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(54) **Title:** TRACER SIMULATION TOOL AND METHOD FOR SIMULATING TRACERS IN SUB-SURFACE RESERVOIRS.

(57) **Abstract:** The invention concerns a method and a tool in which pre-solved reservoir simulation is used as input for sub-sequentially solving the tracer transport equations. By solving tracer transport equations in a separate step, evaluation of a particular tracer scenario can be performed in minutes. A modular tracer simulator tool capable of making tracer simulations based on input from reservoir simulations enable inter alia efficient planning of tracer injections, visualization of reservoir simulation results and conditioning of reservoir simulation models to production data.



TRACER SIMULATION TOOL AND METHOD FOR SIMULATING TRACERS IN SUB-SURFACE RESERVOIRS

DESCRIPTION

Technical field

The invention concerns a method for simulating transport of tracers in sub-surface reservoirs, such as oil and gas reservoirs, water reservoirs, reservoirs for CO₂ storage, geothermal reservoirs etc. and a tool for such simulations.

Background of the invention

A tracer may be defined as any substance having atomic or molecular, physical, chemical or biological properties which provide for identification, observation and study of the behaviour of various physical, chemical or biological processes, which occur either instantaneously or in a given lapse of time.

A natural tracer is a tracer naturally occurring in various physical, chemical or biological processes, which occur either instantaneously or in a given lapse of time. Typical examples include heat, chemical compounds and elements, radioactive compounds and elements, isotopic fractions or compound fractions naturally present in solid, gas and fluid phases in the subsurface or in phases injected into the subsurface. Examples of natural tracers are compounds commonly found naturally in water, for example sulphate, magnesium, potassium, strontium etc. or isotope ratios as for example ⁸⁷Sr/⁸⁶Sr or isotope signatures of water (deuterium or ¹⁸O signatures).

An injected tracer is a tracer added to injected phases in various physical, chemical or biological processes, which occur either instantaneously or in a given lapse of time. Typical examples include chemical compounds and elements, radioactive compounds and elements or heat.

Examples of synthesised radioactive tracers are water and hydrocarbon compounds labelled with H³ or C¹⁴. Non-radioactive tracers can be fluorinated benzoic acids or perfluorocarbons.

A purpose of interwell tracer tests is to map the flow field in a reservoir and to monitor qualitatively and quantitatively the fluid connections between injection and productions wells in order to optimize reservoir exploitation.

Tracer simulation is convenient for planning of tracer studies in petroleum or other reservoirs. Such planning involves estimating optimal tracer amounts, locating the most interesting well-pairs to be studied as well as estimating background concentrations, if tracers are to be used several times. At present this requires that a full reservoir simulation is performed for each

tracer scenario, solving fluid phase transport and pressure equations and tracer transport equations simultaneously. A typical simulation case of a petroleum reservoir uses a time in the order of 1 day to complete.

The complication of using existing tracer simulation tools has lead to few uses of tracer simulations for studying and evaluating actual simulation results.

Description of the invention

An object of the invention is to design a method and a tool for simulating transport of tracers in sub-surface reservoirs that is faster than today's methods.

The object of the invention is met by using a method and a tool in which reservoir simulation is solved in advance and sub-sequentially solving the tracer transport equations. By solving tracer transport equations in a separate step, evaluation of a particular tracer scenario can be performed in minutes.

A modular tracer simulator tool capable of making tracer simulations based on input from reservoir simulations enable inter alia efficient planning of tracer injections, visualization of reservoir simulation results and conditioning of reservoir simulation models to production data. Input data imported from the reservoir simulation to the modular tracer simulator can be description of mass, energy and momentum conservation of individual components of fluids present in the reservoir. Input data commonly used by the modular tracer simulator is mass and volumes for the individual fluids at each reservoir grid cell, the flow field defined at each connection between grid cells, and the injection/production fluid flow rates for all wells included in the reservoir model.

A fluid can have one or more components in one or more phases.

In addition to the data retrieved from the reservoir simulation, data on initial tracer concentrations in the reservoir and for each well and if applicable injected fluid tracer concentrations with time are fed to the modular tracer simulator. The initial tracer data comprises data on tracer concentrations in the reservoir and in each well and data on phase properties governing distribution of tracer mass between fluid phases.

The distribution of tracer mass between the fluid phases can be described by partitioning coefficients K , for each tracer component. In order to avoid singularities in the calculations of tracer concentrations in different phases, an absolute partitioning coefficient K_q^p is defined.

The solved tracer concentrations in the reservoir are defined for a grid having a number of grid cells, the size of which may coincide or be different than the original reservoir grid.

Modelling of the tracer components is performed after the reservoir simulation has been finished. The modular tracer simulation tool reads the output files generated in a reservoir simulation run and predicts the propagation and well production of one or several tracers. Since the tracer calculations itself is much faster than solving the full 3-phase set of flow equations, the tool is very fast.

Once reservoir flow field data have been produced by a host simulator, the modular tracer simulation tool can simulate new tracer scenarios involving hypothetical tracers in the reservoir and model them. In terms of minutes, it becomes possible to predict breakthrough times of the new hypothetical tracers. A hypothetical tracer is a tracer which is only defined in the simulation model, it has not been measured.

The modular tracer simulator may be set up to work together with any reservoir simulator. It will assist the reservoir engineer or others in predicting tracer flow behaviour in reservoirs in an efficient manner, and will be useful in connection with tracer activities in petroleum or other reservoirs. Examples of applications are planning of tracer injections, visualization of reservoir simulation results and conditioning of reservoir simulation models to production data.

The modular tracer simulator may be applied also for simulating tracer data for other types of sub-surface reservoirs than oil and gas reservoirs. For example simulation of CO₂ underground storage facilities, ground water reservoirs or geothermal sites.

The method and the tool can be used for simulation of transport of one or more tracers. The method and tool is also applicable for reservoirs containing one or more phases.

Detailed description of the invention

There are important differences between prior works that focus on tracer simulations and the present invention. In prior works, tracer and phase transport are resolved simultaneously, whereas the present invention is based on a sequential resolution of the flow field and the tracer transport. The possibility to identify tracer concentration fields from pre-solved and stored solutions to the phase equations enables much faster tracer transport simulations. The tracer conservation equations are thus solved in a post-processing manner. The sequential nature of the methodology has several advantages regarding computational efficiency, including the possibility of exploring multiple tracer injection strategy plans without recalculating flow and pressure fields and addition of hypothetical tracers to visualize flow-paths in simulation models.

The modular tracer simulator and the method for simulating tracer components are described in more detail in the example below.

The concentration distribution of a tracer between the phases is described by partitioning coefficients specific for each tracer and the composition of the fluids. In general, the partitioning coefficients have a functional dependency of pressure, temperature and composition of the fluid system. In reservoirs, where composition, temperature and pressure gradients are relatively flat, a convenient, but not required, simplification occurs if the functional dependency of the partitioning coefficients is constant throughout the simulations.

For a water tracer q the partitioning coefficient (K-value) between oil and water is defined by:

$$K_q = \frac{C_q^o}{C_q^w} \quad (1.1)$$

For a gas tracer r the partitioning coefficient between oil and gas is:

$$K_r = \frac{C_r^o}{C_r^g} \quad (1.2)$$

For three-phase flow, similar expressions may be used to define the partitioning of tracer between each pair of phases. A practical and numerical problem associated with the above expressions, is that (1.1) and (1.2) become singular when C_r^g or C_p^w becomes zero.

To eliminate this problem in the model, it is introduced a concept of absolute K-values K_q^p defined by the equation:

$$C_q^p = K_q^p C_q \quad (1.3)$$

In equation (1.3), C_q is a generic concentration which is chosen as the unknown variable in the tracer equations. Note that equation (1.3) opposed to (1.1) and (1.2) is valid for any tracer q in any phase p . In the model, the phase concentrations C_q^p are the calculated output parameters based on K_q^p and the solved concentrations C_q .

Without loss of generality, one of the K-values K_q^p (p =oil, water or gas) can be set to one, so that the two other K-values are equivalent to the definition in (1.1) and (1.2). The phase with K-value equal to one, is called the primary phase for the tracer.

With the generic concentration C_q as unknown variable, the general conservation equation for a tracer component q is:

$$\begin{aligned}
& \frac{\partial}{\partial t} \left(\sum_{p=w,o,g} \phi K_q^p S_p C_q \right) + \nabla \cdot \left(\sum_{p=w,o,g} \underline{v}_p K_q^p C_q \right) - \nabla \cdot \left(\sum_{p=w,o,g} \phi S_p \left(\frac{D_q^p}{\tau} \underline{I} + \underline{D}_q^{*p} \right) \nabla (K_q^p C_q) \right) \\
& - \sum_{\substack{\text{wellperf} \\ \text{injector}}} \sum_{p=w,o,g} C_{q,\text{wellperf}}^p q_{\text{wellperf}}^p \delta(\underline{r} - \underline{r}_{\text{wellperf}}^{\text{injector}}) + \sum_{\substack{\text{wellperf} \\ \text{producer}}} \sum_{p=w,o,g} C_{q,\text{wellperf}}^p q_{\text{wellperf}}^p \delta(\underline{r} - \underline{r}_{\text{wellperf}}^{\text{producer}}) = 0
\end{aligned} \tag{1.4}$$

where

$$\underline{D}_q^{*p} = D_q^p \{ D_{p\parallel}^* \underline{e}_{\parallel} \underline{e}_{\parallel} + D_{p\perp}^* (\underline{I} - \underline{e}_{\parallel} \underline{e}_{\parallel}) \} \tag{1.5}$$

$\underline{e}_{\parallel}$ is a unit vector parallel to the flow velocity, $\underline{e}_{\perp}$ is a unit vector normal to the flow velocity, and D_q^p is the solute molecular diffusion coefficient for tracer q in phase p . The coefficients $D_{p\parallel}^*$ and $D_{p\perp}^*$ depend on the flow velocity of phase p through the Péclet number

$$P_{eq}^p = \frac{v_p d}{D_q^p} \tag{1.6}$$

and can be approximated by power laws

$$D_{p\parallel}^* = \beta_{\parallel} P e^{\alpha_{\parallel}} \quad \text{and} \quad D_{p\perp}^* = \beta_{\perp} P e^{\alpha_{\perp}} \tag{1.7}$$

The exact expression for the phase velocity $\underline{v}_p$ is dependent on the host simulator used for generating the flow field. For instance in case of Darcy flow with gravity, we have:

$$\underline{v}_p = - \frac{k_r^p}{\mu_p} \underline{k} (\nabla P_p - \rho_p \underline{g}) \tag{1.8}$$

$\underline{k}$ is the permeability tensor, μ_p is viscosity for phase p , k_r^p is the relative permeability, ∇P_p is pressure gradient for phase p , ρ_p is density for phase p , $\underline{g}$ is gravity vector.

The tracer equation (1.4) is a partial differential equation in time and space, and here is adopted a finite volume method to solve it. To describe the geometry and geology of the reservoir, the reservoir is divided in N grid cell volumes dV_i , usually not equal in size. The index i go from 1 to N . Note that the tracer simulator may use a different grid than the host simulator for the reservoir simulation. Equation (1.4) is also discretized in time, assuming a time step Δt which varies in time. The time step for the tracer simulator may be chosen differently than the host simulator time step. The finite volume form of (1.4) is obtained by

integrating the equation over one grid cell volume dV_i and approximating the time differential

$\frac{\partial}{\partial t}$ by the finite difference operator $\frac{\Delta}{\Delta t}$.

By integrating (1.4), we obtain one equation for each grid cell volume, N equations in total.

The unknown variables are the N concentrations C_q .

$$\int \frac{\Delta}{\Delta t} \left(\sum_{p=w,o,g} \phi K_q^p S_p C_q \right) dV_i + \int \nabla \cdot \left(\sum_{p=w,o,g} \underline{v}_p K_q^p C_q \right) dV_i - \int \nabla \cdot \left(\sum_{p=w,o,g} \phi S_p \left(\frac{D_q^p}{\tau} \underline{I} + \underline{D}_q^{*p} \right) \nabla (K_q^p C_q) \right) dV_i \quad (1.9)$$

$$- \int \sum_{\substack{\text{wellperf} \\ \text{injector}}} \sum_{p=w,o,g} C_{q,\text{wellperf}}^p q_{\text{wellperf}}^p \delta(\underline{r} - \underline{r}_{\text{wellperf}}) dV_i \\ + \int \sum_{\substack{\text{wellperf} \\ \text{producer}}} \sum_{p=w,o,g} C_{q,\text{wellperf}}^p q_{\text{wellperf}}^p \delta(\underline{r} - \underline{r}_{\text{wellperf}}) dV_i = 0$$

Applying the Gaussian theorem

$$\int (\nabla \cdot \underline{u}) dV_i = \oint_{\Gamma} \underline{u} \cdot \underline{n} d\Gamma \quad (1.10)$$

and

$$\int f(\underline{r}) \delta(\underline{r} - \underline{r}_0) dV_i = f(\underline{r}_0) \quad (1.11)$$

for any vector-valued function $\underline{u}(\underline{r})$ and any scalar function $f(\underline{r})$, we obtain the finite volume tracer equation.

In equation (1.13) we have also multiplied by Δt and applied the following finite volume approximations:

$$\int f(\underline{r}) dV_i = f(\underline{r}_c) V_i \\ \oint_{\Gamma} \underline{u} \cdot \underline{n} d\Gamma = \sum_{jc} \underline{u}(\underline{r}_{jc}) \cdot \underline{n} A_{jc} \quad (1.12)$$

The finite volume equation for grid block i is:

$$\sum_{p=w,o,g} V_i \Delta (\phi K_q^p S_p C_q) + \sum_{jc} \sum_{p=w,o,g} K_q^p C_q \underline{v}_p \cdot \underline{n} A_{jc} \Delta t - \sum_{jc} \sum_{p=w,o,g} \left(\phi S_p \left(\frac{D_q^p}{\tau} \underline{I} + \underline{D}_q^{*p} \right) \nabla (K_q^p C_q) \right) \cdot \underline{n} A_{jc} \Delta t \\ - \sum_{\substack{\text{wellperf} \\ \text{injector}}} \sum_{p=w,o,g} C_{q,\text{wellperf}}^p q_{\text{wellperf}}^p \Delta t + \sum_{\substack{\text{wellperf} \\ \text{producer}}} \sum_{p=w,o,g} C_{q,\text{wellperf}}^p q_{\text{wellperf}}^p \Delta t = 0 \quad (1.13)$$

Equation (1.13) shows that it is possible to solve the tracer equation after the flow field has been solved by the host simulator. This procedure is also consistent with the fact that the

tracer component does not influence the fluid flow field. In equation (1.13), C_q for each grid block are the only unknown parameters. The NxN equation system is solved at each tracer time-step by applying a linear iterative sparse matrix solver.

As an example of potential time saved using the tracer simulation tool, a reservoir simulation performed on a North Sea reservoir case needed a CPU time of 11.16 hours to complete on an Intel Xeon 3.4 MHz x86 system. By using the tracer simulation tool, the tracer simulation needed a CPU time of 0.11 hours to complete on the same system. In the example the tracer simulation performed by the tracer simulation tool thus used about 1% of the CPU time needed for tracer simulation using existing technology. This allows for making several tracer simulations using the reservoir simulation data instead of requiring a full reservoir simulation for each tracer simulation.

A modular tracer simulator tool is a convenient tool to create, for example effective visualization of inter-well fluid flow patterns. Based on stored, previously solved fluid phase transport data and pressure equations, a hypothetical tracer can be added to an injection well and allocated a continuous injection concentration of 1. By displaying the concentrations at producing wells, the fraction of produced fluid originating from a particular injection well in the stored simulation can be estimated. In addition, using conventional visualization software, the hypothetical tracer concentrations can be displayed as a function of space and time and provide an effective display of significant flow-paths in the simulation model.

Evaluation of tracer studies can improve petroleum reservoir models.

Inter-well tracer testing (IWTT) has been established and proven as an efficient technology to obtain information on well-to-well communication, heterogeneities and fluid dynamics. During such tests, chemical or radioactive tracers are used to label water, gas or oil from specific injection wells. The tracers are then subsequently used to trace the fluids as they move through the reservoir together with the injected phase.

One of the features of IWTT is that tracer production curves can be used to reveal shortcomings in reservoir simulation models since tracers give information on injection well - production well communication that complements other data. These simulation model improvements rely on efficient simulation of tracer production curves that can be compared to measured production curves. Shortcomings in the reservoir model manifest themselves as mismatches of data and simulation results.

Natural tracers (geochemical and isotopic variations in injected and formation waters) can be used as a source of information in reservoir modelling. Natural tracer data are sometimes available due to monitoring of hazardous (toxic or scale) components in discharged water from oil production. A potentially large gain may therefore be available at a low additional cost.

Natural tracer data can conveniently be added to a reservoir simulation by treating natural tracers as an ordinary tracer component, i.e., as a component that is associated with a phase and that affect the flow of fluid phases in the model in such a way that it can be neglected for the purpose of comparison to measured data. Formulations of natural tracer transport equations suitable for finite difference implementations are similar to that of ordinary tracer.

The modular tracer simulation tool can be used to simulate natural tracer transport and therefore contribute to improving reservoir models by exploiting natural tracer data.

When tracer tests are performed it is desirable to inject as little tracer as possible. The reasons for this include a desire to reduce cost, potential environmental impact and to satisfy governmental regulations. On the other hand, it is important to inject enough tracer mass to ensure reliable results. To estimate the required tracer mass, simple volumetric calculations are commonly used. However, a better way of estimating may be to use a modular tracer simulator to evaluate the dilution and dispersion of injected tracer mass.

In addition to amount estimations, it is also important to choose the optimal timing, location and number of tracer injections. One should choose injection wells where one can expect short enough travel times to the relevant production wells, as well as choosing injection locations that maximise the information one can obtain from a tracer programme. This is particularly important since the number of available tracers is relatively limited. Tracer simulations can help also in this respect, as various injection scenarios can be evaluated by simulations prior to injection.

The proposed methodology can be used to simulate tracer transport for tracer programme planning purposes and therefore contribute to improving tracer test planning.

Injection of water is commonly used to maintain the pressure in petroleum reservoirs, which leads to a significant production of water, which is often re-injected for environmental purposes. Produced water re-injection has the consequence that tracer mass in the produced water is also re-injected with the water. Similarly, produced gas, and thus produced tracer mass, is re-injected in many reservoirs and yield a background concentration.

Re-injection of water and gas therefore leads to a potential for misinterpretation of tracer results. A simple procedure to avoid such misinterpretations is to compare produced tracer

concentrations to measured background concentrations in the re-injected fluids. If tracer concentrations are not measured in the injection stream, previous re-injected mass can be estimated by a mass balance from produced volumes and production well tracer concentrations.

A crude procedure to evaluate if re-injection concentrations are affecting the tracer results is to directly compare measured concentrations in a production well to the concentration in the re-injection stream. If production well concentrations are larger than re-injection stream concentrations it can be assumed that the production well concentrations are due to the tracer injection pulse reaching the production well.

A problem with this simple comparison is the time-lag due to the time it takes for re-injected tracers to move from an injection well to a production well. Since this lag may be several months, or even years, there is a risk of comparing production well concentrations to re-injection stream tracer as a separate tracer in a modelling, and use the concentration results from the tracer modelling as comparison to evaluate if a result is above or below a re-injection background.

The modular tracer simulator tool can be used to simulate transport of tracers injected due to re-injection stream concentrations and help to establish more realistic background concentrations.

CO₂ sequestration is studied extensively in Norway and world-wide, and there is a strong focus on combining CO₂-storage and EOR. According to some studies due to increased oil-prices, coupled EOR and sequestration projects may become economically interesting.

Conventional chemical tracers have been used to monitor CO₂ injection. Tracer technology has successfully been used to monitor water-alternating-gas (WAG) and foam-assisted WAG (FAWAG) projects based on natural gas and it may be possible to monitor CO₂-based WAG projects.

To plan injections and to evaluate results from tracer programmes in relation to CO₂-projects, tracer simulations based on the modular tracer simulator can be useful.

CLAIMS

1. A method for simulating transport of a tracer in a subsurface reservoir comprising one or more well, characterised by that data on reservoir flow field is extracted from a pre-performed reservoir simulation and are used as input together with initial tracer data for sub-sequentially simulating tracer transport.
2. A method in accordance with claim 1, characterised by that data on the reservoir flow field comprises mass and volumes for individual fluids at each reservoir grid cell, flow field defined at each connection between grid cells, and fluid flow rates for injection and production of the wells included in the reservoir simulation.
3. A method in accordance with claim 1 or 2, characterised by that the initial tracer data comprises data on tracer concentrations in the reservoir and in each well and data on phase properties governing distribution of tracer mass between fluid phases.
4. A method in accordance with claim 1, 2 or 3, characterised by that the distribution of tracer mass between the fluid phases is described by an absolute partitioning coefficient K_q^p .
5. A method in accordance with claim 4, characterised by that the partitioning coefficient K_q^p for each phase of the reservoir is assumed constant throughout the simulation.
6. A method in accordance with any of claim 1 - 5, characterised by that geometry and geology of the reservoir is divided into N grid cells and that the grid cells used for the tracer simulation are set independently of the reservoir grid cells used for the pre-performed reservoir simulation.
7. A method in accordance with any of claims 1- 7, characterised by that the reservoir comprises a hydrocarbon reservoir injection well - production well pair.
8. A method in accordance with any of claims 1-7, characterised by that the reservoir is a CO₂ storage reservoir or geothermal reservoir.
9. A modular tracer simulation tool for simulating tracer transport in accordance with any of claims 1 - 8..
10. A modular tracer simulation tool in accordance with claim 9, characterised by that the tool reads output files generated in a pre-performed reservoir simulation run, and that data on initial tracer concentration in the reservoir and data on phase properties governing distribution of tracer mass between fluid phases are fed to the tool whereby the tool calculates propagation and well production of one or several tracers.

11. A modular tracer simulation tool in accordance with claim 10, characterised by that the distribution of tracer mass between fluid phases is described by an absolute partitioning coefficient K_q^p .
12. Use of a modular tracer simulation tool in accordance with claim 9, 10 or 11 characterised by that inter-well fluid flow patterns are calculated based on stored, previously solved fluid phase transport data and pressure equations generated in a pre-performed reservoir simulation run, and a hypothetical tracer added to an injection well and allocated a continuous injection concentration of 1 and by displaying the concentration C_q of the hypothetical tracer at producing wells, the fraction of produced fluid originating from a particular injection well in the stored simulation is estimated.
13. Use of a modular tracer simulation tool in accordance with claim 9, 10 or 11 characterised by that tracer transport simulations of an injection scenario is evaluated prior to actual injection of a tracer.
14. Use of a modular tracer simulation tool in accordance with claim 13, characterised by that an estimate of required injection tracer mass is evaluated by simulating dilution and dispersion of the required injection tracer mass.
15. Use of a modular tracer simulation tool in accordance with any of claims 9-14, characterised by that information on well-to-well communication, heterogeneities and fluid dynamics are obtained by using an injected chemical or radioactive tracer to label water or gas or oil from specific injection wells and subsequently trace the water or gas or oil as they move through the reservoir together with the injected tracer and used to compare with simulated tracer response.
16. Use of a modular tracer simulation tool in accordance with any of claims 9-15, characterised by that re-injected tracer concentrations are simulated, to compare tracer concentrations in production wells to background concentrations from fluids re-injected into an injection well.

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/057115

A. CLASSIFICATION OF SUBJECT MATTER

INV. E21B47/10 E21B49/00 G01V11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B G01V

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, TULSA

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	VALESTRAND R. ET AL: "The Effect of Including Tracer Data in the EnFK Approach" SPE 113440, 19 April 2008 (2008-04-19), XP007911743 pages 1-4 the whole document	1-16
X	ALI E. ET AL: "Tracer Simulation to Improve the Reservoir Model in the Snorre Field" SPE 64796, 7 November 2000 (2000-11-07), XP007911748 page 2, paragraphs 2,3 the whole document	1-3, 6-10, 13-16
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/057115

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	SAGEN J. ET AL: "Reservoir Chemical-Thermal Simulation with Tracers" SPE 36921, 22 October 1996 (1996-10-22), XP007911751 page 4, column 1, paragraph 2-6; figures 1-3,6 page 6, column 1, paragraph 6 - column 7, paragraph 1 the whole document -----	1-3, 6-10, 13-16
X	CHATZICHTISTOS C. ET AL: "Advanced numerical modelling for tracer flow" IAHS PUBL. NO 262, 2000 TRACERS AND MODELLING IN HYDROGEOLOGY, 1 May 2000 (2000-05-01), pages 17-23, XP008116947 the whole document -----	1
X	US 4 278 128 A (SATTER ABDUS ET AL) 14 July 1981 (1981-07-14) the whole document -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/057115

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4278128	A	14-07-1981	NONE