for assessing the commercial feasibility of in situ copper mining at any selected oxide deposit.

Developed during a contract study, the method features--

* Identification of site-specific parameters that must be quantified.

* Descriptions of laboratory and field tests to measure these parameters.

* A method for selecting the best mining scenario for any specific site.

* A computer model for determining all capital and operating expenses associated with the well field, solvent extraction-electrowinning plant, and environmental permitting activities. The model also allows a company to conduct an economic analysis of the proposed operation.

* A description of the procedures, specifications, designs, costs for environmental permitting in the State of Arizona.

Bureau researchers also developed techniques for evaluating the nfluence of geological and geochemical characteristics of an ore deposit on the design of an in situ mining operation. The Bureau developed several computer models describing leaching solution flow in certain hydrologic regimes. Hydrologists need such models to design the most efficient well field.

Further details concerning methods for designing in situ leaching operations for copper oxide deposits, as well as sample applications, can be found in the following contract final reports. These reports are sold by the National Technical Information Service (NTIS). Each volume can be ordered separately at the the prices noted.

Volume I, Executive Summary; NTIS No. PB89-148217/AS, $15.95 for paper copy, $6.95 for microfiche.

Volume II, Draft Generic In Situ Copper Mine Design Manual;

NTIS No. PB89-148225/AS, $49.95 for paper, $6.95 for microfiche.

Volume III, Lakeshore Field Experiment and Design of Commercial Scale Operation; NTIS No. PB89-153228/AS, $36.95 on paper, $6.95 on microfiche.

Volume IV, Santa Cruz Field Experiment and Design of Commercial Scale Operation; NTIS No. PB89-153290/AS, $36.95 on paper, $6.95 on microfiche.

Volume V, Field Testing at the Santa Cruz Site; NTIS No. PB89-153303/AS, $21.95 for paper copy, $6.95 on microfiche.

To order, write NTIS at 5285 Port Royal Road, Springfield, VA 22161.

A summary of the Bureau's most recent developments in computer modeling of solution flow and their applications in designing well fields are contained in the Bureau's Information Circular (IC) 9216, "In Situ Leaching Mining. Proceedings: Bureau of Mines, Technology Transfer Seminars, Phoenix, AZ, April 4, and Salt Lake City, UT, April 6, 1989." This report also discusses the impact of geocharacteristics on in situ copper leach mine design. A copy of the IC may be obtained by writing to the Bureau's Publication Distribution Section, P.O. Box 18070, Cochrans Mill Road, Pittsburgh, PA 15236. Additional technical information is available from Jon K. Ahlness, Twin Cities Research Center, Bureau of Mines, 5629 Minnehaha Avenue South, Minneapolis, MN 55417 (612) 725-4673.

★U.S.GPO:1989-0-234-431

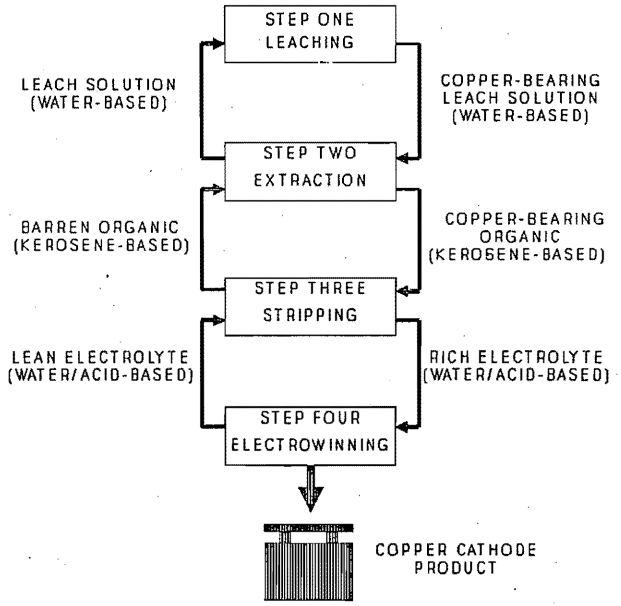
After seven days in the cell, a starter sheet has grown to a slab of virtually pure copper weighing about 200 pounds. At that point, it is removed from the cell and replaced with a new starter sheet. The harvested cathodes are ready for sale or for further processing into other copper products.

The electrolyte that has passed through the tankhouse, partially depleted of its copper, is recycled to the stripping process to have its copper content restored.

Environmental Protection

The solvent extraction/electrowinning process involves virtually no waste because all of the solutions are continuously recycled through three separate, closed-loop circuits. Sulfuric acid mist will be controlled in accordance with local air quality regulations. The plant will have the appearance of a small-scale industrial facility.

SX/EW PROCESS FLOW DIAGRAM



The U.S. Bureau of Mines acknowledges Phelps Dodge Corporation, for text and graphics used in this information sheet.

Solvent Extraction/Electrowinning of Copper from Copper-Bearing In Situ Leach Solution

The solvent extraction/electrowinning (SX/EW) process is a relatively simple way of removing dissolved copper from solutions produced by leaching of copper oxide ore. The process is widely used in connection with leaching of previously-excavated or broken copper with essentially no waste.

The solution is pumped via pipeline from the leaching operation to the SX/EW plant. The SX/EW process consists of three steps, which are described below and illustrated on the next page.

Extraction

The first step in the SX/EW process is removal of the copper from the copper-bearing leach solution. The leach solution is vigorously mixed with an equal volume of kerosene-based solvent that contains an organic chemical specifically designed to extract the copper from the solution, leaving other metals and minerals behind. After the solutions have been mixed for about two minutes, the mixture is allowed to settle.

The water-based leach solution, which has given up its copper to the organic chemical, is the heavier of the two solutions and sinks to the bottom. This barren leach solution is re-acidified and recycled through the injection wells into the leach zone in the ore body.

The kerosene-based solvent containing the copper-laden organic chemical floats to the surface and is pumped to the next step in the solvent extraction process.

Stripping

In this, the second step in the process, the copper-bearing organic is mixed with a copper-bearing sulfuric acid solution called "electrolyte." The electrolyte solution strips the copper from the organic solution, leaving it barren of copper. These mixed solutions are allowed to settle. The kerosene-based organic, now barren of copper, again rises to the top and the electrolyte containing the copper, called "rich electrolyte" settles to the bottom. The barren organic solution is recycled to the extraction process and the copper-rich electrolyte solution is pumped to the electrowinning tankhouse.

Electrowinning

In the final step, electrowinning, the rich electrolyte is pumped through a series of tanks or "cells." Hanging in the tanks are insoluble lead plates alternating with sheets of copper. Each lead plate serves as the anode pole of an electric circuit: each cathode pole begins as a "starter sheet" of pure copper. A direct current is passed through the electrolyte, reducing some of the copper ions to copper metal, which accumulates on the starter sheet.

Santa Cruz Copper mine file

OFR 57-92. The Natural Attenuation Capacity of Santa Cruz Area Rocks To Partition Mobile Solutes From In Situ Leachate, by Dianne C. Marozas, Steven E. Paulson, and Timothy J. Callahan. 1992. 44 pp. 4 figs. The U.S. Bureau of Mines, under a cooperative agreement with the Santa Cruz Joint Venture, owned by Santa Cruz, ASARCO Inc., and Freeport Copper Co., has started to investigate the feasibility of in situ leach mining a deep copper oxide deposit near Casa Grande, AZ. Because this investigation involves a Federal agency, all requirements of the National Environmental Policy Act (NEPA) must be observed. To meet these requirements, the Bureau intends to prepare an environmental assessment (EA) for this project to evaluate the significance of anticipated environmental impacts that may result. The EA provides in brief sufficient evidence and analysis for determining whether to prepare an environmental impact statement (EIS) or a finding of no significant impact (FONSI). An EIS is prepared if the action is determined to have a significant effect on the human environment. A FONSI is written if it is determined that no significant effect on the human environment will result from the proposed action. Under a FONSI, the proposed action is exempt from requirements to prepare an EIS. Preliminary investigations, discussion between Bureau and industry researchers, and comments and concerns expressed at a public meeting held in Casa Grande, AZ, in July 1990 revealed several specific issues of potential environmental concern. Those issues are air quality, sulfuric acid handling and use, groundwater and hydrologic modeling, surface subsidence, attenuation, and recycle of fluids. Each of these issues will be addressed in a separate Bureau of Mines Open File Report (OFR) to be used as background documents in support of the EA. In addition, several other points of interest will be addressed in other background documents, including the overall process description, geology and hydrology, mineralogy and petrology, rock quality and structure, and geophysics. The present report summarizes the results of the investigation into the natural attenuation capacity of rock from the Santa Cruz site; this material will then be incorporated by reference in the draft Environmental Assessment. Research was done by the Bureau of Mines Twin Cities Research Center. Available for reference at LIB, PRC, and TCRC. Order ONLY from NTIS: PB 92-166586; paper copy price code A04. $19 (microfiche $9).

NTIS = NATIONAL TECHNICAL INFORMATION SERVICE
1-800-553-NTIS (6847)

Santa Cruz Copper
mine file

OFR 46-92. Sulfuric Acid Handling and Use Issues Related to the In Situ Copper Leach Mining Demonstration Project, Arizona, by Pamela J. Watson. 1992. 33 pp. 5 figs. The U.S. Bureau of Mines under a cooperative agreement with ASARCO Santa Cruz, Inc., has started an investigation into the feasibility of in situ leach mining of a deep copper oxide deposit near Casa Grande, AZ. Because this investigation involves a Federal agency, all requirements of the National Environmental Policy Act (NEPA) must be observed. To meet these requirements, the Bureau intends to prepare an environmental assessment (EA) for this project to evaluate the significance of anticipated environmental impacts that may result. The EA briefly provides sufficient evidence and analysis for determining whether to prepare an environmental impact statement (EIS) or a finding of no significant impact (FONSI). An EIS is prepared if the action is determined to have a significant effect on the human environment. A FONSI is written if it is determined that a significant effect on the human environment will not result from the proposed action. Under a FONSI, the proposed action is exempt from requirements to prepare an EIS. Preliminary investigations, discussion between Bureau and industry researchers, and comments and concerns expressed at a public meeting held in Casa Grande, AZ, in July 1990 revealed several specific issues of potential environmental concern, as follows: air quality, sulfuric acid handling and use, ground water and hydrologic modeling, surface subsidence, attenuation, and recycle of fluids. Research was done by the Bureau of Mines Twin Cities Research Center. Available for reference at LIB, PRC, and TCRC. Order ONLY from NTIS: PB 92-139138; paper copy price code A03. $17 (microfiche $9).

NTIS = National Technical Information Service

1-800-553-6847

AGENDA
FOR
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
PUBLIC MEETING
JULY 25, 1990

In accordance with the National Environmental Policy Act of 1969, the Bureau of Mines intends to prepare a draft Environmental Assessment (EA) for the In Situ Copper Mining Research Project. The selected location for conducting the project is the Santa Cruz site, located approximately seven miles west of the city of Casa Grande, AZ. The purpose of tonight's meeting is to allow you an opportunity to participate in preparation of the draft EA. The proposed action to be evaluated is the leaching of copper from an undisturbed oxide ore zone using a pattern of up to eight injection and recovery wells completed from the surface, and construction and operation of a solvent extraction-electrowinning facility to remove copper from recovered solutions. We are requesting your input regarding concerns and the environmental issues that you believe should be addressed in the draft EA.

Tonight's program will proceed according to the following agenda:

- INTRODUCTION--Meeting Moderator, Lewis V. Wade, Bureau of Mines, Minneapolis, MN
- PRESENTATION OF IN SITU COPPER MINING RESEARCH PROJECT--Daniel J. Millenacker, Bureau of Mines, Minneapolis, MN
- OPEN COMMENT PERIOD
- BREAK
- CONTINUATION OF OPEN COMMENT PERIOD
- ADJOURN

Oral comments can be made during the Open Comment Periods. Individuals are asked to make their comments brief.

If you wish to submit a written statement, please fill out one of the blue cards in the handout package and return it to the Registration Table or mail it to:

Mr. William C. Larson
U.S. Bureau of Mines, Twin Cities Research Center
5629 Minnehaha Avenue South
Minneapolis, MN 55417-3099

To be most useful to the Bureau in preparing the draft EA, all comments on the proposed action are requested by August 8, 1990. All comments will become a part of the permanent record of the meeting. The draft EA will be released to the public for review and comment before it is made final.

FOR FURTHER INFORMATION, CONTACT WILLIAM C. LARSON AT THE U.S. BUREAU OF MINES: (612) 725-4690, or (FTS) 789-4690.

originally installed for use during a site hydrogeologic investigation. The four recovery wells are arranged in a square pattern on the ground surface with side dimensions of 127 ft. The single injection well is located in the center of the square. This arrangement is referred to as a "five-spot" well pattern. During the research project, the well pattern may be expanded by installing an additional injection well and two additional recovery wells to form a "double five-spot" with side dimensions of approximately 127 ft by 254 ft. The expanded well pattern, if completed, will bring the total number of injection/recovery wells to eight. Massive pit excavations or tailings piles will not be required. The total area of the research project is about 27 acres.

Water Use: Water use is less than traditional mining because solutions are continuously recycled. Water use is estimated not to exceed 20 acre feet per year during the research project. The Santa Cruz Joint Venture holds non-irrigation Type 1 water rights for 3609 acre feet of groundwater.

Groundwater Protection: Protection of groundwater is a major focus of the engineering design. Elements of this design include:

1. Injection of a tracer solution prior to acid injection to verify the ability to contain and control fluids.

2. Injection and recovery wells to be constructed to prevent the loss of process fluids into the basin-fill deposits aquifer.

3. Injection and recovery well pressures and flow rates to be regulated to ensure control of fluids within the mining zone.

4. Monitoring wells in the basin-fill deposits aquifer to be used to detect changes in water quality.

Duration of the Research Project: Approximately five years: at least two years of data collection prior to receiving environmental permits and authorizations, and at least three years of operation and post-leaching evaluation.

Status of the Project: Data collection for environmental permitting and analysis is in progress now.

Opportunities for Public Comment: The public will have an opportunity to comment on the draft EA before it is made final. The Arizona Department of Environmental Quality aquifer protection permit application process will allow for public review and comment before permit approval.

INFORMATION ON THE
IN SITU COPPER MINING RESEARCH PROJECT

Proposed Action To Be Evaluated In Draft Environmental Assessment: Leaching of copper from an undisturbed oxide ore zone using a pattern of injection and recovery wells completed from the surface, and construction and operation of an adjacent solvent extraction-electrowinning facility to remove copper from recovered solutions.

Objectives of the Research Project: 1) To evaluate the technical, economic, and environmental feasibility of in situ leach mining of copper oxide minerals and 2) provide industry with the means to develop engineering designs for copper in situ leach mining.

Project Location: Seven miles west of Casa Grande, Arizona.

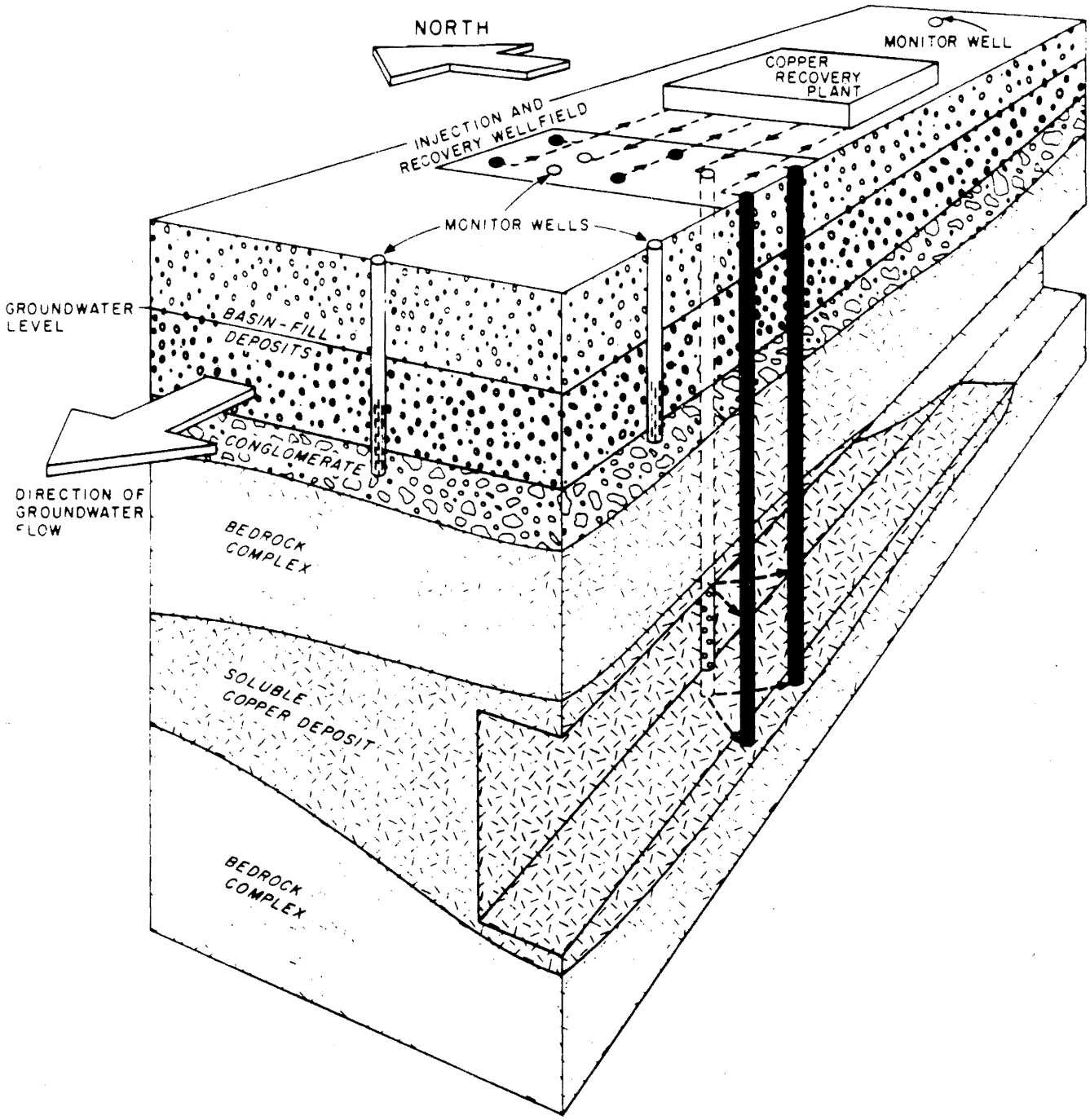
Project Participants: The U.S. Bureau of Mines and the Santa Cruz Joint Venture (SCJV). The SCJV is a joint venture formed between ASARCO Santa Cruz, Inc. and Freeport Copper Co.

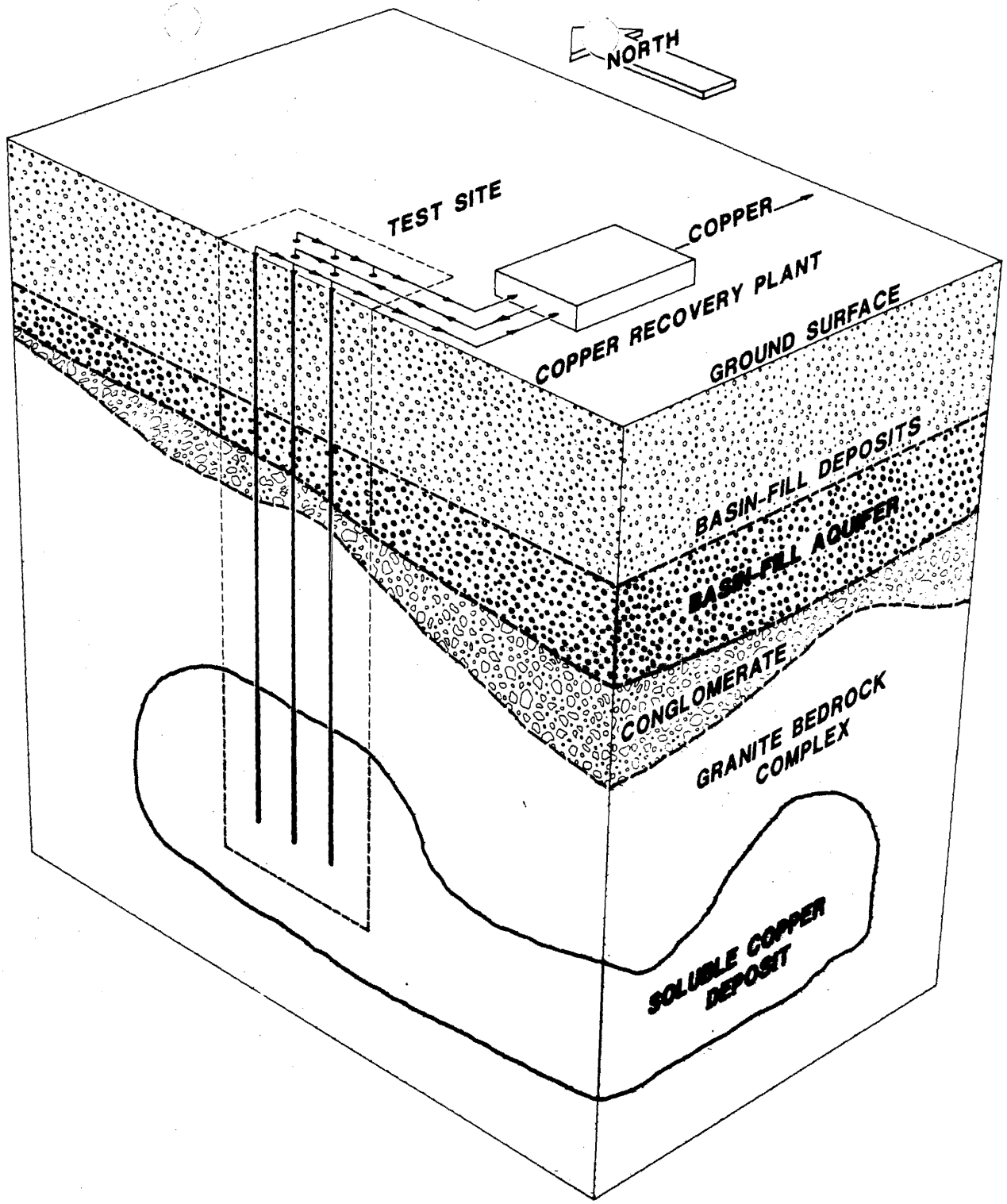
Source of Funding: Congressional appropriation to the Bureau of Mines to cover 75 pct of the cost, and the SCJV to cover the remaining 25 pct.

Nature of the Research Project: A weak (one to five pct) solution of sulfuric acid will be pumped via injection wells into that portion of the copper oxide ore zone located at a depth of 1570 ft to 1770 ft below the land surface. The copper is leached from the ore as the solution travels through the fractures which contain the copper mineralization. The solution will be recovered by wells located along the perimeter of the well field. Copper will be removed from the solution using conventional solvent extraction-electrowinning methods. Once stripped of its copper, the barren solution will be rejuvenated back to its original acid concentration and recycled back into the ore zone. Movement of all fluids injected into the rock will be controlled through pumping. Approximately one to two percent of the rock in the leach zone will be removed.

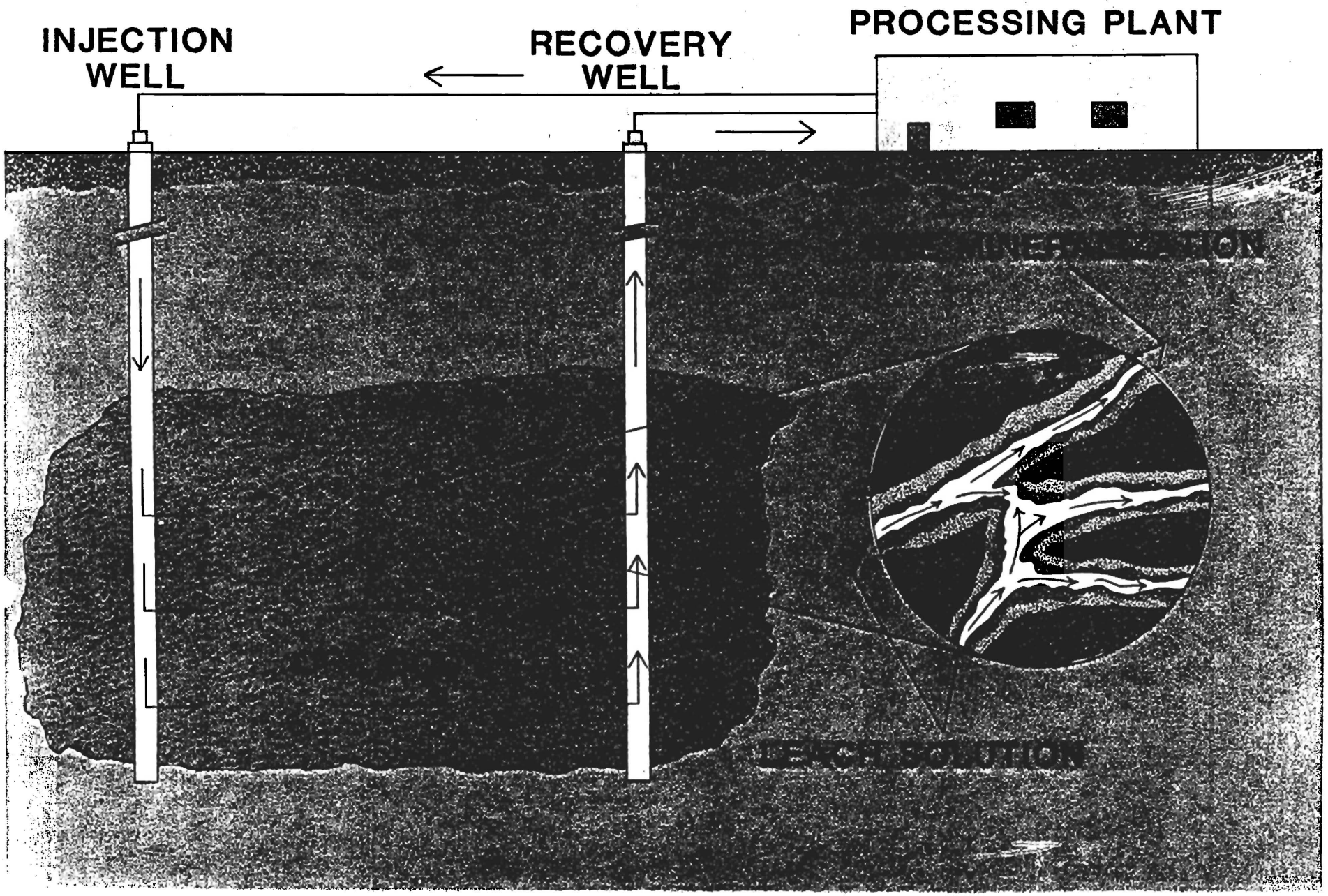
Environmental Requirements: Before construction of the surface processing facility and the actual leaching operation may commence, the significance of any environmental effects will need to be evaluated by the Bureau of Mines in accordance with criteria of the National Environmental Policy Act of 1969. The Arizona Department of Environmental Quality will require approval of an aquifer protection permit before acid injection may begin. The Arizona Department of Water Resources will have jurisdiction over well construction activities. The U.S. Environmental Protection Agency will regulate well injection activities under the Underground Injection Control program. Air quality protection permits will need to be obtained from the Pinal County Air Quality Control District.

Surface Facilities: Facilities on the surface include wellheads, pipes, tanks to hold solvent, evaporation and storage ponds, and buildings. Wells to be utilized during the term of the project include one injection well together with four recovery wells. These wells are presently in place and were


NORTH
MONITOR WELL
COPPER RECOVERY PLANT
INJECTION AND RECOVERY WELLFIELD
MONITOR WELLS
GROUNDWATER LEVEL
BASIN-FILL DEPOSITS
CONGLOMERATE
DIRECTION OF GROUNDWATER FLOW
BEDROCK COMPLEX
SOLUBLE COPPER DEPOSIT
BEDROCK COMPLEX



IN SITU COPPER MINING RESEARCH PROJECT


INJECTION WELL
RECOVERY WELL
PROCESSING PLANT

U.S. Bureau of Mines

NEWS

Office of Public Information (202) 634-1001

For Immediate Release

Contact: Jon Ahlness
(612) 725-4673

ALL 5 VOLUMES IN LIBRARY - SOLUTION MINING

IN SITU MINE DESIGN MANUAL DEVELOPED BY BUREAU OF MINES

In situ leach mining is a new method of mineral extraction that may offer the U.S. mining industry an environmentally sound, low-cost way to produce copper from small, deep and often low-grade copper oxide ore deposits.

Unlike conventional mining techniques—which require crushing of rocks and transportation of ore to a processing facility—in situ leach mining recovers minerals without disturbing the ore. This is done by circulating solvents, such as dilute sulfuric acid, through the ore.

The in situ method of mining copper combines the operation of both surface and subsurface facilities. First, chemicals used to dissolve and maintain the copper in solution are prepared in the surface facility. Then, the solvent is forced through a set of injection wells into the pores and fractures in the rock by using a pressure in excess of the hydrostatic pressure in the deposit.

The solvent travels through flow channels in the rock and reacts with the copper minerals, dissolving the copper into the liquid. A set of production wells is used to collect the copper-enriched solution so that it can be pumped to the surface. On the surface, copper is recovered from the enriched solutions, and acid is added to prepare the solution for recirculation through the ore zone. The solution will make many trips through the ore zone before the copper in a given well pattern is depleted.

The U.S. Bureau of Mines has studied the feasibility of in situ leach mining of copper in several projects over the past 15 years. Now, the Bureau has developed a detailed manual to encourage wider use of the method.

Written for the Bureau by the Science Applications International Corporation, the ***Generic In Situ Copper Mine Design Manual*** provides a systematic method for assessing the commercial feasibility of in situ copper mining at a selected deposit.

— more —

The manual consists of five volumes and more than 1,400 pages. It contains:

— A method of identifying the most economical mining scenarios for a commercial operation at any specific site.

— A list of site-specific parameters that must be quantified to design a commercial operation and a description of laboratory and field tests to measure these parameters.

— A description of procedures for designing each component of an in situ copper mining system and a method of estimating costs of these components.

— A computer model for the economic analysis of all capital and operating expenses associated with the well field, solvent extraction-electrowinning plant and environmental permitting activities.

— A description of the procedures, specifications, designs and costs for environmental permitting and monitoring in the State of Arizona.

The manual is sold by the National Technical Information Service (NTIS). Each volume can be ordered separately at these prices: Volume I, ***Executive Summary*** (NTIS PB89-148217/AS), $15.95 for a paper copy, $6.95 for microfiche. Volume II, ***Draft Generic In Situ Copper Mine Design Manual*** (NTIS PB89-148225/AS), $49.95 on paper, $6.95 on microfiche. Volume III, ***Lakeshore Field Experiment and Design of Commercial Scale Operation*** (NTIS PB89-153228/AS), $36.95 on paper, $6.95 on microfiche. Volume IV, ***Santa Cruz Field Experiment and Design of Commercial Scale Operation*** (NTIS PB89-153290/AS), $36.95 on paper, $6.95 on microfiche. Volume V, ***Field Testing at the Santa Cruz Site*** (NTIS PB89-153303/AS), $21.95 on paper, $6.95 on microfiche.

To order, write NTIS at 5285 Port Royal Road, Springfield, VA 22161. Additional technical information is available from the Bureau's technical project officer for this research, Jon K. Ahlness, Twin Cities Research Center, U.S. Bureau of Mines, 5629 Minnehaha Avenue South, MN 55417. Or phone (612) 725-4673.

— DOI —

IN SITU COPPER MINING FIELD RESEARCH PROJECT

PROGRAM UPDATE

The signing on September 6, 1988, of Cooperative Agreement No. C0289001 "In situ Copper Mining Field Experiment", between the Bureau and the Santa Cruz Joint Venture (SCJV), will allow the Bureau to evaluate the feasibility of true in situ mining and to prepare a manual for use by the U.S. mining industry. The Bureau has completed a draft manual which has been recommended for open file and NTIS. In addition a Technology News item has been prepared and will be released as soon as the NTIS numbers for the report are available. We expect to have this information available for the Technology Transfer Seminar, April 4-6, 1989.

Geologic and hydrologic field work began at the Bureau approved site on the Santa Cruz property near Casa Grande, AZ. on November 28, 1988 with Bureau personnel on site to log core beginning December 2, 1988. Core drilling in hole C-1 to verify geological conditions including mineralization, host rock type and ore grade has been completed to a depth of 1,850 feet and the mineralized zone is being assayed for copper content and overall evaluation. The Bureau also is evaluating orientated core samples to determine fracture planes. Hydrologic test hole HC-1 has been rotary drilled and pump testing completed. The data is being evaluated at this time. Preliminary indications are that the ore grade and continuity of copper at the target internal are less than expected. The Bureau is reviewing the situation.

SCJV has prepared the necessary procurement documents to develop the cementing and hydraulic fracturing activities associated with injection well T3 and production wells T1 and T2. These wells will be part of the five-spot pattern. Currently the contract is being modified to include the Bureau's Public Meeting in Arizona in May.

The Phase II modification for spending FY-89 appropriations, has been drafted and sent to the Washington Office and the Denver Procurement Office for review. The objective of the modification is the continuation of the program initiated under Phase I at the Santa Cruz field experiment site, by the preparation and testing of wells T4 through T7 and the determination of the necessity of large radius hydraulic fracturing and a continuation of the permitting process. Phase II modification will be negotiated during the 2nd Qtr. FY-89, and signed by June 30, 1989.

LIST OF ORGANIZATIONS CONTACTED FOR THE COPPER FIELD PROJECT

Federal

U.S. Environmental Protection Agency
Region IX
San Francisco, CA
Purpose: Underground Injection Control Program requirements

Mike Greeley
U.S. Bureau of Mines
Tucson, AZ Field Office
Purpose: Communication and coordination of activities

State of Arizona

Department of Environmental Quality
Phoenix, AZ
Purpose: Aquifer Protection Permit requirements

Department of Water Resources
Phoenix and Casa Grande, AZ
Purpose: Authorization to drill
Water use permits

Pinal County, AZ

Planning and Zoning
Florence, AZ
Purpose: Facility siting

Air Quality Control District
Florence, AZ
Purpose: Air quality protection

BUREAU OF MINES PUBLICATIONS, PRESENTATIONS, AND MEETING RELATED TO THE IN SITU COPPER MINING FIELD RESEARCH PROJECT

Presented and/or Published

Ahlness, J. K. The Bureau of Mines In-Situ Copper Mining Field Research Experiment near Casa Grande, Arizona. Pres. at the Northwest Min. Assoc. 94th Annu. Conv. and Trade Show, Spokane, WA, Nov. 30 - Dec. 3, 1988.

Ahlness, J. K. Copper Deposit Characterization in Preparation for In Situ Mining. Pres. at U. S. Bureau of Mines Open Industry Briefing, Denver, CO, Feb. 17, 1988.

Cook, S. S. Petrologic Analysis of Laboratory Core Leaching Experiments. Pres. at the Eng. Foundation Conf. on the In Situ Recovery of Minerals, Santa Barbara, CA, Oct. 25-30, 1987.

Cook, S. S., and S. E. Paulson. Leaching Characteristics of Selected Supergene Copper Ores. Soc. Min. Eng. AIME preprint 88-195, 1988, 15 pp.

Dahl, L. J. Joint Orientations in the Santa Cruz Porphyry Copper Deposit, Pinal County, Arizona. Poster session at Geol. Soc. of America Ann. Meeting, Denver, CO, Oct. 31 - Nov. 3, 1988.

Larson, W. C., J. K. Ahlness, and S. E. Paulson. The Bureau of Mines' Role in the Development of True In Situ Copper Mining as a Future Technology. Min. Res. Eng., v. 1, No. 2, 1988, pp. 171-180.

Paulson, S. E. Core Leaching Experiments to Assess Leaching Characteristics During In Situ Mining of Oxide Copper Ores. Pres. at the Eng. Foundation Conf. on the In Situ Recovery of Minerals, Santa Barbara, CA, Oct. 25-30, 1987.

Paulson, S. E., L. J. Dahl, and H. L. Kuhlman. In situ mining geologic characterization studies: experimental design, apparatus, and preliminary results. Soc. Min. Eng. AIME preprint 87-139, 16 pp., Miner. and Metall. Processing, Nov., 1987, pp. 181-189.

Weeks R. E., and D. J. Millenacker. Environmental Permitting Considerations for True In Situ Copper Mining in the State of Arizona. Soc. Min. Eng. AIME preprint 88-196, 1988, 7 pp.

BUREAU OF MINES PUBLICATIONS, PRESENTATIONS, AND MEETINGS RELATED TO THE IN SITU COPPER MINING FIELD RESEARCH PROJECT--Continued

To Be Presented and/or Published

Ahlness, J. K. The Copper In Situ Mining Field Research Project. To be pres. at the Bureau's Technol. Transfer Seminar on In Situ Mining of Copper, Phoenix, AZ, Apr. 4, 1989 and Salt Lake City, UT, Apr. 6, 1989.

Ahlness, J. K. U.S. Bureau of Mines' In Situ Copper Mining Program: An Update. To be presented at the Soc. Min. Eng. AIME, 118th Annu. Meeting, Las Vegas, NV, Feb. 27 - Mar. 2, 1989.

Ahlness, J. K., D. J. Millenacker, and S. A. Swan. The Bureau of Mines' Copper In Situ Mining Field Research Project. To be presented at and published in the proceedings of the In Situ All Minerals Symposium. Wyoming Min. and Met. Sec. of AIME, Casper, WY, May 22-24, 1989.

Millenacker, D. J. Introduction to the Environmental Permitting Process for In Situ Copper Mining. To be pres. at the Bureau's Technol. Transfer Seminar on In Situ Mining of Copper, Phoenix, AZ, Apr. 4, 1989 and Salt Lake City, UT, Apr. 6, 1989.

Millenacker, D. J., and J. K. Ahlness. In Situ Extraction of Copper as an Alternative to Conventional Mining Methods. To be presented at and published in the proceedings of the 1989 Multinational Conf. on Mine Planning and Design. Univ. of Kentucky, Lexington, KY, May 22-26, 1989.

Paulson, S. E. Laboratory Core Leaching and Petrologic Studies to Evaluate Oxide Copper Ores for In Situ Mining. To be pres. at the Bureau's Technol. Transfer Seminar on In Situ Mining of Copper, Phoenix, AZ, Apr. 4, 1989 and Salt Lake City, UT, Apr. 6, 1989.

Paulson, S. E. Leaching Chemistry of Oxide Copper Ores From the Santa Cruz Deposit, Casa Grande, Arizona. To be presented at the Soc. Min. Eng. AIME, 118th Annu. Meeting, Las Vegas, NV, Feb. 27 - Mar. 2, 1989

Pugliese, J. M. Generic Design Manual: Cost Model for In Situ Copper Mining. To be pres. at the Bureau's Technol. Transfer Seminar on In Situ Mining of Copper, Phoenix, AZ, Apr. 4, 1989 and Salt Lake City, UT, Apr. 6, 1989.

IN SITU COPPER MINING FIELD RESEARCH PROJECT - KEY PERSONNEL

Bureau of Mines

William C. Larson, Research Supervisor, Advanced Mining Division, TCRC, FTS 789-4690

Jon K. Ahlness, Group Supervisor, In Situ Systems Group, TCRC, FTS 789-4673

Daniel J. Millenacker, Hydrologist, In Situ Systems Group, TCRC, Area of responsibility: National Environmental Policy Act (NEPA) and permitting consultant to Santa Cruz Joint Venture, FTS 789-4588

Stephen A. Swan, Mining Engineer, In Situ Systems Group, TCRC, Area of responsibility: Technical Project Officer, FTS 789-4576

Linda J. Dahl, Geologist, In Situ Systems Group, TCRC, Area of responsibility: Geologic structure analysis of test site, FTS 789-4568

Steven E. Paulson, Geologist, Geochemical/Hydrologic Applications Group, TCRC, Area of responsibility: Laboratory leaching tests and geologic characterization of ore, FTS 789-4585

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Santa Cruz Joint Venture--Continued

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NEWSPAPER AND MAGAZINE ARTICLES ABOUT IN SITU COPPER MINING FIELD RESEARCH PROJECT

American Metal Market. BuMines Takes Preliminary Step Toward In-Situ Copper Mining. V. 94, No. 201, 1986, p. 2.

The Arizona Daily Star (Tucson). New copper Extraction technique to be tested near Casa Grande. Sept. 3, 1988.

The Arizona Daily Star (Tucson). Senate panel OKs funds to purchase Arivaca Creek, continue copper project. Sept. 23, 1987.

The Arizona Republic (Phoenix). Copper-mining site picked: pilot project will be joint venture. Sept. 3, 1988, p. F2.

The Arizona Republic (Phoenix). Leaching process touted for copper. Oct. 2, 1985, p. E1.

California Mining Journal. In Situ Mine Design Manual Planned For Copper Industry. V. 56, No. 4, 1986, p. 72.

Casa Grande Dispatch. CG Selected for New Copper Mining Research. Sept. 1, 1988, p. 1.

Chemical Engineering. In-situ mining of oxide copper will be tested. Sept. 26, 1988, pp. 19-21.

The Daily Mining Gazette (Houghton). Copper extraction technique planned. Nov. 8, 1986.

Daily Territorial (Tucson). Copper mining research scheduled near Casa Grande. Sept. 8, 1988.

Daily Territorial (Tucson). Mining experiment could help copper industry. Oct. 1, 1985.

Engineering & Mining Journal. In-situ mining methods will be explored by Santa Cruz. Nov., 1988, p. 9.

Mining Activity Digest. USBM & Santa Cruz Joint Venture Sign Agreement on Copper Project. V.15, No. 9, 1988, p. 2.

Mining Magazine. In situ copper mining tests in U.S.A. Dec., 1988, p. 460.

The Mining Record (Denver). Santa Cruz Joint Venture Signs Agreement On Copper Mining Project. Sept. 21, 1988, p. 16.

Skillings' Mining Review. JV Signed for In Situ Copper Mining Research Project. V. 77, No. 38, 1988, p. 16.

Southwestern Pay Dirt. Funding moving for more in situ copper leaching research. No. 567, Sept., 1986, p. 32A.

Southwestern Pay Dirt. Research copper leaching project may be set in Arizona. Oct., 1985, p. 3A.

Southwestern Pay Dirt. Two copper research projects in Arizona are progressing. No. 580, Oct., 1987, pp. 22A-23A.

Southwestern Pay Dirt. USBM in situ leaching project in Arizona is moving ahead. No. 569, Nov., 1986, pp. 12A-13A.

Southwestern Pay Dirt. Work is to begin immediately on an in situ copper leaching research project. Sept., 1988, p. 2A.

Tucson Citizen. Acid mining test target: marginal copper deposits. Sept. 21, 1988, p. 8B.

Tucson Citizen. Copper project due near Casa Grande. Sept. 3, 1988.

TIMETABLE FOR FY89 COOPERATIVE AGREEMENT MODIFICATION

Draft SOW sent to Denver Procurement through WO by 2/6/89.

RFP sent to SCJV by 2/27/89.

Proposal received from SCJV by 4/28/89.

Negotiations completed and modification signed by 6/30/89.

TIMETABLE FOR PUBLIC MEETING

Draft Statement of Work (SOW) to modify Cooperative Agreement (CA) with the Santa Cruz Joint Venture (SCJV) for the purpose of preparing the public meeting presentation to WO by 1/23/89.

Negotiate and sign meeting modification to CA by 3/3/89.

Draft meeting presentation to WO and SCJV by 4/14/89.

Dry run of presentation by 4/28/89.

Finalize presentation by 5/19/89.

Tentative public meeting date is 5/31/89.

IN SITU COPPER MINING FIELD RESEARCH PROJECT BRIEFINGS
(Bureau Attended)

Date	Person or Group	Location
8/24/88	Casa Grande Valley Newspapers Inc.	Casa Grande, AZ
10/27/88	Representative Jim Kolbe (AZ)	Casa Grande, AZ
12/7/88	Senator Dennis DeConcini (AZ)	Tucson, AZ
12/8/88	Red River Resources	Phoenix, AZ

IN SITU COPPER MINING FIELD RESEARCH PROJECT--A JOINT PROJECT OF THE UNITED STATES BUREAU OF MINES AND THE SANTA CRUZ JOINT VENTURE

BACKGROUND

The United States Bureau of Mines is undertaking a unique field experiment at a site near Casa Grande, Arizona, to test a non-traditional method of mining copper from certain deep ore deposits. The method, known as in situ mining, differs from conventional mining in that it does not require massive excavation of rock. In situ mining has the potential to produce copper from some deposits at less cost than traditional methods.

Federal funding for the project was sponsored by Senator Dennis DeConcini and has been supported by Representatives Morris K. Udall and Jim Kolbe and other members of the Arizona delegation because of the potential technological advances to be gained from this research and because of the economic benefits to Casa Grande, the State of Arizona and the nation.

The Bureau's charge is to evaluate the feasibility of true in situ mining and to prepare a handbook for use by the industry. The Bureau has completed the draft handbook, which is subject to revision based on field results, and the first part of the extensive laboratory testing that will continue throughout the project.

The first phase of the project, which is beginning now and will last about a year, will evaluate the fluid flow characteristics at the site to ensure that the research project can be conducted in an environmentally acceptable manner.

After examining a number of sites, the Bureau selected the Santa Cruz ore body, located about 7 miles west of Casa Grande, for the project. This site was chosen because it is a typical buried copper oxide ore body.

The property is jointly owned by subsidiaries of ASARCO Incorporated and Freeport McMoran Gold Company. The two mining Companies have formed the Santa Cruz Joint Venture and this entity will share in the cost of the project with the Bureau of Mines. The Santa Cruz Joint Venture will manage the project under a contract with the Bureau of Mines.

If the technical and environmental results of the first phase are successful, the Santa Cruz Joint Venture and the Bureau of Mines will begin a test in situ mining operation in the second phase. The Santa Cruz Joint Venture may pursue a commercial scale operation at this site if the process proves economically feasible.

Environmental Safeguards

The in situ mining research project must pass several environmental tests before it will be permitted to operate. One of the major objectives of the first phase of the project is to demonstrate that these conditions will be met.

Protection of the aquifer is the most important test. The Arizona Environmental Quality Act of 1986 requires any facility with a potential to pollute groundwater to obtain an Aquifer Protection Permit. The Department of Environmental Quality cannot issue the permit until the applicant has demonstrated that the aquifer will not be contaminated. The environmental managers of ASARCO Incorporated, Freeport McMoran Gold Company and the U.S. Bureau of Mines must also give the project their full approval before any injection of acids will occur.

Two tasks have been established within the project to establish the environmental compatibility of in situ mining. The first of these will require the Santa Cruz Joint Venture (SCJV) to obtain the required Federal, State, and local environmental permits necessary to construct and operate the well field and surface processing facility. This is a particularly important aspect of the project in that it will establish the ability of this mining technology to meet comprehensive permitting requirements and environmental protection performance standards.

The second task will require the Bureau to evaluate the anticipated environmental effects of the field test under requirements of the National Environmental Policy Act (NEPA). This is an obligation of any Federal agency which conducts an environmental-related activity. To meet the Bureau's obligation, an Environmental Assessment (EA) will be prepared to determine the significance of any effects which may result from the field test. Preparation of the EA will require the Bureau to hold a public meeting in Casa Grande, AZ. This meeting will likely occur in May, 1989. The meeting will be used as a forum to both introduce the community to the project, as well as to solicit input and comments from the residents as to the environmental issues which they feel need to be addressed by the EA. The EA will produce an objective analysis of environmental effects and will be used as the basis for preparing either a Finding of No Significant Impact (FONSI), or Notice of Intent (NOI). If a FONSI is written, no significant impacts will result to the human environment from the field test and activities may proceed as planned. If a NOI is developed, an Environmental Impact Statement will need to be prepared. Twin Cities Research Center staff intend to prepare the EA concurrently with the field test permitting effort of the SCJV.

Injection and recovery of the acid solution will occur in bedrock, several hundred feet below the basin-fill aquifer. The rocks that separate the injection zone from the basin-fill aquifer will act as a barrier between the two zones because these rocks have a very low permeability. Water moves very slowly through these rocks, if at all.

The injection and recovery wells will be sealed to prevent any leakage of solution from the wells or from the injection zone into the aquifer in the overlying basin-fill deposits.

The injection and recovery well system will be tested with fresh water before any acid is used to make sure that the groundwater will be protected. No acid can be injected until after the demonstration of safety has been made to the satisfaction of all participants and the Aquifer Protection Permit has been issued.

Groundwater monitoring wells will be constructed to document that the quality of groundwater in the basin-fill deposits is not degraded by activities at the Santa Cruz Project.

Public Information Program

The Santa Cruz Joint Venture and the Bureau of Mines are committed to maintaining an active community education program throughout the project. A Bureau of Mines Technology Transfer Seminar is scheduled in Phoenix, AZ on April 4, 1989 and Salt Lake City, UT on April 6. The subject of the seminar will be the Bureau's in situ mining research program and is open to the general public, free of charge. The Bureau of Mines is also planning a public meeting in Casa Grande, AZ in May, 1989 to explain the project to the local community.

The In Situ Mining Process

A dilute solution of acid and water is injected under pressure into the fractures and veins in the ore-bearing rock far below the surface of the ground. The solution travels through fluid flow paths in the rock, leaching soluble copper out of the ore and carrying it to the recovery wells.

The copper-bearing solution is pumped to the surface and the copper is removed from the solution through a process known as solvent extraction/electrowinning, or SX/EW. After the copper has been removed, the spent acid is replaced and the rejuvenated solution is recycled repeatedly through the deposit.

Leaching with dilute acid solutions is widely used on copper oxide ores that have been previously excavated and stockpiled on the land surface and on ore remaining in the ground that has been fractured by previous mining activities. However, no mining operations are using the in situ process on totally undisturbed copper ore bodies. This project will be exploring new technology.

In general, in situ mining is considered to be potentially feasible for copper deposits which are too deeply buried to be mined by low cost open pit methods. Of these buried deposits, those with a high proportion of copper oxides are more likely to be amenable to the in situ method, but deposits with less readily leachable copper sulfides are not ruled out for future research.

IN SITU COPPER PROJECT FIELD ACTIVITIES

FIELD WORK PERTAINING TO FIELD TEST	FIELD WORK PERTAINING TO ENVIRONMENTAL PROTECTION
Fiscal Year Funding 1988	
* Drill core hole for geological characterization.	* Drill hole for hydrological characterization.
* Drill three large diameter test holes into ore body.	* Conduct permeability tests in above hole and determine water quality in the bedrock area below the usable aquifer.
* Conduct permeability and transmissivity tests in the three test holes.	* Install one monitor well.
* Perform preliminary engineering on solvent extraction/electrowinning plant (long lead time procurement items.)	* Make application for Aquifer Protection Permit. (SCJV)
	* Initiate work to satisfy requirements for NEPA Process (BOM)
Fiscal Year Funding 1989	
* Drill four additional large diameter test holes to complete a single five-spot leach pattern.	* Complete requirements for the Aquifer Protection Permit. (SCJV).
* Conduct additional permeability and transmissivity tests within the Five-spot pattern.	* Plug existing drill holes not required for project to prevent solution movement up the holes.
* Complete preliminary engineering on solvent extraction/electrowinning plant.	* Complete requirements for the NEPA Process (BOM).

IN SITU COPPER PROJECT FIELD ACTIVITIES--(Continued)

FIELD WORK PERTAINING TO FIELD TEST	FIELD WORK PERTAINING TO ENVIRONMENTAL PROTECTION
Fiscal Year Funding 1990**	
* Complete engineering on solvent extraction/electrowinning plant and all other surface facilities. * Construct solvent extraction/ electrowinning plant and all other surface facilities. * Drill three additional test wells to complete a double five-spot leach pattern.	* Continue monitoring of monitor wells to accumulate baseline data and other hydrological information.
Fiscal Year Funding 1991	
* Start up the in-situ copper mining field test and continue program throughout test year. * Evaluate data during continuing test and make modifications to the program as required.	* Continue monitoring of monitor wells and evaluate data.
Fiscal Year Funding 1992	
* Continue operating field test so that the total duration is between 18 and 24 months. * Continue evaluating data and modifying program as required. * Close plant operation according to the cooperative agreement.	* Continue monitoring of monitor wells and evaluate data.

**Note: Prior to proceeding from this point with the In-Situ Copper Mining Research Project, the following items must be satisfied:

1. The Arizona Aquifer Protection Permit is obtained.

2. All Local, State, and Federal environmental requirements have been met. This includes the Bureau of Mines' Environmental Assessment and NEPA Requirements.

1/13/95

Schedule of Events

Master of Ceremonies
Francis R. McAllister
Executive Vice President
ASARCO Incorporated

Remarks

Richard de J. Osborne
Chairman of the Board, President and
Chief Executive Officer
ASARCO Incorporated

Rhea Graham
Director, United States Bureau of Mines

Frederick T. Graybeal
Chief Geologist, Exploration, ASARCO Incorporated

Introduction of Honored Guests

Special Acknowledgment

Richard de J. Osborne to Senator Dennis DeConcini

Groundbreaking Ceremony

Heading	Sub-Heading	Category	Santa Cruz Site
Technical factors	Geology	Tonnage	800,000,000
		Shape	6,000 ft by 5,000 ft
		Grade	0.43 pct total copper
		Depth	1,500 ft to 2,000 ft
		Thickness	300 ft to 750 ft
		Mineralogy	chrysocolla, atacamite, chalcocite, brochantite
		Mineral Distrib.	ave. distance of 2-in from broken fracture
		Geol. Structure	5 fractures per ft of core
	Fluid Flow Management	Permeability	?
		Porosity	?
		Solution containment barriers	?
	Chemistry (laboratory tests)	Metal recovery	74 pct to 90 pct in bottle leaching tests
		Metal Conc. vs time	?
		Acid consumption	1.5 to 4.5 lb H_2SO_4 per lb of copper recovered
Logistic factors	Access	Roads	yes
		Power	?
		Water	?
	Facilities	Pregnant sol. proc.	no
		Support capabilities	no
	Environmental	Baseline envir. monitor	?
		In situ mining permit	no

USBM DATA 1985