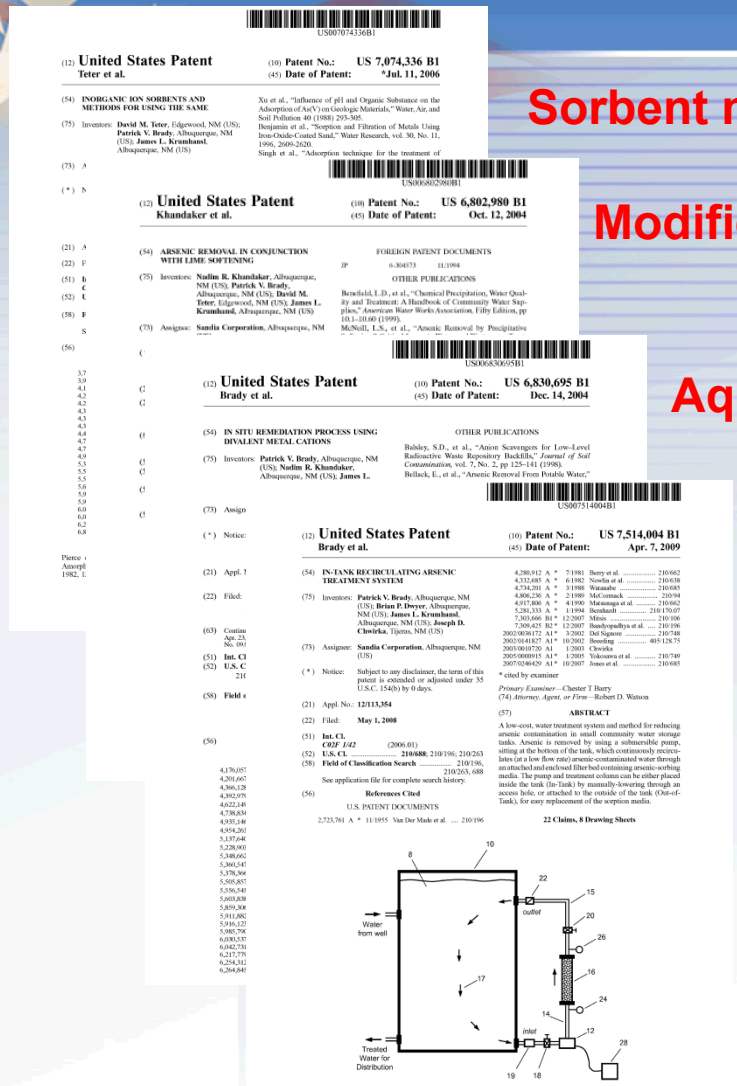
Treatment of Difficult Waters: Arsenic Removal, Silica Control, Carbon Capture, and Enhanced Oil Recovery

SAND2012-3479C

Patrick V. Brady



US007074336B1

(12) **United States Patent**
Teter et al.

(10) **Patent No.: US 7,074,336 B1**
(45) **Date of Patent: *Jul. 11, 2006**

(54) **INORGANIC ION SORBENTS AND METHODS FOR USING THE SAME**

(75) Inventors: **David M. Teter**, Edgewood, NM (US); **Patrick V. Brady**, Albuquerque, NM (US); **James L. Krumhansl**, Albuquerque, NM (US)

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(51) I C

(52) U

(58) F S

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(12) **United States Patent**
Khandaker et al.

(10) **Patent No.: US 6,802,980 B1**
(45) **Date of Patent: Oct. 12, 2004**

(54) **ARSENIC REMOVAL IN CONJUNCTION WITH LIME SOFTENING**

(75) Inventors: **Nadim R. Khandaker**, Albuquerque, NM (US); **Patrick V. Brady**, Albuquerque, NM (US); **David M. Teter**, Edgewood, NM (US); **James L. Krumhansl**, Albuquerque, NM (US)

(73) Assignee: **Sandia Corporation**, Albuquerque, NM

(56)

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(12) **United States Patent**
Brady et al.

(10) **Patent No.: US 6,830,695 B1**
(45) **Date of Patent: Dec. 14, 2004**

(54) **IN SITU REMEDIATION PROCESS USING DIVALENT METAL CATIONS**

(75) Inventors: **Patrick V. Brady**, Albuquerque, NM (US); **Nadim R. Khandaker**, Albuquerque, NM (US); **James L.**

(73) Assign

(*) Notice:

(21) Appl. N

(22) Filed:

(63) Continu
Apr. 23,
Sec. 120

(51) Int. Cl

(52) U.S. C
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(58) Field o

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(12) **United States Patent**
Brady et al.

(10) **Patent No.: US 7,514,004 B1**
(45) **Date of Patent: Apr. 7, 2009**

(54) **IN-TANK RECIRCULATING ARSENIC TREATMENT SYSTEM**

(75) Inventors: **Patrick V. Brady**, Albuquerque, NM (US); **Brian P. Dwyer**, Albuquerque, NM (US); **James L. Krumhansl**, Albuquerque, NM (US); **Joseph D. Chwirka**, Tijeras, NM (US)

(73) Assignee: **Sandia Corporation**, Albuquerque, NM (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **12/133,354**

(22) Filed: **May 1, 2008**

(51) **Int. Cl.**
C02F 1/42 (2006.01)

(52) **U.S. Cl.** **210/688**; 210/196; 210/263

(58) **Field of Classification Search** 210/196, 210/263, 688
See application file for complete search history.

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Primary Examiner—Chester T Barry
(74) *Attorney, Agent, or Firm*—Robert D. Watson

(57) **ABSTRACT**

A low-cost, water treatment system and method for reducing arsenic contamination in small community water storage tanks. Arsenic is removed by using a submersible pump, sitting at the bottom of the tank, which continuously recirculates (at a low flow rate) arsenic-contaminated water through an attached and enclosed filter bed containing arsenic-sorbing media. The pump and treatment column can be either placed inside the tank (In-Tank) by manually-lowering through an access hole, or attached to the outside of the tank (Out-of-Tank), for easy replacement of the sorption media.

22 Claims, 8 Drawing Sheets

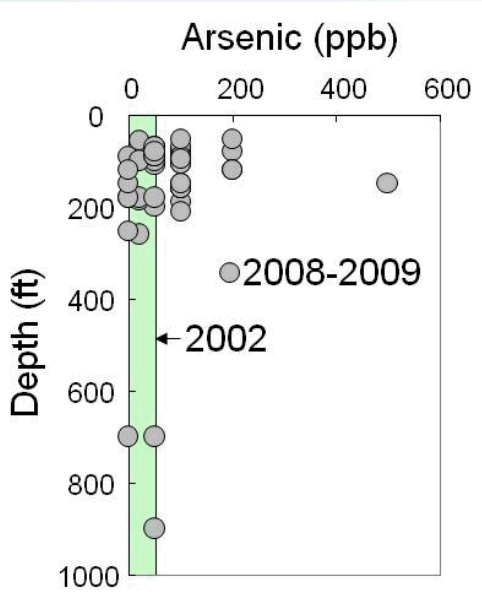
Sorbent media

Modified lime softening

Aquifer remediation

Trailer parks!

Arsenic in Asia



Sardi, Bangladesh

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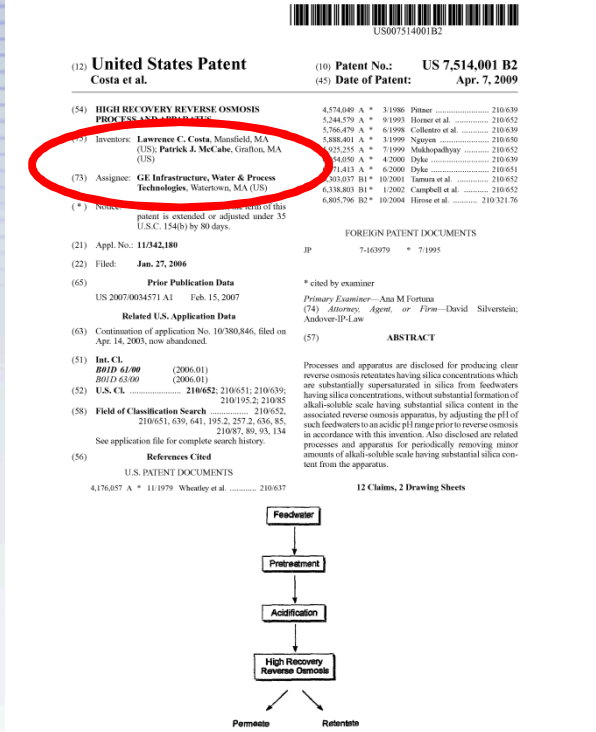
US007514001B2

(12) **United States Patent**
Costa et al.

(10) **Patent No.: US 7,514,001 B2**
(45) **Date of Patent: Apr. 7, 2009**

(54) **HIGH RECOVERY REVERSE OSMOSIS PROCESS AND PRODUCTS**

(75) Inventors: **Lawrence C. Costa**, Mansfield, MA (US); **Patrick J. McCabe**, Grafton, MA (US)

(73) Assignee: **GE Infrastructure, Water & Process Technologies**, Watertown, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 80 days.

(21) Appl. No.: **11/342,180**

(22) Filed: **Jan. 27, 2006**

(65) **Prior Publication Data**

US 2007/0034571 A1 Feb. 15, 2007

Related U.S. Application Data

(63) Continuation of application No. 10/380,846, filed on Apr. 14, 2003, now abandoned.

(51) **Int. Cl.**
B01D 61/00 (2006.01)
B01D 63/00 (2006.01)

(52) **U.S. Cl.** **210/652**; 210/651; 210/639; 210/195.2; 210/85

(58) **Field of Classification Search** 210/652, 210/651, 639, 641, 195.2, 257.2, 636, 85, 210/87, 89, 93, 134
See application file for complete search history.

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Primary Examiner—Ana M Fortuna
(74) *Attorney, Agent, or Firm*—David Silverstein; Andover-IP-Law

(57) **ABSTRACT**

Processes and apparatus are disclosed for producing clear reverse osmosis retentates having silica concentrations which are substantially supersaturated in silica from feedwaters having silica concentrations, without substantial formation of alkali-soluble scale having substantial silica content in the associated reverse osmosis apparatus, by adjusting the pH of such feedwaters to an acidic pH range prior to reverse osmosis in accordance with this invention. Also disclosed are related processes and apparatus for periodically removing minor amounts of alkali-soluble scale having substantial silica content from the apparatus.

12 Claims, 2 Drawing Sheets

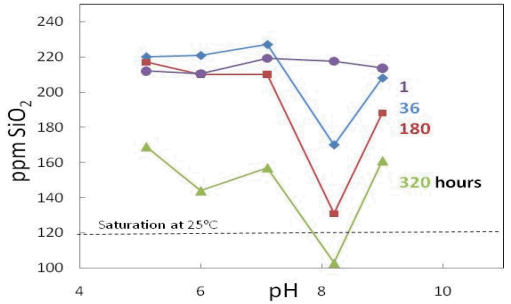
Existing Solutions

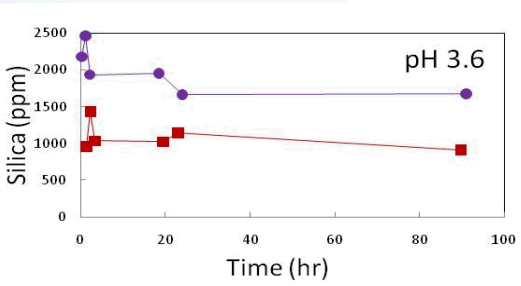
Solid forming reactions

Silica Control Method	Targeted Chemical Process			
	Monomer Deposition	Polymerization	Coagulation	Metal-Silicate Formation
Ion exchange			decreases	decreases
+ Acid		decreases	decreases	decreases
+ Anti-scalant	decreases?	decreases?	decreases	decreases
Mixing	decreases	decreases	decreases	
Magnets		decreases?		
+ Seeds	increases			can increase
+ Coagulant			increases	can increase
WLS	decreases	decreases	increases	increases
Ageing	decreases	increases	increases	

keep silica dissolved

make silicate solids





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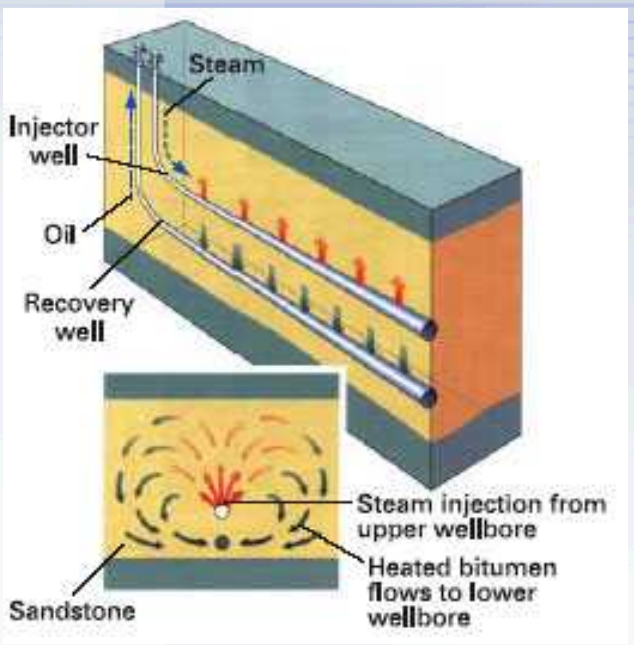
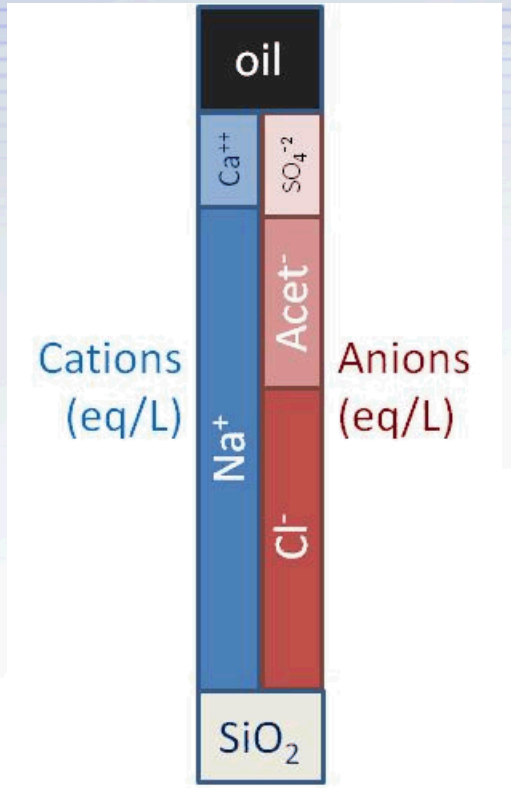
Steam-assisted Gravity Drainage (SAGD) of Bitumen in Alberta



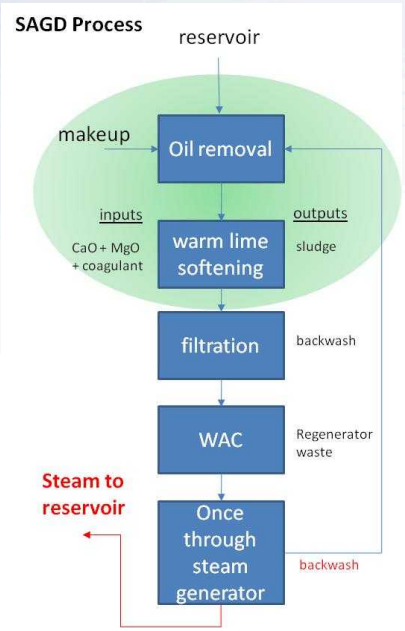
(source: http://pubs.usgs.gov/fs/fs070-03/fig3.jpg).

Effluent



pH 7.4; 45°C

Warm lime softening



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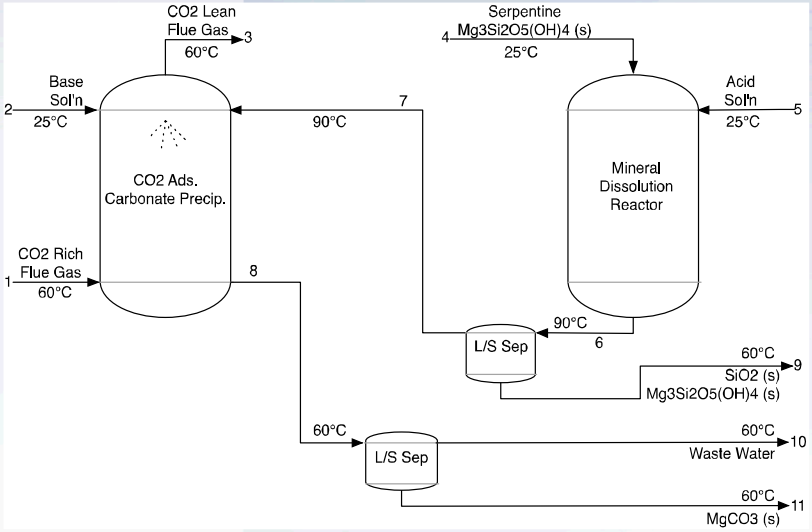
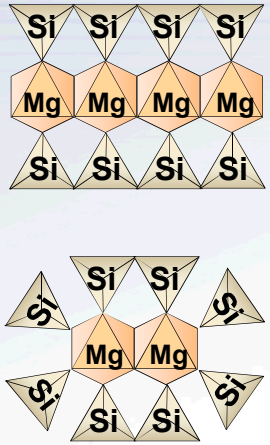
very slow *slow*

$$CO_2 + MgSiO_3 \rightarrow MgCO_3 + SiO_2$$



$MgSiO_3$ Dissolution



$MgCO_3$ Growth

H_2O

H_2O Mg^{+2} H_2O CO_3^{-2}

H_2O

$MgCO_3$

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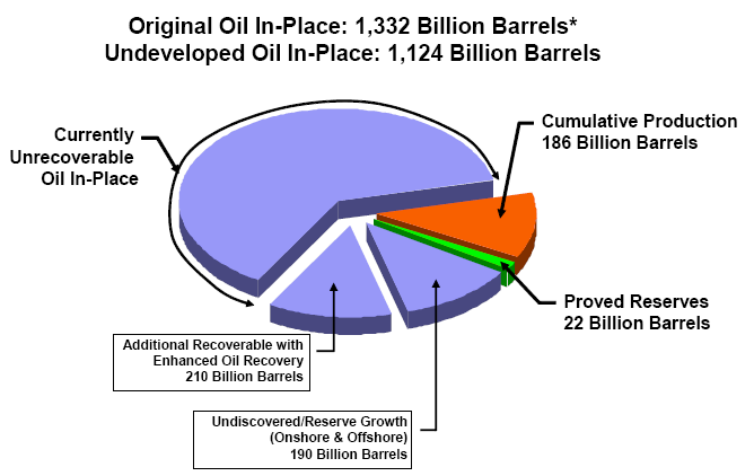

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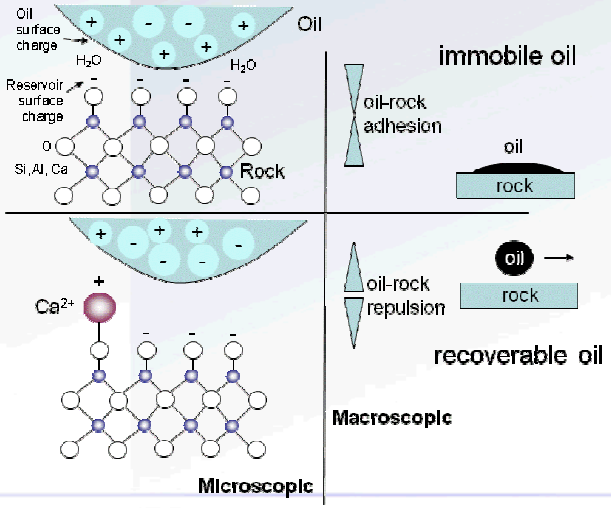

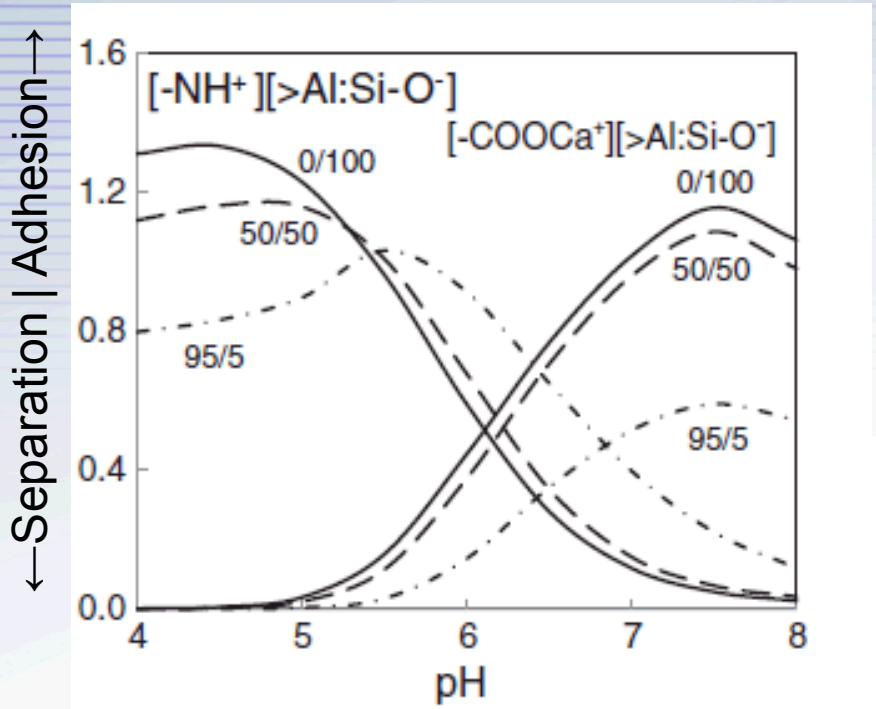

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