WJTA Jet News

Water Jet Technology Association

SEPTEMBER 1996

Published by the Water Jet Technology Association for the benefit of its members

917 Locust Street, Suite 1100 • St. Louis, MO 63101-1413, USA • Telephone: (314)241-1445, Fax: (314)241-1449

Water jets issuing from sluice gates in the Kariba Dam on the Zambezi River in Africa. Photograph reproduced by permission of Garrett Educational Corporation, Ada, OK , from *How We Build Dams* by Neal Ardley.

Abstracts Due Now For 9th American Water Jet Conference

Authors who wish to present papers at the 9th American Water Jet Conference should submit abstracts immediately to ensure consideration. The deadline date for abstract submission is November 15, 1996.

To submit an abstract(s) please complete the Abstract Submission Form enclosed with this issue and forward to the attention of the Conference Coordinator at the Water Jet Technology Association.

WJTA Administration

Vulcan Waterjet Cuts Prototypes And Lunar "Phantoms"

Vulcan Waterjet Cutting Services' ability to cut prototypes without expensive tooling recently pared off 75% of the previously needed lead time for Hayes Brake, Inc. Hayes, of Mequon, Wisconsin, is a manufacturer of mechanical and hydraulic brakes, designing and developing brake rotors for a broad cross-section of industries.

A spokesman for Hayes lauded Vulcan Waterjet's performance, citing savings in more than one area of the prototyping process. "The savings begin with the electronic transfer of the DXF drawings," he stated. "There were no paper drawings to send back and forth, so we gained an immediate time savings there. Of course, the most notable expense reduction was the elimination of the need for costly tooling. And, Vulcan Waterjet cut down the turnaround time on these prototypes from one month to **one week**! In our case, time really **is** money."

Vulcan Waterjet Cutting services was chosen for the prototype project by Hayes after consideration of several crucial factors. First, the brake rotor material is hardened, precision-ground stainless steel. The blanks given to Vulcan Waterjet have been machined to the proper flatness and are the 0.200 inch +/- .005 inch thickness that is required for precision. The brake-specific configuration of holes and openings must be cut without jeopardizing either the flatness or the material properties of the blanks. Any thermal cutting process might distort the edges of the cuts, or even the flatness or shape of the blanks. The water jet's cool erosion process was selected in preference to lasers and EDM because it maintains total integrity of the material.

The second consideration in Hayes' decision was run size. Only a few brake rotor prototypes, generally between one and five, would be cut at any one time. Because of this, a cost effective cutting process was critical to efficiency. Since there is no high-priced tooling required by the water jet before production begins, the prototypes proceed from concept to completion in a very short time. Vulcan Waterjet's full CNC capabilities

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Our New Address!

Effective September 16, 1996, WJTA has located to a new office at the following address:

Water Jet Technology Association
917 Locust Street — Suite 1100
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The telephone, fax and e-mail numbers remain **unchanged** as follows: telephone: (314)241-1445 fax: (314)241-1449 e-mail: wjta@aol.com.

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Mining Through Boreholes With Water Jets

Reprinted by permission of the publisher McGraw-Hill Companies from the McGraw-Hill Yearbook Of Science And Technology, 1993 Edition, pp. 56-59, "Borehole Mining," by George A. Savanick, Ph.D.

Borehole mining, also known as slurry mining, is a process in which a tool incorporating a water jet cutting system and a downhole slurry pumping system is used to mine minerals through a borehole drilled from the ground surface to the buried mineralized rock. Water jets from the mining tool erode the ore to form a slurry, which flows into the inlet of a slurry pump at the base of the tool. The slurry is then pumped to the surface in a form suitable for transfer to a processing plant by pipeline (Fig. 1).

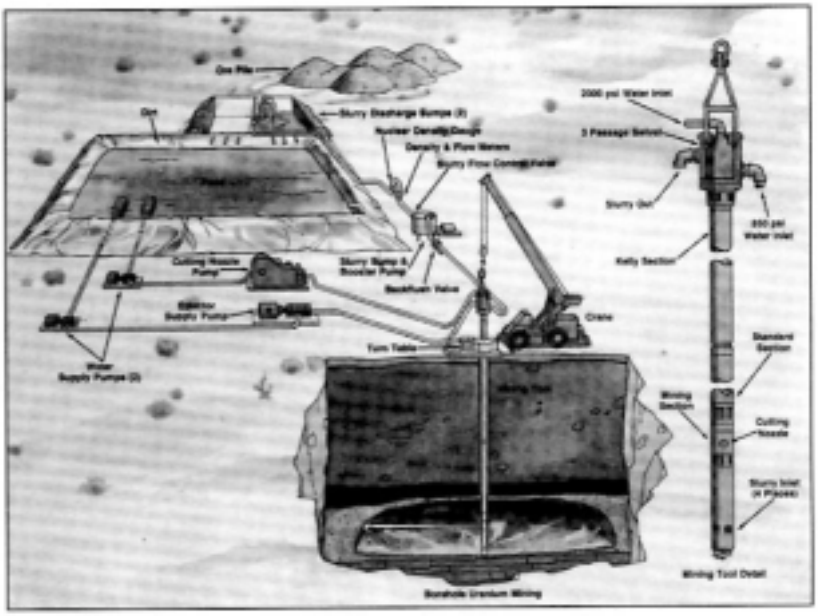

Figure 1. Borehole Mining System. (a) Diagram showing the various components of the system. (b) Mining tool details.

Borehole mining offers important advantages over conventional open-pit and underground mining methods, and it can access mineral deposits that presently are not mined because of technical or economic difficulties. Borehole mining can achieve immediate production, because there is no need to drive openings to and in an ore body to admit workers. More conventional mining methods require 3-5 years of development before production and return on investment can be expected.

The systems for transportation and fragmentation of ore are incorporated into a single machine that is operated remotely from the surface by a two- or three-person crew, thus eliminating health and safety problems inherent in underground mining. Disturbance to the environment is minimal and short-term; no overburden is removed and subsidence can be avoided by backfilling. Ore fragmented by the water jet is brought to the surface in a slurry; thus it is ideally suited to economical transport by pipeline (Fig. 2).

Borehole mining is selective and can extract deposits that are small or erratically mineralized, thereby broadening the resource base. This selectivity allows the ore to be extracted without disturbing the surrounding rock, thereby avoiding dilution. Crushing and grinding costs are minimal, since the ore is reduced to grain size by jet impact.

Rock Fragmentation

The water jet cutter in the borehole miner must be capable of producing enough broken ore to pay for the cost of the mining operation and to yield a profit. In order to maximize profit, the largest possible volume must be cut; thus the effective reach of the jet must be as long as possible.

Water jets in air dissipate by entrainment of air at the water-air interface; thus the ratio of surface area to volume of a jet influences the rate at which a jet will dissipate. Since jet volume increases as the square of the jet radius while surface area increases linearly with increasing radius, smaller jets dissipate in a shorter distance than larger jets. As jet volume increases, a smaller portion of the mass of the jet resides near the surface, where it can be dissipated by air entrainment. Thus, in order to maximize the effective range of a jet, its diameter should be as large as possible.

Rock fragmentation, however, requires that a high energy density be deposited on the rock surface. Maximizing the density of the kinetic energy on the rock surface requires that the jet be as small as possible. Because pump power is finite and the power delivered by a jet is a product of jet pressure and flow rate, it is necessary to find an appropriate compromise between pressure and flow rate that will yield the maximum volume of slurry ore per borehole. The jet must have an energy density high enough to disaggregate the rock and a diameter large enough to enable the jet to stay

(continued on page 6)

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Mining Through Boreholes With Water Jets, from page 4

coherent over long distances. Given constant pump power, high jet pressures give small jets with high velocities, while lower pressures give longer, slower jets.

Figure 2. Phosphate slurry at the outlet of a borehole mining tool.

The particular pressure and flow rate chosen depend upon the power available and the hardness of the ore. The energy required to break hard rock at long distances is so large as to make borehole mining of hard rock impractical; thus borehole mining is limited to softer rocks. Some jetting parameters that have been employed in borehole mining are as follows: 4500 pounds per inch^2 (31 megapascals), 200 gallons per minute (760 liters per minute) for coal in Wilkeson, Washington; 1500 pounds per inch^2 (10 megapascals), 350 gallons per minute (1330 liters per minute) for sandstone in Natrona County, Wyoming; 1000 pounds per inch^2 (6.9 megapascals), 300 gallons per minute (1200 liters per inch) for oil sands at Taft, California; and 1800 pounds per inch^2 (12 megapascals), 420 gallons per minute (1600 liters per minute) for phosphate ore in St. Johns County, Florida.

Borehole-mining cavity radii have been measured at 26 feet (7.9 meters) in sandstone in Natrona County, Wyoming, and 20 feet (6.1 meters) in phosphate ore in St. Johns County, Florida. The Wyoming cavity was created by mining with the jet in air, while the Florida cavity was mined underwater. Water jets can be effective underwater at long distances if the jet is shrouded by compressed air.

Water jets for borehole mining are most effective if the nozzle can be rotated 360° and translated along the axis of the borehole. Translating the jet permits cutting a large vertical interval while the slurry pump stays at the base of the borehole where the slurry density is the highest.

Borehole mining is most successful in granular rocks, especially sandstones, which are amenable to disaggregation with water jets; the jet pressurizes the grain boundary pores and liberates the individual grains. Nonporous ores such as kaolin or bauxite have not proved to be amenable to borehole mining with water jets.

Slurry Pumping

Centrifugal pumps, Moyno pumps (which operate on a progressing cavity principle), jet pumps, and air lifts have been

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1996-97 Calendar Of Events

October 7-10, 1996: Water Jet Cutting Techniques Course, Minneapolis, MN. For more information, call (330)633-7698.

October 4-5, 1996: Glass Expo Midwest '96, Chicago, IL. Contact: USGlass at (540)720-5584 or fax (540)720-5697.

October 6-8, 1996: Glass Association Of North America (GANA) Fall Conference, Lake Tahoe, NV. Contact: GANA at (913)266-7013 or fax (913)266-0272.

October 6-9, 1996: DECO '96, Orlando FL. Contact: Society of Glass and Ceramic Decorators (SGCD) at (202)728-4132.

October 20-23, 1996: American Architectural Manufacturers Association (AAMA) 60th Annual Meeting, Napa, CA. Contact: AAMA Headquarters at (708)202-1350.

October 22-26, 1996: GLASTEC '96, Dusseldorf, Germany. Contact: Greg Wendt, Dusseldorf Trade Shows, Inc. at (312)781-5180 or fax (312)781-5188.

October 29-31, 1996: 13th International Conference On Jetting Technology, Sardinia, Italy. For more information, contact BHR Group Limited, Cranford, Bedfordshire MK43 OAJ, UK, Phone: 44(0)1234 750422, Fax: 44(0)1234 750074.

November 20-22, 1996: Canadian Window and Door Manufacturers Association (CWDMA) Win-Door '96, Toronto, Ontario. Contact: Shield Associates Ltd. at (416)444-5225 or fax (416)444-8268.

February 19-21, 1997: GlassLat '97, Monterrey, Mexico. Contact USGlass magazine at (540)720-5584 or fax (540)720-5687.

May 10-16, 1997: American Society for Surface Mining and Reclamation 14th Annual Meeting, Austin, Texas. For more information, contact the North American Coal Corporation, 14785 Preston Road, Suite 1100, Dallas, TX 75240, fax: (214)387-1051.

Mining Through Boreholes With Water Jets, from page 6

used as downhole slurry pumps in borehole mining equipment. Moyno and staged centrifugal pumps are not used as frequently as jet pumps or air lifts. Centrifugal pumps require a larger-diameter borehole than jet pumps, and Moyno pumps are not capable of pumping abrasive slurries. Jet pumps and air lifts are more reliable because they have no moving parts and can pump abrasive slurries with minimal wear.

Applications

Borehole mining has been attempted in the United States, Canada and the former Soviet Union. This mining has demonstrated the technical feasibility of the remote extraction of coal, oil sands, uranium ore, phosphates, iron ore, sand, gravel, and amber as a slurry through a borehole.

Borehole mining of deep phosphate ore, ore too deep for economical open-pit mining, provided the most successful of the field trials in the United States. Productivity was higher than that of other commodities because of the lack of induration of the phosphate ore and because the mining took place under 250 feet (76 meters) of groundwater. The ability to mine underwater increased the efficiency of the slurry pump by placing 250 feet (76 meters) of positive suction head on the inlet of the pump. Mining underwater also has the advantage of providing roof support during mining. Tests in Florida indicated that the roofs of phosphate borehole mining cavities will collapse if the mining takes place in air.

Borehole mining is selective; only ore is extracted, leaving the adjacent barren rock intact. In order to exploit this advantage, either the rock must be strong enough to remain standing when the ore is removed, or the ore must be overlain by a cap rock strong enough to support the overburden and form the roof of the borehole-mined cavity. Otherwise, the barren rock above the ore will fall into the cavity and dilute the ore. This uncontrolled caving could propagate to the surface and endanger the borehole mining tool. Many sandstones, such as the uraniferous Teapot sandstone of Wyoming, are self-supporting; and a cylindrical cavity with a diameter in excess of 50 feet (15 meters) will stand unsupported. The Hawthorne Formation in St. Johns County, Florida, contains layers of weak phosphate ore overlain by a cap rock of dolomite that keeps the barren overburden from falling into the ore.

Borehole mining fulfills the need for a method to mine incremental uranium ore. Incremental ore comprises small, irregular, high-grade uranium ore bodies that are adjacent to working open pits but cannot be included in the pit because of engineering limitations. The small sizes and irregularities of these deposits make them ideal candidates for borehole mining because of the high areal selectivity of the method.

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Mining Through Boreholes With Water Jets, from page 7

Field tests of borehole mining of oil sands and coal have demonstrated the technical feasibility of the remote extraction of these commodities through boreholes, but the mining rate was too low for commercial viability because of the low unit value of the ore. Generally, ores with high unit value are better candidates for borehole mining, because the value of the ore mined is the product of the production rate and the unit value of the ore.

Environmental Impact

Surface subsidence and the presence of piles of tailings represent potentially adverse environmental impacts resulting from borehole mining operations. Both impacts can be mitigated by backfilling the borehole-mined cavities with slurry jets as shown in Fig. 3. Mill tailings can be used as backfill.

However, borehole mining is one of the mining methods that are least disruptive to the environment. Ground subsidence is eliminated by backfilling, no foreign substances are introduced into the groundwater, and no overburden is removed. Thus borehole mining seems ideally suited for mining in environmentally sensitive areas.

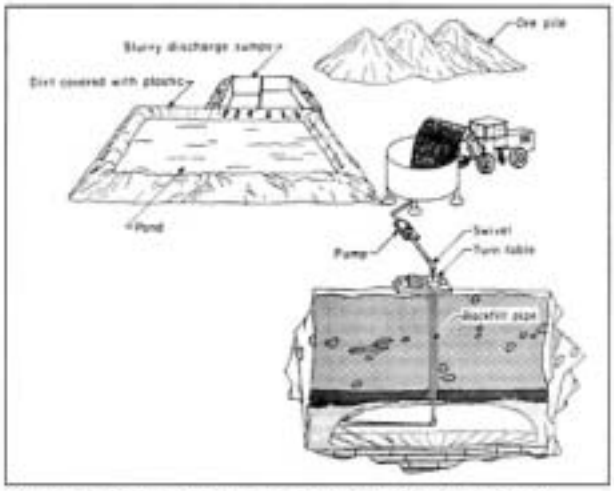

Figure 3. Diagram of the method of backfilling a borehole-mined cavity.

Bibliography

H. Hartman (ed.), Hydraulic mining: Borehole slurry, *SME Mining Handbook*, 2d ed., 1992; G.A. Savanick, Borehole mining of deep phosphate ore in St. Johns County, Florida, *Min. Eng. J.*, 37(2):144-148, 1985; G.A. Savanick, *Borehole (Slurry) Mining of Coal, Uraniferous Sandstone, Oil Sands, and Phosphate Ore*, U.S. Bureau of Mines, Rep; Investig. 9101, 1987.

Cutting Services Cooperation

Waterjet Connection, a division of Richel, Inc., a water jet consulting group, (Tallmadge, OH) is attempting to connect abrasive water jet cutting services in the U.S. Water Jet Connection is combining the resources of existing water jet cutting companies across the U.S.

Until now, the industry has remained fragmented, made up of a multitude of operators, each having their own speciality, but ready to take on any type of work. With the versatility of abrasive water jet cutting, virtually all materials known, from composites to standard sheet stock of alloys can be cut efficiently. The water jet cutting process can be described as an accelerated erosion process under controlled conditions. There is no heat generated eliminating heat affected zones (HAZ), and burring can be reduced or eliminated depending on the application. In the past, it has been difficult to hold tight tolerances, but with the growth of the industry, and the development of machinery specifically for water jet cutting, it is now common to have tolerances of 0.003 specified, and met.

One of the factors limiting the growth of water jet cutting has been the lack of a concerted effort to market the cutting services provided across the country. Waterjet Connection is attempting to make this a thing of the past. Because the group has members specializing in nearly every application addressed to date, customers can be assured to being directed to the provider who can professionally meet their requirements. From smaller high tolerance 2 axis CNC systems, to multiple head 3 axis systems on tables over 20 feet x 8 feet, to large 5 axis ultra high tolerance cutting systems.

Included are businesses specializing in the supply of marble, granite and natural stones, offering the full service of fabrication, assembly and installation of intricate designs for commercial (building foyers - corporate logos etc.) and residential work, to wholesale suppliers of every alloy and steel available, enabling the customer to have the material cut to shape by the supplier, reducing the cost of purchasing blanks prior to shaping the parts. Because of the nature of many of the members; plasma, laser, CNC milling, welding and assembly of parts are available in some locations. Businesses specializing in gasket supply, through to a manufacturer of ceramic tile who offers refiring of tiles after cutting designs, are all part of Waterjet Connection.

All advertisements list the central offices based in Ohio. Callers are asked for their location and directed to the nearest water jet business. The data of the caller is forwarded to the water jet business via modem, internet or fax. All members are encouraged to use the same database/contact manager programs enabling a seamless transfer of data. If the local provider realizes the work could be performed more efficiently by an associate member, the work is referred to the associate, giving the customer an effective one stop service. Pricing of work is extremely competitive, each operator realizing their strengths and being able to focus on them.

Waterjet Connection has not limited itself to extensive advertising only, but also contacts up to 400 customers in the immediate area of each member with informative and up-to-date newsletters every six weeks.

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New Products, Equipment, Supplies

New Water Jet Nozzle Catalog, High Pressure Water Jet Systems Available From NLB Corporation

NLB's new 68-page catalog describes a wide range of standard and custom water jet nozzles for pressures to 36,000 psi (2,500 bar). Included are dimensions and specifications in English and metric, detailed ordering instructions and safety procedures. The catalog features all NLB nozzle styles for standard cleaning, tube and pipe cleaning, and abrasive cleaning and cutting. Photographs and cutaway drawings make it easy to determine which nozzle to order.

NLB has also introduced six new high pressure water jet systems featuring advanced-design pumps with one-piece, stainless steel manifolds to minimize flow restrictions and turbulence. A new valve design improves reliability to reduce maintenance costs. Various pressures and flow rates are available to suit the user's application. All six systems can be ordered with diesel or electric engine drives. A variety of options, including high pressure cleaning lances, foot control valves, cleaning nozzles, and rotating SPINNOZLE® and SPIN JET® equipment, help tailor a system for a wide range of uses.

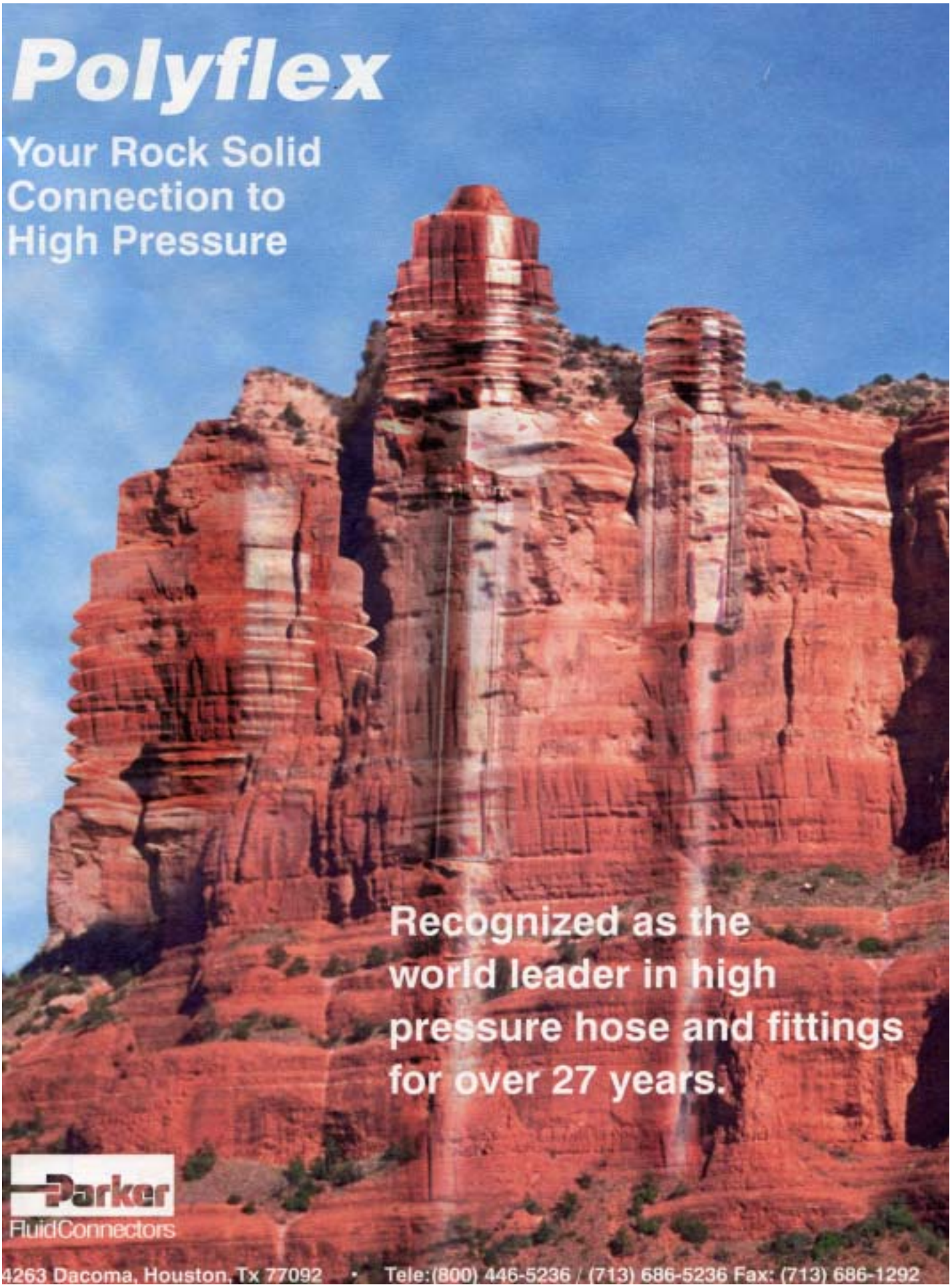
For more information, contact NLB Corporation, 29830 Beck Road, Wixom, MI 48393-2824, telephone: (810)624-5555, fax: (810)624-0908.

Aqua-Dyne Introduces Magnetic Rotary Cleaner

Aqua-Dyne has introduced a Magnetic Rotary Cleaner unit for cleaning and coating removal on the inside and outside of tanks as small as 50 feet in diameter and for use on ship hulls. The units 30-inch diameter deck can be disassembled into two sections for insertion through tank manways as small as 18 inches in diameter. The rotary cleaning head is attached to a two track, hydraulically driven carriage that moves and positions the unit. The carriage also contains a proprietary magnetic holding system that holds the unit against the side of the tank/ship. The Magnetic Rotary Cleaner requires a hydraulic unit and a water jet pump to operate. It is capable of handling flows of up to 20 gallons per minute at pressures of 40,000 psi.

Aqua-Dyne has also introduced a Tank Cleaning Tractor option to its Recycle Tank Cleaning System. The new Tank Cleaning Tractor provides a less expensive and smaller alternative to the Recycle Tank Cleaning System's trailer mounted 500 Probe and Manipulator modules.

For more information, contact Aqua-Dyne, Inc., 3620 W. 11th Street, Houston, TX 77008-6004, telephone: (713)864-6929, fax: (713)864-0313.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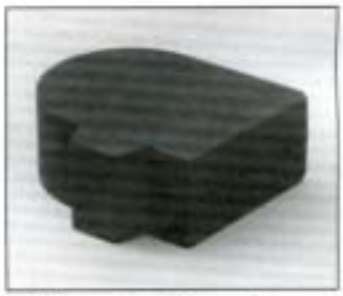
Vulcan Waterjet Cuts Prototypes And Lunar "Phantoms," from page 2

enable engineering changes to be incorporated swiftly into the water jet cutting programs, further shortening lead time.



Vulcan also recently completed cutting a series of "phantoms" for LUNAR Corporation, a Madison, Wisconsin, manufacturer of medical diagnostic equipment. The "phantoms" were cut from blanks of special high density neoprene. Neoprene was utilized because it closely imitates the ultrasound response of a human heel.

A "phantom" is a substitute used to mimic a human body part in the calibration and registration of diagnostic medical devices. The "phantoms" are routinely used to accurately register the ultrasound transducers, both at the factory, and in the diagnostic setting.

In this application, LUNAR's equipment uses changes to ultrasound's velocity and spectral characteristics as it passes through the patient's heel. The changes are specific indicators of bone strength. The device is used in clinics and hospitals to help in the diagnosis of osteoporosis.

Neoprene, although readily available as raw material, is difficult to cut with traditional methods. The material tends to cling to bandsaw teeth, and the heat produced with saw cutting only makes the procedure more difficult. Blades are quickly ruined, and are costly to replace. Water jet technology is ideal for the high density neoprene. Since it is a cool process, and involves erosion of the material by a jet of water, there is no heat distortion. Nor is there any actual contact between the blanks and the cutting head.

Vulcan Waterjet met several challenges in developing the process to individually cut these small, hand sized blanks. A special vacuum jig was devised to hold each blank, thus increasing efficiency and safety.

For more information about Vulcan Waterjet Cutting Services, call (414)645-2040 or (800)932-5323.

The spillway of the Itaipu Dam in South America. Photograph reproduced by permission of Garrett Educational Corporation, Ada, OK , from *How We Build Dams* by Neal Ardley.

WJTA New Members

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Cominco American/Green Diamond Products - Ruby Garnet
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Member News

Mohamed Hashish Honored by ASME

Mohamed Hashish, Ph.D., of Bellevue, Washington, has been named a Fellow of the American Society of Mechanical Engineers (ASME). The Fellow grade is conferred upon a member with at least 10 years of active engineering practice who has made significant contributions to the field.

Dr. Hashish is vice president of technology at QUEST Integrated, Kent, Washington. He earned his doctoral degree from Concordia University in Montreal, Canada. A longtime member of the Water Jet Technology Association, Dr. Hashish serves on the WJTA Board of Directors and he is the session organizer and *Proceedings* editor for the upcoming 9th American Water Jet Conference. Dr. Hashish also serves on the Board of Directors of the Society of Manufacturing Engineers, the Society of Experimental Mechanics and the Society of Precision Engineering.

Safety Alert

Rotary or spinning nozzles, if allowed to operate in an unbalanced condition, can result in fatigue failure of gun barrels. Barrels may rupture at the point where they attach to the gun body creating a dangerous and potentially lethal water jet.

Operators should be instructed to be aware that spinning nozzles can begin vibrating if they become clogged or worn and that such vibration can lead to barrel failure. Operators of water jetting guns equipped with spinning nozzles should; (1) be alert to the potential for vibration with spinning nozzles; (2) cease blasting if vibration is experienced; (3) correct the cause of the vibration; and (4) inspect the gun barrel for evidence of fatigue damage and replace if damaged.

For additional information contact Butterworth Jetting Systems at (800)231-3628.

WJTA Seeks Safety Videos

The WJTA is studying the possibility of creating a videotape that demonstrates good safety practices for employers and employees who are working near or with high pressure water jetting equipment.

In order to have as much information as possible to work with, WJTA members are asked to submit suggestions for the video tape as well as footage from safety videos already in use.

If you have specific suggestions and/or a video that you think might be helpful, please forward your written suggestions and a written description of your video to the WJTA office by mail or fax.

If you have any questions, contact Rhonda Stevens at the WJTA office.

WJTA 1997 Conference Hotel: Hyatt Regency Dearborn, Michigan

The Hyatt Regency Dearborn, site of the 1997 Water Jet Technology Association Conference, offers excellent service and accommodations. At the hotel entrance, a majestic 16-story atrium towers over the lush garden lobby. Hotel rooms and suites are luxuriously appointed. Specially designed business plan rooms come equipped with everything you need to increase business productivity. Four restaurants offer everything from casual classics to the cuisines of Japan, France and Italy. The revolving rooftop lounge offers spectacular panoramic views and is an ideal spot to relax. An indoor pool, a sauna, and a whirlpool and a fully equipped exercise facility are also available.

Make your hotel reservations early to take advantage of the special WJTA Conference rates. To make reservations, use the convenient form on page 15, or call the Hyatt reservation system toll-free at 1-800-233-1234, or dial the Hyatt Regency Dearborn direct at (313)982-6880. Be sure to request the special group rate for the 1997 WJTA Conference.

Points of Interest

- The Fairlane Town Center Shopping Mall, located directly across from the Hyatt, features over 230 specialty shops, stores and restaurants, five major department stores, and ten movie theatres.
- Greenfield Village, where over 240 of America's most treasured buildings are preserved in pristine condition, including Thomas Edison's laboratory, Noah Webster's home, Firestone's farm and the Wright Brothers Bicycle Shop.
- The Henry Ford Museum, where hundreds of antique automobiles and thousands of 19th and 20th century machines are on display.

Donald J. Huber, Supervisor for the City of Alton, Illinois, removes gang graffiti from a building in Salu Park in Alton. See "Water Jets Erase Gang's Signs" on page 4 of the June/July 1996 *Jet News*. Photograph courtesy of Russ Smith of the *Alton Telegraph*.

Cutting Services Cooperation,

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One of the reasons behind the competitive pricing is that Waterjet Connection utilizes the combined buying power of the group to purchase consumables in bulk. Shipments are combined where possible, with savings passed on to clients.

Waterjet Connection takes no finders fee or commission from its service, and revenue is generated through subscription by its members. In effect, moneys that would otherwise be used by individual companies in promoting their services in a limited way, are now available in a combined manner, bringing the expected results - more work - lower costs - increased productivity - greater specialization and increased efficiency by its members.

It is estimated that savings on the purchase of consumables alone more than cover the membership fee.

Hyatt Regency Dearborn Welcomes: 9th American Water Jet Conference

August 23- 26, 1997

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Please note: A $25.00 departure charge fee will be incurred if there are any changes to the departure date after check-in.

To guarantee convention rates, reservations must be received by the Hyatt Regency Dearborn by **August 2, 1997.**

9th American Water Jet Conference

August 23-26, 1997 • Hyatt Regency Dearborn • Dearborn, MI • USA

Call For Papers: Deadline Extended to November 15, 1996

Impressive progress and a fast-growing understanding of the diversified applications of water jet technology are generating a growing excitement in the industry. New techniques and applications are being developed and current ones are being improved. Water jet technology, now being used in nearly all types of industry — manufacturing, mining, construction, concrete, stone, aerospace, engineering, process, and medical industries — continues to expand at a rapid pace.

The **9th American Water Jet Conference** will focus, from a practical and scientific viewpoint, on the most up-to-date industry advances in water jetting equipment, techniques, and applications. Some of the areas to be addressed include but are not limited to:

- **Automotive Applications**
- **Contractor Applications and Processes**
- **Jet Mechanics**
- **Jet-Material Interaction**
- **Safety, Training, and Environmental Protection**
- **Process Modeling and Control Studies**
- **Excavation, Tunneling, and Mining Applications**
- **Drilling Applications**
- **Rock Cutting**
- **Cleaning and Coating Removal**
- **Construction and Non-Manufacturing Applications**
- **Manufacturing Processes**
- **Advanced Industrial Applications**
- **Components and Systems**
- **Novel Jets and Applications**
- **High Pressure Equipment and Systems**
- **Abrasives, Water, and the Environment**
- **Advances in High Pressure Technology**
- **Market and Future Needs**

Commercial and academic authors are encouraged to submit titles and abstracts for consideration. To submit an abstract(s), please complete the Abstract Submission Form on the back of this sheet, attach a copy of your abstract(s), and forward to the attention of the Conference Coordinator at the Water Jet Technology Association. **The deadline date for submission of abstracts is extended to November 15, 1996.**

An Abstract Review Committee consisting of six referees, chosen from the Organizing Committee and the International Advisors, will review the abstracts. Authors will be advised by February 3, 1997, regarding the decision of the Abstract Review Committee.

The 9th American Water Jet Conference is organized by the **Water Jet Technology Association** and is endorsed by the **International Society of Water Jet Technology**. The Water Jet Technology Association looks forward to providing this forum and to your involvement and participation.

Water Jet Technology Association, 917 Locust Street, Suite 1100, St. Louis, MO 63101-1413, telephone: (314)241-1445, fax: (314)241-1449, E-mail: wjta@aol.com

WJTA

Water Jet Technology Association

9th American Water Jet Conference
August 23*-26, 1997
Hyatt Regency - Dearborn, Michigan

Abstract Submission Form

For each paper to be submitted for consideration, please complete this form, **attach a copy of the abstract**, and mail to WJTA by November 15, 1996. Authors will be advised by February 3, 1997, regarding the decision of the Abstract Review Committee.

Paper Information

Paper Title .....
Authors .....

Contact Person

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Position/Title .....
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Street Address .....
City, Province ..... State .....
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Indexing words (Check the boxes under the different categories that apply to your paper.):

Type of Study
- ☐ Modeling (theoretical)
- ☐ Experimental study
- ☐ Hardware development
- ☐ Contractor case study
- ☐ Manufacturing case study
- ☐ Software development
- ☐ Economic analysis
- ☐ Legal
- ☐ Other _____

Process
- ☐ Cutting
- ☐ Drilling
- ☐ Surface preparation
- ☐ Cleaning
- ☐ Stripping
- ☐ Safety
- ☐ Milling
- ☐ Jet-assisted
- ☐ Other _____

Related Industry
- ☐ Generic
- ☐ Shipyard
- ☐ Mining
- ☐ Construction
- ☐ Aerospace/Aircraft
- ☐ Automotive
- ☐ Oil/Gas/Refractory
- ☐ Quarrying
- ☐ Other _____

Jets
- ☐ Waterjet
- ☐ Abrasive-waterjet
- ☐ Abrasive suspension jet (Diajet)
- ☐ Pulsed
- ☐ Cavitation
- ☐ Polymer Jets
- ☐ Other _____

Material
- ☐ Metal
- ☐ Rock
- ☐ Glass
- ☐ Ceramic
- ☐ Composite
- ☐ Concrete
- ☐ Other _____

Environment
- ☐ Field work
- ☐ Factory work
- ☐ Submerged
- ☐ Nuclear
- ☐ Demilitarization
- ☐ Offshore
- ☐ Other _____

Mail completed form and abstract, **NO LATER THAN NOVEMBER 15, 1996**, to: **Conference Coordinator, 9th American Water Jet Conference, Water Jet Technology Association, 917 Locust Street, Suite 1100, St. Louis, MO 63101-1413, USA, telephone: (314)241-1445, fax: (314)241-1449.**

* August 23 is reserved for a waterjet "Short Course" and Conference Reception.


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