Recovery of Gas Hydrates: Many Ideas, Any Solutions?

Gas hydrates have the basic problem that their endothermic decomposition requires heat that the poor conduction of rocks and soils cannot provide at the appropriate rate.

So the first idea is to try to bring heat from above. The imagination of the inventors produced some rudimentary paper proposals which we report as they may be the basis of more evolved ones.

As said before, in my opinion the best trick is to inject CO₂ in the hydrate layers, and use its heat of hydration to pull CH₄ out. This line is followed in Japan already.

The description of the various possibilities when injecting steam to heat the hydrates to decomposition are schematically given in Figs.7–14. To my knowledge there is no systematic experimentation yet on these methods although in many ways they resemble the ones used to extract thick oils.

A CO₂ injection system would work exactly with the same mechanism. However, fixation should be precise as CO₂ does not separate as easily as steam in case it is carried back by ascending methane.

In actual operation very little shows up. Filtering the outcome of a recent “Gas Hydrates” workshop at the University of Leeds (April 1998), one finds a sizable amount of explorations, even in out of hand oceanic places, but no actual extraction experiments, except the ones announced by Japanese sources (Tokyo and Osaka Univerities, JAPEX, and JNOC) for drilling in the Nankai trough.

Excellent papers on the physical chemistry of hydrates containing CH₄, CO₂, C₂H₆ and other components have recently been published by R.K. Bakker. These studies can be of fundamental importance in establishing the right strategy to extract CH₄ from hydrates.
SCHEMATIC OF STEAM INJECTION INTO A HYDRATE RESERVOIR
ILLUSTRATION OF RADIAL STIMULATION
(TOP VIEW)

HYDRATED SEDIMENTS

EXTENSIVE RADIAL STIMULATION

WELL

HYDRATED SEDIMENTS
CONTINUOUS STEAM MODEL WITH HORIZONTAL FRACTURE
(SIDE VIEW)
DETAILED DESCRIPTION OF
CONTINUOUS INJECTION MODEL WITH HORIZONTAL FRACTURE
(SIDE VIEW)

P1, T1
STEAM IN

OVERBURDEN

HYDRATED SEDIMENTS

GAS

DISASSOCIATED ZONE

WATER

HORIZONTAL

FRACURE

WATER

HYDRATED SEDIMENTS

STEAM IN

GAS & WATER OUT

Fig. 10.
HEAT CONDUCTION PROBLEM IN VERTICAL DIRECTION
FOR HORIZONTAL FRACTURE CASE - CYCLIC MODEL
(SIDE VIEW)

Figure 11.
CONTINUOUS STEAM MODEL WITH VERTICAL FRACTURE

(TOP VIEW)

STEAM IN
DISSOCIATED ZONE
HYDRATED SEDIMENTS
VERTICAL FRACTURE
GAS & WATER OUT
HYDRATED SEDIMENTS

(SIDE VIEW)

STEAM IN
GAS & WATER OUT
OVERBURDEN
HYDRATED SEDIMENTS
VERTICAL FRACTURE

Fig. 12.
HEAT CONDUCTION PROBLEM IN HORIZONTAL DIRECTION
FOR VERTICAL FRACTURE CASE - CYCLIC MODEL
(TOP VIEW)

HYDRATED SEDIMENTS

$\frac{\partial T}{\partial x} = 0$

$x = x_{\text{max}}$

$T = T_D$

DISSOCIATION FRONT

$\eta_1, T_0$

$T = T_{\text{D}}$

DISSOCIATED ZONE

$\eta_2, T_{\text{D}} - T_{\text{s}}$

STEAM IN

GAS & WATER OUT

VERTICAL FRACTURE

Fig. 13.
DECOMPRESSION HYDRATE CAP MODEL WITH HORIZONTAL FRACTURE
(SIDE VIEW)

Fig. 14.
What about Hydrates Under Permafrost

Having a mean surface temperature around $-10^\circ$C creates conditions for hydrate formation under the land. Normally, the geothermal gradient produces too high temperatures versus depth, i.e., pressure, to find zones of hydrate stability.

Because working on terra firma is much easier than working over the ocean, there is a special interest for detecting and hopefully exploiting gas hydrates under permafrost, i.e., geographically in boreal regions.

As Fig.15 shows, most permafrost land (and ocean) are located in Russia. The hydrate reserves could then be found at very convenient depths, between 300 and 1000 meters (Fig.16).

As said before, because these hydrate layers could accommodate CO$_2$ in place of CH$_4$, it would be very ecological if the Russians could reform their CH$_4$ to 4H$_2$ and CO$_2$ and pipe H$_2$ to the final consumers. It could be their best contribution to the Kyoto agreements.
The approximate location of the \(-5^\circ\) and \(-15^\circ\)C isotherms of annual mean surface air temperature and the areas of continuous Northern Hemisphere permafrost and identified subsea permafrost. (Permafrost data courtesy of Jerry Brown of the U.S. Army's Cold Regions Research and Engineering Laboratory.)
Who Is Doing Research on Gas Hydrates

We scanned the listed literature, and some not listed, to try to find out whether there are centers of excellence, so to say, for research on hydrates.

We found really none. The papers come from disparate places, basically universities, showing that the driving force is just academic curiosity.

In the case of Russia, a number of papers come from Moscow inevitably, but also from Irkutsk (that has a computer model to establish where hydrates can be found) and Novosibirsk.

The coagulation points can be expected when real interest and proportionate money will start moving. The Russian–Indian deal may foster research in Russia. Gasprom is the richest company in Russia. And Japan is also condensing a line of action with various institutions collaborating.

Some driving forces in the study and practical handling of hydrate may come from the possibility, recently suggested, *to transport methane in form of hydrate*. A slurry of hydrate would be mixed with crude oils and shipped in current oil tankers, at atmospheric pressure. To ensure stability one should cool to −10°C or so, but decomposition of hydrate grains generate an ice skin on the grain and finally practice will suggest the best compromise. A certain decomposition level can be acceptable if the evolving gas can be used to propel the ship.

At present an amount of gas equivalent to the whole consumption in Europe is flared around the world because of the expense of transporting methane over long distances as LNG. A cheap way could mobilize important resources and incidentally *reduce CO₂ emissions in a very important measure* (equivalent to zeroing Europe’s emissions, more or less). A fact which Kyoto legislators did not seem to have weighted sufficiently.
Papers Filtered


Bell, P.R., 1982, Methane hydrate and the carbon dioxide question.


Crovetto, R., 1990, Solubility data of the system CO₂–H₂O from 273K to the critical point of water,


Gold, T., 1999, *The Deep Hot Biosphere*, Copernicus, An Imprint of Springer-Verlag, where most of the related bibliography can be found.


http://www.public.iastate.edu/~jkradke/abstrdir/rivkina134.html


Annex

Japanese Papers on CO₂ and CH₄ Hydrates
ABSTRACT: The phenomena of clathrate-hydrate formation has been conducted by molecular dynamics simulation. Positions of Ar molecules (guest molecules) were fixed and formation of cage structure by H2O molecules around the Ar molecules was precisely simulated by the present calculation. The interpretation of the formation mechanism was discussed in detail. (author abst.)

DESCRIPTORS: clathrate compound; hydrate; water molecule; molecular dynamics; argon; water; intermolecular interaction; hydrogen bond; computer simulation; molecular orientation

BROADER DESCRIPTORS: molecular compound; addition compound; compound (chemical); solvate; triatomic molecule; polyatomic molecule; molecule; dynamics; rare gas; element; third row element; interaction; binding and coupling; computer application; utilization; simulation; orientation (direction)

CLASSIFICATION CODE(S): BK90050T
storage; solvate; addition compound; compound(chemical); molecular compound; surface treatment; underwater disposal; waste disposal

CLASSIFICATION CODE(S): SC04020W

3/9/4

DIALOG(R)File 94:JCST-EPlus
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0296629 JICST ACCESSION NUMBER: 95A0694225 FILE SEGMENT: JICST-E

High-pressure phase behavior of the mixed system including CO2 clathrate hydrate.

OGAKI KAZUNARI (1); HANAMURA TAKAHIRO (1)
Kogak Kogaku, 1995, VOL. 59, NO. 8, PAGE 583-584, FIG. 3, REF. 3
JOURNAL NUMBER: P009984T ISSN NO: 0175-9253 CODE: KGKKA
UNIVERSAL DECIMAL CLASSIFICATION: 66.021.4

LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan

ARTICLE TYPE: Short Communication

MEDIA TYPE: Printed Publication

ABSTRACT: A visible type high-pressure cell of 100MPa resistant provided with vibrational agitation was prepared. The coexistence relations of CO2 hydrate, liquid CO2 and H2O was measured up to a maximum pressure of 92MPa. With deep-sea bed storage of CO2 in mind, density reversal phenomena of CO2 hydrate, liquid CO2 and H2O phases depending on changes in temperature and pressure was observed. From these results, the possibility of a long-term stability storage of liquid CO2 in the Japan Deep was suggested.

DESCRIPTORS: carbon dioxide; clathrate compound; hydrate; high pressure; multiphase; phase diagram; mixture; water; liquefied gas; density; natural gas

BROADER DESCRIPTORS: carbon oxide; oxide; clathogen; oxygen group element compound; oxygen compound; carbon compound; carbon group element compound; molecular compound; addition compound; compound(chemical); solvate; pressure; phase(topology); diagram and table; object; liquid

CLASSIFICATION CODE(S): XD01030U

3/9/5

DIALOG(R)File 94:JCST-EPlus
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0295589 JICST ACCESSION NUMBER: 95A0744555 FILE SEGMENT: JICST-E


MIRAI S (1); OKAZAKI K (1); KAWAMURA K (1)
(1) Tokyo Inst. Technol., Tokyo, JPN
Therm Sc Eng., 1995, VOL. 32, NO. 1, PAGE 69-74, FIG. 7, TBL. 1, REF. 9
JOURNAL NUMBER: LI615AA5 ISSN NO: 0918-9963
UNIVERSAL DECIMAL CLASSIFICATION: 544.112.144

LANGUAGE: English COUNTRY OF PUBLICATION: Japan

ARTICLE TYPE: Original paper

MEDIA TYPE: Printed Publication

ABSTRACT: The stability of carbon dioxide clathrate hydrate which is the crystal solid in which the water molecule seems to be tied by the hydrogen combining by making cage grid structure filled up in the carbon dioxide molecule, is examined by the molecular dynamics simulation. Result shows that the clathrate hydrate of the carbon dioxide is more unstable than that of nitrogen and argon. This paper explains the reason for this instability on basis of the database which obtain from simulation.

DESCRIPTORS: hydrate; clathrate compound; carbon dioxide; argon; molecular dynamics; numerical calculation; stability analysis; interatomic potential

BROADER DESCRIPTORS: solvate; addition compound; compound(chemical); molecular compound; carbon oxide; oxide; clathogen; oxygen group element compound; oxygen compound; carbon compound; carbon group element compound; rare gas; element; third row element; dynamics; calculation; analysis; potential

CLASSIFICATION CODE(S): CB02000C

3/9/10

DIALOG(R)File 94:JCST-EPlus
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02261926 JICST ACCESSION NUMBER: 95A0139281 FILE SEGMENT: PreJICST-E

Diffusion of CO2 Gas and its Transformation to Clathrate Crystals in Polar Ice Sheets.

MAE SHINJI (1)
(1) Hokkaido Univ., Fac. of Eng.
Asahi Glass, 1994, VOL. 1994, PAGE 583-590
JOURNAL NUMBER: G0061BA6 ISSN NO: 0918-9979 CODE: AS01H

LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan

DOCUMENT TYPE: Journal

MEDIA TYPE: Printed Publication
ABSTRACT: Microscopic observation of air-hydrate crystals were carried out with ice core samples retrieved at Vostock Station, Antarctica. It was found that the volume and number of air-hydrate varied with the climatic change. For example, the number concentration of air-hydrate crystals was about half in the interglacial ice compared with that in the glacial ice. The mean volume gradually increased as the depth increased and this means that the gas molecules can diffuse in the ice and their rearrangement takes place. Formation investigation of air-hydrate crystals shows that the nucleation of the crystals at the boundaries between ice and air is most predominant mechanism in the transformation process from air to air-hydrate crystals. (author abst.)

3/9/15
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02142984 JICST ACCESSION NUMBER: 94A010684 FILE SEGMENT: JICST-8
Research on the fixation technology of carbon dioxide by clathrate and hydrate.
SAI AKIRA (1); NOZAKI HIDETOMO (1); TANIZA TADAHIRO (2); YAMASHITA TOSHIHIRO (3);
KITAUMA HITAKU (3)
(1) Chubu Electric Power Co., Ltd.; (2) Mitsubishi Heavy Industries, Ltd.,
Takasago Technical Inst.; (3) Mitsubishi Heavy Industries, Ltd., Kobe
Shipyard and Engine Works
JSP.19
JOURNAL NUMBER: F090025P
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Conference Proceeding
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
ABSTRACT: Generation principle supporting experiment, continuous generation experiment and sedimentation experiment of CO2 clathrate were carried out in order to examine the system which stores large amount of CO2 recovered from thermal power plants in deep-sea floor, and generation and sedimentation characteristics of CC which is reaction product between CO2 and water were obtained. The generation speed of CC was in proportion to CO2 - water interface, continuous generation and separation of 10-20mm size CC was possible, and it was proven that sedimentation velocity increased with the increase in particle size.

DESCRIPTORS: carbon dioxide; clathrate compound; hydrate; thermal power generation; power plant; gas recovery; undersea storage; system evaluation; reaction product; reaction rate; fugacity; particle size(diameter); settling tank; settling velocity

BROADER DESCRIPTORS: carbon dioxide; oxide; chelogenes; oxygen group element compound; oxygen compound; carbon compound; carbon group element compound; molecular compound; addition compound; compound(chemical); solvate; power generation; electric power energy operation; electric power facility; recovery; storage; evaluation; product material; velocity; activity(thermodynamics); thermodynamic property; diameter; length; geometric quantity; chemical equipment; equipment

CLASSIFICATION CODE(S): SC0406D: SH0204D

3/9/15
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01833600 JICST ACCESSION NUMBER: 93A0429357 FILE SEGMENT: JICST-E
Recent heat pumps and applications. Technological trends in the development of electric and gas HPS. Ice-unused heat storage system. Clathrate heat-storage heat pump system.
SUZUKI MICHITOSHI (1)
(1) Shionogi Construction Co., Ltd.
Shoeneru(energy Conservation), 1993, VOL.45.NO.4, PAGE.66-68, FIG.2.
JOURNAL NUMBER: F0218ACY ISSN NO: 0387-1819
UNIVERSAL DECIMAL CLASSIFICATION: 621.577: 628.8+697.9 629.9.004.4
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Commentary
MEDIA TYPE: Printed Publication
ABSTRACT: This paper presents an introduction example of a heat-storage heat pump system using clathrate made up of CFC-11 and water as the cold heat storage material. Clathrate is formed at 8.5.12.0C. and is a fluid. The heat-storage heat pump system was designed to be responsible for 50% of a peak air-conditioning load for an office building with a total floor area of 8,480m2. Operation performance for 102 days in the summer showed a midnight power utilization of 35%.

DESCRIPTORS: heat pump; heat storage; energy storage; clathrate compound; heat storage material; freezes; thermal storage tank; heat exchanger; coefficient of performance; cold; air conditioning equipment

BROADER DESCRIPTORS: thermal operating device; storage and accumulation; storage; molecular compound; addition compound; compound(chemical); material; aliphatic chlorine compound; aliphatic halogen compound; organochlorine compound; organofluorine compound; organofluorine compound; storage tank; container; coefficient
This paper discusses the high-performance thermal storage tank for the air conditioning system using a gas hydrate, which is called a "clathrate". This is formed from the mixture of cooled water and hydrating agent. In the thermal storage tank, the clathrate is formed, stored, and also dissolved. For making thermal storage tank more efficient and smaller, we have analyzed the flow in the tank and found the proper arrangement of heat exchangers and agitators. Based on the results, an experimental unit with the high-performance thermal storage tank has been manufactured and tested. The clathrate packing factor in the tank has become greater than 40%. This proves that the clathrate thermal storage system has an advantage of the conventional ice thermal storage systems. (Author abst.)

Descriptors: air conditioning equipment; energy system; thermal storage tank; clathrate compound; agitated equipment; overall heat transfer coefficient; accelerated test; heat transfer medium; broader descriptors: equipment; system; storage tank; container; molecular compound; addition compound; compound (chemical); machinery; mixing equipment; heat transmission coefficient; coefficient; ratio; test.
FOREFRONT OF THE METHANE HYDRATE RESEARCH: OCCURRENCE AND RESOURCES OF METHANE HYDRATE DISTRIBUTED IN SEA OF OKhotsk.

ODA Hiroshi

1 Univ. of Tokyo, Grad. Sch.

Geokken Chiyo(Chikyu Monthly), 1996, Vol.18, No.10, PAGE.675-679, FIG.2, REF.8

JOURNAL NUMBER: L0342AAU
ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 553.9.871 / 952
LANGUAGE: Japanese
COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Review article
MEDIA TYPE: Printed Publication
DESCRIPTORS: submarine sediment; gas hydrate; methane gas; Sea of Okhotsk; reserves of petroleum; natural gas

FOREFRONT OF THE METHANE HYDRATE RESEARCH: HEAT FLOW OF THE KUNANO TROUGH GOTTEN FROM GAS-HYDRATE BSR.

NAKAZA Yasuhiko (1); ASHI JUICHIRO (2); TAKAYAMA Eiichi (3)
1 Shizuoka Prefectural University; 2 Univ. of Tokyo, Grad. Sch.; 3 Ocean Res. Inst., Univ. of Tokyo

Gekken Chiyo(Chikyu Monthly), 1996, Vol.18, No.10, PAGE.660-666, FIG.5, REF.19

JOURNAL NUMBER: L0342AAU
ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 553.9.551.23 551.35
LANGUAGE: Japanese
COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTORS: hydrate; natural gas; ocean trench; submarine sediment; terrestrial heat flow; reflection survey; reflection plane; Northwest Pacific Ocean


KOYUKI Kenji (1); MATSUBARA MAKOTO (1); NAKANO Shin'ya (1)

Gekken Chiyo(Chikyu Monthly), 1996, Vol.18, No.10, PAGE.685-689, FIG.6, REF.7

JOURNAL NUMBER: L0342AAU
ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 551.14 622.24.085.5
LANGUAGE: Japanese
COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTORS: clathrate hydrate compound; carbon dioxide; submarine sediment; mixed gas; phase equilibrium; reaction rate; ocean floor resource; submarine mining

JICST ACCESSION NUMBER: 96A0894437 FILE SEGMENT: JICST-E
Forefront of the methane hydrate research. On the characteristics of BSR of Nankai Trough and the offing of Abashiri.
SAXAI AKIO (1)
Gekkan Chikyu(Chikyu Monthly), 1996, VOL.18.NO.10, PAGE.652-659, FIG.6, TBL.1, REF.14
JOURNAL NUMBER: L0342AAU ISSN NO: 0387-1499
UNIVERSAL DECIMAL CLASSIFICATION: 550.834
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTIONS: ocean trough; Northwest Pacific Ocean; reflection plane; reflection survey; well logging; geothermal gradient; submarine sediment
IDENTIFIERS: Nankai Trough
BROADER DESCRIPTIONS: ocean basin; basin(geomorphology); geomorphic element; North Pacific Ocean; Pacific Ocean; name of oceans; face; seismic exploration; geophysical exploration; exploration; investigation; temperature gradient; gradient; sediment
CLASSIFICATION CODE(S): D61030B

JICST ACCESSION NUMBER: 96A0895126 FILE SEGMENT: JICST-E
Forefront of the methane hydrate research. Analysis of the methane hydrate natural sample using X-ray CT and NMR. Example of the natural sample gotten from ODP Leg164.
UCHIDA TAKEASHI (1); YASUMOTO JUNJI (1); OKADA SHIN'ICHI (1); OKATSU KOMEI (2)
Gekkan Chikyu(Chikyu Monthly), 1996, VOL.18.NO.10, PAGE.704-709, FIG.5, TBL.1, REF.4
JOURNAL NUMBER: L0342AAU ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 551.14:547
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTIONS: hydrate; methane gas; submarine sediment; Northwest Atlantic Ocean; boring core; excavation; X-ray computed tomography; 13C NMR; natural gas
BROADER DESCRIPTIONS: solvate; addition compound; compound(chemical); combustible gas; sediment; North Atlantic Ocean; Atlantic Ocean; name of oceans; geological sample; sample; X-ray inspection; radiographic inspection; nondestructive inspection; inspection; computed tomography; diagnostic imaging; diagnosis; tomography; image technology; technology; radiography; NMR; magnetic resonance; resonance
CLASSIFICATION CODE(S): D01043K

JICST ACCESSION NUMBER: 96A0895125 FILE SEGMENT: JICST-E
Forefront of the methane hydrate research. Methane hydrate synthesis experiment and examination of the stable condition.
MAESAKA TATSUGI (1); INAI NOBUKU (1)
(1) Geol. Surv. of Jpn., Agency of Ind. Sci. and Technol.
Gekkan Chikyu(Chikyu Monthly), 1996, VOL.18.NO.10, PAGE.695-699, FIG.2, REF.11
JOURNAL NUMBER: L0342AAU ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 551.14
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTIONS: methane gas; hydrate; natural gas; chemical synthesis; sodium chloride; aqueous solution; stability constant
BROADER DESCRIPTIONS: combustible gas; solvate; addition compound; compound(chemical); chemical reaction; synthesis; alkali metal halide; alkali metal compound; halide; halogen compound; chloride; chlorine compound; sodium compound; solution(liquid); liquid; chemical equilibrium; equilibriu
CLASSIFICATION CODE(S): D01041C

JICST ACCESSION NUMBER: 96A0895125 FILE SEGMENT: JICST-E
Forefront of the methane hydrate research. Methane hydrate synthesis experiment and examination of the stable condition.
MAESAKA TATSUGI (1); INAI NOBUKU (1)
(1) Geol. Surv. of Jpn., Agency of Ind. Sci. and Technol.
Gekkan Chikyu(Chikyu Monthly), 1996, VOL.18.NO.10, PAGE.695-699, FIG.2, REF.11
JOURNAL NUMBER: L0342AAU ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 551.14
LANGUAGE: Japanese COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTIONS: methane gas; hydrate; natural gas; chemical synthesis; sodium chloride; aqueous solution; stability constant
BROADER DESCRIPTIONS: combustible gas; solvate; addition compound; compound(chemical); chemical reaction; synthesis; alkali metal halide; alkali metal compound; halide; halogen compound; chloride; chlorine compound; sodium compound; solution(liquid); liquid; chemical equilibrium; equilibriu
CLASSIFICATION CODE(S): D01041C
Forefront of the methane hydrate research. Collapse sediment observed in the Amazon submarine fan. Dissolution of gas hydrate and slope failure.

SO DON (1); SUZUKI KIYOFUMI (1); OKATSU KOMEI (2)
(1) Kyushu Univ., Faculty of Science; (2) Technol. Res. Center Jpn. Natl. Oil Corp.
Gekkan Chikyu(Chikyu Monthly), 1996, VOL.18.NO.10, PAGE.667-674, FIG.5, TBL.2
JOURNAL NUMBER: L0342AAU  ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 551.35
LANGUAGE: Japanese  COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTORS: submarine fan; submarine sediment; slope failure; hydrate; natural gas; dissolution; debris flow; South America; river
IDENTIFIERS: Amazon
BROADER DESCRIPTORS: alluvial fan; geomorphic element; sediment; decay; solvate; addition compound; compound(chemical); Americas
CLASSIFICATION CODE(S): DE060006F

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03553302  JICST ACCESSION NUMBER: 96A0885122  FILE SEGMENT: JICST-E
Forefront of the methane hydrate research. Physical property measurement, well logging and BSR of the breaking ridge transsect.
SATO MIKIO (1)
(1) Geol. Surv. of Jpn., Agency of Ind. Sci. and Technol.
Gekkan Chikyu(Chikyu Monthly), 1996, VOL.18.NO.10, PAGE.667-652, FIG.4, REF.6
JOURNAL NUMBER: L0342AAU  ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 550.834
LANGUAGE: Japanese  COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Original paper
MEDIA TYPE: Printed Publication
DESCRIPTORS: hydrate; natural gas; well logging; boring core; petrophysical property; reflection plane; reflection survey; oceanic ridge; Northwest Atlantic Ocean; submarine sediment
BROADER DESCRIPTORS: solvate; addition compound; compound(chemical); exploration; investigation; geological sample; sample; lithologic character; property; face; seismic exploration; geophysical exploration; geomorphic element; North Atlantic Ocean; Atlantic Ocean; name of oceans; sediment
CLASSIFICATION CODE(S): DE10030B

4/9/13

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03553100  JICST ACCESSION NUMBER: 96A0885119  FILE SEGMENT: JICST-E
Forefront of the methane hydrate research. Followings are investigated:

MATSUOTO FUYO (1)
(1) Univ. of Tokyo, Grad. Sch.
Gekkan Chikyu(Chikyu Monthly), 1996, VOL.18.NO.10, PAGE.633-639, FIG.6, REF.5
JOURNAL NUMBER: L0342AAU  ISSN NO: 0387-3498
UNIVERSAL DECIMAL CLASSIFICATION: 553.987/.982 551.14:567
LANGUAGE: Japanese  COUNTRY OF PUBLICATION: Japan
DOCUMENT TYPE: Journal
ARTICLE TYPE: Review article
MEDIA TYPE: Printed Publication
DESCRIPTORS: methane gas; hydrate; submarine sediment; excavation; boring core; Northwest Atlantic Ocean; international cooperation; natural gas
BROADER DESCRIPTORS: combustible gas; solvate; addition compound; compound(chemical); sediment; geological sample; sample; North Atlantic Ocean; Atlantic Ocean; name of oceans; cooperation(partnership)
CLASSIFICATION CODE(S): DE505050; DE01043K