

TarSands.doc , 15 Sept 2010

<http://www.nasw.org/users/swarm/how.html>

<http://www.heavyoil.utah.edu/>

<http://www.heavyoil.utah.edu/outreach.html>

Township/range to lat,long

<http://www.earthpoint.us/Townships.aspx>

Section S35 T15S R23E

Meridian Salt Lake

State Utah

Source [BLM](#)

39 27 54.32 x 109 18 13.06

GPS observed EER site on Seep Ridge Rd, WGS84 base: lat 39 27 53.1; long 109 17 59.1; Elev 7700'

[http://tlamap.trustlands.utah.gov/plat/MapView.aspx?](http://tlamap.trustlands.utah.gov/plat/MapView.aspx?mer=26&township=15.0S&range=23.0E&place=&classID=&number=&suffix=&layer=&actionType=township)

[mer=26&township=15.0S&range=23.0E&place=&classID=&number=&suffix=&layer=&actionType=township](http://tlamap.trustlands.utah.gov/plat/MapView.aspx?mer=26&township=15.0S&range=23.0E&place=&classID=&number=&suffix=&layer=&actionType=township)
[Range&selPlat=null](http://tlamap.trustlands.utah.gov/plat/MapView.aspx?mer=26&township=15.0S&range=23.0E&place=&classID=&number=&suffix=&layer=&actionType=township)

SITLA leases to EER:

ML49579 , 50 acres, 1/1/2005

ML49927 , 4319 acres, 7/1/2005

ML51705 , 1560 acres, 2/1/2005

9 Oct 2010 Field trip; water quality results, using PondCare test kit:

pH = 9, salty (> 0.24 %), no ammonia, no nitrates

DOGM materials

All of our public documents related to the PR Springs Mine can be found at <http://ogm.utah.gov/fs/mineralsfilesbypermit.php?M0470090> .

The approved Notice of Intention to Commence Large Mining Operations can be found at:
<https://fs.ogm.utah.gov/FILES/MINERALS/PERMITS/047/M0470090/2009/NOI/09192009apv/0001.pdf>

When prompted for a user name and password, enter ogmquest in both fields.

<http://waterrights.utah.gov/cblapps/wrprint.exe?wrnum=49-495>

Please be aware that the claim under this Water Right Number has NOT been established in accordance with statute and

its validity is in question. Therefore, CAUTION is advised when relying upon this record!!!

FLOW: 0.015 cfs

SOURCE: Meadow Spring

No well water rights in area found. All other rights are surface, small volumes, eg < 0.5 cfs or often < 0.2 cfs

<http://www.earthenergyresources.com/corporate.htm>

Earth Energy Resources Executive Team

Mr. Kevin Ophus

Director & Chief Technology Officer

Mr. Ophus is the inventor of the Ophus Process, which is the foundation of the Earth technology. Kevin Ophus has over 20 years experience in oilfield operations. He has a wealth of knowledge in solving oilfield productions problems, including the use of catalysts. As General Manager and part owner of an oilfield service company, Kevin was in charge of oil well treatments (paraffin, asphaltenes, scale removal etc.) tank cleaning and sales.

Mr. D. Glen Snarr, C.A.

President & Chief Financial Officer

Since 1994, Glen Snarr has been involved in the senior financial management of numerous companies as Vice President of Finance at BanCor Inc., a successor company to Travis Chemicals Inc. He was treasurer of Decarson Rentals (2000) Inc. until it was sold to Builders Energy Services Trust in January 2005. Glen is currently a director of ESG Filtration Ltd. and CFO of Storage Management Inc. Prior to joining Travis in 1994, Glen worked 13 years for Deloitte and Touche Chartered Accountants where he concentrated on mergers & acquisitions, public company auditing and reporting.

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Much is claimed, independent lab, 2 trials claimed, no proof published.

<http://www.earthenergyresources.com/faq.htm>

Our technology is designed around 1,000 BOPD daily extraction modules. – ie contaminated soil. These fully mobile modules can be assembled in three to four months and transported directly to the worksite, anywhere in the world. It is estimated that the creation of a turnkey operation using Earth Energy modules would cost \$3 to \$4 million US.

<http://www.earthenergyresources.com/technology.htm>

results of 2005 Utah field test

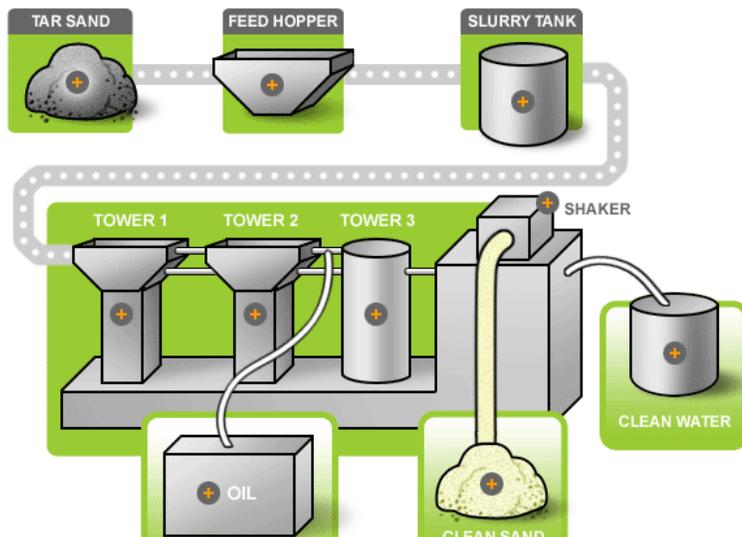
http://www.earthenergyresources.com/current_news_32.htm

Technology

The extraction process begins when the tar sand is sent through a crusher and reduced to 3/4 inch crush. From there, the sand travels to a water/sand slurry where the catalyst solution is introduced and mixed with a pump specially designed for this process. Once mixed, the slurry travels to the first recovery tower where the tar is pulverized and individual grains of sand are exposed to the catalyst. Oil separates from the slurry and floats to the top while the slurry continues to the second recovery tower where the sand is pulverized and immersed in catalyst for a second time. The oil is captured and sent to the sales tank.

The sand that is produced and the solution containing the catalyst travel to a third tower while the soiled fluids are recycled to the clean water system. The clean water is then sent to the initial injection point in front of the crusher, where additional catalyst solution is added to bring it back to full strength. The sand passes over a shaker that removes most of the water and is then conveyed away and piled. That sand and clays can then be sold, returned to the open pit or mixed with the overburden. At this point the sand and clays are 98.22% by weight and the remaining 0.29% or less are hydrocarbons, based on independent laboratory tests.

Process Diagram



Archived news

Earth Energy Resources with the State of Utah Trust Lands Administration have entered into what is a groundbreaking lease agreement. This finds, Earth Energy Resources to be the only oil sands extraction company to hold a lease on State lands. This contract clearly places Earth Energy as a front runner in the highly competitive oil sands industry. With approximately two million barrels of reserves in Earth Energy Resource's first lease, and over eight billion barrels available in Utah, Earth Energy looks forward to continued growth in the State of Utah.

July 14, 2006

Earth Energy Resources is pleased to report on its second quarter 2006 activities.

During the quarter, the Company continued to perform batch test runs on both Athabasca and Utah oil sand. Modifications to the shop demonstration unit were made and continue to be made to delineate the most favourable economic operating parameters. To facilitate ongoing development and to ensure that the Ophus Process is designed to fully accommodate the characteristics of Utah oil sands, the Company arranged for and received delivery of 25 tons of oil sand from Utah to its Grande Prairie facility.

Oil sands are known to and do vary significantly from deposit to deposit and that is true of the oil sands in Utah and those found in the Athabasca region in Alberta. It is important that the Ophus Process be developed to

process different sources and be designed to accommodate feedstock from all anticipated sources where the Company expects to operate. While the Company intends to return to Utah to operate its prototype production equipment, it is much more cost effective to conduct the development in the controlled environment of the Company's facility in Grande Prairie. The facility is fully equipped with laboratory equipment and personnel to more rapidly advance the development compared to remote field situations where access to power, water and necessary industrial support services are limited.

Late in the quarter, Earth Energy Resources added 1,808 additional acres of land to its land position in PR Spring, Utah, bringing its total acreage under lease in PR Spring to 5,930 acres. These additional lands are contiguous to the Company's current land position, further strengthening the economic commercial viability of PR Spring. During the third quarter, Earth Energy Resources will have several initiatives underway:

- Expand the batch capability of the shop demonstration unit to full recirculating capability with ore conditioning equipment and fluids separation and handling equipment on the output streams. Completing the expansion will allow the Company to run the shop demonstration unit on a continuous basis, facilitating fine tuning of process variables and associated economics. Additional testing will verify the effects associated with variable process water chemistry and other factors arising from the recirculation of process chemicals.
- Continue its work with the Utah State Department of Natural Resources for a large mining permit, covering production of its 5,930 acres of land in PR Spring. We expect that one year will be required to complete the application process; ensuring full access to our resources is available for commercial production in 2007.
- Decide on the timing of a second production test on its site in PR Spring, Utah. With the acquisition of 25 tons of Utah oil sand, the Company is able to conduct testing in its Grande Prairie facility in a more cost effective and time efficient manner than could be achieved in a field production test.
- Conduct a resistivity (Electrical Resistance Tomography - ERT) survey on 450 acres of the PR Spring leases with results correlated to log data from existing core holes. The Company will engage Worley Parsons Komex (WPK) to carry out the resistivity survey. A full resource estimate (for entire lease holdings), with certified results, will be completed after the next financing.
- Evaluate and selectively add to its land base, focusing on assets that can sustain a long term surface mining operation.
- Investigate local sources of water in PR Spring for production purposes, including obtaining an allocation of water rights from the State of Utah.
- Secure access to the local natural gas gathering system as a source of fuel for energy requirements
- Evaluate production opportunities in the Athabasca region of Alberta, Canada.
- Continue financing initiatives to properly capitalize the Company which, at this time is anticipated to include a \$15 million round of financing in the fourth quarter of 2006 followed by a second and larger round in 2007 or 2008 as needs dictate. The first round, which may be private equity or an initial public offering, will be primarily used to procure and fabricate the commercial production unit and to fund all associated activities which include the resource estimate on the Company's entire land holdings, completion of the large mine permit, environmental studies, process water acquisition and mine planning and pre-production activities.

Tar sands basics

<http://ostseis.anl.gov/guide/tarsands/index.cfm>

<http://ostseis.anl.gov/index.cfm>

<http://ostseis.anl.gov/guide/maps/index.cfm>

http://en.wikipedia.org/wiki/Tar_sands

In addition to being much smaller than the oil sands deposits in Alberta, Canada, the U.S. oil sands are hydrocarbon wet, whereas the Canadian oil sands are water wet. As a result of this difference, extraction techniques for the Utah oil sands will be different than those used for the Alberta oil sands. A considerable

amount of research has been done in the quest for commercially viable production technology to be employed in the development of the Utah oil sands. A special concern is the relatively arid climate of eastern Utah, as a large amount of water may be required by some processing techniques.^[16] **Section 526 of the Energy Independence And Security Act prohibits United States government agencies from buying oil produced** by processes that produce more greenhouse gas emissions than would traditional petroleum including oil sands.^[27]
^[28]

After excavation, hot water and [caustic soda](#) (NaOH) is added to the sand, and the resulting slurry is piped to the extraction plant where it is agitated and the oil skimmed from the top.^[35] Provided that the water chemistry is appropriate to allow bitumen to separate from sand and clay, the combination of hot water and agitation releases bitumen from the oil sand, and allows small air bubbles to attach to the bitumen droplets. The bitumen froth floats to the top of separation vessels, and is further treated to remove residual water and fine solids. [Bitumen](#) is much thicker than traditional [crude oil](#), so it must be either mixed with lighter petroleum (either liquid or gas) or chemically split before it can be transported by pipeline for upgrading into synthetic crude oil. The bitumen is then transported and eventually upgraded into synthetic crude oil. About two tons of oil sands are required to produce one barrel (roughly 1/8 of a ton) of oil. Originally, roughly 75% of the bitumen was recovered from the sand. However, recent enhancements to this method include [Tailings Oil Recovery \(TOR\)](#) units which recover oil from the [tailings](#), [Diluent Recovery Units](#) to recover [naptha](#) from the froth, [Inclined Plate Settlers \(IPS\)](#) and [disc centrifuges](#). These allow the extraction plants to recover well over 90% of the bitumen in the sand. After oil extraction, the spent sand and other materials are then returned to the mine, which is eventually reclaimed....

It is estimated that approximately 90% of the Alberta oil sands and nearly all of Venezuelan sands are too far below the surface to use [open-pit mining](#). Several [in-situ](#) techniques have been developed to extract this oil.^[37]

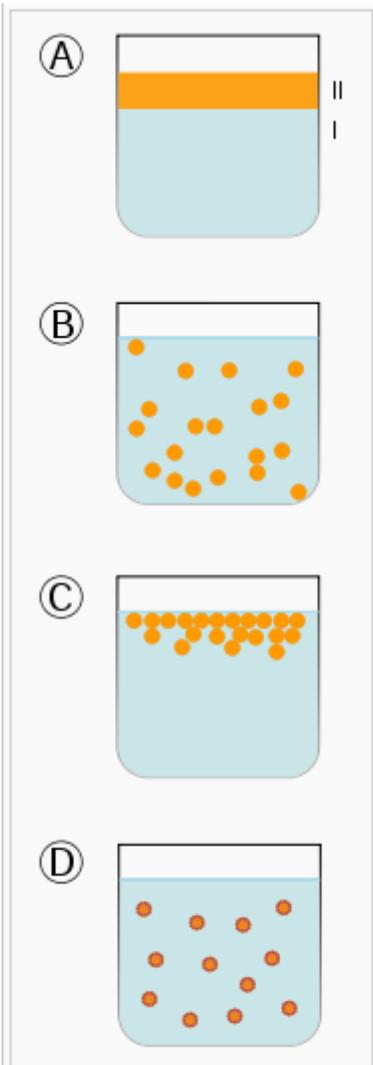
Clark process

http://www.abheritage.ca/abresources/innovation/research_oilsands_clark.html

Enter Dr. Karl Clark, a chemist with the Alberta Research Council. In 1929, Clark patented a hot water and caustic soda mixture for the extraction of bitumen from oil sands. He fed the mined oil sands into a large rotating drum, then mixed them under high temperatures with steam, hot water and caustic soda to separate sand and bitumen. The resulting liquid could then be processed further and upgraded into [synthetic crude](#) oil.

chemical engineering) Softening of water by adding alkaline solutions of calcium hydroxide so that the acid carbonates are converted to normal carbonates.

connate fluids, wiki: The term **connate fluids** in the context of [geology](#), and of [sedimentology](#) in particular, refers to the liquids that were trapped in the pores of [sedimentary rocks](#) as they were deposited. These liquids are largely composed of [water](#), but also contain many [mineral](#) components as ions in [solution](#).



- A. Two immiscible liquids, not yet emulsified.
- B. An emulsion of Phase II dispersed in Phase I.
- C. The unstable emulsion progressively separates.
- D. The surfactant (purple outline around particles) positions itself on the interfaces between Phase II and Phase I, stabilizing the emulsion

<http://www.freshpatents.com/Removal-of-hydrocarbons-from-particulate-solids-dt20080717ptan20080169222.php>

Abstract: A process and composition for removing heavy oil and bitumen from oil sands is disclosed. The composition comprises an emulsion of d-limonene and water, with an anionic surfactant as an emulsifying agent. The emulsion is contacted with an oil sand slurry until the aqueous and hydrocarbon phases separate. The process may take place at temperatures less than about 80° C. (end of abstract)

See Chem textbook, pg119 for CO₂ production from acid+(base=carbonate) reaction

See Chem textbood, pg 703, for water softening

<http://www.chem1.com/CQ/hardwater.html>

Use heat:

One class of impurity that is of special interest is "hardness". This refers to the presence of dissolved ions, mainly of calcium Ca²⁺ and magnesium Mg²⁺ which are acquired through contact with rocks and sediments in the environment. The positive electrical charges of these ions are balanced by the presence of anions (negative ions), of which bicarbonate HCO₃⁻ and carbonate CO₃²⁻ are most important. These ions have their origins in limestone sediments and also from carbon dioxide which is present in all waters exposed to the atmosphere and especially in groundwaters.

This refers to hardness whose effects can be removed by boiling the water in an open container. Such waters have usually percolated through limestone formations and contain bicarbonate HCO₃⁻ along with small amounts of carbonate CO₃²⁻ as the principal negative ions. Boiling the water promotes the reaction



by driving off the carbon dioxide gas. The CO₃²⁻ reacts with Ca²⁺ or Mg²⁺ ions, to form insoluble calcium and magnesium carbonates which precipitate out. By tying up the metal ions in this way, the amounts available to form soap scum are greatly reduced.

Or use lime:

<http://www.usbr.gov/pmts/water/publications/reportpdfs/Primer%20Files/07%20-%20Lime%20Softening.pdf>

http://www.gewater.com/handbook/ext_treatment/ch_7_precipitation.jsp

A **colloid** is a substance microscopically dispersed evenly throughout another one.^[1]

A colloidal system consists of two separate phases: a *dispersed phase* (or *internal phase*) and a *continuous phase* (or *dispersion medium*). A colloidal system may be [solid](#), [liquid](#), or [gaseous](#).

Many familiar substances are colloids, as shown in the [chart](#) below. As well as these naturally occurring colloids, modern chemical process industries utilize [high shear mixing technology](#) to create novel colloids.

The dispersed-phase particles have a diameter of between approximately 5 and 200 [nanometers](#).^[2] Such particles are normally invisible to an optical [microscope](#), though their presence can be confirmed with the use of an [ultramicroscope](#) or an [electron microscope](#). [Homogeneous](#) mixtures with a dispersed phase in this size range may be called *colloidal aerosols*, *colloidal emulsions*, *colloidal foams*, *colloidal dispersions*, or *hydrosols*. The dispersed-phase particles or droplets are affected largely by the [surface chemistry](#) present in the colloid.

Some colloids are translucent because of the [Tyndall effect](#), which is the scattering of light by particles in the colloid. Other colloids may be opaque or have a slight color.

An **emulsion** (pronounced [/iˈmʌljən/](#)^[1]) is a mixture of two or more [immiscible](#) (unblendable) liquids.

Emulsions are part of a more general class of two-phase systems of matter called [colloids](#). Although the terms colloid and emulsion are sometimes used interchangeably, emulsion tends to imply that both the dispersed and

the continuous phase are [liquid](#). In an emulsion, one liquid (the dispersed [phase](#)) is [dispersed](#) in the other (the continuous phase).

Examples of emulsions include [vinaigrettes](#), the photo-sensitive side of [photographic film](#), [milk](#) and [cutting fluid](#) for [metal working](#).

Flocculation is, in the field of [chemistry](#), a process where [colloids](#) come out of [suspension](#) in the form of floc or flakes. The action differs from [precipitation](#) in that, prior to flocculation, colloids are merely suspended in a liquid and not actually dissolved in a [solution](#). In the flocculated system there is no formation of a cake since all the flocs are in the suspension.

According to the [IUPAC](#) definition, flocculation is "a process of contact and adhesion whereby the particles of a dispersion form larger-size clusters." Flocculation is synonymous with [agglomeration](#) and [coagulation](#).^[1]

Precipitation is the formation of a [solid](#) in a [solution](#) or inside another solid during a [chemical reaction](#) or by [diffusion](#) in a solid. When the reaction occurs in a liquid, the solid formed is called the **precipitate**, or when compacted by a [centrifuge](#), a **pellet**. The liquid remaining above the solid is in either case called the **supernate** or **supernatant**. Powders derived from precipitation have also [historically](#) been known as **flowers**.

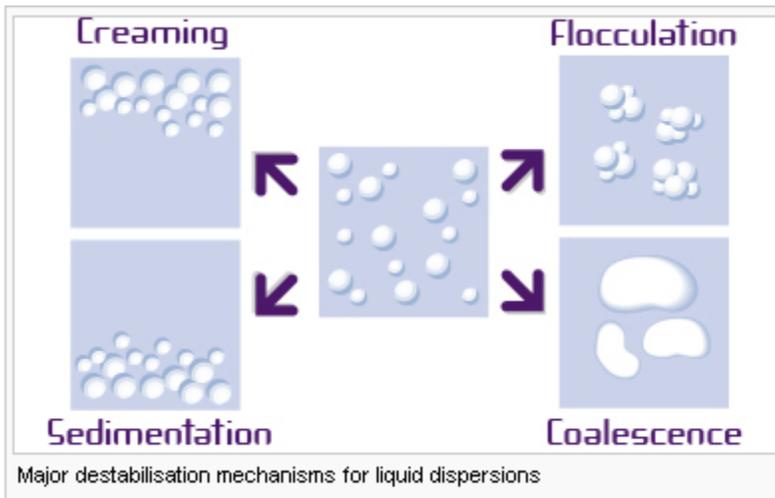
Natural methods of precipitation include [settling](#) or [sedimentation](#), where a solid forms over a period of time due to ambient forces like gravity or [centrifugation](#). During chemical reactions, precipitation may also occur particularly if an [insoluble](#) substance is introduced into a solution and the density happens to be greater (otherwise the precipitate would float or form a [suspension](#)). With soluble substances, precipitation is accelerated once the solution becomes [supersaturated](#)

Sedimentation is the tendency for [particles](#) in [suspension](#) to settle out of the fluid in which they are entrained, and come to rest against a barrier. This is due to their motion through the fluid in response to the forces acting on them: these forces can be due to [gravity](#), [centrifugal acceleration](#) or [electromagnetism](#). In geology sedimentation is often used as the polar opposite of erosion, i.e., the terminal end of [sediment transport](#). In that sense it includes the termination of transport by [saltation](#) or true [bedload transport](#). [Settling](#) is the falling of suspended particles through the liquid, whereas sedimentation is the termination of the settling process.

In [chemistry](#), a **suspension** is a heterogeneous fluid containing solid particles that are sufficiently large for [sedimentation](#). Usually they must be larger than 1 micrometer.^[1] The internal phase (solid) is dispersed throughout the external phase (fluid) through mechanical [agitation](#), with the use of certain excipients or suspending agents. Unlike [colloids](#), suspensions will eventually settle. An example of a suspension would be sand in water. The suspended particles are visible under a microscope and will settle over time if left undisturbed. This distinguishes a suspension from a [colloid](#), in which the suspended particles are smaller and do not settle.^[2] Colloids and suspensions are different from solutions, in which the dissolved substance (solute) does not exist as a solid, and solvent and solute are homogeneously mixed.

Creaming, in the [laboratory](#) sense, is the [migration](#)^[disambiguation needed] of the [dispersed phase](#) of an [emulsion](#), under the influence of [buoyancy](#). The [particles](#) float upwards or sink, depending on how large they are and how much less [dense](#) or more dense they may be than the continuous phase, and also how viscous or how thixotropic the [continuous phase](#) might be. For as long as the particles remain separated, the process is called creaming.

Where it is important that either the form or the concentration of the emulsion should be stable, it is desirable that the continuous and the dispersed phases should have similar densities, and it also is desirable that the continuous phase should be viscous or thixotropic. [Thixotropy](#) is particularly valuable in paints, sauces, and similar products, partly because it counteracts tendencies towards creaming. It also is important that the particles be as small as practicable because that reduces their tendency to migrate under the influence of buoyant forces. The electric charges on their surfaces should preferably tend to be uniform, so that the particles repel rather than attract each other.



These destabilisations can be classified into two major processes:

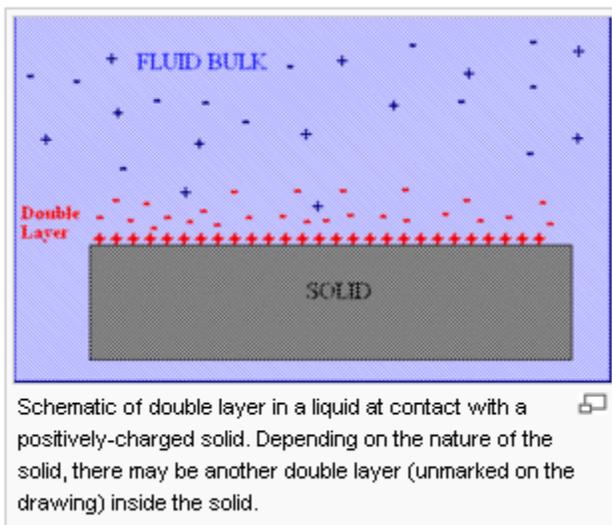
- 1-Migration phenomena : whereby the difference in density between the continuous and dispersed phase, leads to gravitational phase separation. In the case of suspensions [sedimentation](#) occurs as the dispersed phase is denser than the continuous phase.
- 2-Particle size increase phenomena: whereby the suspended particles join together and increase in size. Below are the two types of this phenomena.

- reversibly ([flocculation](#))
- irreversibly ([aggregation](#))

Particle aggregation in [materials science](#) is direct mutual attraction between particles ([atoms](#) or [molecules](#)) via [van der Waals forces](#) or [chemical bonding](#).

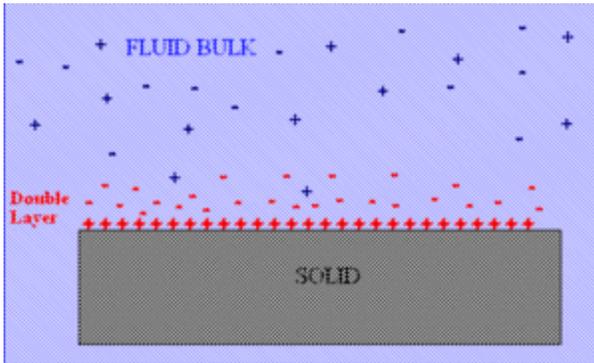
When there are collisions between particles in fluid, there are chances that particles will attach to each other and become larger particle. There are 3 major physical mechanisms to form aggregate: Brownian motion, Fluid shear and differential settling.

coalescence is a process in which two phase domains of the same composition come together and form a larger phase domain.



double layer (DL), also called an **electrical double layer, EDL**) is a structure that appears on the surface of an object when it is placed into a liquid. The object might be a solid particle, a gas bubble, a liquid [droplet](#), or a [porous body](#). The DL refers to two parallel layers of charge surrounding the object. The first layer, the [surface](#)

[charge](#) (either positive or negative), comprises ions [adsorbed](#) directly onto the object due to a host of chemical interactions. The second layer is composed of ions attracted to the surface charge via the coulomb force, electrically screening the first layer. This second layer is loosely associated with the object, because it is made of free ions which move in the fluid under the influence of [electric attraction](#) and [thermal motion](#) rather than being firmly anchored. It is thus called the **diffuse layer**.



Schematic of double layer in a liquid at contact with a positively-charged solid. Depending on the nature of the solid, there may be another double layer (unmarked on the drawing) inside the solid.

[Interfacial](#) DL is usually most apparent in systems with a large ratio of surface area to volume, such as [colloid](#) or porous bodies with particles or pores (respectively) on the scale of micrometres to nanometres. However, the importance of DLs extends to other systems, e.g., DL is fundamental to the [electrochemical](#) behavior of [electrodes](#).

The DL plays a fundamental role in many real-world systems. For instance, milk exists only because fat droplets are covered with a DL that prevent their [coagulation](#) into butter. DLs exist in practically all [heterogeneous](#) fluid-based systems, such as blood, paints, inks, ceramic slurries and cement slurries.

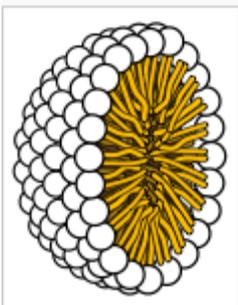
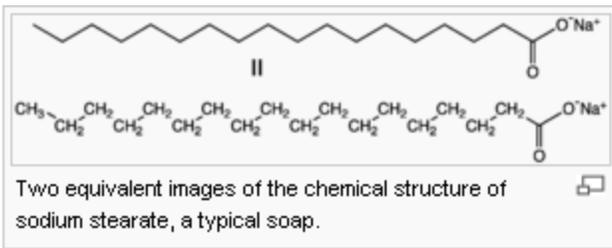
Zeta potential is a scientific term for [electrokinetic potential](#) in [colloidal systems](#). In the colloidal chemistry literature, it is usually denoted using the Greek letter [zeta](#), hence ζ -potential. From a theoretical viewpoint, zeta potential is [electric potential](#) in the interfacial [double layer](#) (DL) at the location of the [slipping plane](#) versus a point in the bulk fluid away from the interface. In other words, zeta potential is the potential difference between the [dispersion medium](#) and the stationary layer of fluid attached to the [dispersed particle](#).

A value of 25 mV (positive or negative) can be taken as the arbitrary value that separates low-charged surfaces from highly-charged surfaces.

The significance of zeta potential is that its value can be related to the stability of colloidal dispersions (e.g., a multivitamin syrup). The zeta potential indicates the degree of repulsion between adjacent, similarly charged particles (the vitamins) in a dispersion. For molecules and particles that are small enough, a high zeta potential will confer stability, i.e., the solution or dispersion will resist aggregation. When the potential is low, attraction exceeds repulsion and the dispersion will break and flocculate. So, colloids with high zeta potential (negative or positive) are electrically stabilized while colloids with low zeta potentials tend to [coagulate](#) or [flocculate](#) as outlined in the table.^[1]

Zeta potential [mV] Stability behavior of the colloid

from 0 to ± 5 ,	Rapid coagulation or flocculation
from ± 10 to ± 30	Incipient instability
from ± 30 to ± 40	Moderate stability
from ± 40 to ± 60	Good stability
more than ± 61	Excellent stability



Structure of a micelle, a cell-like structure formed by the aggregation of soap subunits (such as sodium stearate). The exterior of the micelle is hydrophilic (attracted to water) and the interior is hydrophobic (dissolves grease).

In [chemistry](#), an **amphoteric** substance is one that can react as either an [acid](#) or [base](#).^[1] The word is derived from the Greek word amphoterai (ἀμφότεροι) meaning "both". Many metals (such as [zinc](#), [tin](#), [lead](#), [aluminium](#), and [beryllium](#)) and most [metalloids](#) have amphoteric oxides or hydroxides.

A **reagent** is a "substance or compound that is added to a system in order to bring about a [chemical reaction](#) or is added to see if a reaction occurs".^[1] Such a reaction is used to confirm the presence of another substance. Examples of such *analytical reagents* include [Fehling's reagent](#), [Millon's reagent](#) and [Tollens' reagent](#).

When used for cleaning, soap serves as a [surfactant](#) in conjunction with [water](#). The cleaning action of this mixture is attributed to the action of [micelles](#), tiny spheres coated on the outside with polar carboxylate groups, encasing a hydrophobic (lipophilic) pocket that can surround the grease particles, allowing them to dissolve in water. The hydrophobic portion is made up of the long [hydrocarbon](#) chain from the fatty acid. In other words, whereas normally oil and water do not mix, the addition of soap allows oils to dissolve in water, allowing them to be rinsed away. Synthetic [detergents](#) operate by similar mechanisms to soap.

Some commonly encountered surfactants of each type include:

- Ionic
 - [Anionic](#): based on permanent anions ([sulfate](#), [sulfonate](#), [phosphate](#)) or pH-dependent anions ([carboxylate](#)):
 - Sulfates:
 - Alkyl sulfates: [ammonium lauryl sulfate](#), [sodium lauryl sulfate](#) (SDS);

- Alkyl ether sulfates: [sodium laureth sulfate](#), also known as sodium lauryl ether sulfate (SLES), [sodium myreth sulfate](#);
- Sulfonates:
 - [Docusates](#): [dioctyl sodium sulfosuccinate](#);
 - Sulfonate fluorosurfactants: [perfluorooctanesulfonate](#) (PFOS), [perfluorobutanesulfonate](#);
 - Alkyl benzene sulfonates;
- Phosphates:
 - Alkyl aryl ether phosphate
 - Alkyl ether phosphate
- Carboxylates:
 - Alkyl carboxylates: [Fatty acid salts](#) (soaps): [sodium stearate](#);
 - [Sodium lauroyl sarcosinate](#);
 - Carboxylate fluorosurfactants: [perfluorononanoate](#), [perfluorooctanoate](#) (PFOA or PFO)...

A **slurry** is, in general, a thick [suspension](#) of solids in a liquid.

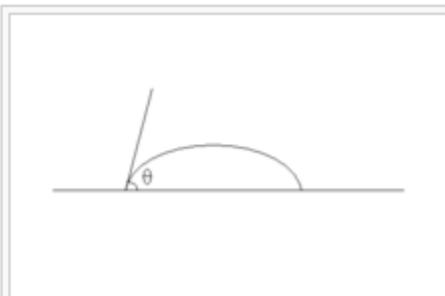


Figure 1: Droplet of water on an ideal surface.

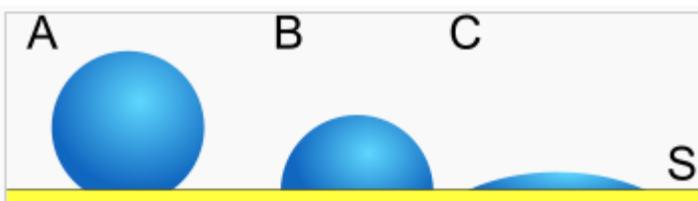


Figure 2: Wetting of different fluids. A shows a fluid with very little wetting, while C shows a fluid with more wetting. A has a large contact angle, and C has a small contact angle.

Explanation

[Adhesive](#) forces between a [liquid](#) and [solid](#) cause a liquid drop to spread across the [surface](#). [Cohesive](#) forces within the liquid cause the drop to ball up and avoid contact with the surface.

Contact angle	Degree of wetting	Strength of:	
		Sol./Liq. interactions	Liq./Liq. interactions
$\theta = 0$	Perfect wetting	strong	weak

$0 < \theta < 90^\circ$	high wettability	strong	strong
		weak	weak
$90^\circ \leq \theta < 180^\circ$	low wettability	weak	strong
$\theta = 180^\circ$	perfectly non-wetting	weak	strong

Figure 2: Wetting of different fluids. *A* shows a [fluid](#) with very little wetting, while *C* shows a fluid with more wetting. *A* has a large contact angle, and *C* has a small contact angle.

The [contact angle](#) (θ), as seen in Figure 1, is the angle at which the liquid-vapor interface meets the solid-liquid interface. The contact angle is determined by the resultant between adhesive and cohesive forces. The tendency of a drop to spread out over a flat, solid surface increases as the contact angle decreases. Thus, the contact angle provides an inverse measure of wettability.^[1]

A contact angle less than 90° (low contact angle) usually indicates that wetting of the surface is very favorable, and the fluid will spread over a large area of the surface. Contact angles greater than 90° (high contact angle) generally means that wetting of the surface is unfavorable so the fluid will minimize contact with the surface and form a compact liquid droplet.

Iron chloride:

In industrial application, iron(III) chloride is used in [sewage treatment](#) and [drinking water production](#).^[9] In this application, FeCl_3 in slightly basic water reacts with the [hydroxide](#) ion to form a [floc](#) of iron(III) hydroxide, or more precisely formulated as $\text{FeO}(\text{OH})^-$, that can remove suspended materials.



Froth is [foam](#) consisting of [bubbles](#) in a [liquid](#).

A **foam** is a substance that is formed by trapping many gaseous [bubbles](#) in a [liquid](#) or [solid](#).

A **bubble** is a [globule](#) of one substance in another, usually [gas](#) in a [liquid](#). Due to the [Marangoni effect](#), bubbles may remain intact when they reach the surface of the immersive substance.

A soap bubble can exist because the surface layer of a liquid (usually water) has a certain [surface tension](#), which causes the layer to behave somewhat like an [elastic](#) sheet. Soap film is extremely flexible and can produce waves based on the force exerted. However, a bubble made with a pure liquid alone is not stable and a dissolved [surfactant](#) such as soap is needed to stabilize a bubble. A common misconception is that soap increases the water's surface tension, soap actually does the opposite, decreasing it to approximately one third the surface tension of pure water. Soap does not *strengthen* bubbles, it *stabilizes* them, via an action known as the [Marangoni effect](#). As the soap film stretches, the surface concentration of soap decreases, which in turn causes the surface tension to increase, thus soap selectively strengthens the weakest parts of the bubble and tends to prevent them from stretching further. In addition, the soap reduces [evaporation](#), making the bubbles last longer, but this effect is relatively small.

The [American Petroleum Institute](#) gravity, or **API gravity**, is a measure of how heavy or light a [petroleum](#) liquid is compared to water. If its API gravity is greater than 10, it is lighter and floats on water; if less than 10, it is heavier and sinks. API gravity is thus an inverse measure of the relative density of a petroleum liquid and the density of water, but it is used to compare the relative densities of [petroleum liquids](#). For example, if one petroleum liquid

Terpenes (pronounced /ˈtɜrpiːn/ TUR-peen) are a large and varied class of [hydrocarbons](#), produced primarily by a wide variety of plants, particularly [conifers](#),^[1] though also by some insects such as termites or swallowtail butterflies, which emit terpenes from their [osmeterium](#).

An **aromatic hydrocarbon** or **arene** ^[1] (or sometimes **aryl hydrocarbon**)^[2] is a [hydrocarbon](#) characterized by general alternating double and single bonds between carbons. The term 'aromatic' was assigned before the physical mechanism determining [aromaticity](#) was discovered, and was derived from the fact that many of the compounds have a sweet scent. The configuration of six carbon atoms in aromatic compounds is known as a [benzene ring](#), after the simplest possible such hydrocarbon, [benzene](#). Aromatic hydrocarbons can be *monocyclic* (MAH) or *polycyclic* (PAH).

Limonene is a colourless liquid [hydrocarbon](#) classified as a cyclic [terpene](#) possessing a strong smell of [oranges](#). It is used in chemical synthesis as a precursor to [carvone](#) and as a renewably-based solvent in cleaning products.

Limonene takes its name from the [lemon](#), as the [rind](#) of the lemon, like other [citrus](#) fruits, contains considerable amounts of this compound, which contributes to their smell. Limonene is a [chiral](#) molecule, and biological sources produce one [enantiomer](#): the principal industrial source, citrus fruit, contains D-limonene ((+)-limonene), which is the (*R*)-[enantiomer](#) ([CAS number](#) 5989-27-5, [EINECS number](#) 227-813-5). [Racemic](#) limonene is known as dipentene.^[1] D-Limonene is obtained commercially by extraction from orange peel with liquid CO₂

Limonene is a relatively stable [terpene](#) and can be distilled without decomposition, although at elevated temperatures it [cracks](#) to form [isoprene](#).^[2] It oxidizes easily in moist air to produce [carveol](#) and [carvone](#).^[3] With sulfur, it undergoes dehydrogenation to *p*-[cymene](#).

Limonene is increasingly being used as a [solvent](#) for cleaning purposes, such as the removal of oil from machine parts, as it is produced from a renewable source (citrus oil, as a byproduct of [orange juice](#) manufacture). It also serves as a paint stripper when applied to painted wood. Limonene is also used as a solvent in some [model airplane](#) glues.

http://www.floridachemical.com/dlimonenechemical_constants.htm

Witconate P-1059 is an Alkyl aryl sulfonate. Witconate P-1059 penetrates the paraffin mass and chemically coats the small paraffin particles. Once coated, the particles are unable to adhere to metal surfaces or each other. These coated particles re-disperse into liquid hydrocarbon and remain suspended in the oil.

From patent app:

[0048] This compound's IUPAC name is (R)-4-isoprenyl-1-methylcyclohexene or p-mentha-1,8-diene. The structure shown above is of d-limonene which has a pleasing citrus odor. Its enantiomer l-limonene has a harsher odor more reminiscent of turpentine. The preferred compound for the present invention comprises d-limonene of Brazilian origin. D-limonene is also commonly sourced from Californian or Floridian origin.

A **chiral molecule** is a type of [molecule](#) that lacks an internal plane of [symmetry](#) and has a non-superimposable [mirror image](#). The feature that is most often the cause of [chirality](#) in molecules is the presence of an [asymmetric carbon atom](#).^{[1][2]}

In chemistry, racemization refers to partial conversion of one enantiomer into another..

Bitumen is a mixture of [organic liquids](#) that are highly [viscous](#), black, sticky, entirely soluble in [carbon disulfide](#), and composed primarily of highly condensed [polycyclic aromatic hydrocarbons](#).

http://en.wikipedia.org/wiki/Athabasca_oil_sands

http://en.wikipedia.org/wiki/Oil_sands#Extraction_process

According to the [National Energy Board](#), it requires about 1,200 cubic feet (34 m³) of natural gas to produce one barrel of bitumen from *in situ* projects and about 700 cubic feet (20 m³) for integrated projects.^[37] Since a [barrel of oil equivalent](#) is about 6,000 cubic feet (170 m³) of gas, this represents a large gain in energy. That being the case, it is likely that Alberta regulators will reduce exports of natural gas to the United States in order to provide fuel to the oil sands plants. As gas reserves are exhausted, however, oil upgraders will probably turn to bitumen [gasification](#) to generate their own fuel. In much the same way the bitumen can be converted into synthetic crude oil, it can also be converted into synthetic natural gas.

Making liquid fuels from oil sands requires energy for steam injection and refining. This process generates two to four times the amount of [greenhouse gases](#) per barrel of final product as the production of conventional oil.^[3] If combustion of the final products is included, the so-called "Well to Wheels" approach, oil sands extraction, upgrade and use emits 10 to 45% more greenhouse gases than conventional crude.^[4]

Utah has hard rock overburden, as opposed to Athabasca's unconsolidated peat bog.

http://www.oilsandsdiscovery.com/oil_sands_story/separation_demo.html

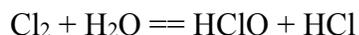
Temporary hardness is caused by a combination of calcium ions and bicarbonate ions in the water. It can be removed by boiling the water or by the addition of [lime \(calcium hydroxide\)](#). Boiling promotes the formation of carbonate from the bicarbonate and precipitates calcium carbonate out of solution, leaving water that is softer upon cooling.

The following is the equilibrium reaction when [calcium carbonate](#) (CaCO₃) is dissolved in water:



Upon heating, less CO₂ is able to dissolve into the water (see [Solubility](#)). Since there is not enough CO₂ around, the reaction cannot proceed from left to right, and therefore the CaCO₃ will not dissolve as rapidly. Instead, the reaction is forced to the left (i.e., products to reactants) to re-establish equilibrium, and solid CaCO₃ is formed. Boiling the water will remove hardness as long as the solid CaCO₃ that precipitates out is removed. After cooling, if enough time passes, the water will pick up CO₂ from the air and the reaction will again proceed from left to right, allowing the CaCO₃ to "re-dissolve" into the water.

Addition of [chlorine](#) to [water](#) gives both hydrochloric acid (HCl) and hypochlorous acid^[8]:



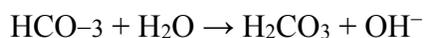
The presence of light or transition metal oxides of copper, nickel or cobalt accelerates the exothermic decomposition into [hydrochloric acid](#) and [oxygen](#)^[9]:



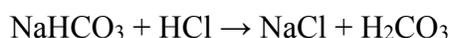
In [aqueous](#) solution, hypochlorous acid partially dissociates into the anion *hypochlorite* OCl⁻:



Sodium bicarbonate is an [amphoteric](#) compound. Aqueous solutions are mildly [alkaline](#) due to the formation of [carbonic acid](#) and [hydroxide](#) ion:



Sodium bicarbonate can be used as a wash to remove any acidic impurities from a "crude" liquid, producing a purer sample. Reaction of sodium bicarbonate and an [acid](#) to give a salt and carbonic acid, which readily decomposes to carbon dioxide and water:





<http://ostseis.anl.gov/guide/tarsands/index.cfm>

After mining, the tar sands are transported to an **extraction plant**, where a hot water process separates the bitumen from sand, water, and minerals. The separation takes place in **separation cells**. Hot water is added to the sand, and the resulting slurry is piped to the extraction plant where it is agitated. The combination of hot water and agitation releases bitumen from the oil sand, and causes **tiny air bubbles to attach to the bitumen** droplets, that float to the top of the separation vessel, where the bitumen can be skimmed off. Further processing removes residual water and solids. The bitumen is then transported and eventually upgraded into synthetic crude

Bitumen isn't particularly bonded to sand, just a stiff liquid at room temp

So we must only heat it up to make it flow out.

Bitumen is too heavy to float on its own, so surround a droplet of it in an air bubble

To get a stable supply of air bubbles, we need a foam, a froth, a lather, can't have hard water.

Thus, heat and NaOH to lower pH, remove Ca, Mg divalent cations.

Asphaltenes are molecular substances that are found in [crude oil](#), along with [resins](#), [aromatic hydrocarbons](#), and [alkanes](#) (i.e., saturated hydrocarbons).^{[1][2]} The word "asphaltene" was coined by [Boussingault](#) in 1837 when he noticed that the [distillation](#) residue of some [bitumens](#) had [asphalt](#)-like properties. Asphaltenes in the form of distillation products from [oil refineries](#) are used as "tar-mats" on roads.

From anl.gov links page,

http://en.wikipedia.org/wiki/Tailings_pond

Decantation is a process for the [separation of mixtures](#). This is achieved by carefully pouring a solution from a container in order to leave the [precipitate](#) ([sediments](#)) in the bottom of the original container. Usually a small amount of solution must be left in the container, and care must be taken to prevent a small amount of precipitate from flowing with the solution out of the container. It is generally used to separate a liquid from an [insoluble](#) solid (e.g. in red [wine](#), where the wine is decanted from the [potassium bitartrate](#) crystals).

Pond storage

Tailing ponds are areas of refused [mining](#) tailings where the water borne refuse material is pumped into a [pond](#) to allow the [sedimentation](#) (meaning separation) of solid particles from the water. The pond is generally impounded with a dam, and known as tailings impoundments or tailings dams. It was estimated in 2000 that there were about 3,500 active tailings impoundments in the world.^[5] The ponded water is of some benefit as it minimizes fine tailings from being transported by wind into populated areas where the toxic chemicals could be potentially hazardous to human health; however, it is also harmful to the environment. Tailing ponds are often somewhat dangerous because they attract wildlife such as waterfowl or caribou as they appear to be a natural pond, but they can be highly toxic and harmful to the health of these animals. Tailings ponds are used to store the waste made from separating minerals from rocks, or the slurry produced from oil sands mining. Tailings are sometimes mixed with other materials such as [bentonite](#) to form a thicker slurry that slows the release of impacted water to the environment.

There are many different subsets of this method, including valley impoundments, ring dikes, in-pit impoundments, and specially dug pits.^[3] The most common is the valley pond, which takes advantage of the

natural topographical depression in the ground.^[3] Large earthen dams may be constructed and then filled with the tailings. Exhausted open pit mines may be refilled with tailings. In all instances, due consideration must be made to contamination of the underlying water table, amongst other issues. Dewatering is an important part of pond storage, as the tailings are added to the storage facility the water is removed - usually by draining into decant tower structures. The water removed can thus be reused in the processing cycle. Once a storage facility is filled and completed, the surface can be covered with topsoil and revegetation commenced. However, unless a non-permeable capping method is used, water that infiltrates into the storage facility will have to be continually pumped out into the future.

Dry stacking

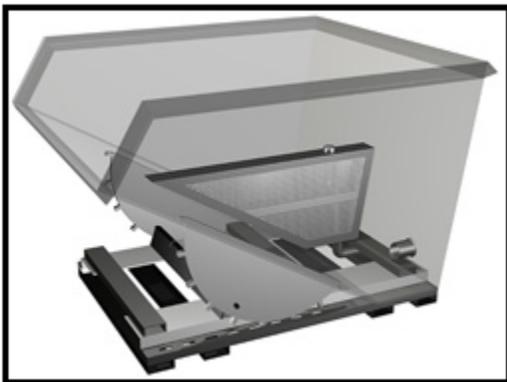
Tailings do not have to be stored in ponds or sent as slurries into oceans, rivers or streams. There is a growing use of the practice of dewatering tailings using vacuum or pressure filters so the tailings can then be stacked.^[9] This saves water, reduces the impacts on the environment in terms of space used, leaves the tailings in a dense and stable arrangement and eliminates the long-term liability that ponds leave after mining is finished.

Reducing water req'd for tailings

<http://www.freepatentsonline.com/3869384.html>

This invention has to do with the treatment of the tailings stream from a hot water extraction plant for recovering bitumen from tar sand. This stream comprises water and coarse and fine solids. The stream is fed into a mined-out cavity to settle the coarse solids. Some of the decanted water from the cavity is transferred to a large settling pond for clarification. The remainder of the decanted water is returned to the plant and added to the tailings stream to fluidize it and render it pumpable. The process has the following advantages: some of the fines become trapped in the beach of coarse sand formed in the cavity, thereby reducing the volume of sludge which is generated in the settling pond. The use of decanted water to fluidize the tailings issuing from the extraction process reduces the amount of water needed for the extraction process itself, thereby reducing the amount of clarified water required for the plant.

Dewatering hopper cccmix.com



Upgrading

http://en.wikipedia.org/wiki/Oil_sands#Extraction_process

This is because heavy crude feedstock needs pre-processing before it is fit for conventional refineries. This pre-processing is called 'upgrading', the key components of which are as follows:

1. removal of water, sand, physical waste and lighter products
2. catalytic purification by [hydrodemetallisation](#) (HDM), [hydrodesulfurization](#) (HDS) and [hydrodenitrogenation](#) (HDN)
3. hydrogenation through carbon rejection or [catalytic hydrocracking](#) (HCR)

As carbon rejection is very inefficient and wasteful in most cases, catalytic hydrocracking is preferred in most cases. All these processes take large amounts of energy and water, while emitting more carbon dioxide than conventional oil.

Athabaskan upgrading, via oilsandsdiscovery.com:

The oil in oil sand is called bitumen, a complex hydrocarbon made up of a long chain of molecules. In order for bitumen to be processed in refineries, this chain must be broken up and reorganized. Unlike smaller hydrocarbon molecules bitumen is carbon rich and hydrogen poor. Upgrading means removing some carbon while adding additional hydrogen to make more valuable hydrocarbon products. This is done using four main processes: coking removes carbon and breaks large bitumen molecules into smaller parts, distillation sorts mixtures of hydrocarbon molecules into their components, catalytic conversions help transform hydrocarbons into more valuable forms and hydrotreating is used to help remove sulphur and nitrogen and add hydrogen to molecules. The end product is synthetic crude oil, which is shipped by underground pipelines to refineries across North America to be refined further into jet fuels, gasoline and other petroleum products.

It must be noted that some of the oil companies pipe their bitumen south in diluted form for upgrading at other refineries. Others produce either a single high quality synthetic crude oil or multiple petroleum products to suit market feedstock demand.

Syncrude upgrading:

Raw bitumen is upgraded to synthetic crude by either vacuum distillation or in a coking process that removes part of the carbon content of the feedstock, producing hydrocarbon gases, naphtha and gas oils. An alternative route is to add hydrogen to the feedstock, so reducing the tonnage of surplus petroleum coke produced. Further treatment and blending gives Syncrude's principal product, Syncrude Sweet Blend crude oil, a high-naphtha, low-sulphur synthetic crude which is then sent to refineries in both Canada and the United States.

Utah pilot plant, 2000, SPE paper, \$25, not EER, another group, Asphalt Ridge, near Vernal

Viscosity there much higher than Athabasca, see below

<http://www.onepetro.org/mslib/servlet/onepetropreview?id=00086945&soc=SPE>

Study and Demonstration of a Process to Extract Bitumen from Utah Tar Sand

Authors Philip W. Coleman, DTE Energy Services, Inc.; R. Burk Adams, Consultant

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Language English

PreviewAbstract

The successful implementation of a demonstration scale, continuous flow, modified hot water process to extract bitumen from Utah tar sands has potentially significant economic implications to the future of mineable hydrocarbon production in the United States.

In 1999 and 2000 a 20-ton per hour demonstration facility was operated to definitively test all aspects of a proposed hot water extraction process to extract bitumen from the Asphalt Ridge tar sand deposit near Vernal, Utah. Detailed analysis was performed on oil-water emulsions, solvent losses to rejected solids, recycle water quality and bitumen extraction efficiency.

Although the process concept is similar to Canadian oil sand operations, a fundamental difference between the Asphalt Ridge demonstration process and commercial Canadian operations is the production of dry tailings. This area of the process also required detailed investigation and optimization.

The demonstration facility was operated as three processes: extraction, froth treatment and refining. Although these areas were not operated in concert due to available equipment sizes, each area was operated successfully to equilibrium and for significant time thereafter to prove steady state operation. The demonstration facility operation culminated in a 12 day, uninterrupted operation of the extraction process in September 2000.

The results of the study have concluded the demonstration process was operated long enough to achieve steady state conditions with an economic quantity of solvent losses and high bitumen extraction efficiency. Significant amounts of data were collected with which to design a full-scale extraction and froth treatment operation.

Introduction

In 1999 a pilot facility was installed at an existing heavy oil refinery for the purpose of extracting bitumen from the Asphalt Ridge tar sands located near Vernal, Utah. Asphalt Ridge is one of many known tar sands deposits located in the Uinta Basin. The pilot facility was designed and operated at approximately 20-ton per hour tar sands feed, resulting in bitumen production of approximately 250 bbls per day.

The process is a derivative of the Clark hot water extraction technology that has been in commercial operation in the Fort McMurray (Athabasca) region of Alberta for over 35 years. A comprehensive bench scale study of the Asphalt Ridge tar sands ore was undertaken in 1999. Based on the positive bench study results, it was decided to pursue operation of a fully integrated pilot facility at the site.

Although the process is derived from the Clark process used in Alberta, the Asphalt Ridge process contains some unique aspects. The most notable difference between the processes is the production of "stackable", dry sand and clay tailings from the Asphalt Ridge process versus the use of tailings pond impoundments in Alberta operations. It is also noteworthy that **Asphalt Ridge bitumen viscosity averages 10 to 100 times higher than Athabasca bitumen**, creating unique processing and handling challenges.

The pilot facility was operated from November 1999 through December 2000. The process operation was fully comprehensive and included mining, extraction, bitumen froth treatment, bitumen separation by distillation, continuous process water recycle, and stacking of the sand tailings back into the mine area. Bitumen recovery from the pilot facility ranged from 80 to 95%. Bitumen froth produced from the extraction plant was of very high quality (60% bitumen). The froth treatment circuit consistently produced refinery specification bitumen feed (<0.5% BS&W). Specification asphalt was produced from the refinery. Process water recycle was found to be a key operational issue and much of the piloting effort was focused on optimization of this circuit. Pilot operations culminated in a continuous 12 day run where recycle water solids and

Tar Sands Resources

Difficult to estimate resources in PR Springs / Hill Creek area

Utah Geological Society

<http://www.heavyoil.utah.edu/Conference/OilSands/2008/1-Gwynn-P.R.%20Spring.pdf>

<http://www.heavyoil.utah.edu/Conference/OilSands/2008/3-Baza-Utah%20DNR.pdf>

Permitted Tar Sand Activity in Utah

- As of the beginning of this year, DOGM had 15 individual tar sand applications or permits identified – all in Uintah County
- SITLA – 7, Private/fee – 9
- Note that these numbers do not include oil shale exploration or mining activities, but those activities are few at this time

Demonstration Unit Schematic (Simplified)

