Claims

What is claimed is:

1. A method for drilling a geothermal well in a subterranean zone, comprising:

drilling, with a drill bit at the end of a drill string, a wellbore of the geothermal well in the subterranean zone, wherein an inherent temperature of the rock adjacent a rock face ahead of the drill bit~~at a downhole end of the wellbore~~ is at least 250 degrees Celsius; and

flowing, while drilling, a water- or oil-based drilling fluid at a temperature at the rock face ahead of the drill bit such that the temperature of the drilling fluid is less than the inherent temperature of the rock adjacent the rock face ahead of the drill bit and a difference between the inherent temperature of the rock adjacent the rock face and the temperature of the drilling fluid flowing where convective cooling of ~~at~~ the rock face occurs ahead of the drill bit is at least 100 degrees Celsius causing, at the rock face ahead of the drill bit, a thermally induced stress that is greater than a tensile strength of the rock.

~~2. The method of claim 1, wherein the difference between the inherent temperature of the rock adjacent the rock face and the temperature of the drilling fluid at the rock face causes a thermally induced stress in the rock at the rock face that is greater than the tensile strength of the rock at the rock face.~~

2~~3~~. The method of claim 1, wherein a~~the~~ downhole end of the wellbore is at a measured depth of at least 4000 meters.

3~~4~~. The method of claim 1, wherein a~~the~~ downhole end of the wellbore is at vertical depth of at least 6000 meters.

4~~5~~. The method of claim 1, wherein the difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid flowing where convective cooling of ~~at~~ the rock face occurs ahead of the drill bit is at least 175 degrees Celsius.

56. The method of claim 1, wherein the inherent temperature of the rock adjacent the rock face ahead of the drill bit is at least 350 degrees Celsius and the difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid flowing where convective cooling of ~~at~~ the rock face occurs ahead of the drill bit is at least 200 degrees Celsius.

67. The method of claim 1, wherein the inherent temperature of the rock adjacent the rock face ahead of the drill bit is at least 500 degrees Celsius and the difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid flowing where convective cooling of ~~at~~ the rock face ahead of the drill bit is at least 350 degrees Celsius.

78. The method of claim 1, wherein the wellbore is a lateral wellbore.

~~9. The method of any of claims 1-7, wherein the downhole end of the drill string comprises a rotary drilling bit.~~

810. The method of any of claims 1-7, wherein ~~the downhole end of~~ the drill bit comprises a contactless drilling bit configured to break formation material at the rock face ahead of the drill bit without requiring contact between the bit and the rock face.

911. The method of any of claims 1-87, further comprising forming a closed-loop geothermal well system, wherein the closed-loop geothermal well system comprises the wellbore.

1012. The method of claim 911, wherein the wellbore is a lateral wellbore and wherein forming the closed-loop system comprises drilling the lateral wellbore from a first surface wellbore and connecting, by the lateral wellbore, the first surface wellbore with a second surface wellbore.

11~~13~~. The method of any of claims 1-10~~7~~, wherein the difference between an~~the~~ inherent temperature of the rock adjacent a~~the~~ rock face at a wall of the wellbore behind the drill bit and the temperature of the drilling fluid at the rock face at the wall of the wellbore behind the drill bit induces radial tensile fractures in at least a portion of ~~a~~the wall of the wellbore behind the drill bit, and further comprising sealing the radial tensile fractures with a sealing material.

12~~14~~. The method of any of claims 1-11~~7~~, wherein the drill string comprises a plurality of tubular segments, wherein at least one of the tubular segments comprises a coating layer at least partially covering a circumferential surface of the tubular segment, and wherein a length normalized thermal resistance of a coated wall portion of the tubing string is at least 0.002 meters kelvin per watt.

13~~15~~. The method of claim 12~~14~~, wherein a length normalized thermal resistance of the coated wall portion is at least 0.01 meters kelvin per watt.

14~~16~~. The method of claim 12~~14~~, wherein the plurality of tubular segments are connected to each other at connection joints, and wherein said coating layer at least partially covers a circumferential surface of one or more of the connection joints.

15~~17~~. The method of any of claims 2-14~~1-7~~, wherein the wellbore is a first wellbore and further comprising:

forming a second wellbore that intersects the first wellbore; and

at least one of:

flowing a second stream of drilling fluid down the second wellbore, wherein the second stream provides at least a portion of the drilling fluid flowing at the rock face ahead of the drill bit, and

diverting a return stream of drilling fluid from the downhole end of the first wellbore up the second wellbore.

16~~18~~. The method of claim 1, further comprising:

positioning an intermediate tubular string in the well;

positioning the drill string within the intermediate tubular string; thereby forming an inner annulus between the exterior of the drill string and the interior of the intermediate tubular string that extends downhole at least partially along the length of the drill string; and

at least partially filling the inner annulus with an insulating material.

17.~~19~~ The method of claim 16~~18~~, wherein the insulating material comprises a gas.

18~~20~~. The method of any of claims 1-17~~7~~, further comprising adding to the drilling fluid a phase-change material specified to undergo a phase change proximate to the downhole end of the drill string.

19~~21~~. The method of claim 1, wherein the drill string comprises an uphole portion comprising a first plurality of tubular segments and a downhole portion comprising a second plurality of tubular segments and wherein a majority of the first plurality of tubular segments have a tensile strength at least 25% greater than the tensile strength of the majority of the second plurality of tubular segments, and a majority of the second plurality of tubular segments are at least 35% lighter than the majority of the first plurality of tubular segments.

20~~22~~. A method for forming a geothermal system in a subterranean zone, comprising:

drilling a first surface wellbore and a second surface wellbore;

drilling a lateral wellbore from the first surface wellbore to connect the first surface wellbore with the second surface wellbore in the subterranean zone, wherein drilling the lateral wellbore comprises:

positioning a drill string in the lateral wellbore, wherein the drill string comprises a drill bit at its downhole end and defines a conduit for flowing a drilling fluid to a rock face ahead of the drill bit at a downhole end of the lateral wellbore to displace broken formation material from the rock face ahead of the drill bit;

drilling with the drill bit~~string~~ the lateral wellbore further into the subterranean zone, wherein an inherent temperature of the rock adjacent the rock face ahead of the drill bit ~~at a downhole end of the lateral wellbore~~ is at least 250 degrees Celsius; and

flowing the drilling fluid in the lateral wellbore ahead of the drill bit where convective cooling with the rock face occurs at a temperature ~~at the rock face~~ at least 100 degrees Celsius cooler than the inherent temperature of the rock adjacent the rock face ahead of the drill bit;

removing the drill string from the lateral wellbore; and

circulating a working fluid in a closed loop in the first surface wellbore, the second surface wellbore, and the lateral wellbore.

21~~23~~. The method of claim 20~~22~~, further comprising extracting heat energy from the working fluid.

22. The method of claim 1, wherein the drilling fluid has a temperature of greater than twenty-five degrees Celsius when flowing in the drill string a surface location at an uphole end of the wellbore.

23~~24~~. A system for drilling a wellbore in a geothermal well in a subterranean zone, wherein an inherent temperature of the rock ~~adjacent a rock face at a downhole end of the wellbore~~ is at least 250 degrees Celsius, comprising:

a drill string comprising a drill bit to break a formation at ~~the~~ a rock face ahead of the drill bit; and

a drilling fluid wherein the drill bit and drill string are configured to circulate the drilling fluid~~circulated~~ at the rock face ahead of the drill bit at a temperature such that a difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid where convective cooling occurs with ~~at~~ the rock face ahead of the drill bit is at least 100 degrees Celsius causing a thermally induced stress in the rock at the rock face that is greater than the tensile strength of the rock at the rock face.

~~25. The system of claim 24, wherein the difference between the inherent temperature of the rock adjacent the rock face and the temperature of the drilling fluid at the rock face causes a thermally induced stress in the rock at the rock face that is greater than the tensile strength of the rock at the rock face.~~

24~~26~~. The system of claim 23~~24~~, wherein the downhole end of the wellbore is at a measured depth of at least 4000 meters.

25~~27~~. The system of claim 23~~24~~, wherein the difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid at the rock face ahead of the drill bit where convective cooling with the rock face occurs is at least 175 degrees Celsius.

26~~28~~. The system of claim 23~~24~~, wherein the inherent temperature of the rock adjacent the rock face ahead of the drill bit is at least 350 degrees Celsius and the difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid at the rock face ahead of the drill bit where convective cooling with the rock face occurs is at least 200 degrees Celsius.

27~~29~~. The system of claim 23~~24~~, wherein the wellbore is a lateral wellbore.

28. A method for drilling a geothermal well in a subterranean zone, comprising:

drilling, with drill bit at a downhole end of a drill string, a lateral wellbore of the geothermal well in the subterranean zone, wherein an inherent temperature of the rock adjacent a rock face ahead of the drill bit is at least 250 degrees Celsius; and

flowing, while drilling, a drilling fluid at a temperature at the rock face ahead of the drill bit such that a difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid flowing where convective cooling of the rock face occurs ahead of the drill bit is at least 100 degrees Celsius.

29. A method for drilling a geothermal well in a subterranean zone, comprising:

drilling, with a drill bit at a downhole end of a drill string, a wellbore of the geothermal well in the subterranean zone, wherein:

an inherent temperature of the rock adjacent a rock face ahead of the drill bit is at least 250 degrees Celsius;

the drill string comprises a plurality of tubular segments;

at least one of the tubular segments comprises a coating layer at least partially covering a circumferential surface of the tubular segment; and

a length normalized thermal resistance of a coated wall portion of the tubing string is at least 0.002 meters kelvin per watt; and

flowing, while drilling, a drilling fluid at a temperature at the rock face ahead of the drill bit such that a difference between the inherent temperature of the rock adjacent the rock face ahead of the drill bit and the temperature of the drilling fluid flowing where convective cooling of the rock face occurs is at least 100 degrees Celsius, thereby causing, at the rock face ahead of the drill bit, a thermally induced stress that is greater than the tensile strength of the rock.