METHOD OF CONDITIONING A WALL OF A BORE SECTION

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ABSTRACT

A method to condition a portion of a wall surrounding a borehole section drilled in a formation fluid-bearing formation comprising locally injecting a gas to displace working fluid from a laser path adjacent a drill head, providing an underbalanced pressure at the portion of the borehole section to be conditioned, impinging laser light on the portion of the wall to be conditioned to melt a component of the formation material in the portion of the bore wall to be conditioned, and drawing fluid from the formation through the solidifying component of the material to create fluid flow passageways to facilitate the flow of fluid from the formation into the borehole section. Injected gas may be provided to the drill head through a conduit within an umbilical that includes a plurality of optical fibers to transmit laser light to the drill head.
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STATEMENT OF RELATED APPLICATIONS

[0001] This application depends from and claims priority to International PCT/US2012/039767 filed on May 26, 2012, which claims priority to Hungarian Application No.: P1100276 filed on May 30, 2011.

BACKGROUND

[0002] 1. Field of the Invention

[0003] The present invention relates to wells drilled to recover fluids from geologic formations.

[0004] 2. Background of the Related Art

[0005] Borehole systems are drilled into the earth’s crust to penetrate subsurface geologic formations bearing a fluid, such as water, oil or gas, to facilitate the production of the fluid to the surface. A borehole system may comprise a single bore surrounded by a bore wall or, alternately, it may comprise a primary bore having one or more intersecting lateral bores surrounded, along with the primary bore, by the bore wall.

[0006] A borehole system may be bored in the earth’s crust using mechanical drilling rigs at the earth’s surface to rotate a drill bit at a leading end of a drill string extending from the rig. Some rigs rotate the entire drill string, which may comprise a plurality of segments or stands of drill pipe threadedly coupled to form the drill string. The drill string can be made up by adding segments as the drill string is extended deeper into the earth’s crust or laid down by removing segments as the drill string is withdrawn from the earth’s crust. The rotation of the drill string and the drill bit at the leading end of the drill string, while urging the drill bit against the end of the portion of the borehole system to be extended to break apart rock engaged by the drill bit. Alternately, a drill string may comprise a mud motor proximal the leading end and hydraulically powered by fluid provided through the center of the drill string to rotate a drill bit coupled to the mud motor to break apart the rock engaged by the drill bit. Drill cuttings are removed from the portion of the bore to be extended by circulating working fluid down the drill string and back to the earth’s surface through the annulus between the drill string and the wall of the bore.

[0007] Other methods for extending a borehole system include the use of high-power laser light to melt components of rock within a laser path adjacent to a drill head at the leading end of a drill string. Laser drilling may include the removal of debris resulting from the drilling process by circulating fluid into and from the portion of the borehole system being extended. A laser path between the drill head and a portion of the wall to be irradiated using the drill head must be cleared of laser obstructing materials so that the laser light can impinge on the portion of the wall to be irradiated by the laser.

[0008] Still other methods for extending a borehole system include the use of a high-pressure jet to mechanically fracture rock within a fluid path adjacent to a liquid jet at the leading end of a drill string. High-pressure jet drilling may include the removal of debris resulting from the drilling process by circulating fluid into and from the portion of the borehole system being extended. For best results, the jet path between the liquid jet and the portion of the bore wall to be jet blasted should be as short as possible to impart a maximum amount of liquid kinetic energy on the portion of the wall to be jet blasted.

[0009] A completed borehole system generally comprises a non-productive portion, into which no fluids enter from adjacent geologic formations, and a productive portion of the borehole system having a plurality of bore sections into which fluids may enter from adjacent geologic formations. It is important to prevent undesirable fluids from entering the borehole system and also to cause desirable fluids to enter the borehole by providing a flow passageway. For example, a drilled borehole system to obtain fresh water should be isolated from penetrated geologic formations bearing brackish or salty water in favor of producing water from penetrated geologic formations bearing fresh water. In another example, a borehole system drilled to obtain oil or gas should be isolated from penetrated geologic formations bearing water in favor of producing oil or gas from penetrated geologic formations bearing oil or gas.

[0010] To achieve this end in conventional borehole systems, bore sections in a productive portion of the borehole may be lined or cased with a pipe called casing, then the casing is cemented in place within the bore by circulating cement into a casing/bore annulus. The casing and the cement liner can then be perforated with a perforating tool to establish fluid communication between the formation adjacent to the perforations and the interior of the bore. Alternately, or in addition to perforating, a productive portion of a bore may be packed with fine gravel to promote the flow of fluid from adjacent geologic formations into the bore while preventing entrained particles, or the productive portion of the bore may be lined or cased with a previously perforated liner to provide structural support against bore collapse while facilitating a flow of formation fluids into the bore section for production to the earth’s surface.

BRIEF SUMMARY

[0011] The present invention provides a method comprising providing an umbilical having a plurality of optical fibers, a gas supply conduit and a leading end connected to a drill head, introducing the drill head into a surface end of a borehole system drilled into the earth’s crust, positioning the drill head within a portion of the borehole system in a geologic formation in which a fluid resides, introducing a volume of gas through the gas conduit into the portion of the borehole system to displace laser obstructing materials therefrom, transmitting laser light through the plurality of optical fibers to the drill head, impinging laser light on a portion of the bore wall to be conditioned to melt at least a component of the formation material along the portion of the bore wall, providing an underbalanced pressure at the portion of the bore wall to be conditioned, and inducing a flow of the fluid from the formation across the portion of the wall and into the borehole system as the melted component solidifies, wherein the flow of fluid across the solidifying component of the portion of the wall to be conditioned creates interconnected cavities, or fluid flow passages, through which fluid may flow from the formation into the borehole system.

[0012] Another embodiment of the invention provides a method of conditioning a portion of a wall of a borehole system comprising disposing a drill head into the borehole system, positioning the drill head proximal to the portion of the wall to be conditioned, injecting a gas to displace laser obstructing material from a laser path intermediate the drill
head and the portion of the wall to be conditioned, irradiating the portion of the wall using laser light emitted from the drill head to melt at least a component of the wall opposite the laser path from the drill head, providing an underbalanced pressure at the portion of the wall to be conditioned, and drawing a formation fluid residing in the formation across the portion of the wall to be conditioned as the component of the formation solidifies to create passageways within the wall for the flow of the fluid from the formation into the borehole system.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0013] FIG. 1 is a schematic illustrating a system of the present invention.

[0014] FIG. 2 is an enlarged perspective view of an alternative spool that can be used to store an umbilical of a system of the present invention.

[0015] FIG. 3 is an enlarged top view of a second alternative spool that can be used to store an umbilical of a system of the present invention.

[0016] FIG. 4 is a perspective view of a drill head that can be used to implement an aspect of the system of the present invention.

[0017] FIG. 5 is an enlarged partial section view of a drill head that can be used to implement an aspect of the system of the present invention.

[0018] FIG. 6 is an elevation view of a portion of a borehole system comprising a single lateral bore intersecting a primary bore at a window in a casing installed within the primary bore.

[0019] FIG. 7 is an elevation view of the portion of a borehole system of FIG. 6 after a guide tool is disposed in the primary bore to guide the drill head through the casing window into the lateral bore to condition the wall of the lateral bore.

[0020] FIG. 8 is the elevation view of FIG. 6 after the system of the present invention is used to create a congealed permeable liner along the wall of the lateral bore.

[0021] FIG. 9 is an enlarged view of a portion of the lateral bore of FIG. 8 wherein the system of the present invention has been used to condition the liner with connected cavities to facilitate flow of formation fluid from the formation and into the lateral bore for production to the surface through the primary bore.

DETAILED DESCRIPTION

[0022] One embodiment of the present invention provides an umbilical for positioning a drill head connected to a leading end of the umbilical within a borehole system. The umbilical includes a gas conduit and a plurality of optically transmitting fibers to supply gas and laser light to the drill head, respectively. The umbilical may be stored on and fed from a reel, spool or other storage device into the borehole system. The reel, spool or other storage device on which the umbilical may be wound or coiled facilitates transportation of the umbilical to and from the surface location of the borehole system. The storage device may include a rotatable fluid coupling coupled to a surface end of the gas conduit of the umbilical to facilitate the flow of gas from a gas source on the earth's surface to a surface end of the gas conduit. Similarly, the storage device may include a rotatable fluid coupling coupled to a surface end of the optical fibers of the umbilical to facilitate the transmission of laser light from a laser generator on the earth's surface to a surface end of the optical fibers. The rotatable couplings accommodate rotary movement of the storage device on which the umbilical relative to the earth's surface and enable a continuous supply of gas and/or laser light without unwanted twisting or binding of the umbilical.

[0023] The umbilical comprises a leading end to which a drill head is connected, for being introduced into the borehole system. The reel can be rotated to feed out the umbilical to the borehole system in an amount sufficient to position the drill head at the leading end of the umbilical proximal a portion of a wall of the borehole system to be conditioned using the drill head. The drill head can, in one embodiment, comprise one or more gas injection ports strategically located on the drill head to introduce gas to displace laser obstructing materials, such as working fluid or other fluids and debris, from the laser path. The laser path, as that term is used herein, is the path through which the laser light emitted from the drill head will beam to impinge on the portion of the wall of the bore to be conditioned using the drill head.

[0024] The drill head further comprises one or more optical elements optically coupled to a leading end of the plurality of optical fibers to focus and condition the laser light transmitted from the surface for providing the maximum impact on the portion of the wall of the bore to be conditioned using the drill head. The optical elements may comprise lenses housed in the drill head and optically coupled to a leading end of optical fibers extending from the leading end of the umbilical into the drill head. The optical elements may be housed, for example, at an end of the drill head generally opposite the connected end of the drill head, and the optical elements may be protected using a transparent protective member through which emitted laser light may pass to impinge upon the bore wall.

[0025] An embodiment of the invention provides an underbalanced pressure to the portion of the wall to be conditioned by deploying a seal coupled to the drill head, or to the umbilical at a position spaced away from the drill head, to expand upon deployment to seal off an annulus between the drill head (or the umbilical) to which the seal is connected and the wall of the bore. The deployment of the seal isolates the portion of the bore to be conditioned from working fluid, produced fluid or other laser obstructing material in the bore through which the umbilical is extended. In one embodiment, the seal is an inflatable member, and the deployment of the seal may be implemented by remotely opening a valve fluidically coupled between the gas conduit and the seal to inflate the seal using gas provided through the gas conduit. In a second embodiment, the seal may be retracted from a deployed configuration by remotely opening a second valve coupled to release the gas from the inflated seal to the bore. In another embodiment, a first valve, coupled to selectively introduce gas from the gas conduit to the seal to inflate the seal, and a second valve, coupled to selectively release gas from the seal to the bore, may be released using a single remotely controllable three-way valve having a first selectable position to establish communication between the gas conduit and the seal to inflate the seal and a second selectable position to establish communication between the inflated seal and the bore.

[0026] An embodiment of the invention includes providing an underbalanced pressure to the portion of the bore to be conditioned to facilitate the flow of fluid from the formation and into the bore as components of the wall of the bore conglomerate after being melted by application of laser light. In one embodiment, the underbalanced pressure is provided by artificially lifting a column of working fluid in the bore by injec-
tion of gas. It will be understood that, as the injected volume of gas migrates toward the surface end of the bore, it expands as it encounters decreasing pressure thereby displacing working fluid from the bore at the surface and decreasing the pressure at the portion of the bore to be conditioned. Other embodiments of the method include swabbing the bore by removing material from the surface end of the bore. For example, but not by way of limitation, a bore may be swabbed to provide an underbalanced pressure by introducing gas or low-density liquid into the bore, even at a shallow depth relative to the portion of the bore to be conditioned, to displace a more dense fluid and to thereby alter the hydrostatic pressure provided by the fluid in the borehole system to the portion of the wall to be conditioned using the method of the present invention.

[0027] FIG. 1 is a schematic illustrating an aspect of the system 10 of the present invention. A borehole 90 is drilled into the earth's crust 11 so that a portion 17 of the borehole 90 penetrates a geologic formation 19 bearing a fluid medium such as, for example, hydrocarbons. The system 10 comprises a coiled tubing unit at the surface 15 having a source of pressurized gas 12 fluidically coupled through a gas leader 13 to a gas conduit (not shown) within an umbilical 34, a portable electric generator 14 electrically coupled through a power supply leader 18 to power a laser light generator 16 that is, in turn, optically coupled through a laser leader 26 to a plurality of optical fibers 47 (not shown in FIG. 1) within the umbilical 34. The system 10 of FIG. 1 further comprises a wellhead 25 sealing the surface end 91 of the borehole 90 through which the umbilical 34 is received into the borehole 90, a working fluid tank 20 coupled through a working fluid leader 22 to the wellhead 25 to enable the introduction and removal of working fluid 21 into and from an annulus 24 between the umbilical 34 and the wall 94 of the borehole 90. The system further comprises a spool 30 on which an extended length of umbilical 34 may be stored, and a coiled tubing unit guide support 27 to support an umbilical guide 38 having a plurality of rolling elements 37 therein to reduce friction of movement of the umbilical 34 into and from the wellhead 25 and the borehole 90. The system 10 and the coiled tubing unit thereof further comprise a drill head 50 connected at a connected end 36 to the umbilical 34 and positionable within the borehole 90 by letting out and reeling in the umbilical 34 from and onto the spool 30.

[0028] The system 10 comprises the spool 30 that is rotatable on an axle (not shown in FIG. 1) using a motor and related gears (not shown) to control the position of the drill head 50 by letting out and reeling in the umbilical 34 thereon. In FIG. 1, the spool 30 has been reeled out to provide sufficient umbilical 34 through the wellhead 25 to position the drill head 50 adjacent to a portion of the wall to be conditioned 92, which is a small portion of the wall 94 of the borehole 90 that is adjacent the drill head 50. The drill head 50 comprises a deployable circumferential seal 54 that, upon deployment, seals the annulus between the exterior surface of the drill head 50 and the wall 94 of the borehole 90 in which the drill head 50 is positioned.

[0029] FIG. 2 is a perspective view of an alternative umbilical storage spool 32A that can be used to store an umbilical 34 of a system of the present invention by coiling the umbilical 34 against the interior wall 33 of the spool 32A. After a portion of the interior wall 33 is covered with outer coils 42 of the umbilical 34, additional, smaller coils can be disposed within the initial, outer coils 42 for additional storage capacity.

[0030] FIG. 4 is an enlarged perspective view of the drill head 50 of FIG. 1 that can be used to implement an aspect of the system of the present invention. The drill head 50 of FIG. 4 comprises a plurality of optical elements 45 optically coupled to a plurality of elongate optical fibers 47 that optically conduct laser light (not shown in FIG. 4) provided from the laser light source 16 (not shown in FIG. 4) through the laser leader 26 (not shown in FIG. 4) to a surface end of the optical fibers 47 (not shown in FIG. 4). The optical elements 45 in the drill head 50 of FIG. 4 are disposed in a generally concentric pattern within a leading end 56 of the drill head. It will be understood that the optical elements may be disposed in a number of various patterns or positions within the drill head 50.

[0031] The drill head of FIG. 4 further comprises a plurality of gas injection ports 46 disposed within the leading end 56 of the drill head 50 and positioned to inject gas into a portion of the borehole having a wall to be conditioned by laser light (not shown) emitted from the optical elements 45. In the drill head 50 of FIG. 4, the gas injection ports 46 are disposed within the interior of the concentric pattern of the optical elements 45. It will be understood that the gas injection ports 46 can be disposed in a number of various patterns or positions within the drill head 50. The drill head 50 of FIG. 4 further comprises a deployable seal 54 around the exterior surface 59 of the drill head 50. The deployable seal 54 is illustrated in FIG. 4 in the deployed mode to seal an annulus between a wall of a bore (not shown) in which the drill head 50 of FIG. 4 may be positioned and the exterior surface 59 of the drill head 50 to facilitate the displacement of laser obstructing materials from the portion of a bore system to be conditioned using the system of the present invention. The drill head 50 of FIG. 4 further comprises one or more relief ports 57 into which laser obstructing materials may be displaced and through which laser obstructing materials may be removed from the portion of a borehole to be conditioned using the system of the present invention.

[0032] For example, but not by way of limitation, the drill head 50 of FIG. 4 may be positioned within a portion of a bore to be conditioned thereby; the deployable seal 54 may be deployed to engage a wall of a portion of the bore to seal an annulus between the exterior surface 59 of the drill head 50 and the wall of the bore. Gas provided to the drill head through a gas conduit 49 within an umbilical 34 used to position the drill head 50 is injected into a portion of the bore proximal to the leading end 56 of the drill head 50 to displace laser obstructing materials, such as working fluid, formation fluid or a mixture thereof, from the portion of the bore through the relief port 57. In the drill head 50 of FIG. 4, the deployed laser obstructing material and the gas injected through the gas injection ports 46 to displace the laser obstructing material are moved towards the surface and beyond the seal 54 through material conduits 48 within the drill head 50. The material conduits 48 may empty into the portion of the annulus (not shown) between the surface and the seal 54 or, alternately, the umbilical 34 may comprise an additional conduit through
FIG. 5 is an enlarged partial section view of the drill head 50 that can be used to implement a system of the present invention positioned within a bore 40 to condition a portion 92 of the wall 94 of the bore 40 within a geologic formation 19 bearing the fluid medium to be recovered. The drill head 50 of FIG. 5 comprises a case 65 having an exterior surface 59, relief ports 57 through the case 65 and connected to exit ports 58 opposite a deployable seal 54 around the case 65 through relief conduits 53, a plurality of optical fibers 47 within the case 65 and optically coupled to optical elements 45 housed in a generally concentric pattern at a leading end 56 of the drill head 50 to irradiate the wall portion 92 with laser light 52 upon activation. The drill head 50 of FIG. 5 further comprises a pair of gas conduits 49 to provide gas to gas injection ports 46 (not shown in FIG. 5) for displacing laser obstructing material from a laser path 17 proximal the leading end 56 of the drill head 50. The drill head 50 of FIG. 5 further comprises a gas lateral 64 to receive gas from a gas conduit 49 upon opening of the seal gas valve 63 and to deliver the gas to the deployable seal 54 to deploy the seal to the sealing mode shown in FIG. 5. The drill head 50 of FIG. 5 further comprises a deflation stem 60 having a seal deflation valve 61 to relieve gas pressure within the deployable seal 54 to restore the deployable seal 54 to a retracted mode (not shown in FIG. 5). It will be understood that a borehole system may comprise a single bore without intersecting laterals or, alternatively, a borehole system may comprise a primary bore having one or more interesting lateral bores. The system of the present invention may be used to condition a portion of a wall of a single bore without intersecting laterals, to condition a portion of a wall of a lateral bore that intersects a primary bore. It will be further understood that tools exist, such as guide tools and whipstocks, to guide the drill head 50 of the system of the present invention into a lateral bore intersecting a primary bore in a borehole system.

FIG. 6 is an elevation view of a portion of a borehole system comprising a lateral bore 72 intersecting a primary bore 90 at a window 84 in a casing 82 installed within the primary bore 90 and cemented into place using cement 80. The lateral bore 72 of FIG. 6 has an initial section 70 and a plurality of bends 73 indicating that the lateral bore 72 is bored with a tool steered to penetrate and drain formation fluid from a geologic formation 19.

FIG. 7 is an elevation view of the portion of a borehole system of FIG. 6 after a guide tool 98 is disposed in the primary bore 90 to guide the drill head 50 (not shown in FIG. 7) through the casing window 84 and into the lateral bore 72 to condition a portion of a wall 94 of the lateral bore 72 to better drain the adjacent geologic formation 19. The guide tool 98 has shoes 96 to grip the casing 82, and an inclined surface 97 thereon to deflect a drill head 50 (not shown in FIG. 7) into the window 84 milled in the casing 82 and the cement liner 80. It will be understood that the size, length and diameter of the drill head 50 (not shown) to be positioned in the lateral bore 72, an angle of the inclined surface 97, the configuration of the guide tool 98, the size of the window 84 and an angle of intersection 99 of the initial section 70 of the lateral bore 72 are among factors to be considered in conditioning a portion of a wall 94 of a bore 72 in accordance with the present invention.

FIG. 8 is the elevation view of FIG. 6 after the system of the present invention is used to create a congealed permeable liner 79 along a portion of a wall 94 of a lateral bore 72 intersecting a primary bore 90. The liner 79 is conditioned, using the drill head 50 (not shown) and an under-balanced pressure to facilitate the flow of formation fluid residing in the formation 19 into the lateral bore 72 through a plurality of fluid passages 88 through the liner 79. The liner 79 comprises one or more components of the formation 19 melted by laser light and congealed to form the liner. For example, but not by way of limitation, the formation 19 may be sandstone, and the component melted by exposure to the laser light may be silica, which congeals after melting to form the liner 79. The fluid passages 88 through the liner 79 are formed by physical reaction of the formation fluid, moved from the formation to the bore as a result of the under-balanced pressure, with the congealing formation components. For example, formation fluid components such as water or hydrocarbons will, upon exposure to the hot, congealing formation components along the wall 94 of the lateral bore 72, expand within a matrix of congealing formation components resulting in small cavities (not shown in FIG. 8) within the liner 79, as illustrated in FIG. 9.

FIG. 9 is an enlarged view of a portion of the lateral bore 72 of FIG. 8 wherein the system of the present invention has been used to condition the liner 79 formed along the wall of the conditioned bore section with a plurality of cavities 93. Many of the cavities 93 are fluidically connected to adjacent cavities 93 to create fluid passageways 88 to facilitate the flow of fluid from the formation 19 adjacent to the lateral bore 72 through the liner 79 and into the lateral bore 72 for production in the direction of arrow 75 to the surface through the primary bore 90. A factor affecting the size of cavities 93 formed in the liner 79 along the conditioned bore section depends on the pressure imbalance between the pressure of the fluid residing in the formation 19 and the lower underbalanced pressure in the lateral bore 72. A slightly underbalanced pressure (i.e., when the pressure within the lateral bore 72 is only slightly less than the pressure of the fluid residing in the formation 19 adjacent to the lateral bore 72) existing during the interval of time in which the liner 79 congeals will result in the formation of fewer cavities 93 in the liner 79 and an overall lower flow capacity of formation fluid across the congealed liner 79 and into the lateral bore 72. A more underbalanced pressure (i.e., when the pressure in the lateral bore 72 is substantially less than the pressure of the fluid residing in the formation 19 adjacent to the lateral bore 72) existing during the interval of time in which the liner 79 congeals will result in the formation of more cavities 93 in the liner 79 and an overall greater flow capacity of formation fluid across the congealed liner 79 and into the lateral bore 72.

It will be understood that sections of the borehole system conditioned using the present invention may be customized by manipulation of the underbalanced pressure. For example, but not by way of limitation, a balanced or overbalanced pressure may be provided to substantially isolate a conditioned section of the borehole system from fluid residing in the formation adjacent thereto, a slightly underbalanced pressure may be provided for a restrained amount of fluid communication between the conditioned section of the borehole system and the fluid residing in the formation adjacent thereto, and a substantially underbalanced pressure may be provided for a generous amount of fluid communication between the conditioned section of the borehole system and the fluid residing in the formation adjacent thereto.
In one embodiment of the method of the present invention, a deployable seal is coupled to the drill head or to the umbilical at a position spaced apart from the drill head. The seal is deployable to isolate the portion of the borehole system adjacent to the portion of the wall to be conditioned from the remainder of the borehole system so that an underbalanced pressure can be provided to promote the flow of formation fluid across the solidifying component of the formation proximal to the borehole.

It will be understood that the system and method of the present invention can be used to condition a portion of the bore wall of an existing borehole system to modify a drainage profile of the borehole system. For example, but not by way of limitation, the system can be used to isolate or to impair fluid drainage into the borehole system in a first location by using the drill head during an overbalanced condition to create a substantially impermeable sleeve, and the system can be used to promote fluid drainage into the borehole system in a second location by using the drill head during an underbalanced condition to create a permeable sleeve with fluid passageways. In this manner, the system and method of the present invention can provide for the customization of a borehole system to selectively drain portions of the borehole system adjacent to geologic formations with favorable fluid contents, such as hydrocarbons, and to selectively prevent the drainage of portions of the borehole system adjacent to geologic formations with unfavorable fluid contents, such as water.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the term “working fluid” refers to a fluid introduced into the borehole for the purpose of lubricating the borehole system to facilitate the smooth insertion, positioning and removal of the apparatus comprising the drill head, for the purpose of hydrostatically opposing or balancing formation pressure to minimize the potential for well control problems due to an unwanted and unexpected influx of formation fluids into the bore.

As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components and/or groups, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The terms “preferably,” “preferred,” “prefer,” “optionally,” “may,” and similar terms are used to indicate that an item, condition or step being referred to is an optional (not required) feature of the invention.

The corresponding structures, materials, acts, and equivalents of all means or steps plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present invention has been presented for purposes of illustration and description, but it is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. The embodiment was chosen and described in order to best explain the principles of the invention and the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

We claim:

1. A method comprising:
   providing an umbilical having a plurality of optical fibers, a gas conduit and a leading end connected to a drill head;
   introducing the drill head through a surface end of a borehole system drilled in the earth’s crust;
   positioning the drill head within a bore section of the borehole system penetrating a geologic formation in which a formation fluid resides;
   introducing a volume of gas through the gas conduit into a portion of the bore section to be conditioned to displace laser obstructing materials;
   transmitting laser light through the plurality of optical fibers to the drill head;
   impinging laser light on a portion of the wall of the bore section to be conditioned to melt at least a component of the formation material of the wall;
   providing an underbalanced pressure at the portion of the wall to be conditioned; and
   inducing a flow of the formation fluid from the formation across the portion of the wall to be conditioned and into the bore section as the melted component of the formation solidifies;
   wherein the flow of formation fluid across the solidifying component of the portion of the wall to be conditioned creates formation fluid flow passages through which the formation fluid may flow from the formation into the bore section.

2. The method of claim 1 wherein the gas is one of nitrogen, a noble gas, and a combination thereof.

3. The method of claim 1 wherein providing an underbalanced pressure at the portion of the wall to be conditioned comprises:
   reducing the average density of a working fluid circulated into the borehole system.

4. The method of claim 3 wherein reducing the average density of the working fluid circulated into the borehole system comprises:
   introducing a low density fluid into the borehole system through a working fluid conduit within at least a portion of a length of the umbilical.

5. The method of claim 1 wherein providing the underbalanced pressure at the portion of the wall to be conditioned comprises:
   reducing the volume of a working fluid disposed within the borehole system to hydrostatically balance formation pressure.

6. The method of claim 1 wherein providing the underbalanced pressure at the portion of the wall to be conditioned comprises:
   deploying a seal on the drill head to isolate the portion of the wall to be conditioned from a remaining portion of the borehole system.

7. The method of claim 1 wherein the drill head connected to the leading end of the umbilical comprises:
   at least one gas injection port connected to the gas conduit.

8. The method of claim 1 wherein the drill head connected to the leading end of the umbilical comprises:
   at least one optical element optically connected to the plurality of optical fibers.
9. The method of claim 8 wherein the drill head connected to the leading end of the umbilical comprises:
a plurality of optical elements optically connected to the plurality of transmission fibers.

10. The method of claim 7 wherein the drill head connected to the leading end of the umbilical comprises:
at least one optical element optically connected to the plurality of optical fibers.

11. A method of conditioning a portion of a wall of a bore section of a borehole system comprising:
disposing a drill head into the bore section of the borehole system;
positioning the drill head within the bore section and proximal to the portion of the wall to be conditioned;
injecting a gas into the bore section to displace laser obstructing material from a laser path intermediate the drill head and the portion of the wall to be conditioned;
irradiating the portion of the wall to be conditioned using laser light emitted from the drill head to melt at least a component of the wall opposite the laser path from the drill head;
providing an underbalanced pressure at the portion of the wall to be conditioned; and
drawing a formation fluid residing in the formation across the portion of the wall to be conditioned and into the bore section as the melted component of the wall solidifies to create passageways within the portion of the wall of the bore section for the flow of the formation fluid from the formation into the bore section.

12. The method of claim 11 wherein the gas is one of nitrogen, a noble gas, and a combination thereof.

13. The method of claim 11 wherein providing the underbalanced pressure at the portion of the wall to be conditioned comprises:
reducing the volume of working fluid disposed within the borehole system.

14. The method of claim 11 further comprising:
providing an umbilical having a plurality of optical fibers, a gas conduit and a leading end connected to the drill head;
connecting the gas conduit to a gas injection port in the drill head;
optically connecting the plurality of optical fibers to a plurality of optical elements in the drill head; and
deploying a seal on the drill head to isolate the portion of the wall to be conditioned from a remaining portion of the borehole system.

15. The method of claim 14 wherein irradiating the portion of the wall using laser light emitted from the apparatus to melt at least a component of the formation adjacent to the drill head comprises:
transmitting laser light through the plurality of optical fibers to the optical elements in the drill head; and
emitting laser light from the drill head through the laser path onto the portion of the wall to be conditioned.

16. The method of claim 11 wherein the drill head connected to the leading end of the umbilical comprises:
at least one gas injection port connected to the gas conduit.

17. The method of claim 11 wherein the drill head connected to the leading end of the umbilical comprises:
an optical element optically coupled to the plurality of optical fibers.

18. The method of claim 17 wherein the drill head connected to the leading end of the umbilical comprises:
a plurality of optical elements optically coupled to the plurality of optical fibers.

19. The method of claim 17 wherein the drill head connected to the leading end of the umbilical comprises:
at least one gas injection port connected to the gas conduit.