Western Site Technologies Inc

Stabilization and Encapsulation of Diverse Waste Streams

Stabilization

A prime constituent of many stabilization formulas are pozzolans

What is a Pozzolan?

The classical definition of a pozzolan is a crystalline, porous aluminosilicate.

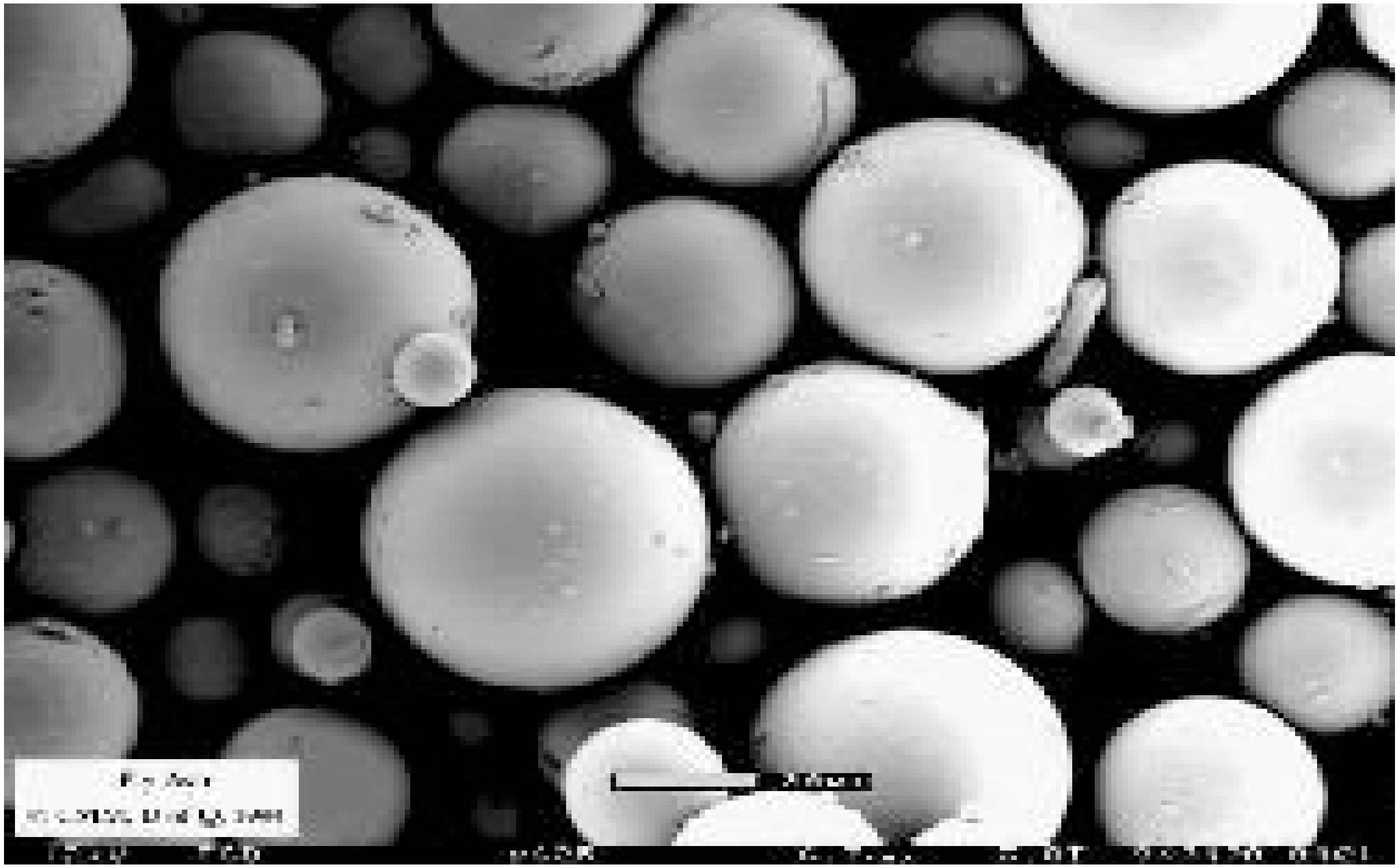
However, some relatively recent discoveries of materials virtually identical to the classical pozzolan, but consisting of oxide structures with elements other than silicon and aluminum have stretched the definition. Most researchers now include virtually all types of porous oxide structures that have well-defined pore structures due to a high degree of crystallinity in their definition of a pozzolan.

Pozzolans are present on earth's surface such as diatomaceous earth, volcanic ash, opaline shale, pumicite, and tuff. These materials sometimes require further processing such as calcining, grinding, drying, etc to enhance their effectiveness

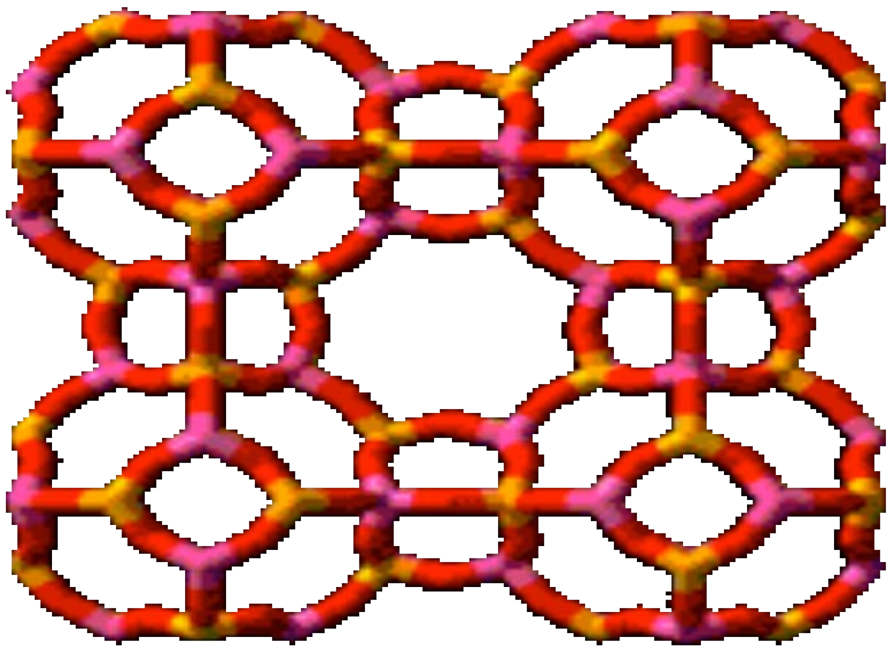
The Aegean island of Santorini has natural deposits of volcanic ash (Santorin earth.)

In the United States, volcanic tuffs and pumicites, diatomaceous earth, and opaline shales are found principally west of the Mississippi River in Oklahoma, Nevada, Arizona, and California.

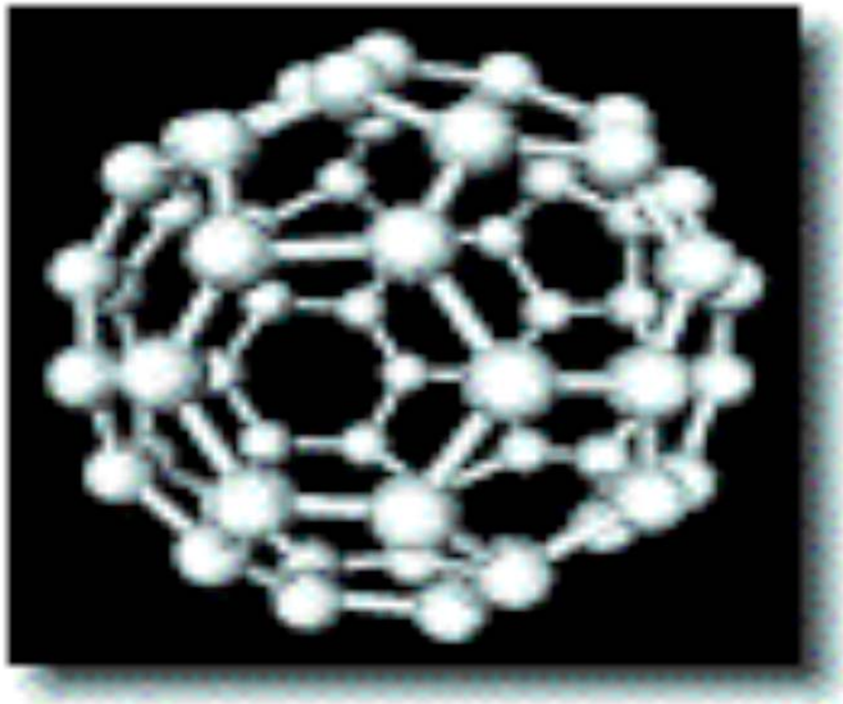
Natural pozzolans have been used in dams and bridges to lower the heat of hydration and increase resistance of concrete to sulfate attack and control the alkali-silica reaction.



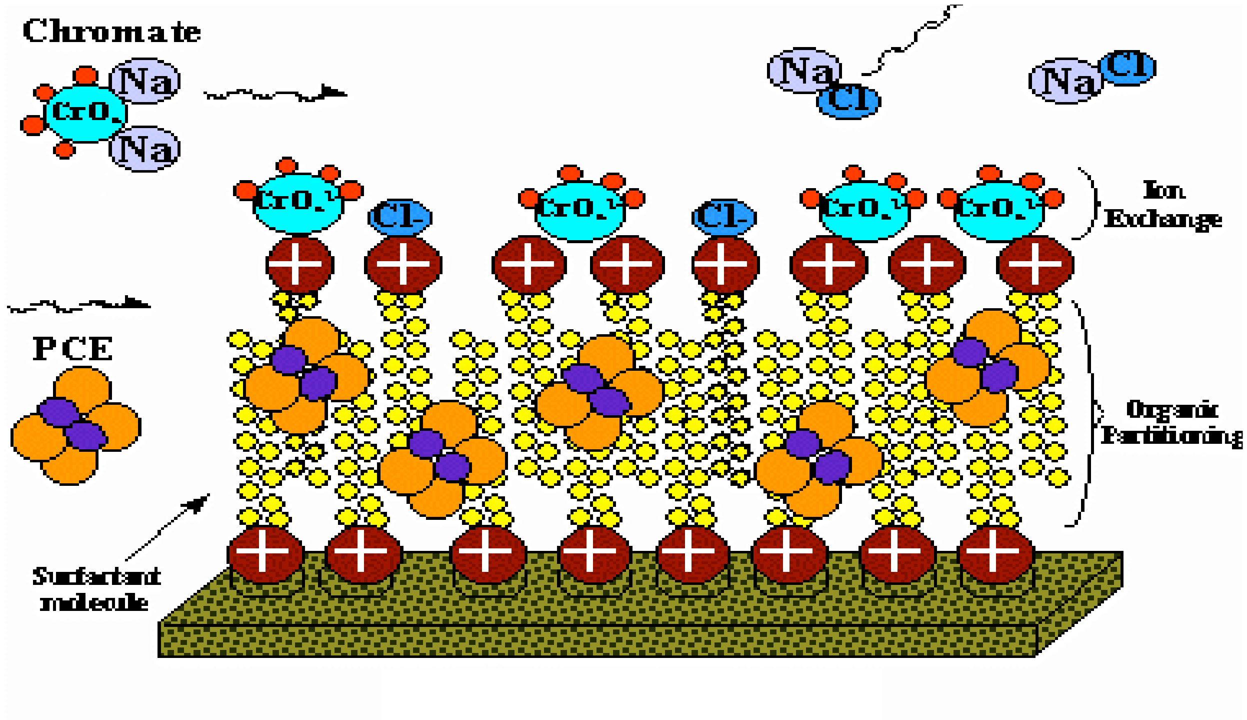
A pozzolan requires the presence of a reactive alumino-silicate glass. These glassy particulates must be fine enough to provide a sufficient reactive surface area for the solid-state chemical reactions. This reactive glass reacts with available calcium hydroxide and alkalies to produce cementitious compounds.(calcium-silicate hydrate gel and calcium-alumino silicates, etc.)



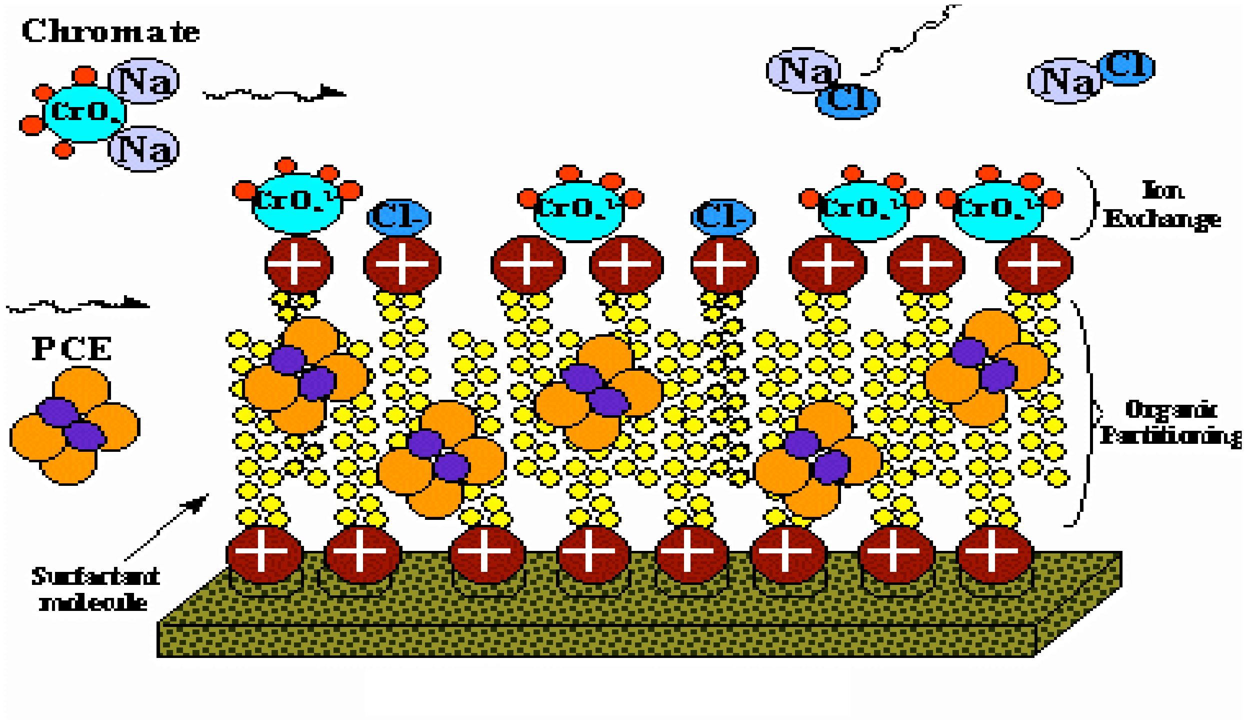
The pozzolanic channels (or pores) are microscopically small, and in fact, have molecular size dimensions such that they are often termed "molecular sieves". The size and shape of the channels have extraordinary effects on the properties of these materials for adsorption processes, and this property leads to their use in separation processes. Molecules can be separated via shape and size effects related to their possible orientation in the pore, or by differences in strength of adsorption.



In these crystalline materials we call pozzolans, the metal atoms (classically, silicon or aluminum) are surrounded by four oxygen anions to form an approximate tetrahedron consisting of a metal cation at the center and oxygen anions at the four apexes. The tetrahedral metals are called T-atoms for short, and these tetrahedra then stack in beautiful, regular or amorphous arrays such that channels form.

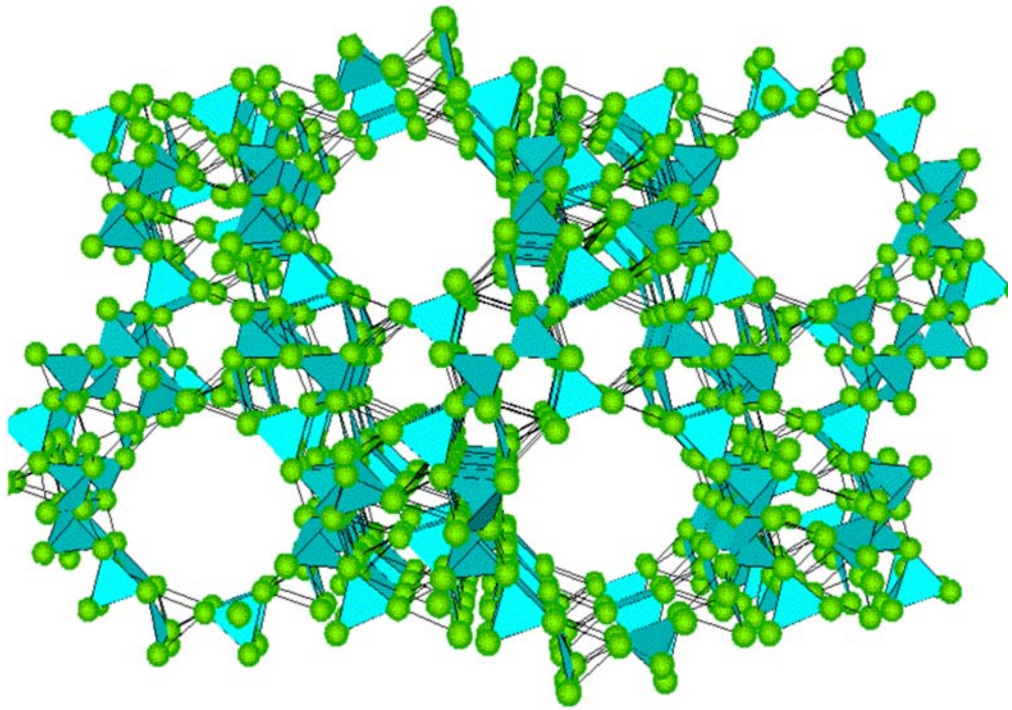


Since silicon typically exits in a 4+ oxidation state, the silicon-oxygen tetrahedra are electrically neutral. However, in pozzolans, aluminum typically exists in the 3+ oxidation state so that aluminum-oxygen tetrahedra form centers that is electrically deficient one electron. Thus, pozzolan frameworks are typically anionic, and charge compensating cations populate the pores to maintain electrical neutrality.



These cations can participate in ion-exchange processes and this yields some important properties for pozzolans.

When charge compensating cations are "soft" cations such as sodium, pozzolans are excellent water softeners because they can pick up the "hard" magnesium and calcium cations in water leaving behind the soft cations.



When the pozzolanic cations are protons, the pozzolan becomes a strong solid acid.

Such solid acids form the foundations of pozzolan catalysis applications including the important fluidized bed cat-cracking refinery process.

Other types of reactive metal cations can also populate the pores to form catalytic materials with unique properties

More than 2000 years ago, Greeks and Romans built structures that survive today that took advantage of the Pozzolan-lime reaction. The Romans used a mixture of lime and Pozzolan(a fine volcanic ash) to produce a hydraulic cement (hardening under water). Romans used pozzolana cement from Pozzuoli, Italy near Mt. Vesuvius to build the Appian Way, the Roman baths, the Coliseum and Pantheon in Rome, and the Pont du Gard aqueduct in south France. Vitruvius reported a 2 parts pozzolana to 1 part lime mixture. Animal fat, milk, and blood were used as admixtures (to improve performance.) These structures still exist today!

Fly ash & natural pozzolans ASTM C 618

- Class N, Raw or calcined natural pozzolans including
  - Diatomaceous earths
  - Opaline cherts and shales
  - Tuffs and volcanic ashes or pumicites
  - Some calcined clays and shales
- Class F, Fly ash with pozzolanic properties
- Class C, Fly ash with pozzolanic and cementitious properties

Trass

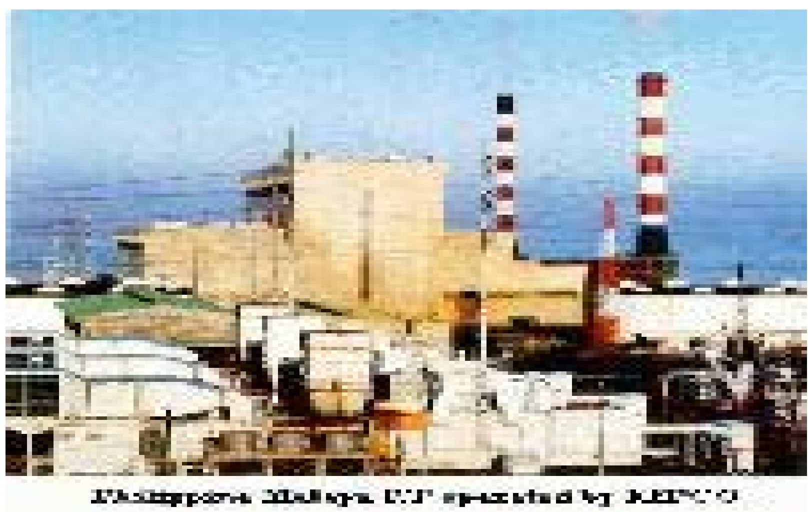
Trass is ground 'tuffstein' from the Rhine valley in Germany. Tuffstein is a rock-like compacted tuff of volcanic dust and ash.

Rhenish trass has been known for some 2000 years, and mortars containing trass have been found in old Roman buildings along the Rhine.

It has been increasingly used in lime mortars since the early 18th century, and was experimented with by John Smeaton in 1756 for the Eddystone lighthouse, although an Italian pozzolana from 'Civita Vecchia' was ultimately used.

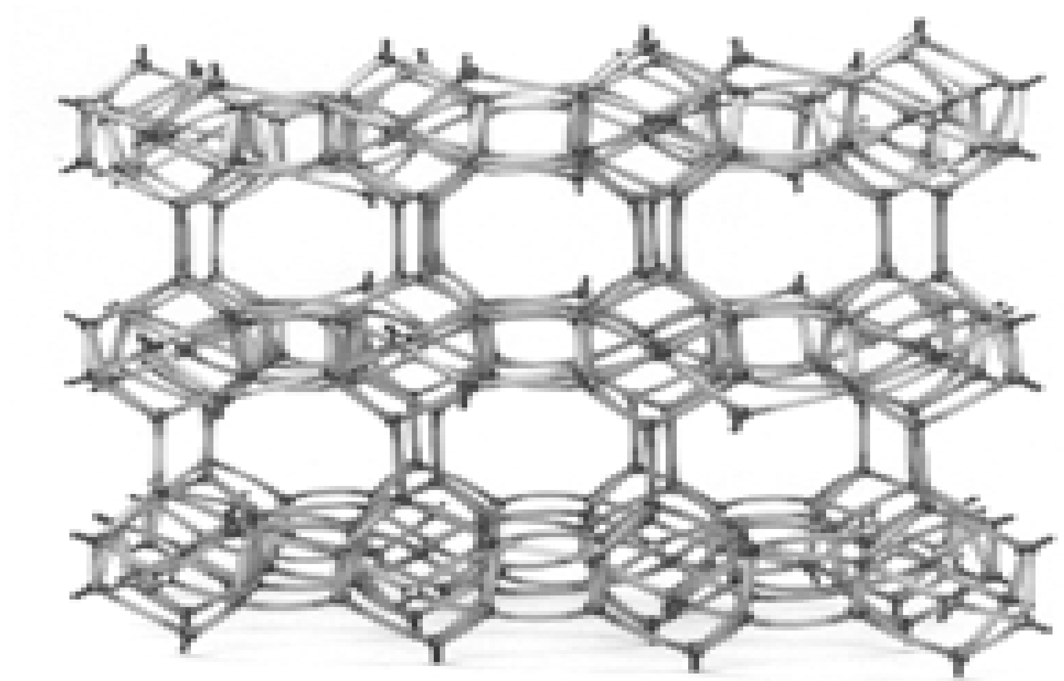
FLY ASH is the finely-divided Coal Combustion Byproduct collected by electrostatic precipitators from the flue gases. Bottom Ash and Boiler Slag are heavier and coarser coal combustion byproducts.All have pozzolanic properties

The glassy (amorphous) spherical particulates are the active pozzolanic portion of fly ash. Fly ash is 66-68% glass. Fly ash readily reacts with lime (produced when portland cement hydrates) and alkalies to form cementitious compounds. Fly ash also may exhibit hydraulic (self-cementing) properties. Hungry Horse, Canyon Ferry, Palisades, Yellowtail dams all contain portland cement-fly ash concrete.



Zeolites

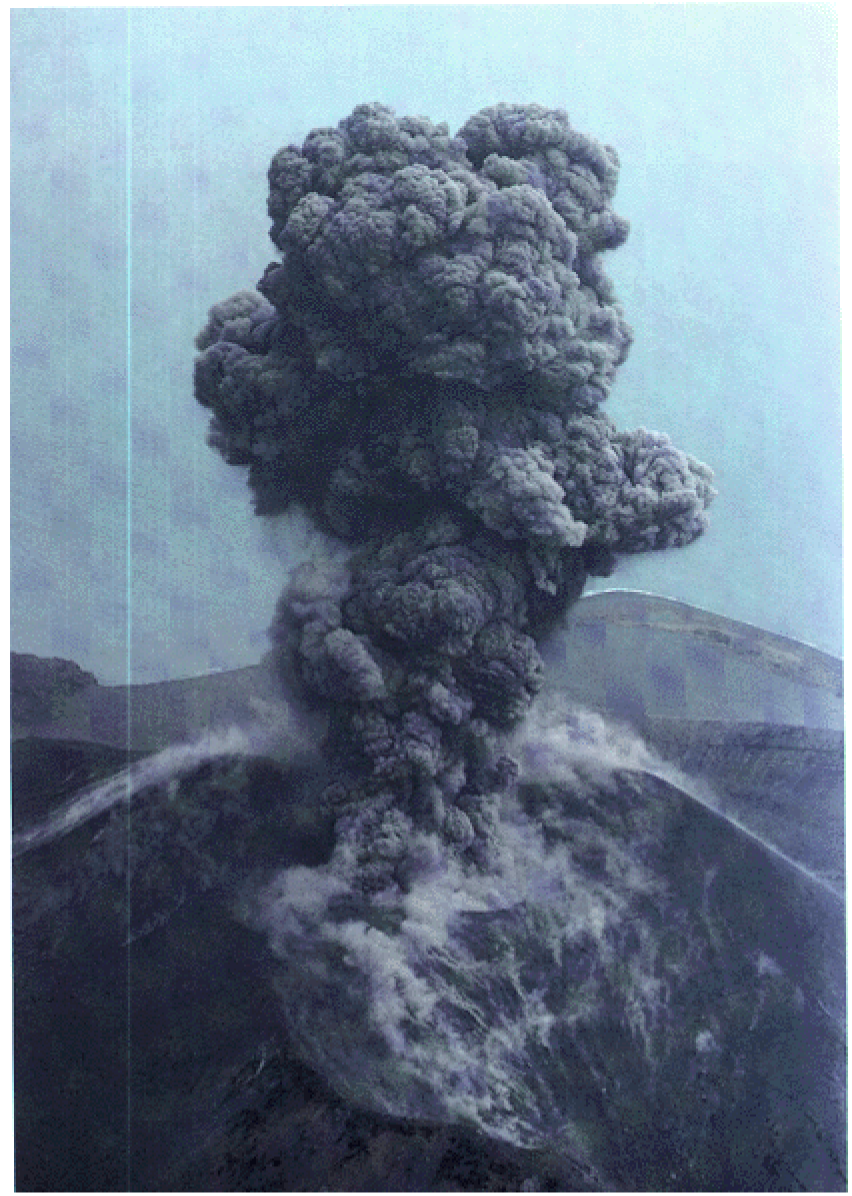
Compositionally, zeolites are similar to clay minerals. More specifically, both are alumino-silicates. They differ, however, in their crystalline structure. Many clays have a layered crystalline structure (similar to a deck of cards) and are subject to shrinking and swelling as water is absorbed and removed between the layers. In contrast, zeolites have a rigid, 3-dimensional crystalline structure (similar to a honeycomb) consisting of a network of interconnected tunnels and cages. Another special aspect of this structure is that the pore and channel sizes are nearly uniform, allowing the crystal to act as a molecular sieve. The porous zeolite is host to water molecules and ions of potassium and calcium, as well as a variety of other positively charged ions, but only those of appropriate molecular size to fit into the pores are admitted creating the "sieving" property.CLINOPTILOLITE



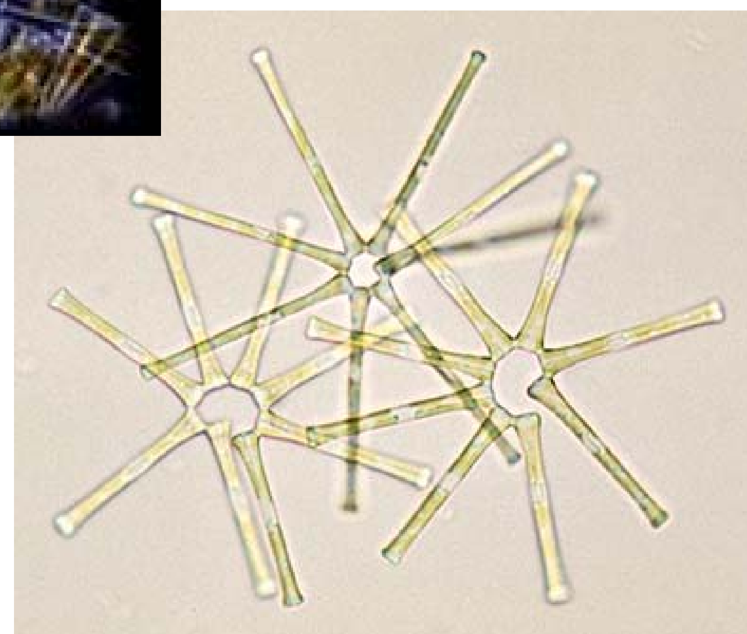
One important property of zeolite is the ability to exchange cations. Zeolites have high CEC's, arising during the formation of the zeolite from the substitution of an aluminum ion for a silicon ion in a portion of the silicate framework (tetrahedral units that make up the zeolite crystal).

LASSANITE

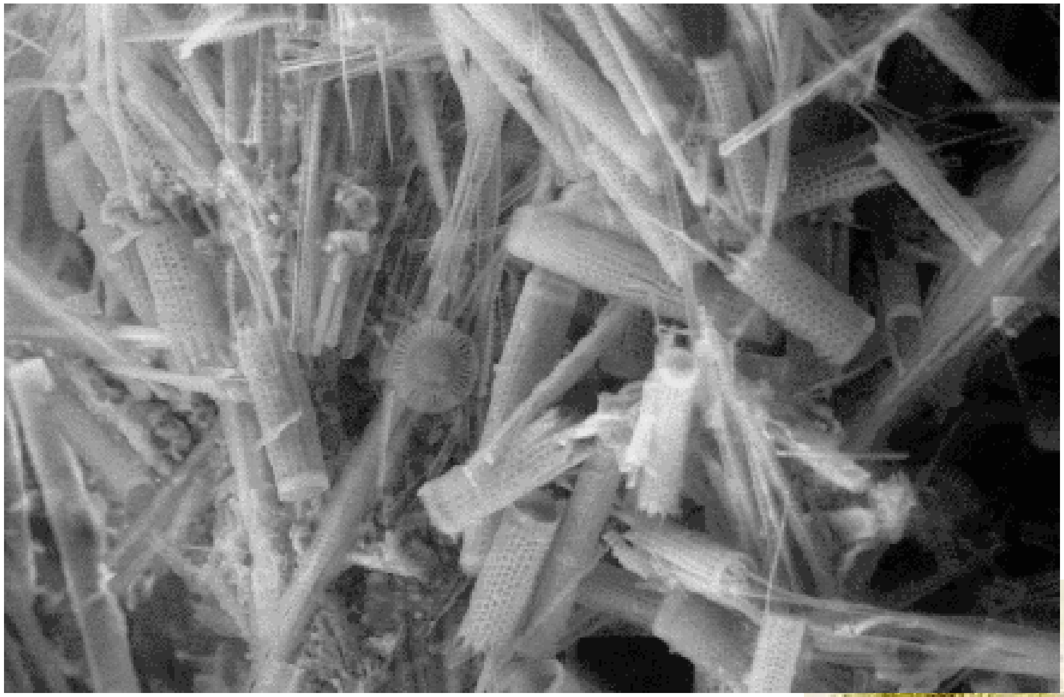
The formation of this amazing material began millions of years ago as volcanic ash



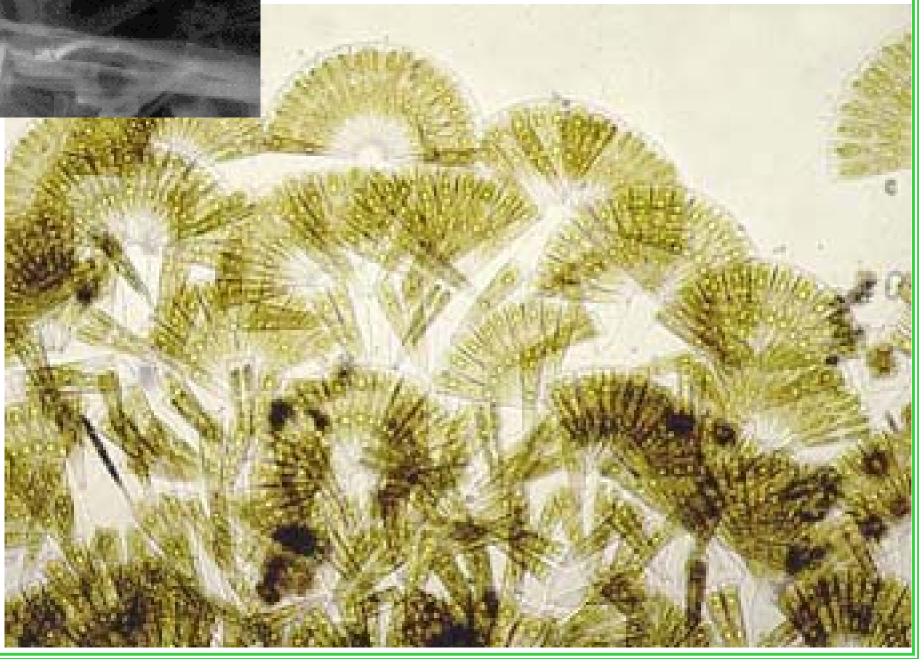
This ash fell into an ancient lake and amalgamated with the silica shells of tiny creatures known as Diatoms



DIATOMS



DIATOMS



What Are Diatoms?

What are diatoms? One celled plants belonging into the plant class *Bacilariophyceae* of the division or phylum *Bacilariophyta*. Diatoms are either solitary and free, attached to a substratum by gelatinous extrusions or joined to each other in chains of varying length. Some species are capable of active movement but others are merely free floating and depend on currents for transport. Individual diatoms range in size from 2 microns to several millimeters, although there only very species that are larger than 200 microns. The actual number of extinct and extant diatom species may well be over 50.000.

Diatoms are one of the most abundant plants on the planet. At the end of the winter, early spring, they bloom in freshwater.

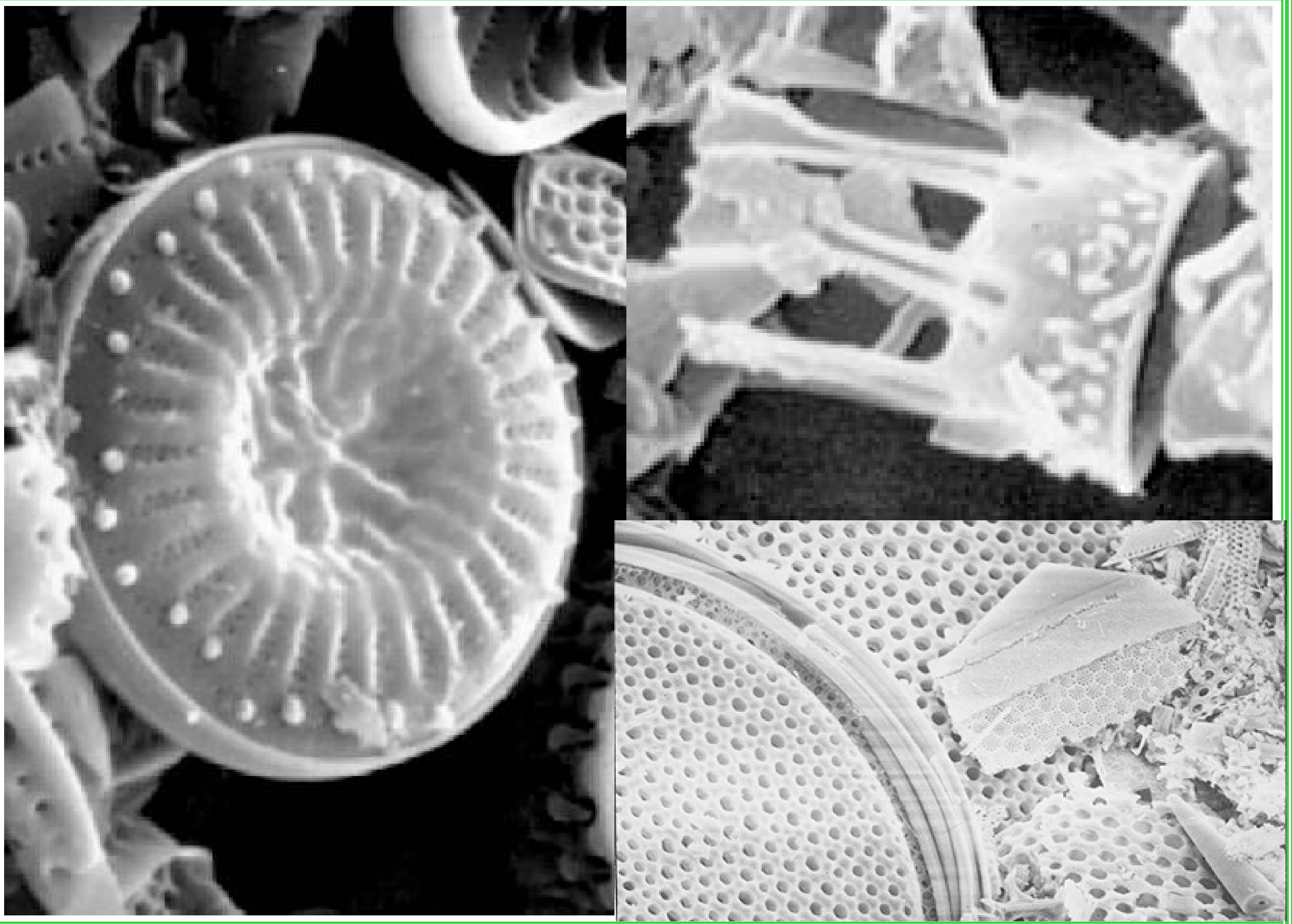
There are two different groups of diatoms, the pennates which are pen shaped (previous pictures) and the centric which are like a cylinder. In fresh water most diatoms are of the pennate type. In marine waters the variety of body shapes is much wider.

The oldest certain fossil diatoms are Lower Cretaceous in age. Diatoms probably had a much longer history than this; there are reports of Precambrian and Triassic fossils that might be diatoms or diatom relatives, but definite fossil diatoms older than the Cretaceous are not known. An older report of diatoms from the Upper Jurassic is now doubted by experts. Since silica recrystallizes under pressure, any older diatom fossils may have been destroyed.

The armor of diatoms is literally glass, that is, amorphous silicon dioxide. The armor is often elaborately sculpted and perforated, with quite beautiful results. Actually, the structures are often to fine for a light microscope to resolve.

Where do they occur?

Diatoms are distributed throughout the world in aquatic, semi-aquatic and moist habitats. They are found in the sea, estuaries, freshwater lakes, ponds, streams, and ditches. More rigorous habitats such as moist rocks or soils or damp bark sometimes support lush growths of diatoms. Though individual diatom cells are microscopic, masses of diatoms can often be seen on stream bottoms, along the surf zones, during plankton blooms as brownish colored waters or films.



ALS Chemex

Certificate of Analysis A0031615

NAME	ELEMENT	METHOD	PERCENT
Aluminum Oxide	Al203	XRF	15.10
Calcium Oxide	CaO	XRF	2.37
Chromium Oxide	Cr2O3	XRF	<0.01
Iron (as Ferric Oxide)	Fe2O3	XRF	5.31
Magnesium Oxide	MnO	XRF	0.08
Phosphorus Oxide	P2O5	XRF	0.14
Potassium Oxide	K2O	XRF	1.83
Silicon Oxide	SiO2	XRF	63.02
Sodium Oxide	Na2O	XRF	2.22
Titanium Oxide	TiO2	XRF	0.53
Loss on Ignition	LOI	XRF	7.52
Total Bulk Density		Calculation	99.07
Moistue %: Dry to constant wet		Furance	1.10

POZZOLAN TEST

TYPE	WEIGHT IN	WEIGHT OUT	RESISTANCE TIME	CAPACITY	CAPICITY/GRMS	CEC
LASSEN	204	362	13.10 MIN	175 ML	.8578 ML/GRM	19.1meg/100g
C2C	172	326	60+ MIN	150 ML	.8720 ML/GRM	45.7meg/100g
LAS VEGAS	300	426	12.12 MIN	150 ML	.500 ML/GRM	23.4meg/100g
SILVER SPRINGS(WATER-loc/AGRO-loc/MUD-loc)	66	208	60+ MIN	165 ML	2.5 ML/GRM	63.4meg/100g
CONTROL (FILTER ONLY)	1	10	2.6 MIN	25 ML	N/A	

WEIGHT IN - DRY WEIGHT
WEIGHT OUT - WET WEIGHT
RESISTANCE TIME - TIME 500 ML OF WATER TAKES TO PASS THROUGH A FILTER CONE TO A SPECIFIC DRIP RATE
CAPACITY - THE DIFFERENCE BETWEEN 500 ML OF WATER INTRODUCED TO THE FILTER CONE AND THE RECOVERED FLUID IN THE BOTTOM OF THE VESSEL
CAPACITY/GRAMS - THE RATIO OF MATERIAL (DRY WEIGHT) TO RETAINED WATER

ALL SAMPLES WERE REDUCED TO FLOUR CONSISTENCY EXCEPT FOR THE LASSEN WHICH WAS REDUCED TO A CONSISTENCY OF CORNMEAL. THE PRODUCT WOULD HAVE PERFORMED (RESISTANCE ONLY) ABOUT 10% BETTER WITH FINER SIEVE SIZE.

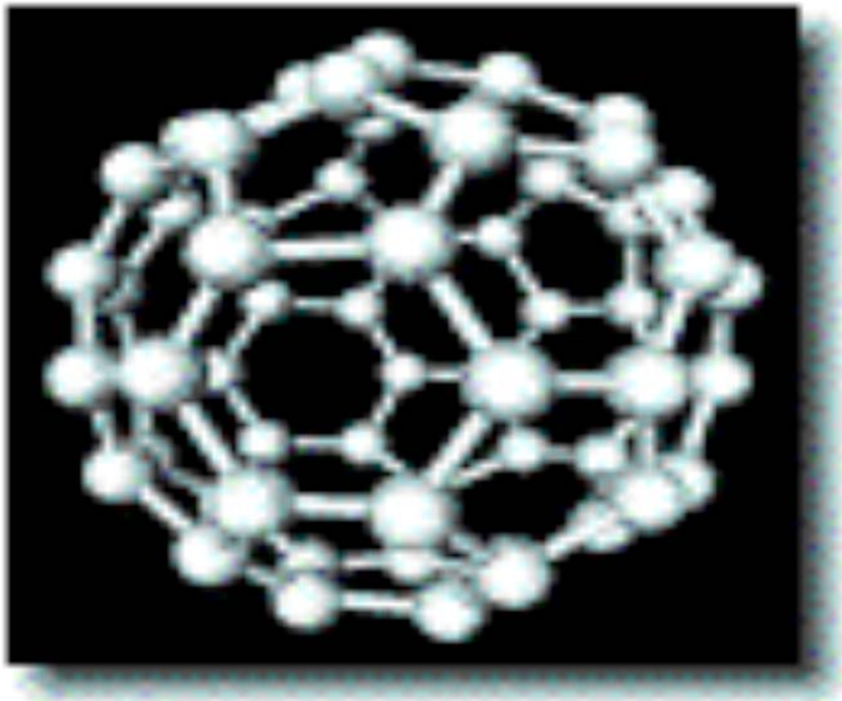
RESIDENT FINES IN THE SILVER SPRINGS AND C2C MAY HAVE BLINDED THE FILTER EARLY AND CAUSED HIGHER THAN EXPECTED RESISTANCE TIME.

CEC - CATION EXCHANGE CAPACITY, TEST PERFORMED BY MAXXAM LABS

THE VOLUME OF MATERIAL PLACED IN THE FILTER CONE WAS 200 ML

The cation exchange capacity (CEC) of a soil refers to the amount of positively charged ions a soil can hold.
Examples of positively charged ions (cations) include: calcium (Ca^{++}), magnesium (Mg^{++}), potassium (K^+), sodium (Na^+), hydrogen (H^+) and ammonium (NH_4^+).

Pozzolans are naturally occurring minerals



They are alumino-silicate micro sieves.

Encapsulation

This process should not be confused with early attempts to treat wastes by encapsulating them with normal concrete

Straight Cement Encapsulation, after some research was determined to be of little value.

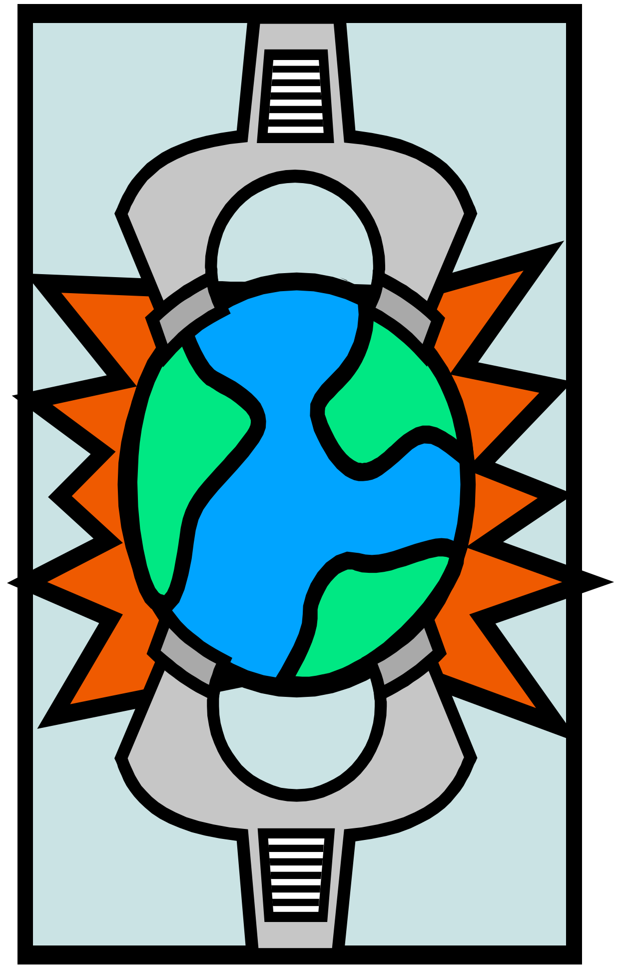
Although the cement reaction bound up some of the heavy metals present in the waste, the porous nature of the concrete released hydrocarbons and other “leachable” wastes over time.

In fact the more heat, and moisture the matrix was exposed to, the faster the wastes would leach out of the pores occurring in the mixture

In order to solve the porosity problem concrete chemists attempted to close the pores of the concrete by adding pozzilanic additives to the cement

In Europe several companies went further to develop treatments for oily waste using pozzolanic additives in conjunction with concrete by first drying the waste with pozzolans, then adding the dried waste to concrete as an aggregate

Meanwhile, the solid waste industry has used stabilization for many years, to prepare waste for encapsulation prior to disposal in normal landfills



Keys to this process:

Adequate analysis of contaminant

Determination of process formula

QA/QC during mixing to ensure formulas are properly applied

The

Stabilization/Encapsulation

Of

Invert Drilling Waste

Job Cost Analysis

Kakwa – Resthaven - Hinton

Chevron

- **The Invert Cuttings present a handling and storage problem.**

- **They provide a high risk of contaminating the drilling area.**

- **They are also difficult to transport in their normal condition.**

The common practice of using sawdust increases the risk of hydrocarbon release

When exposed to moisture sawdust acts as a wick transmitting hydrocarbons and displacing water

MUD-loc (WSTI's processed lassinite) makes a perfect substitute, for sawdust.

- ***Its molecular sieving properties not only trap hydrocarbons, they reduce the hydrocarbon mass into small chambers, where natural bacterial action begins the breakdown of the hydrocarbon molecule.***

We recently completed three projects using a stabilization/encapsulation technique to stabilize approximately 1500 cubic meters of Invert Cuttings in three locations

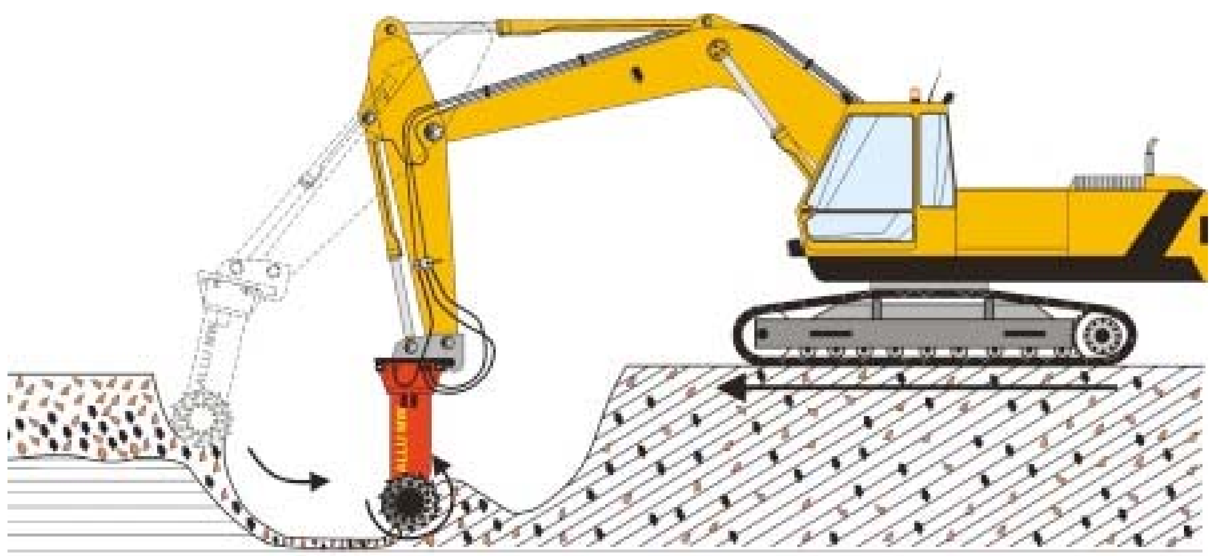
The stabilizer was MUD-loc.

The encapsulator was Common Portland Cement

MUD-loc has an ionic affinity for heavy metals, and makes hydrocarbons extremely stable.

It will absorb its weight in liquid, and is reluctant to release this liquid once absorbed.

Mixing was done by simply turning with a front end loader in small batches, but could also be done by using a backhoe- mounted high speed loader.



Job Cost Analysis

Job Chevron Kakwa 15-34-62-4-W6

Task Item	AFE/Budget	Actual Cost	Difference	Explanation
Trucking Pozz	10500	10500	0	
Trucking Cement	2700	1800	-900	Bigger loads
Towing		600	600	Winter Conditions
Site work			0	
Mixing	15750	15750	0	
Support	3000	3029.52	29.52	site work
Supervision	2400	3975	1575	Extra days due to site work
Water	2600	0	-2600	Water on lease
Pozzolin	29150	31800	2650	Make up loads extra to truckers yard
Cement	15750	13500	-2250	Even loads/less material than anticcipated
Rooms		1080	1080	See support
Disbursement charges		4276	4276	
Totals	81850	86310.52	4460.52	
Total Meters	570			
Cost Net of Site Work/Winter Conditions	77510			
Net cost/Meter	130			

Job Cost Analysis

Job Chevron Resthaven 1-36-60-3-W6

Task Item	AFE/Budget	Actual Cost	Difference	Explanation
Trucking Pozz	10500	10500	0	
Trucking Cement	2700	1800	-900	Bigger loads
Mobe	3000	1329	-1671	
Site work			0	
Extra trucking		6286		winter conditions
Move material to mix site		2720		Move mud
Mixing	15750	12513	-3237	
Support	3000	600	-2400	
Supervision	2400	2800	400	Extra days due to site work
Water	2600	2507	-93	Water on lease
Pozzolin	29150	31800	2650	Make up loads extra to truckers yard
Cement	15750	13500	-2250	Even loads/less material than anticcipated
Rooms		0	0	See support
Disbursement charges		3744	3744	
Totals	84850	90099	-3757	
Total Meters	570			
Cost Net of Site Work/Winter Conditions	78188			
Net cost/Meter	130			

Job Cost Analysis

Job Chevron Polecat Road 15-33-53-26-W5

Task Item	AFE/Budget	Actual Cost	Difference	Explanation
Trucking Pozz	4200	4299	99	
Trucking Cement	900	900	0	
Towing		0	0	
Site work			0	
Mixing	7500	6995	-505	
Support	1500	0	-1500	
Supervision	2400	0	-2400	
Water	1300	882	-418	
Pozzolin	18000	12190	-5810	
Cement	7500	5700	-1800	
Rooms			0	
Disbursement charges		1496	1496	
Totals	43300	32462	-10838	
Total Meters	280			
Cost Net of Site Work/Winter Conditions	32000			
Net cost/Meter	110			

Useful products which may result from this process:

Housekeeping pads

Artificial aggregate for roads and lease areas

Barriers and curbing

Dykes and containment areas

The Stabilization/Encapsulation Of Invert Drilling Waste

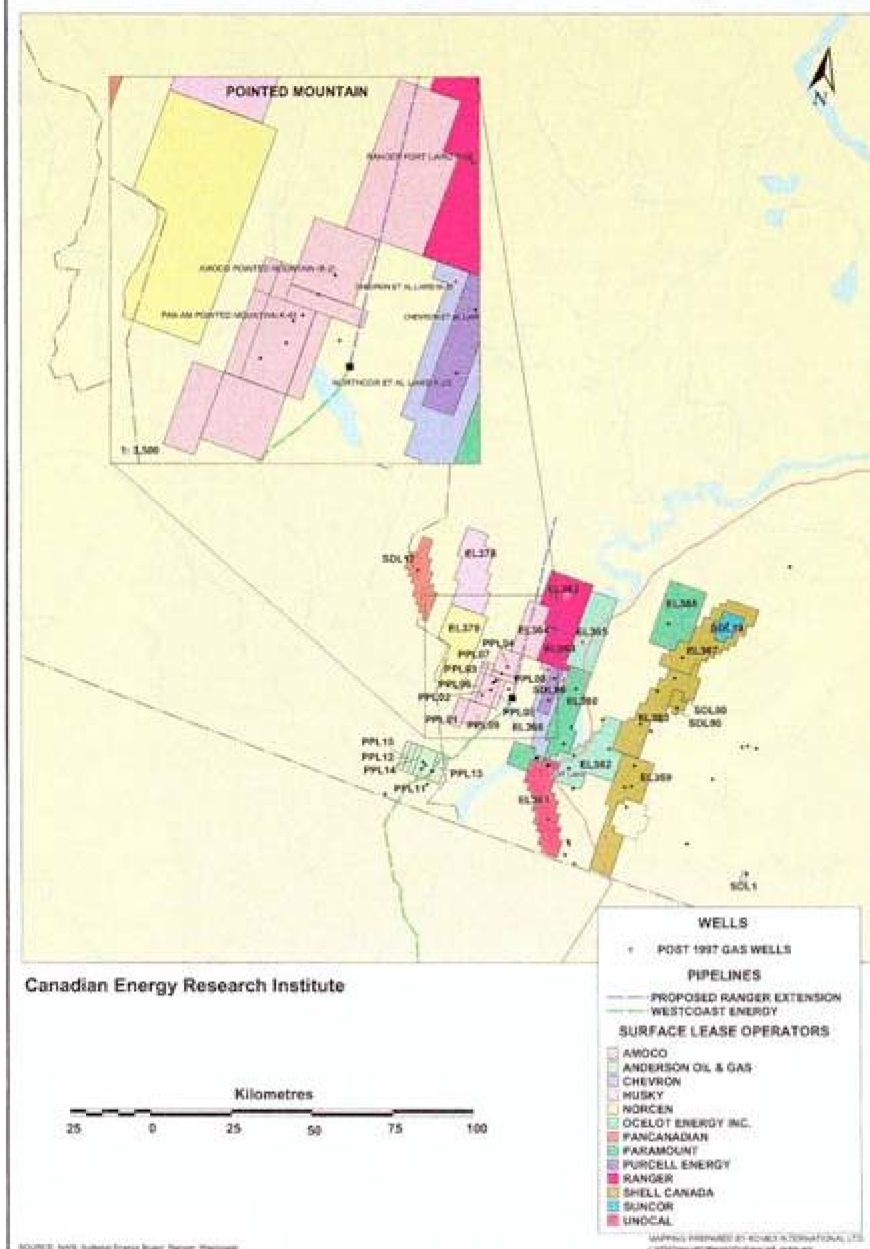
Project Analysis

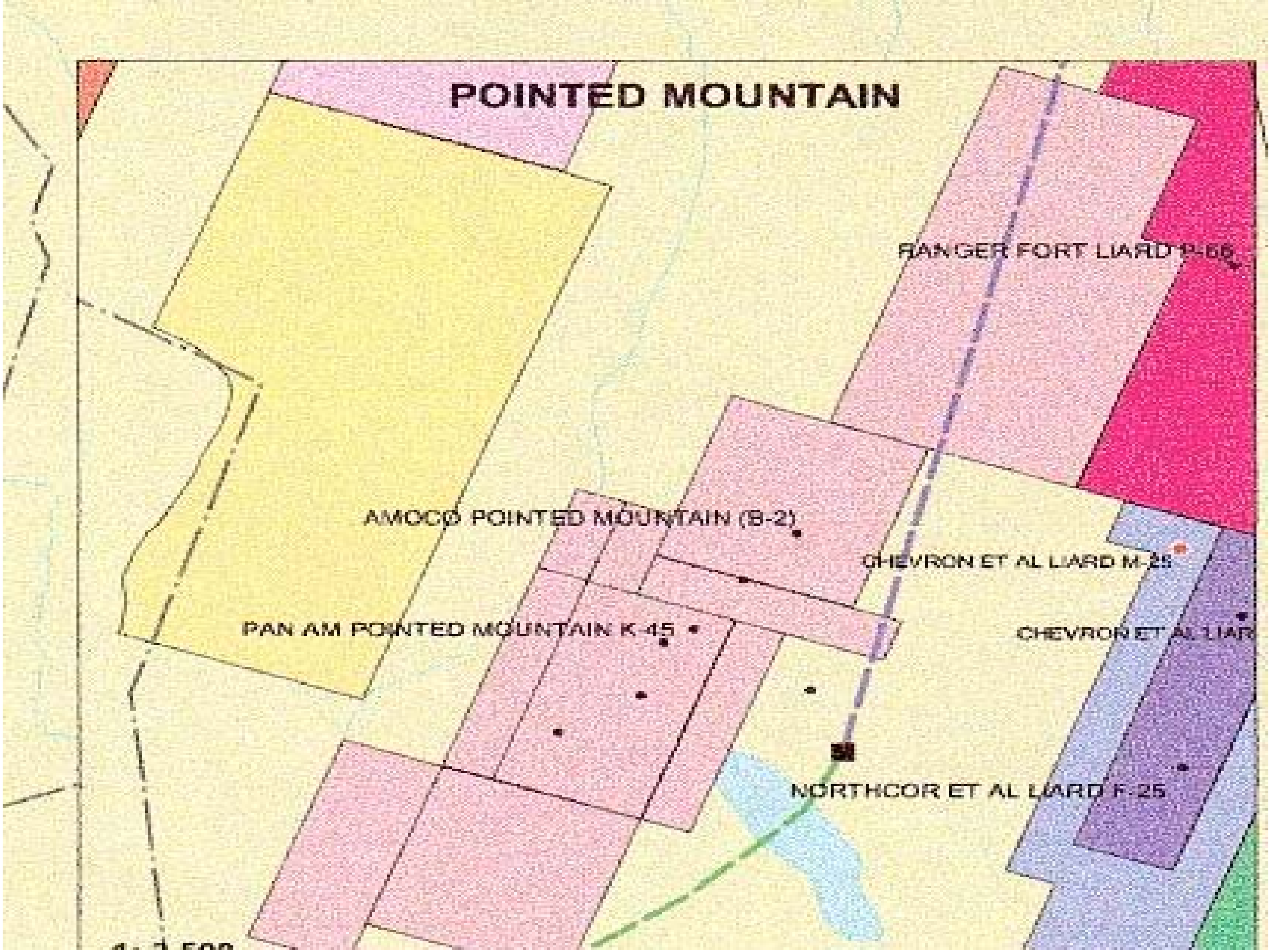
Chevron Et Al Laird M-25

Chevron

The Location -

FT. LIARD - REGIONAL MAP




POINTED MOUNTAIN
RANGER FORT LIARD
AMOCO POINTED MOUNTAIN
CHEVRON ET AL LIARD M-25
PAN AM POINTED MOUNTAIN K-45
CHEVRON ET AL LIAR
NORTHCOR ET AL LIARD F-25

The Problem-

600 Cubic Meters of Oily Invert waste located in a pit on the location, with a hydrocarbon content of 18%+

To compound the problem the lease was located on a man made shelf on the side of a mountain and was not easily accessible.

Possible Solutions:

- Bio Treatment
- Land farming
- Road spreading
- Thermal Desorption
- Land Fill
- Stabilization/Encapsulation

Bio Treatment:

Was eliminated due to the fact that it requires moderate climate to be effective, and requires long term management.

Bio also needs a large area for treatment

Land Farming:

Was eliminated because it required moderate climate to be effective, required long term management and a huge area for treatment

•Road Spreading:

Was eliminated because it required some significant preparation and management

Road spreading also required a substantial area for treatment

Thermal Desorption:

Was eliminated due to a lack of any readily available fuel gas source, and the fact that most of the available equipment required the contamination to be under 2% hydrocarbon content

Land Fill:

Was eliminated due to the extensive transportation required, and the fact that this option is poor long term Risk Management

Stabilization/Encapsulation:

Was chosen because it was relatively inexpensive, and had no threshold for hydrocarbon content.

Once treated to acceptable levels (Alberta Tier 1) the treated material could be left on site.

A contractor was chosen to perform the treatment based on his ability to supply a pug mill mixer, capable of applying a predetermined formula on a constant basis

The project was set up for approximately 40 hours treatment time, however due to the nature of the pit the contractor was only able to treat half of the material in 18 days

The large rocks, timbers and other debris made material handling problematic.

There was also a timing problem, a pipeline was due to arrive on location in three days and there was still half of the material left, the most debris laden half.

A decision was made to attempt to pit mix the remaining material rather than try to sort out the debris

The QA/QC was handled by determining the remaining quantity and applying the stabilizer to the pit en masse.

Water and Portland Cement were then added and the amalgam was mixed for 20 hours with a common backhoe


KOMATSU

Lab analysis indicated that the pit method results were consistent with the pug mill method

Both methods reduced the contaminated material to Tier 1 levels.


00 6 19

Conclusions:

Due to the nature of remote areas and the difficulties of material found in remote locations, Equipment should be robust enough to handle all material problems.

The treatment methods should be kept simple.

Equipment, consumables, and fuel required should be kept to a minimum

A mechanical attachment added to the backhoe will decrease mixing time and increase mechanical contact, which ensures treatment quality