BEAR RIVER ZEOLITE BRZ™

MINE APPLICATIONS

WHAT IS IT?

BRZ™ (Bear River Zeolite) is a naturally occurring volcanic rock that contains the zeolite mineral called “clinoptilolite”. The rock is drilled, blasted, crushed and screened to various sizes. BRZ™ is one of the best zeolites in the world because:

- BRZ™ contains more than 90% clinoptilolite and therefore it holds a high amount of ammonium and other cations.
- It contains very little sodium, which is toxic to plants and causes hard pan in clay soils.
- It contains no crystalline silica and is not a cause for silicosis.
- BRZ™ is a natural cation exchange agent that has a CEC of 190-200 meq/100 grams.
- Low cost.

HOW IT WORKS

BRZ™ has two ways of holding cations (positive ions such as ammonium, calcium, sodium, and potassium). The first way is in its crystal lattice where the ammonium and other cations are held and are not water soluble. The second way is in its channel-ways where BRZ™ can hold up to 55% of its weight in water. BRZ™ is an excellent desiccant. In this case the cations are more loosely held and are water-soluble.

Four hundred and fifty tons of BRZ™ were used to clean up the largest spill of anhydrous ammonia gas in the history of the United States (Canadian Pacific Railroad, Minot, North Dakota, January 18, 2002, where 200,000 gallons of ammonia were released, 13 people were hospitalized and one was killed).

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AMMONIA CONTROL IN BLASTING

Ammonia emissions result from incomplete detonation, spillage, and fugitive dust from loading operations. Reducing the ammonia after shooting means getting back to the face faster, fewer health problems, and greater production.

It has been found that applying about 30% of the weight of the ANFO (Ammonium Nitrate Fuel-Oil) as BRZ™ significantly reduces ammonia after loading and shooting. The weight of the BRZ™ must be determined on a case-by-case basis.

BRZ™ is sold in 50 lb or 25 kg plastic bags (for easy application), 1 ton totes, 1 metric tonne totes, and in bulk.

Shafts and Winzes

- BRZ™ is sprinkled around the blast area prior to loading.
- Top dress the muck pile with BRZ™.
- Has been shown to reduce ammonia levels from 180 - 220 ppm to less than 20 ppm.

Drifts, Scrams, Stopes, Ramps, Raises

- BRZ™ is spread on the floor in front of or under the drilled area prior to loading, and it can also be used to top dress the muck pile.

Open Pit Operations and Seismic Blasting

- The environmental impact of the ammonia can be mitigated by applying BRZ™ around the drill holes or as stemming in the drill holes.
- BRZ™ should not be mixed with ANFO.
  - ✓ BRZ™ will become saturated with ammonium and will lose its ability to exchange ammonia into its lattice.
  - ✓ ANFO will lose its strength.

Magazines and Stockpiles

- ANFO is hygroscopic and pulls water from the atmosphere. The ammonia quickly forms ammonium that leaks from the stockpile or magazine.
- BRZ™ can be applied on the floor around the stockpile, in a trench outside the storage area, or in various other configurations.

Desiccant and flow agent

- BRZ™ is an effective desiccant that can be mixed in small amounts in fine particle sizes (minus 40 mesh) to keep ANFO dry and easily flowing.
- It will prevent caking and clumping.

Control of Nitrous Oxide

- Bear River SMZ (surface modified zeolite) is modified to a positive charge so that it will adsorb NO_3 and NO_2 gas.
- Testing will be necessary to determine the best application method, but top dressing the blast area should be adequate to mitigate nitrous oxide.

CLEANING MINE EFFLUENTS

Ammonia Control

Ammonia quickly becomes ammonium in water and then oxidizes to water soluble nitrites and nitrates that contaminate the water table. This is a critical environmental problem throughout the world.

Many mine effluents are contaminated with ammonium (usually reported as ammonia). To remove the ammonium, the effluent can be treated in various ion exchange zeolite vessels (see Exchange Vessel Operation diagram below) or by applying BRZ™ to ponds or through channels lined with BRZ™. If the effluent has a high hardness measured as Ca, it is recommended that a pretreatment of the effluent be made by adding a small amount of sulfuric acid to precipitate the Ca as gypsum, $CaSO_4$. This will increase the capacity of the BRZ™ to exchange the ammonium.

Cation Removal

Mine tailings, waste rock piles and discharge of acid mine drainage waters contain heavy metals that pollute the environment. Clinoptilolite has high cation selectivity to remove heavy and light metals.

- **Heavy Metals:** Lead (Pb), zinc (Zn), cadmium (Cd), copper (Cu), iron (Fe), manganese (Mn), antimony (Sb), mercury (Hg), nickel (Ni), cobalt (Co), beryllium (Be), zirconium (Zr), arsenic (As), chromium (Cr), thallium (Tl), rubidium (Rb), silver (Ag), barium (Ba), and others.
- **Light metals:** Sodium (Na), lithium (Li), potassium (K), aluminum (Al), calcium (Ca), and magnesium (Mg), etc.

Spill Clean-Up

Mining production machinery also contributes to environmental pollution. BRZ™ is effective for the clean-up of spills of:

- Oil, antifreeze, grease, diesel fuel, gasoline, etc.

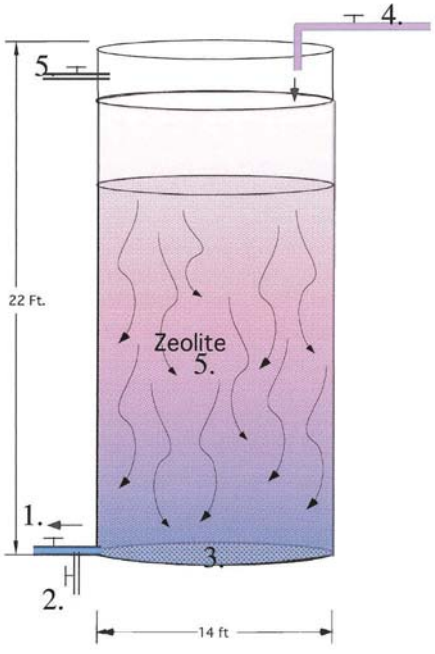
Radioactive Element Removal

Mining of ore deposits containing radioactive elements results in ground and water contamination.

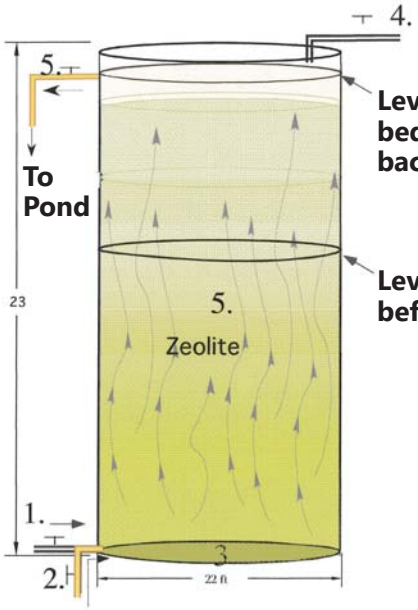
- Clinoptilolite is used to remove radium (Ra), uranium (U), strontium (Sr), cesium (Cs), etc.

EXCHANGE VESSEL OPERATION

Ion Exchange Stage
(elevation view)



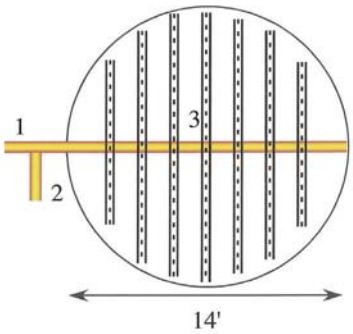
Backwash Operation
(elevation view)



Level of zeolite bed during backwash

Level of zeolite before backwash

Vessel Bottom
(plan view)



Key to diagrams

1. Discharge pipe to discharge or other cation exchange vessel.
2. Pipe to clean sediment from ion exchange bed or for regenerating the zeolite.
3. Piping system with holes in bottom of ion exchange vessel.
4. Inlet pipe from mine
5. Discharge pipe for backwashing or regenerating.

AMMONIA GAS HAZARDS

Ammonia is a health hazard and can be lethal to humans. In low levels it severely affects a man's ability to work. In higher levels it can cause lasting respiratory, other medical problems, and death.

Ammonia (NH_3) Concentration in Air and Health Effects in ppm (parts per million)*

< 25	Detectable by smell.
30	Uncomfortable, breathing support required. Maximum exposure 15 minutes.
50	OSHA maximum exposure limit.
100	Irritated eyes, throat and mucus membranes. Mild eye, nose, and throat irritation.
140	Moderate eye irritation. No long-term effect in exposures less than 2 hours.
400	Moderate throat irritation. Damage of mucus membranes with more than one hour of exposure.
500	Immediate danger to life limit (IDLH).
1000	Caustic to airway.
1700	Fatal after short exposures - less than half an hour.
5000	Immediate hazard to life.
> 15000	Full body protection required.
160000-170000	Flammable in air at 50◦C / 122◦F

*Table adapted from, *Ammonia - NH3 - Concentration in Air and Health Effects.* Accessed 05/02/2017 http://www.engineeringtoolbox.com/ammonia-health-symptoms-d_901.html

Information on file at Bear River Zeolite Co.