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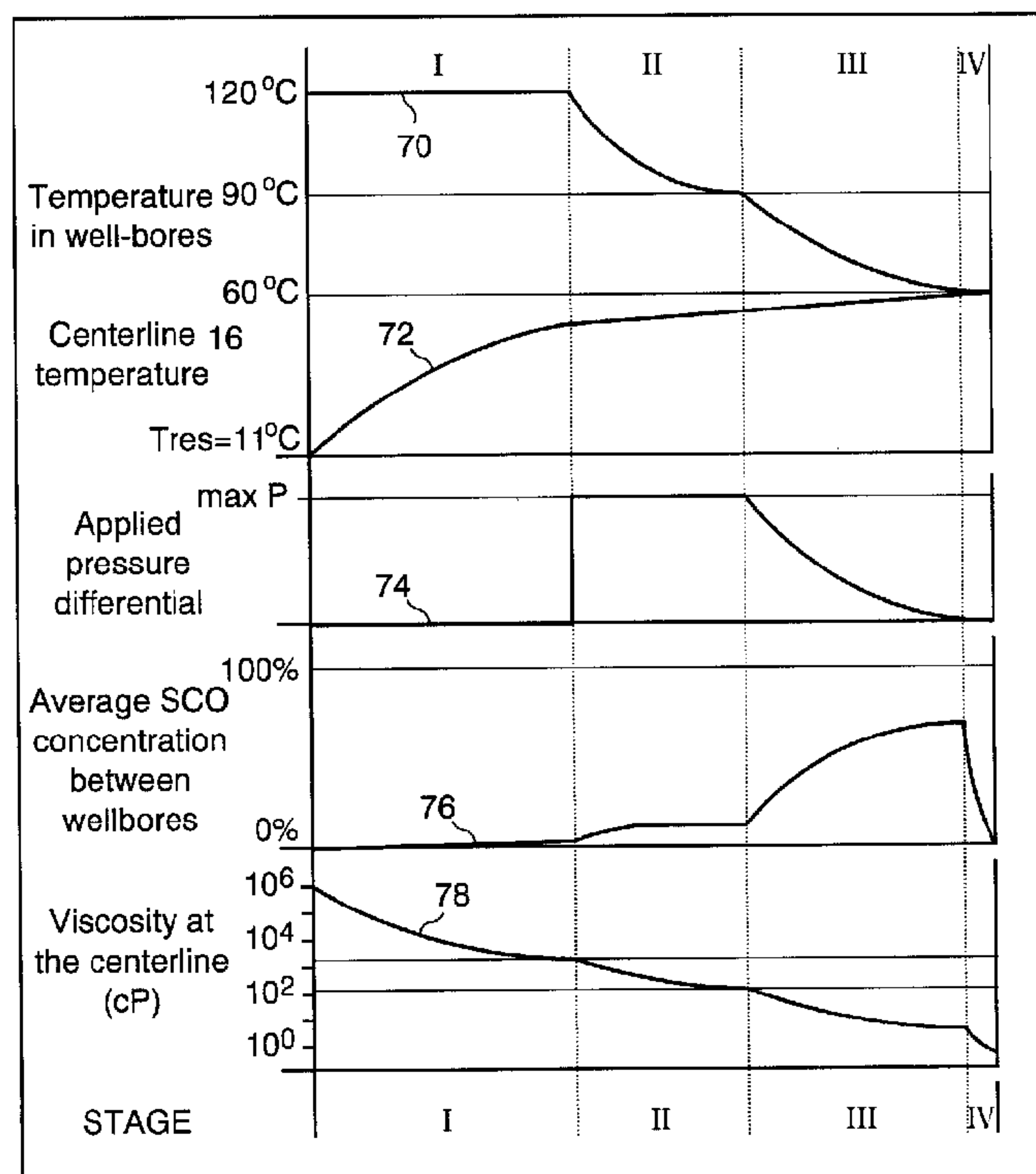
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(54) Titre : PROCÉDE ET APPAREIL POUR ETABLIR UNE COMMUNICATION FLUIDE ENTRE DES Puits
HORIZONTAUX

(54) Title: METHOD AND APPARATUS FOR ESTABLISHING FLUID COMMUNICATION BETWEEN HORIZONTAL
WELLS



(57) Abrégé/Abstract:

A method of starting up a well pair for EOR by establishing fluid communication between the wells is disclosed. The method includes the steps of providing a fluid based heat delivery system in each well of said well pair, and circulating a heated non-

(57) **Abrégé(suite)/Abstract(continued):**

deasphalting start-up fluid in each well at a first temperature. Then, applying a pressure differential between the wells to encourage start-up fluid displacement across an inter well bore region, and controlling a viscosity of the start- up fluid through one or both of temperature and concentration control, to encourage hydraulically sweeping the inter well bore region, and transitioning from displacing the start-up fluid to a working fluid extraction process.

ABSTRACT OF THE DISCLOSURE

5 A method of starting up a well pair for EOR by establishing fluid communication between the wells is disclosed. The method includes the steps of providing a fluid based heat delivery system in each well of said well pair, and circulating a heated non-deasphalting start-up fluid in each well at a first temperature. Then, applying a pressure differential between the wells to encourage start-up fluid displacement across an inter well bore region, and controlling a viscosity of the start-up fluid through one or both of temperature and concentration control, to encourage
10 hydraulically sweeping the inter well bore region, and transitioning from displacing the start-up fluid to a working fluid extraction process.

Title: Method and Apparatus for Establishing Fluid Communication Between Horizontal Wells

FIELD OF THE INVENTION

5 This invention relates the field of hydrocarbon recovery or the extraction of oil and the like from underground reservoirs. In particular this invention relates to methods and apparatuses related to in situ extraction of such hydrocarbons and most particularly to processes that use a generally horizontal well pair that includes an injection well and a production well and requires fluid communication between the
10 wells.

BACKGROUND OF THE INVENTION

 The efficient extraction of heavy hydrocarbons from underground reservoirs is challenging. Reservoir conditions are highly variable and pose many unique
15 challenges for extraction due to unique characteristics of the reservoir. Presently, although new discoveries of conventional oil are still being made, there is an increasing need to produce heavy hydrocarbons. The production of heavy hydrocarbons can involve considerable technical challenges that have to be overcome for these resources to be economically, sustainably, and safely recovered.

20 A prime example of an abundant but technically difficult resource is found in the oil sands, for example, in Alberta, Canada. Surface mining is extensively used, but can only economically reach a small fraction of the total known resource.

 Consequently, efforts have been made to develop in-situ technologies to recover the other hydrocarbons within the oilsands. These technologies seek to recover
25 the hydrocarbons from the surface without significant disturbance of the surface soil and the arboreal forest as is required with the surface mining approach. Current in-situ technologies being used commercially or are in development can be classed as thermal, thermal-solvent and solvent only processes, with this classification based on the media or energy source used to mobilize the heavy, or pay hydrocarbons.

Some in-situ technologies use a pair of generally horizontal wells, one generally above the other, which are sometimes referred to as a well pair. The upper well is the injection well used for injecting a working fluid such as water steam and/or solvent vapour, and the lower well is the production well used for pay zone hydrocarbon and working fluid recovery. Recovery processes employing horizontal wells in such a vertically paired configuration may rely on gravity drainage, with the mobilized liquids draining down into the production well from an extraction chamber which is formed around and above the injection well by means of continuous working fluid injection.

10 The start-up phase may be considered to be that part of the extraction process operation after the wells have been drilled and completed, but before an extraction chamber has been developed. In paired horizontal wells of the type used for gravity drainage, the wells are typically drilled in proximity to a bottom of a pay zone containing hydrocarbons. If the bitumen is immobile at initial reservoir conditions, 15 then fluid communication needs to be established between the wells to permit the drainage to occur from the formation to the production well. Fluid communication, in this sense, means that fluids can travel under the influence of gravity, for example, between the upper well and the lower well so that, for example, gases injected through the upper injector well can condense and these condensed liquids can flow down to be 20 removed through the producer well underneath. If the region between the two wells is filled with immobile hydrocarbons drainage is blocked thus limiting production of mobile hydrocarbons to the surface. In essence then, fluid communication involves removing the immobile, or near immobile hydrocarbons from between the well pair in a manner that permits fluids to easily drain down to the production well. If the liquid 25 drainage is obstructed, then the extraction chamber will just fill up with liquid and the ability to deliver working fluid and/or heat to the reservoir is impaired.

In the SAGD process, steam is typically circulated in the well bores to preheat the surrounding reservoir. By means of such heat the hydrocarbons are rendered somewhat mobile and can be removed from between the well pair. This approach has

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some disadvantages for solvent based processes because it introduces a lot of water into the formation and water can be an effective barrier to solvents, and thus impair the contact between solvent and the bitumen. Further, this would require both solvent and steam processing surface facilities which duplicates capital costs.

5 Canadian Patent Applications 2,691,889 and 2,730,680 relate to solvent extraction processes in which a solvent gas is circulated in both the production well and the injection well to warm the near well bore area. However, these patent applications teach the use of a solvent gas at a temperature above its critical temperature. The problem with using gas to establish communication between the
10 well pair is its relatively low sensible heat content; consequently, the start-up process will take a long time to mobilize the pay hydrocarbons between the well pair and require high gas flow rates and pressure drops to establish the desired temperature rise between the two wells even though a high temperature is being used. High pressures can lead to solvent leak off and loss. Further, as taught in these applications, the high
15 heat creates a de-asphalting effect that can lead to deposits. Such deposits, if located between the upper and the lower well can cause a permanent reduction in the formation porosity between the wells, leading to permanent plugging or poor drainage. Lastly, a high heat, high pressure process will likely lead to spot breakthroughs between the well pair or short circuiting, which will establish some, but only very limited, localized
20 hydraulic drainage between the wells. What is desired is a start-up process that will generally mobilize and remove substantially all of the pay hydrocarbon from the entire length of the zone between the well bores thereby permitting the formation to be freely draining for the working fluids without leaving damaging asphaltene deposits behind in the reservoir region used for well drainage. An improved start-up procedure is
25 required.

SUMMARY OF THE INVENTION

What is desired therefore is a start-up method to establish fluid communication by forming a drainage zone between a pair of horizontal wells that are to be used in

gravity drainage thermal, thermal-solvent, and solvent based extraction processes. Thus, for any process which can create mobile fluids within the formation good drainage rates will lead to good production rates. The preferred start-up method should mobilize and remove the pay hydrocarbon in the inter well bore zone without
5 introducing excess water into the formation or causing other formation damage such as the deposition of asphaltenes. The start-up method should be reasonably quick and reliable to establish good communication along the length of the well pair with a minimum of blocked or impervious regions. The total time for the start-up process should be minimized, be simple and robust, and at the completion of the start-up
10 process, the in situ conditions should be compatible with the desired subsequent working fluid injection conditions. In particular, for example for a heated solvent process, the temperature of the formation between the well bores should be compatible with the operating temperature for the follow on condensing solvent process, for a smooth hand off between start-up and extraction.

15 According to the present invention these and other objectives can be met by using a multi-step start-up procedure. A first step is to deliver heat into each of the well bores. This can be readily achieved by circulating start-up liquid such as a hot hydrocarbon fluid to the toe of the well and back up the annulus or by energizing a heating element placed in the well bore or by some combination of both. Heat supplied
20 to each of the well bores will be conducted outward from the well bore and will eventually raise the temperature of the region between the well bores. The start-up procedure involves optionally preheating the near well bore area for example, using a resistance electrical heating device inserted into each of the well bores. Next, a slight positive pressure differential can be applied between the injection and production
25 wells to displace the start-up liquid into the pay hydrocarbon, to encourage further mixing, warming, and displacement into the one of the production and injection wells where it can be subsequently removed by the recirculating start-up liquid. The temperature may be reduced or increased during this stage and recirculation from both wells is carried on until the pay hydrocarbon starts to become reasonably mobile, as

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evidenced by the amount of pay hydrocarbon content produced to the surface in conjunction with the re-circulating liquids. At an appropriate time, the production well is put into production, with artificial lift if required, and the recirculation rate in the injection well is gradually reduced in favour of a displacement between the upper
5 injection well to the lower production well. This displacement is carried on until the mobilized pay hydrocarbon is largely removed from between the wells and clear communication is established by the start-up liquid. Communication completeness is determined by the amount of pay hydrocarbon in the recirculation fluid at the production well. The mobilization and removal of the inter-well bore pay hydrocarbon
10 is accomplished whilst avoiding the creation of potentially harmful asphaltene deposits in the near well bore region since it is a displacement rather than a solvent mobilization. More specifically, this goal is achieved by avoiding the use of known deasphalting solvents such as propane, butane, pentane and others that cause asphaltene precipitation until after the start-up phase is completed. During a following
15 condensing solvent process for example, where de-asphalting may occur, such de-asphalting will occur at the extraction chamber perimeter, will be widely disbursed and will not adversely affect fluid drainage properties to the production well.

According to one aspect, the present invention provides a method of establishing fluid communication between a pair of vertically spaced apart generally
20 horizontal wells located within a pay zone in an underground hydrocarbon bearing reservoir, said method comprising the steps of:

providing a start-up fluid based heat delivery system in each of said generally horizontal wells;

25 circulating a heated non-deasphalting start-up fluid in each of said wells at a first temperature;

applying a pressure differential between said well bores to encourage start-up fluid displacement across an inter well bore region from one of said wells towards the other to encourage establishing fluid communication between said well pair;

controlling a viscosity of said start-up fluid through one or both of temperature and concentration effects to encourage sweeping pay hydrocarbons out of said inter well bore region; and

transitioning from displacing said start-up fluid to commencing a working fluid
5 extraction process using gravity drainage.

In one embodiment a pre-heating step of using an electrical downhole heater may be used. The pre-heat may be an electrical resistance heater, or any other downhole heat source which can passively warm the inter well bore area before fluid is circulated. Optionally, the present invention provides an electrical resistance-based
10 pre-heating system in each of said generally horizontal wells which can be operated simultaneously with start-up fluid circulation.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made, by way of example only, to preferred
15 embodiments of the invention in which:

Figure 1 is an illustration of a horizontal well pair located within a pay zone of an underground formation;

Figure 2 is a graph showing the change in viscosity of sample pay hydrocarbon such as bitumen for different temperatures and blends with a liquid hydrocarbon such
20 as synthetic crude oil (SCO);

Figure 3 is a schematic showing the different stages of a start-up procedure according to the present invention;

Figure 4a is a diagram indicating the well bore and midline temperatures over time for a typical well pair for a given initial electrical resistance pre-heating period;

25 Figure 4b is a diagram indicating the well bore and midline temperatures over time for a typical well pair for a given initial start-up liquid temperature and flow rate;

Figure 5 is a graph illustrating the temperature at the well bore midline and the amount of heat energy absorbed by the reservoir over a treatment period for a treatment according to the present invention;

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Figure 6 is a chart illustrating the effect of well spacing of the well pair on the timing of the start-up phase according to the present invention;

Figure 7 is a schematic view of the bitumen phase on one side and the temperature profile on the other side of at four different times during the start-up procedure according to the present invention;

Figure 8 shows the effect of spacing between the well pair on the drainage time according to the present invention; and

Figure 9 shows the effect of changing the pressure differential on the drainage time according to the present invention.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a schematic view of a generally horizontal well pair with an upper well 10 and a lower well 12 that are separated by a well spacing 14. Midway between the wells 10 and 12 is a mid or centerline 16. The wells 10, 12 are located within an underground formation 18 which includes a pay hydrocarbon zone 20, with an overburden 19 and an underburden 21. The well pair 10, 12 are positioned towards the bottom of the pay hydrocarbon zone 20 in accordance with a conventional positioning of the well pair for gravity drainage. The preferred type of pay zone is a heavy hydrocarbon pay zone such as may be found in the oilsands of Alberta, Canada.

Although the wells are shown with slanted risers 22, 24, and horizontal casings 26, 28, it will be appreciated by those skilled in the art that these are illustrations only and that in practice the angle of the wells might vary considerably from this. Thus, in this specification, the terms generally horizontal and generally vertical are used to comprehend the field variations that might be encountered from horizontal and vertical. Further, in this specification, the term near well bore area means an area surrounding a well bore in cross section. As well, the term inter well bore area means the space between the well pair.

The present invention comprehends providing the well bores with a pre heating phase which may be electrical resistance heating and or a fluid delivery system to

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provide a heated start-up liquid to the wells in accordance with a preferred method as described below. In one form of the invention, the resistance heating system includes long electrical resistance well bore heaters 27, 29 that extend along the length of each of the wells having electric power lines 31, 33 which extend to the surface and are
5 connected to a power source. While this is one form of pre-heating device it will be understood that the present invention comprehends other forms of in situ or downhole heater as well. What is desired is some form of downhole heat that can be used after the wells are completed, but before the surface facilities are ready to circulate the start-up fluid.

10 In Figure 1, the fluid delivery system includes narrow diameter tubes 30, 32, for example 3½-inch coil tubing, which is fed down the riser portion of the well and then fed out towards the toe 34, 36 of each well 10, 12. A second narrow diameter tube 38, 40, such as the 3½ inch coil tubing, is also fed down the riser portion of each well, but preferably extends only to about a heel 39, 42 of each well 10, 12. Each of
15 the narrow diameter tubes 30, 32, 38 and 40 are connected to appropriate above-grade pumps and heaters to allow a circulation of liquid down to the toe, back along the casing and then up through the tubes 38, 40 to the surface again in each well 10, 12 as shown by arrows 44. Although this is shown as extending from the toe and the heel, the present invention comprehends ending the narrow diameter tubes intermediate the
20 ends depending upon the circumstances.

In the most preferred embodiment of the invention, the start-up liquid is a liquid hydrocarbon that is heated above-grade in an appropriate heat exchanger (not shown) before being circulated through the wells 10, 12, by, for example, a pump. Accordingly, the present invention provides a liquid circulation system for start-up,
25 which permits the start-up liquid to be heated above and / or below grade, pumped down the tubes 34, 36 of each well and out to the toe, where it is released into an annulus formed between the narrow diameter tubing and the well casing. Then the fluid is drawn back along the casing towards the heel, where it enters the second tubes 38, 40, and from there it is brought or pumped up to the surface. At the surface the

start-up liquid can be conditioned to remove solids and water if necessary, reheated and then re-circulated back into the wells as described above. Placing the start-up fluid well inflow end at the toe establishes a countercurrent heat exchange, between the tubing and the annulus. While countercurrent heat exchange is not optimal and initially
5 produces large thermal gradients along the well bore, calculations show that for the preferred embodiment of the invention, within a week, the counter-current temperature gradient flattens out and the well bore is effectively isothermal, permitting most of the heat in the start-up liquid to be delivered to the formation in the near well bore area through conduction.

10 The preferred method of the present invention is a multiple step process, as described in more detail below. In an optional first step or phase, which may or may not be appropriate in all circumstances a downhole heat source, such a downhole heater, for example, an electrical resistance heating device can be placed in each of the well bores. Heat from the downhole heater is delivered to the well bore and in the case
15 of a resistance electrical heater is transferred into the reservoir formation by conduction. Electrical power is supplied to the resistance heating device located above grade through an appropriate connection to an electrical power supply. This is considered a pre-heating step or phase and is continued until a desired amount of heat is delivered to the reservoir. Such a preheating step may reduce the time required to
20 transfer heat through start-up fluid circulation alone.

As for the start-up fluid, assuming that a down hole heater has been used, in the next step the start-up liquid is heated above grade, and then simply circulated within each well for enough time to further increase the reservoir temperature in the region surrounding the well bores or the near well bore area. As the start-up liquid's
25 heat is transferred to the formation through conduction, the temperature will gradually rise in the near well bore region in a circular or radial pattern around each well bore. The heat and volume lost from the circulating start-up liquid is made up by a combination of reheating and the addition of fresh, hot start-up liquid at the surface. It will be appreciated that the preferred start-up liquid is one that is compatible with

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the surface facilities for the extraction process. Thus, in the case of a process that uses a working fluid of a condensing solvent, the preferred start-up liquid is a form of liquid hydrocarbon. Many different start-up liquids are comprehended by the present invention, provided they meet with certain initial criteria. Most preferably, the start-up liquid is hydrocarbon-based so as to avoid using or introducing water into the formation. Fluids such as SCO, diesel fuel and other refined or upgraded products are suitable. What is most preferred is a liquid that does not cause de-asphalting, will remain a liquid in the temperature and pressure ranges used in the start-up process of the present invention, and which is generally available in the local area. Liquids are preferred over gases due to their greater effectiveness in delivering heat to the reservoir and their greater ability to sweep out in situ hydrocarbons located between the well pair.

Of course, the rate of heating will depend on a number of factors, including the rate of flow and initial temperature of the start-up liquid and the initial temperature of the reservoir. According to well understood engineering principles, the greater the temperature difference between the start-up liquid and the reservoir, the more rapid the heating of the reservoir will be. However, there may be temperature and pressure limits imposed by the conditions present in the reservoir or the desired start-up conditions that must be considered in defining the operating conditions for temperature and pressure. In the event that an initial pre-heat is applied with a downhole heater, the start-up fluid must be warmer than the near well bore temperature to add heat to the formation. However, the start-up fluid is also responsible for hydromechanical effects as set out below, namely the displacement of the inter well bore pay hydrocarbons even if the heating has been adequately done by the electrical heat.

Figure 2 shows a graph that illustrates the calculated change in viscosity of representative bitumen with both change in temperature and change in concentration in a preferred hydrocarbon start-up liquid, specifically SCO, in a bitumen/SCO blend. The curve 50 is the change in viscosity curve of pure representative bitumen. Below that are curves 52, 54, 56, 58 and 60, which represent 90% bitumen/10% SCO to 10%

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bitumen/90% SCO in changes of 20% on a per line basis. The line 62 represents the change in viscosity for SCO over a range of temperatures. This graph illustrates that there are significant changes in viscosity for the bitumen with both a temperature change and a change in SCO concentration. As can now be understood, the present invention seeks to take advantage of two ways to reduce viscosity of the bitumen in the inter-well bore zone i.e. by both warming and liquid dilution. In some cases, it may be appropriate to clean out the wells before commencing with the start-up method of the present invention. The clean out of the wells is for the purpose of removing any material that would impede the easy flow of fluids through the well, such as leftover drilling mud or the like, as well as removing any excess free water that might be present. A nitrogen or other gas huff-and-puff optionally is comprehended by the present invention. In this sense a huff-and-puff pretreatment step involves injecting a gas, up to a certain pressure, and then releasing the pressure and removing the gas from the area in which it was applied. In any such clean out preconditioning step, it is important not to use so much pressure as to overpressure the formation. Thus, it is preferred to keep the "huff" pressure well below a formation fracture pressure and most preferably below reservoir pressure during the huff and puff step. By being below the native reservoir pressure it may be possible to prevent a loss of the pressurized gas to the formation. The clean out gas can also be circulated through the well tubes to the toes, then into the annulus and then drawn out again through the well tubes located at the heels as described previously to clean the tubes out if needed or desired.

Once the clean out step has been completed (if the same is necessary or advisable), the start-up method can commence. Figure 3 shows a schematic of a preferred form of the present invention, which has four main stages identified by numerals I, II, III and IV across the top and, for ease of reference, the bottom of the Figure 3. Plots are provided for the changes in various parameters during each of the start-up phases. At the top, line 70 is a plot of the temperature of the well bores during the four phases for the invention implemented in an oilsands reservoir as found in

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Alberta, Canada. Below it is a plot 72 of the temperature of the centerline between the two wells for the like implementation, and Line 74 is a plot of the applied pressure differential between the two wells. The plot 76 identifies the average relative pay hydrocarbon concentration that arises between the well bores in the zone to be cleared.

5 The plot 78 shows the average relative change in the pay hydrocarbon viscosity at the well-pair centerline during the start-up phases. While these values are suitable for the representative bitumen used in this example, the actual values may vary for other bitumen or pay hydrocarbon deposits.

The present invention comprehends a further pretreatment step using a means

10 of delivering heat directly to the formation through a downhole heater such as an electrical downhole heater. In a preferred embodiment the heater is in the form of a long heater element that can run the length of the wells. As can be seen from the Figure 3, Stage I involves raising the temperature of the near to the inter well bore area. This may be done by a downhole heater by circulating hot start-up fluid or a

15 combination of both. Regardless of the source of the heating what is desired is to provide an even heat distribution along the length of wells to help warm the inter well hydrocarbons. In the event downhole heaters are used, one form is to use long heating cables that run the length of the wells to provide heat distribution along the length. As the wells are typically drilled prior to the construction of the above grade facilities, the

20 use of a downhole heater with no fluid circulation may enable well bore heating to start before the plant might otherwise be available to begin the start-up fluid circulation phase, thus beginning pre-heating early and potentially shortening the start-up time. It is desirable to top up the well bore with an appropriate fluid like SCO to enhance the uniform transfer of electrical heat to the reservoir and avoid the potential of

25 overheating during the downhole heater heating step. This also encourages some near well bore dilution of the pay hydrocarbon which is required for viscosity reduction as explained in more detail below.

Another option to deliver heat to the formation in the first stage of the present invention is the circulation of heated liquid, which will further distribute the heat along

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the well length and also carry heat to the formation without asphaltene precipitation. As can be seen by the temperature graph of the centerline temperature 72, over this phase, the temperature between the wells rises from a native reservoir temperature to anywhere between 40⁰C and 70⁰C, most preferably between about 40⁰C to 50⁰C. As
5 shown by the plot line 78, the this application of heat will reduce the bitumen viscosity by about 99% This is accomplished primarily through the temperature conduction as there is no appreciable mixing of the start-up liquid and the pay hydrocarbon during this phase.

The present invention comprehends providing heat by circulating a heated
10 start-up fluid through each of the producer and the injector wells. Assuming a 500 meter well and a 3½-inch coiled tubing, the start-up liquid can be circulated at a rate of 5000 barrels per day (bpd) per well and an initial temperature of anywhere between 30⁰C to 300⁰C, but in this example at about 120⁰C. In this example, the average spacing between the horizontal wells is assumed to be 5.5 meters. Using these values,
15 the temperature increase in the near-well bore area as a function of time can be calculated. The length of time required to complete the this phase is estimated to be about two to six months, with about three months being average, but the time being dependent on the amount of downhole heater pre-heating the start-up fluid temperature, the recirculation flow rate, the length of the wells and the reservoir
20 characteristics. These start-up times are examples of what might be suitable, but other start-up times are also comprehended by the present invention. In choosing the appropriate start-up fluid and temperature, it is important to avoid de-asphalting conditions in the inter well bore area that can damage the porosity of the reservoir formation and inhibit the ability to establish communication between the well pair.

25 It is also highly undesirable to inject hot hydrocarbon based fluid at pressures well above native reservoir pressures because this can lead to loss of confinement and the start-up fluid can be lost from the inter well bore region. This displacement can be avoided or mitigated by the use of artificial lift, so that the downhole circulating pressure is maintained at or perhaps even below the native reservoir pressure. During

the next step, the temperature of the start-up liquid is adjusted to achieve desired operating temperatures for a subsequent formation treatment while still circulating as per Stage I. The main event of phase II is the application of a pressure differential between the two well bores. Most preferably, the pressure is applied from the upper well to the lower well, so that the pay hydrocarbon flows downward assisted by such pressure differential and the viscosity reduction arising from one or both of a temperature change and dilution. A pressure applied from the lower well to the upper well is also comprehended by this invention. The pressure difference may be applied by increasing the pressure in one well, reducing the pressure in the other well, or both. Adjusting the pressure in both wells allows for the optimization of the pressure differential between the wells without exceeding a desired maximum pressure in the reservoir formation. The benefits of the applied pressure differential can now be better understood, as, for example, as pressure is applied to the upper well, it will displace the start-up fluid outwardly. In turn, the start-up liquid will displace the pay hydrocarbon downwardly into a warmer region of the lower well. This displacement further encourages the dissolution and warming of the pay hydrocarbon so as to reduce its viscosity and enhance the ability to displace it from between the well pair.

As can be seen from the plot line 76 in Figure 3, the increased start-up fluid concentration in the pay hydrocarbon and the increased temperature have the effect of further lowering the pay hydrocarbon viscosity, as shown by the plot 78. Most preferably, this phase is completed with little or no further addition of start-up liquid. This means that the circulating fluid reaching the surface trends towards an increasing concentration of pay hydrocarbon content in the start-up fluid. As can now be appreciated, the rising content of pay hydrocarbon in the circulating start-up fluid in combination with a decreasing temperature increases the viscosity of the start-up fluid and helps to limit the amount of fluid flowing between the two horizontal wells, while still allowing a pressure difference to be sustained. In this manner, the present invention is better able to hydraulically sweep out pay hydrocarbons between the wells. Further, the amount of pay hydrocarbon present in the start-up liquid can be

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monitored and used as a proxy for how close the process is to establishing communication along the full length of the well pairs. The present invention contemplates that there will be a non-uniform flow rate of start-up fluid between the wells at various locations along its length. However, by continuing the process of re-

5 circulating the start-up fluid, with the application of moderate pressures over a sufficiently long enough time frame, the present invention can provide for the gentle physical displacement and removal of the pay hydrocarbon from the inter-well bore area without asphaltene deposition.

Now the procedure enters the next stage III of the present invention. As more

10 and more of the inter-well bore pay hydrocarbon is progressively mobilized and displaced, the circulating pumps become rate limited and thus the ability to apply a pressure differential is reduced. Again, it is desirable to continue to adjust the temperature of the circulating fluid gradually so as to permit the formation to assume the design operating temperature for the extraction process that follows. This can

15 involve a reduction in start-up fluid temperature. Also, the viscosity of the circulating fluids may be increased by allowing a greater pay hydrocarbons concentration or a lower temperature or both. A lower viscosity allows a high pressure differential and a more effective sweep of pay hydrocarbons from the inter well bore region. In the case of a following solvent based extraction process, the design operating temperature

20 may generally be between 20°C to 70°C, most preferably 40°C to 60°C, but again dependent on the reservoir conditions. Ideally, the heated start-up liquid-pay hydrocarbon fluid mixture that is circulating is almost at the same temperature as the centerline by the end of this phase. However, due to the mixing and mobilization of the start-up liquid and the pay hydrocarbon there is a higher concentration of start-up

25 fluid between the well bores. As can be seen from the plot 78, the viscosity of the centerline is still further reduced during this next stage as the centerline fluid (bitumen) is progressively displaced with the bitumen start-up fluid blend. The application of a sustained pressure differential over a sufficiently long time ensures almost complete mobilization of the pay hydrocarbon in the inter well bore region. The completion of

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this stage III can be predicted by numerical simulation, and/or confirmed by a variety of physical measurements, such as pressure drop, shut in well bore temperature profiles, fluid properties, tracer residence time analysis, etc.

5 The last stage is stage IV, and it consists of preparing the chamber for production. At the start of this stage, the centerline temperature is about 60°C or whatever other temperature is desired to achieve optimum temperature for the start of the working fluid injection and the fluid between the two well bores is a diluted mixture of pay hydrocarbon and start-up fluid with a viscosity between 10 cP and 1000cP.

10 At this point, the fluid recirculation into the wells is stopped and the mobilized fluid is drained. A means for lifting the liquids out of the formation may be required, such as by using an electrical submersible pump on the production well. The pump is operated for long enough to permit all of the fluid to drain out of the near-well bore area so it can be replaced by the working fluid and to thereby establish good hydraulic
15 drainage along the length of the wells. This is shown as a dramatic reduction in start-up liquid concentration between the wells, and a temperature at the centerline which approaches the temperature of the well bores indicating an even temperature distribution in within the inter-well bore region. In some cases it may be necessary to provide working fluid vapour to the chamber to provide voidage replacement as the
20 mobilized pay hydrocarbon is drained. In other cases, the voidage volume may be filled from dissolved gases that may naturally evolve from the pay hydrocarbon. If it is necessary to supply some working fluid then a small amount of, for example, solvent vapour can be injected into the well provide some vapour pressure support without reaching a pressure that causes condensing conditions so as to minimize the risk of
25 deasphalting the mobilized pay hydrocarbon between the well bores.

When the mobilized pay hydrocarbon is largely drained from the well bore region then the injection of working fluid can now begin. The working fluid is injected from the injection well into the heated, drained chamber and it traverses the chamber and condenses on the cooler extraction interface, located at the periphery of the

extraction chamber, where it releases its heat and reduces the viscosity of the pay hydrocarbon so that the blend can drain by gravity down to the production well. Achieving this condition is mostly a matter of increasing the working fluid injection rate so that the chamber pressure is such that condensing conditions are achieved.

5 From this point on, normal gravity drainage production can proceed. The start-up procedure thus displaces pay hydrocarbon from the inter well bore area through the combined effects of dilution with start-up fluid and raises the temperature. Although 60° C is used in the example, it will be understood by those skilled in the art that any convenient, condensing vapour temperature could be selected based on the working

10 fluid being used. What is desired is to have the temperature of the near-well bore area compatible with the desired operating conditions once the start-up process is complete.

It can now be understood that the working fluid may result in the deposit of immobile asphaltenes with the formation. However, as the start-up stages have displaced the pay hydrocarbons from the inter and near well bore area, these

15 asphaltenes will be located well away from the well bores, and will be dispersed through the formation. Thus, it can be appreciated that the present invention is intended to reduce the production of the asphaltenes at a location where they could substantially interfere with the hydraulic drainage properties of the formation in the vicinity of the production well.

20 Certain features of the present invention can now be appreciated. For example, it can be now understood that the present invention warms, dilutes and drains the pay hydrocarbon between a pair of generally horizontal wells without significant precipitation of asphaltenes in the close proximity of the wells. This is intended to ensure good flowability and drainage of the working fluid and produced fluid both

25 around the wells and between the wells. The pressure differential is applied between the wells to encourage mixing, for better heat transfer, and to mobilize the pay hydrocarbon from the well bore area into one of the wells so that it can be removed from the reservoir. The start-up liquid has an ability to deliver heat efficiently to the formation to encourage a reduction in the viscosity of the in situ pay hydrocarbon.

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Using the toe delivery tube and the heel removal tube in each horizontal well encourages the flow of the start-up liquid along the length of the wells to even out the heat distribution during the process along the full length of the horizontal wells. Figure 4 shows the well bore and center line temperatures, after 3 days, 10 days, 90 days and steady state, for wells with a working fluid supply temperature of 120°C for a 500 meter well pair and a 5000 bpd circulation rate. As shown, the temperature in the wells after one week is about 105°C and it is estimated that the temperatures reach a steady state when the heel is about 110°C and the toe is about 115°C.

The centerline temperature profile (i.e. at the midline 16 of figure 1) is also shown at different times during the start-up process (in this case without a downhole heater pre-heating step). In this same example, the well temperatures are shown at the start, after ten days, after 30 days, after 80 days and after 115 days. As can be seen, the temperature profiles at the centerline are quite uniform despite the large increase in the well bore temperature. This is because it takes time for the heat to be conducted out to the mid-point between the well pair.

Figure 5 is a graph of the total heat supplied to the area and the temperature history over time for this example. The plot line 80 shows the change in temperature and the plot line 82 shows the rate of heat input in kW. As the reservoir surrounding the wells gets warmer, the rate of heat transferred by the start-up fluid gets smaller due to a smaller temperature difference. As shown, after one week the rate of heat input into the ground is about 500kW per well pair, after two weeks it might drop to about 400kW and at the end of the period it has dropped to 300kW.

Figure 6 shows the estimated effect of start-up fluid temperature on the warm-up period. According to the present invention, the warm-up period can be reduced by supplying the start-up fluid at a temperature of 140°C as compared to 120°C, and reduced even further by supplying start-up fluid at 170°C. The reduction in start-up time for a well spacing of 5.5 meters on average is estimated to be to three months for an operating temperature of 140°C as compared to well over four months for a 120°C operating temperature, and two months for 170°C, as shown by plot line 90. Plot lines

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92 and 94 show the start-up time for a well pair spacing of 4.5 meters and 6 meters respectively and various operating temperatures. It will be understood, however, that the end of the start-up procedure defines a starting temperature for the beginning of extraction. The higher the temperature of the extraction process, which in some cases
5 is controlled by selecting an operating pressure and thereby defining a condensation temperature, the greater the overall energy requirement for the extraction. Thus, the present invention is intended to warm the formation up in the near-well bore area to a temperature that is compatible with the extraction process which follows. In a preferred embodiment the hand-off temperature is equal to the extraction temperature,
10 but the present invention comprehends that these two temperatures may also be different, depending upon the extraction process.

Figures 7a to 7d illustrate more clearly the effect on the near- and inter-well bore areas of the start-up method according to one aspect of the present invention. These graphs depict temperature profiles over time, and are estimated at 30, 60, 85 and
15 93 days for a test case. The test case is a well of 500 meters in length, with a start-up liquid temperature of 120°C, a well separation distance of 5.5 meters, and a differential pressure of 2MPa. On the left hand side of each drawing is the pay hydrocarbon concentration and on the right hand side is shown the estimated temperature contours
100. As can be seen by the thermal contours, the temperature wave gradually
20 penetrates outward, further away from the wells 10, 12 in a radial pattern. On the other half of the figures, it can be seen that the pay hydrocarbon is gradually swept out of the inter-well bore region over time with the expansion of swept area, shown as 102, 104, and 106. The exact time required to displace the pay hydrocarbon and complete the start-up process will vary from reservoir to reservoir and will vary along the wells
25 depending on the spacing of the horizontal wells at a particular location but the foregoing illustrates the effect of the preferred invention on the near-well bore region. For ease of illustration, the swept areas are shown for one half of the well bores 10, 12, although it will be understood by those skilled in the art that the swept area will be symmetrically extended on both sides of each of the wells 10, 12.

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Figure 8 shows the effect on the sweeping time of the pay hydrocarbon of well pair separation and start-up fluid operating temperature. The y-axis is sweeping time in days and the x-axis is the temperature of the start-up fluid. The plot lines 110, 112 and 114 show that the closer the well pair 10, 12 is together, and the higher the applied temperature, the quicker the sweeping time for this representative example. Figure 9 shows the effect on sweeping time of start-up fluid temperature and applied pressure. In this figure, the y-axis is sweeping time in days and the x-axis is the temperature of the start-up fluid. Additionally, the plot lines 116, 118 and 120 are three different pressure differentials applied between the wells 10, 12. As can now be appreciated, the present start-up method can be varied to be made quicker or slower as needed to suit local reservoir conditions and operating requirements. Generally, the greater the temperature of the start-up fluid, the faster the displacement can occur, sweeping out the pay hydrocarbons. Generally, the closer the well spacing, the faster the pay hydrocarbon is removed from the inter-well bore area. Generally, the higher the pressure applied between the wells, the faster the desired completion of sweeping the inter-well bore region of pay hydrocarbon. However, the individual conditions of the reservoir may provide upper limits to each of these parameters. Closer well spacing requires good inflow control into the production well to avoid flooding the injector well with liquids. Higher pressure differentials require good reservoir integrity to avoid pushing the start-up fluid out, away from the inter-well bore area through high permeability routes.

As can now be appreciated, the present invention comprehends using certain equipment to implement the preferred start-up process. For example, above grade there is a source of liquid start-up fluid, most preferably a non-asphaltene hydrocarbon that can be heated by a heater to a predetermined temperature. Next, there needs to be a pump and a wellhead connection, to permit the heated hydrocarbons to be circulated through the wells. If the reservoir integrity is sufficient, that the pump pressure can be used to also pump the fluids back out of the well, then that is preferred. However, the present invention also comprehends that it may be necessary to use well heel

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pumps to pump the liquids back up to the surface as a means to reduce the reservoir pressure to match reservoir containment conditions. Such well heel pumps might be any form of suitable pumps such as electrical submersible pumps. This adds expense and complexity and thus is less preferred except when to do otherwise would invite a
5 loss of liquids owing to a lack of reservoir integrity.

The present invention also comprehends using temperature and pressure sensors and the like to instrument the wells during the start-up process to provide monitoring of the progress of the start-up through the different phases. The present invention also comprehends using temperature and pressure sensors and the like to
10 instrument observation wells in order to monitor the start-up process. Sampling facilities located above grade are also required to monitor the pay hydrocarbon content of the circulating fluid.

The present invention also comprehends the use of a downhole heat source such as an electrical resistance heater to use in delivering heat as an initial option phase
15 of the start-up process, as noted above.

As can now be appreciated the present invention provides for a warming of the pay hydrocarbon in the near well bore area by contact with a warm start-up liquid, for the purpose of reducing the viscosity of the pay hydrocarbon. In this sense, warm means moderate temperatures as opposed to the high temperature steam at typical
20 reservoir pressures of 1 MPa or higher. Further, the start-up liquid is dissolved into and mixed with the pay hydrocarbon to further reduce the viscosity without being in sufficient quantity or kind that substantive asphaltenes are deposited in the inter well bore region. Essentially the present invention is aimed at mobilizing and then removing the pay hydrocarbon, as a whole, from the near-well bore area to establish a
25 working fluid injection and extraction chamber. At the end of the start-up process, the extracted zone is at or near to the desired temperature for the extraction process that follows. The start-up process has been carried out in the absence of any water injection. Also, any residual water in the reservoir that may have been turned into steam by the warm start-up liquid, will re-condense and be removed from the near-

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well bore region as the liquids are removed in the start-up process. Once extraction commences, the asphaltene deposits that may occur will be formed at a location distant to the near-well bore region at the extraction interface and thus will not impede fluid flow in the near well bore region. Further, the start-up liquid is preferably compatible
5 with the surface facility that is located above the reservoir for the purpose of working fluid injection and pay hydrocarbon production. Furthermore, the displacement from injector to producer could be reversed and the circulating and displacement fluid could be injected at other locations besides the toe, and withdrawn at other locations besides the heel, as needed.

10 While the foregoing describes preferred embodiments of the present invention, it will be understood by those skilled in the art that various modifications and alterations are possible without departing from the broad spirit of the invention as defined in the attached claims. While some of these variations have been discussed above, others will be apparent to those skilled in the art. All such variations and
15 modifications are comprehended by the present specification.

**THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:**

1. A method of establishing fluid communication between a pair of vertically
5 spaced apart generally horizontal wells located within a pay zone in an
underground hydrocarbon bearing reservoir, said method comprising the steps
of:
 - providing a fluid based heat delivery system in each of said generally
horizontal wells;
 - 10 circulating a heated displacement start-up fluid in each of said wells at
a first temperature;
 - applying a pressure differential between said well bores to encourage
start-up fluid displacement across an inter well bore region from one of said
wells towards the other to encourage establishing fluid communication
15 between said well pair;
 - controlling a viscosity of said start-up fluid through one or both of
temperature and concentration effects to encourage sweeping pay
hydrocarbons out of said inter well bore region; and
 - 20 transitioning from displacing said start-up fluid to commencing a
working fluid extraction process using gravity drainage.
2. A method of establishing fluid communication between a pair of vertically
spaced apart generally horizontal wells as claimed in claim 1 wherein said step
of controlling a viscosity of said start-up fluid further comprises continuing to
25 re-circulate said start-up fluid at a second temperature, said second temperature
facilitating removal of pay hydrocarbons from an inter well bore region.
3. A method of establishing fluid communication between a pair of vertically
spaced apart generally horizontal wells as claimed in claim 1 wherein said step

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of controlling a viscosity of said start-up fluid further comprises allowing a concentration of pay hydrocarbons to rise over time in said start-up fluid.

- 5 4. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 1 further including the steps of beginning to produce fluid from one of said wells while continuing to inject start-up fluid in the other of said wells to further displace pay hydrocarbons from the inter well bore region to establish a drainage path between said well pair.
- 10 5. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 1 further including the step of placing a downhole heater in at least one of said wells of said well pair to provide a passive pre-heat step before said start-up fluid is circulated.
- 15 6. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 5 wherein said downhole heater is an electrical resistance heater that extends substantially along a length of one or both of said wells.
- 20 7. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 6 wherein said downhole heater is energized while said start-up fluid is being circulated.
- 25 8. A method as claimed in claim 7 wherein said downhole heater is energized while surface facilities to circulate said start-up fluid are being built.
9. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 1 further

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comprising the pre-treatment step of cleaning said wells to remove potential contaminants from said wells.

- 5 10. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 9 wherein said cleaning step includes using a gas to remove said contaminants.
- 10 11. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 10 wherein said gas is CO₂.
- 15 12. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 1 wherein said step of providing a start-up fluid circulation system that includes positioning coil tubing within each of said wells.
- 20 13. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 12 wherein said step of positioning said coil tubing includes providing an injector tubing that extends generally towards a toe of each well and a return tubing which extends generally to a heel of each well so that said start-up fluid may be circulated from the toe to the heel within each of said wells.
- 25 14. A method of establishing fluid communication between a pair of vertically spaced apart generally horizontal wells as claimed in claim 1 further including positioning a supply of start-up liquid, a heat exchanger, and a power supply, and a pump at a well head for said pair of wells.

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- 5 15. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 1 wherein said step of heating said hydrocarbon liquid includes the step of selecting a generally non-deasphalting hydrocarbon liquid as said start-up fluid to deliver heat.
- 10 16. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 15 wherein said hydrocarbon liquid is one of the group of synthetic crude oil, diesel, kerosene, jet fuel, conventional crude, and other liquid hydrocarbons.
- 15 17. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 1 wherein said step of heating said hydrocarbon fluid comprises heating said fluid above grade in a heater.
- 20 18. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 1 wherein said step of applying a pressure differential further includes the step of applying pressure to one of said wells.
- 25 19. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 18 wherein said one well is the upper well in the well pair.
20. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 1 wherein said step of applying a pressure differential includes reducing the pressure in one of said wells.

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- 5 21. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 20 wherein said step of reducing the pressure in one of said wells comprises reducing the pressure in the lower of the two wells in the well pair.
- 10 22. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 1 wherein the step of applying a pressure differential between said wells includes the steps of increasing the pressure in the upper of said two wells and reducing the pressure in the lower of said two wells to apply a pressure difference between said two wells without exceeding a preferred maximum pressure in said reservoir.
- 15 23. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 1 wherein said first temperature is in a range of between 60C and 180C.
- 20 24. A method of establishing fluid communication between a pair of generally vertical spaced generally horizontal wells as claimed in claim 2 wherein said second temperature is in the range of 25C to 60C.
- 25 25. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 1 wherein a centerline exists between said two wells spaced generally equally from each well, and said heating circulating step is carried on until said pay zone at said center line is heated to a pay hydrocarbon displacement temperature.

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26. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 25 wherein said pay hydrocarbon displacement temperature at the centerline between the horizontal wells is between 40C and 70C.

5

27. A method of establishing fluid communication between a pair of generally vertically spaced generally horizontal wells as claimed in claim 26 wherein said bitumen displacement temperature is about 60C.

28. A start-up method for a pair of vertically offset horizontal wells located within a hydrocarbon bearing reservoir, the start-up method comprising the steps of:

10

circulating, within each well, a heated start-up fluid to heat at least an inter well bore region by conduction;

15

applying a pressure differential between said well bores to encourage said heated start-up fluid to displace across said inter well bore region to further heat said inter well bore region and hydro mechanically displace pay hydrocarbons; and

increasing a viscosity of said start-up fluid over time to reduce short circuiting of said start-up fluid through more permeable portions of said inter well bore region.

20

29. A start-up method as claimed in claim 28 wherein said vertically offset horizontal wells are less than 6.5 meters apart.

30. A start-up method as claimed in claim 28 wherein said vertically offset horizontal wells are less than 5.5 meters apart.

25

31. A start-up method as claimed in claim 28 wherein said vertically offset horizontal wells are about 4.5 meters apart.

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32. A start-up method as claimed in claim 28 wherein said step of increasing said viscosity of said start-up fluid over time comprises reducing said temperature of the start-up fluid towards a preferred operating temperature for a subsequent formation treatment.
- 5 33. A start-up method for establishing communication between horizontal wells through an inter well bore region, said start-up method comprising:
the steps of circulating a heated start-up fluid within each of said wells and increasing the viscosity of the start-up fluid over time to help physically displace and remove pay hydrocarbons from the inter wellbore region.
- 10 34. A start-up method as claimed in claim 33 wherein said physical displacement is encouraged by applying a pressure differential between the wells.
- 15 35. A start-up method as claimed in claim 33 or 34 wherein said increased viscosity is provided by having a higher concentration over time of formation fluids within said circulating start-up fluid.
- 20 36. A start-up method as claimed in claim 35 wherein said formation fluids include pay hydrocarbons.
- 25 37. A start-up method as claimed in claim 33 or 34 wherein said increased viscosity is provided by reducing a temperature of said heated start-up fluid.
38. A start-up method as claimed in claim 33, 34, 35, or 36 wherein said temperature of said heated start-up fluid is reduced over time towards a desired extraction chamber operating temperature for a following condensing solvent gravity drainage extraction process.
- 30 39. A start-up method as claimed in claim 38 wherein said desired operating temperature is between 20 degrees and 70 degrees C.

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40. A start-up method as claimed in claim 38 wherein said desired operating temperature is between 40 degrees and 60 degrees C.
- 5 41. A start-up method as claimed in claim 34 wherein as said start-up fluid viscosity is increased said applied pressure differential is increased.
42. A start-up method as claimed in claim 33 wherein said step of increasing said viscosity of said start-up fluid comprises increasing the viscosity of said start-up fluid to between 10cp and 1000cp.
- 10 43. A start-up method as claimed in claim 33 wherein said start-up fluid is displaced from between said wells by a working fluid.
44. A start-up method as claimed in claim 33 wherein said of increasing a viscosity of said start-up fluid comprises the step of permitting a higher concentration of formation fluids to accumulate in said start-up fluid over time.
- 15 45. A start-up method as claimed in claim 44 wherein said formation fluid includes pay hydrocarbons.
- 20 46. A start-up method as claimed in claim 33 wherein said start-up fluid is initially introduced towards one end of said horizontal wells and then removed from an opposite end of each said horizontal wells.
- 25 47. A start-up method as claimed in claim 34 including a further step of displacing said start-up fluid in said inter well bore region between said horizontal wells by means of a pressure difference applied in the same direction as gravity, from an upper horizontal well towards a lower horizontal well.

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48. A start-up method for an in situ solvent extraction process for extracting hydrocarbons from an underground hydrocarbon bearing reservoir, said start-up method comprising the steps of:

5 displacing pay hydrocarbon from a near and inter well bore region to thereby displace asphaltenes from said near and inter well bore regions to reduce asphaltene precipitation in the near and inter well bore regions when said in situ solvent extraction process is applied to the underground hydrocarbon bearing reservoir.

10 49. A start-up method to remove pay hydrocarbons from an inter well bore region between horizontal wells, said start-up method comprising the steps of:

warming pay hydrocarbons in an inter well bore region,
diluting pay hydrocarbons in said inter well bore region and
draining pay hydrocarbons from an inter well bore region without significant precipitation of asphaltenes in close proximity to said wells to improve flowability
15 and drainage of a working fluid through said inter well bore region.

50. An apparatus for applying a start-up method to an inter well bore region between two vertically displaced horizontal wells, said apparatus comprising:

20 a source of non deasphalting start-up fluid above grade;
a heater for heating said start-up fluid;
a well head connection from said source to each of said two vertically displaced horizontal wells;

25 a fluid delivery and removal system connected to said well head to permit said start-up fluid to be circulated along each of said two vertically displaced horizontal wells;

one or more circulating pumps for circulating said start-up fluid from said source through said heater down into said formation along each of said vertically displaced horizontal wells and then back up to the surface;

30 a conditioner located above grade to remove solids and water if necessary from said returned start-up fluid, and

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sensors to measure one or more of a temperature, a viscosity, and a composition of said start-up fluid which is returned to the surface.

5 51. The apparatus as claimed in claim 49 wherein said source of start-up fluid is a source of diesel fluid.

10 52. The apparatus as claimed in claims 49 and 50 further including a down hole heater to warm said inter wellbore region between said two vertically displaced horizontal wells.

53. The apparatus as claimed in claims 49, 50, and 51 further including a source of make-up start-up fluid.

15 54. The apparatus as claimed in claims 49, 50, 51 and 52 further including at least one vertical observation well having temperature sensors for measuring a temperature within said inter well bore region.

55. The apparatus as claimed in claims 49 to 53 further including a conditioner to condition the start-up fluid recovered from said horizontal wells.

20 56. A start-up method to remove pay hydrocarbons from an inter well bore region between vertically spaced apart horizontal wells in a reservoir, said start-up method comprising the steps of:

25 warming pay hydrocarbons in an inter well bore region with a down hole heat source, while building surface facilities to be able to circulate a start-up fluid.

57. The start-up method of claim 56 further including the step of circulating a start-up fluid through each of said wells while building further surface facilities to be able to operate a working fluid extraction on said reservoir.

30

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58. The start-up method of claim 56 wherein said step of warming pay hydrocarbons includes the step of using a down hole electric heater.
59. The start-up method of claim 58 wherein said down hole heater heats said pay hydrocarbons by conduction.
60. The start-up method of claim 59 further including the step of reducing the viscosity of said pay hydrocarbons over time by said heating.
61. The start-up method of claim 57 further including the step of reducing the viscosity of said pay hydrocarbons by dilution with said start-up fluid.
62. The start-up method of claim 61 further including the step of increasing the viscosity of the start-up fluid over time to help displace said pay hydrocarbons from said inter well bore area.
63. The start-up method of claims 56 to 62 wherein said step of heating said pay hydrocarbon comprises applying a uniform heating along the length of the wells.
64. A start-up method to remove pay hydrocarbons from an inter well bore region between vertically spaced apart horizontal wells in a reservoir, said start-up method comprising the steps of:
- placing circulation tubing in each of the two horizontal wells to permit a displacement start-up fluid to be circulated along each well before communication is established between said wells, and
 - circulating said displacement start-up fluid along each well to mobilize pay hydrocarbons located adjacent to each of said wells through both thermal and solvent effects.
65. The start-up method of claim 64 wherein said step of placing said circulation tubing includes placing an end of at least one tube in each of a toe and a heel in each of said

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well and the displacement start-up fluid is circulated between the heel and the toe or vice versa.

- 5 66. The start-up method of claim 65 wherein the displacement start-up fluid displaces the pay hydrocarbons from the inter well bore area.
67. The start-up method of claim 66 wherein a pressure differential is applied to assist in displacing said start-up fluid and said pay hydrocarbons from between said wells.
- 10 68. The start-up method as claimed in claim 67 wherein said pressure differential is applied by increasing a pressure above a naturally occurring formation pressure in an upper well of said two wells.
69. The start-up method as claimed in claim 67 wherein said pressure differential is applied by reducing a pressure below a naturally occurring formation pressure in a lower of said two wells.
- 15 70. The start-up method as claimed in claim 67 wherein said pressure differential is applied by increasing a pressure in an upper well of said well pair above naturally occurring formation pressure and lowering a pressure in a lower well to a pressure below a naturally occurring formation pressure.
- 20 71. The start-up method as claimed in claim 65 wherein said displacement start-up fluid is injected at locations other than said toe and withdrawn from other locations than said heel.
- 25 72. The start-up method of any one of claims 67 to 71 wherein said applied pressure differential speeds up a rate of displacement of the displacement start-up fluid and the pay hydrocarbons from said inter well bore area as compared to a rate with not pressure differential.
- 30

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73. The start-up method of any one of claims 65 to 72 wherein the vertical spacing of the wells is less than 5.5 meters to reduce the displacement distance between said wells and to reduce a length of time required to displace pay hydrocarbons from between said spaced apart wells.
- 5
74. The start-up method of any one of claims 65 to 73 further including the step of increasing a viscosity of the displacement start-up fluid over time to help displace the pay hydrocarbons from between the well pair.
- 10
75. The start-up method of claim 74 further including the step of controlling a heat of said displacement fluid to help control a viscosity of said displacement fluid.
- 15
76. The start-up method of claims 74 and 75 further including the step of adjusting the composition of said displacement fluid to increase a viscosity of the displacement fluid to assist with the displacement of pay hydrocarbons from between the well pair.
- 20
77. The start-up method of claim 76 wherein said composition is adjusted to have an increased viscosity by allowing a concentration of formation fluids to increase over time as a percentage of the overall composition.
- 25
78. The start-up method of claim 76 wherein said composition is adjusted by increasing a concentration of pay hydrocarbons in said displacement fluid to increase a viscosity of said displacement fluid over time.
- 30
79. The start-up method of claim 76 wherein said step of increasing a viscosity of said displacement start-up fluid over time permits a larger pressure differential to be maintained between said wells during a displacement phase.
80. The start-up method of claims 1 to 79 further including the pretreatment step of removing any free water from said wells that might be present before the displacement start-up fluid is circulated.

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- 5 81. The start-up method of claims 1 to 79 further including the step of establishing a center line temperature between said wells, by controlling one or both of a temperature and circulation rate of said displacement fluid to achieve a desired temperature range for operation of a follow on working fluid extraction process.
82. A start-up method as claimed in any of claims 28 to 49 and 56 to 81 wherein said start-up fluid is a hydrocarbon based fluid.
- 10 83. A start-up method as claimed in any of claims 28 to 49 and 56 to 81 wherein said start-up fluid is a generally non-deasphalting hydrocarbon based fluid.
- 15 84. A start-up method as claimed in any of claims 28 to 49 and 56 to 81 wherein said start-up fluid is comprised of one of the group of synthetic crude oil, diesel, kerosene, jet fuel, conventional crude, and other liquid hydrocarbons.

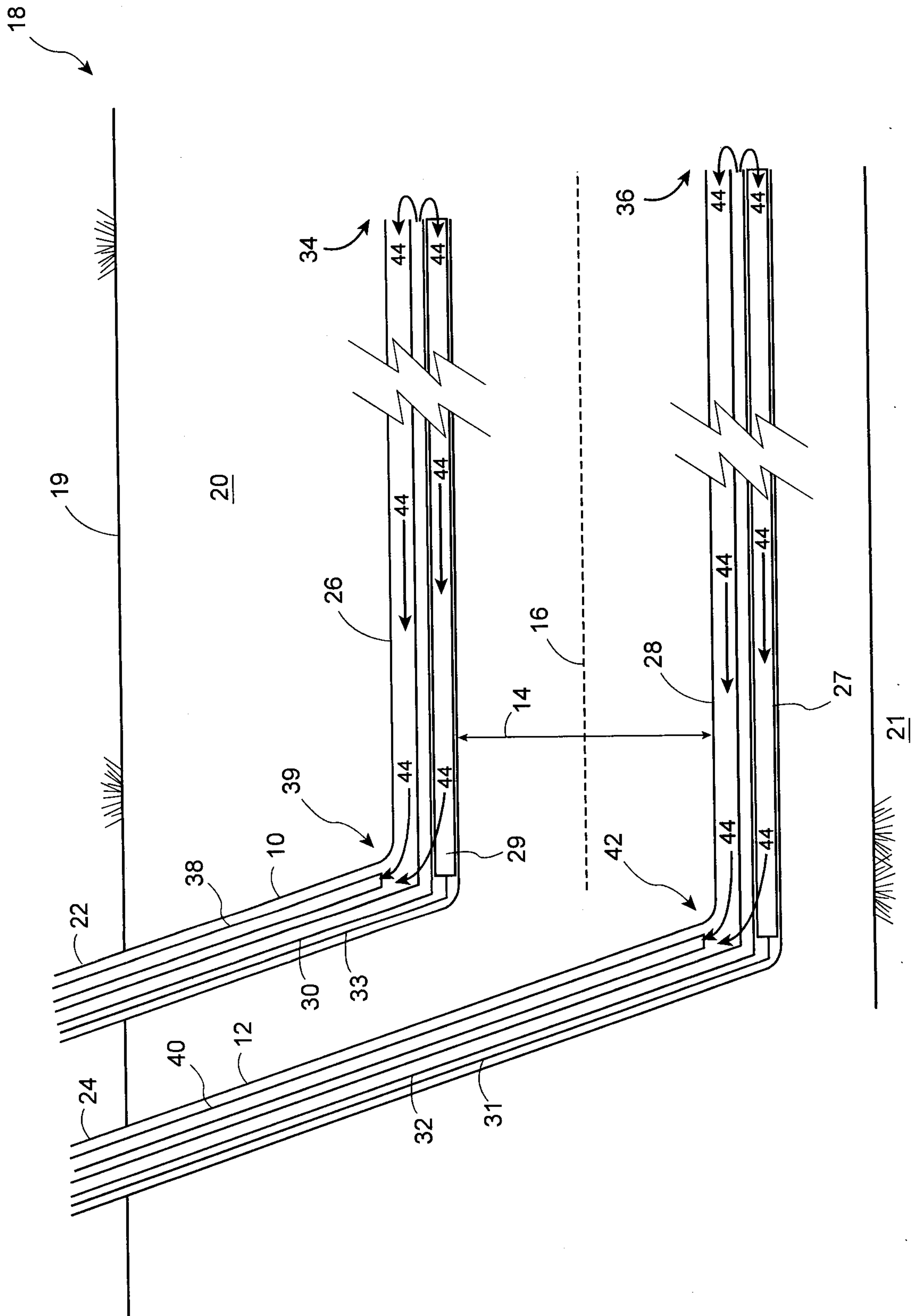
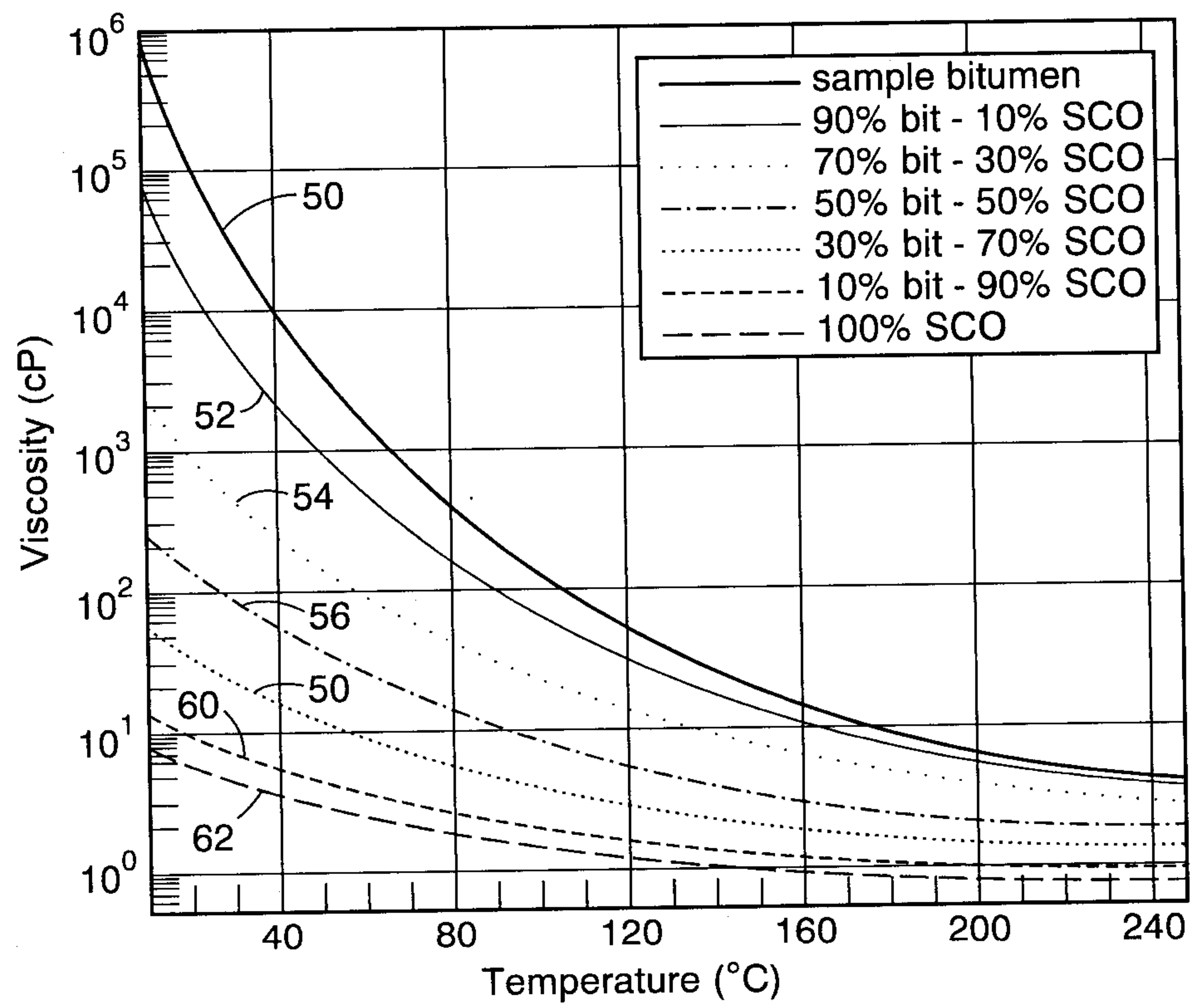


Figure 1

**Figure 2**

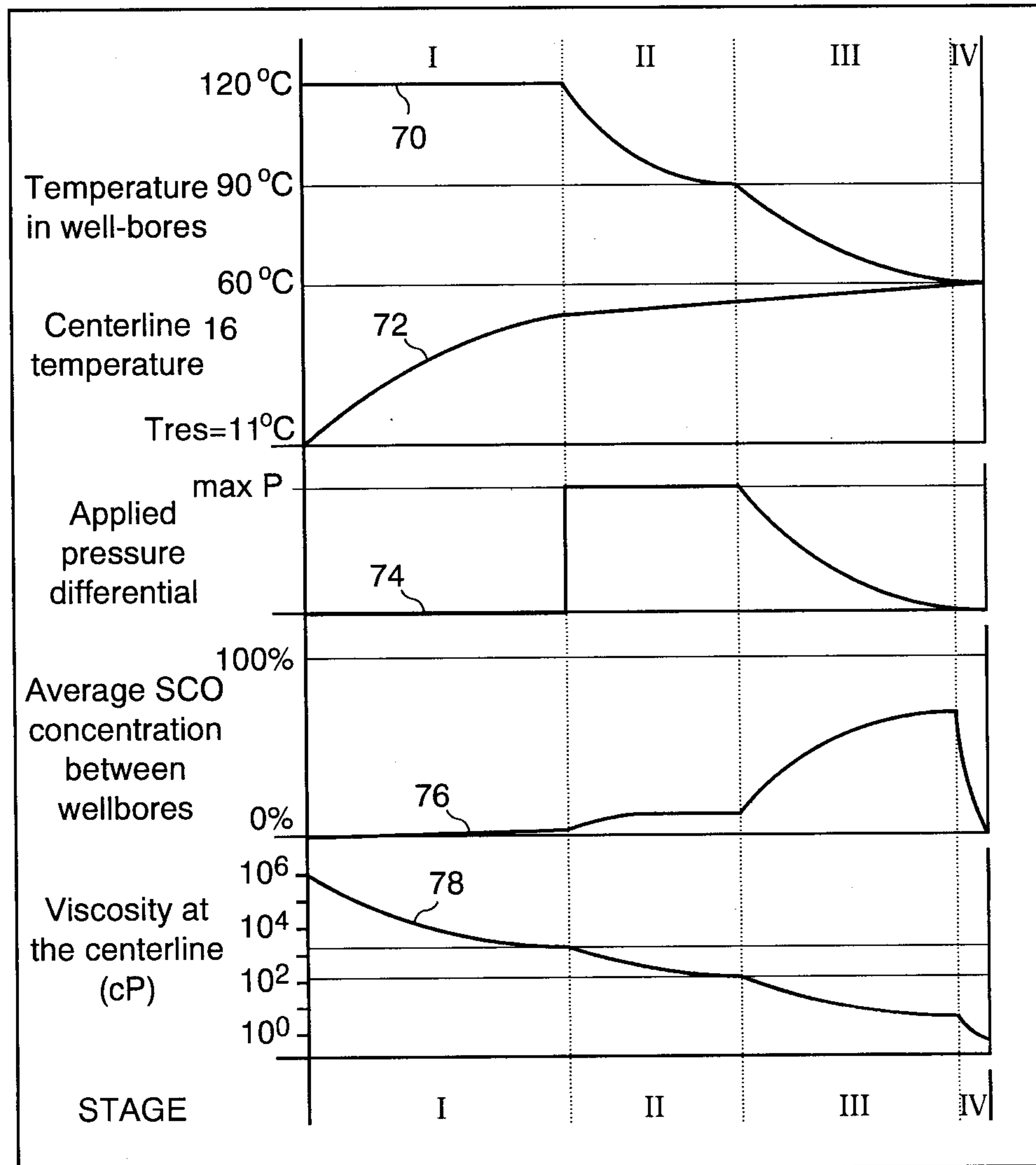
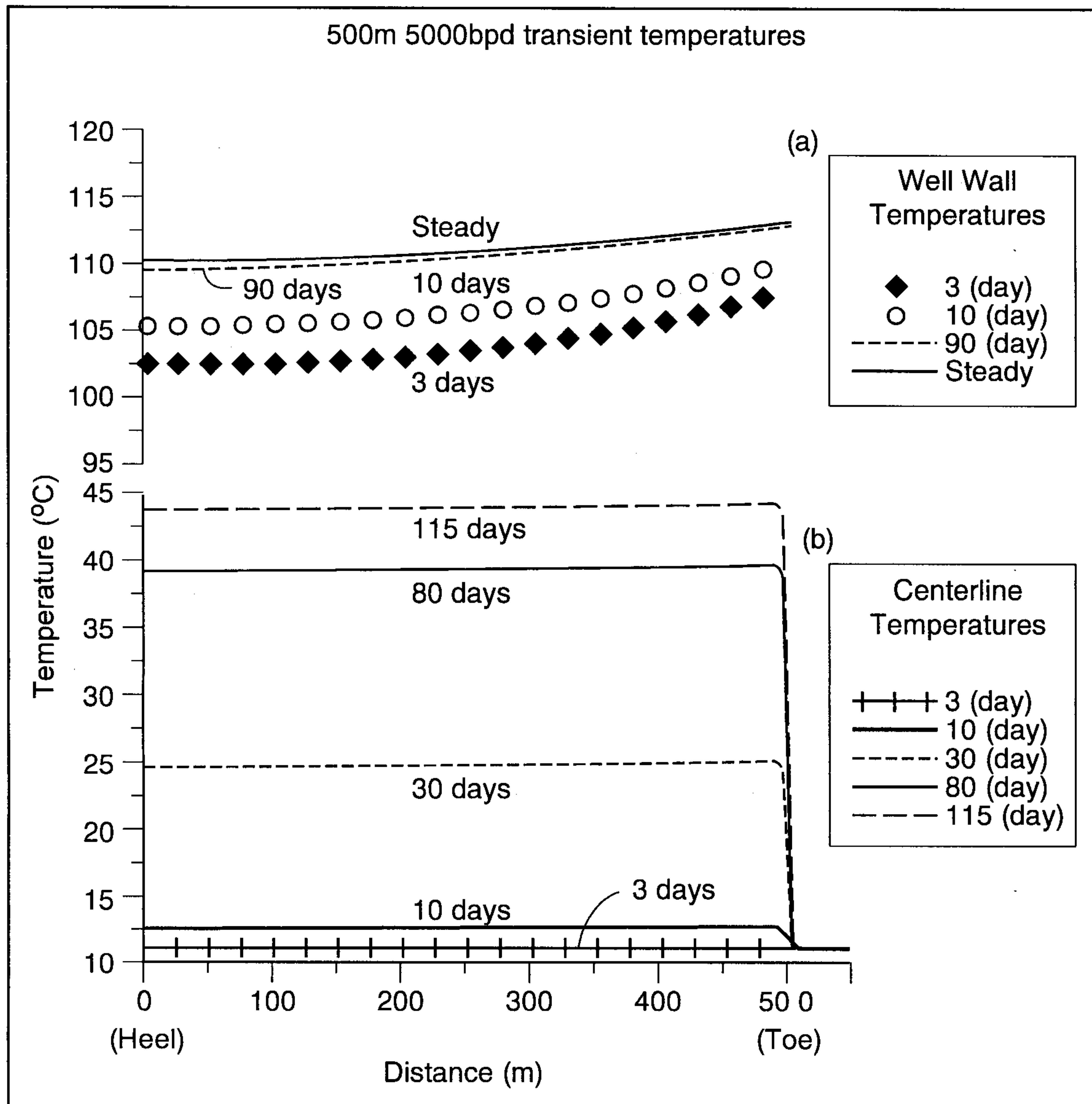


Figure 3

**Figure 4**

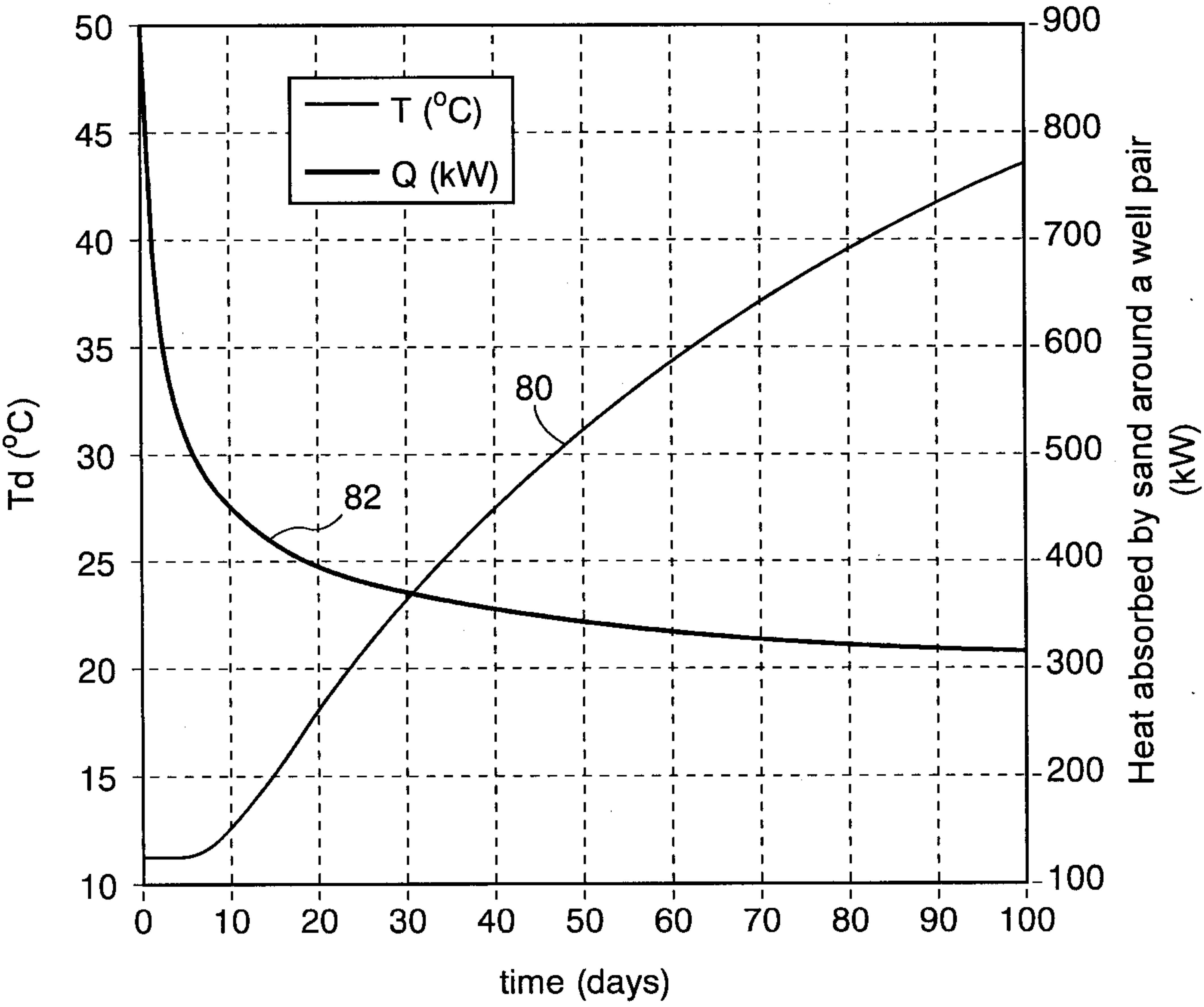
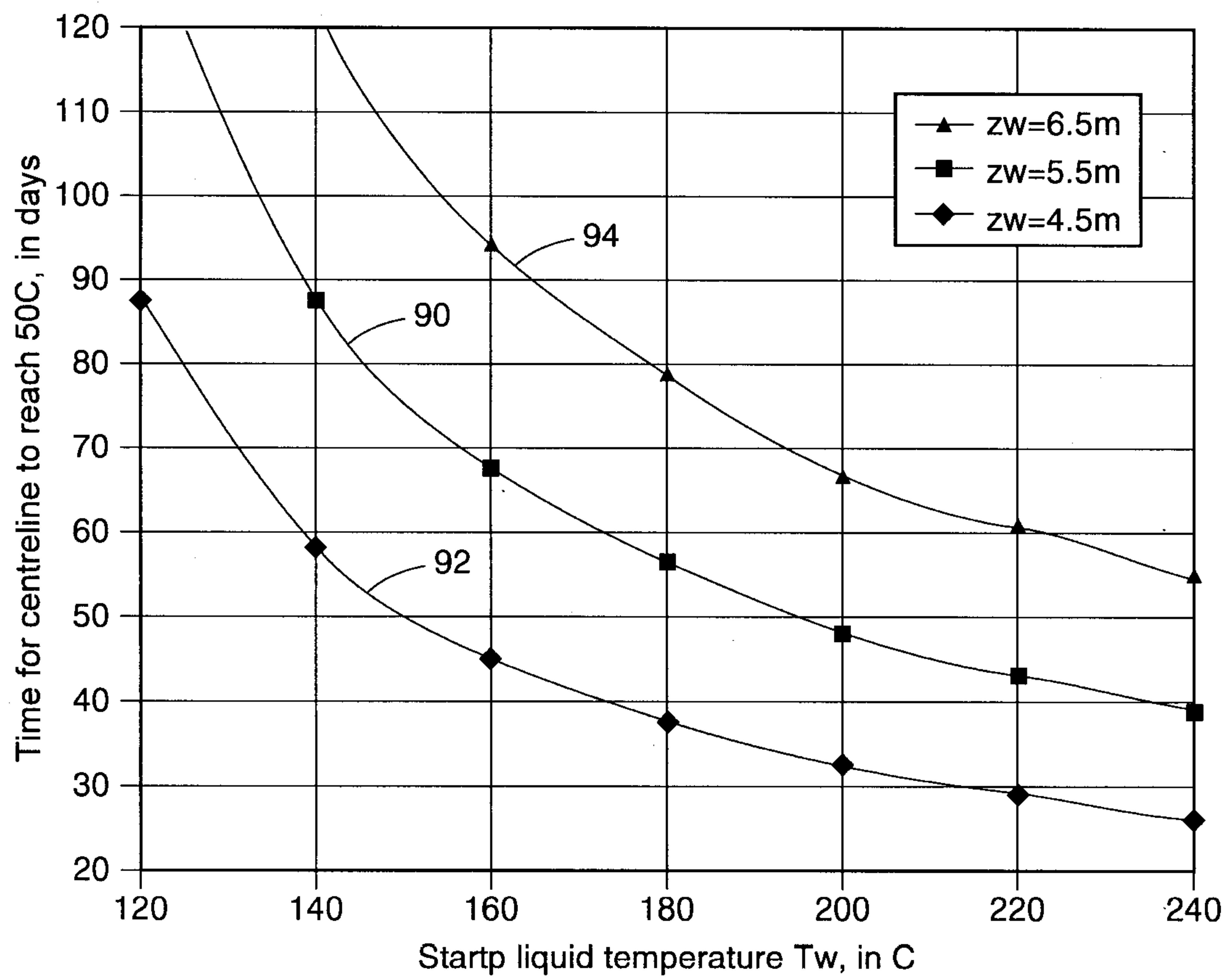


Figure 5

**Figure 6**

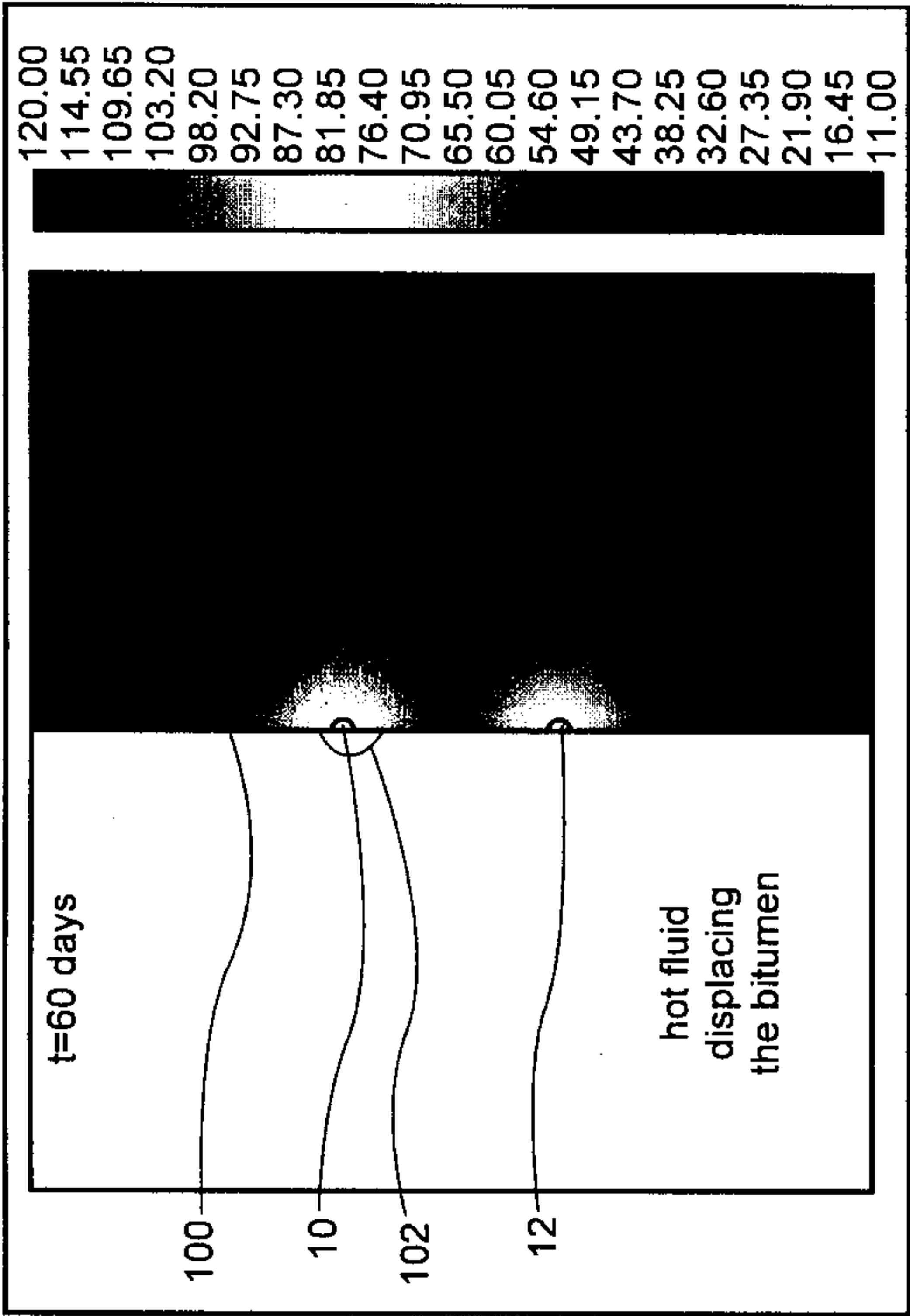


Figure 7a

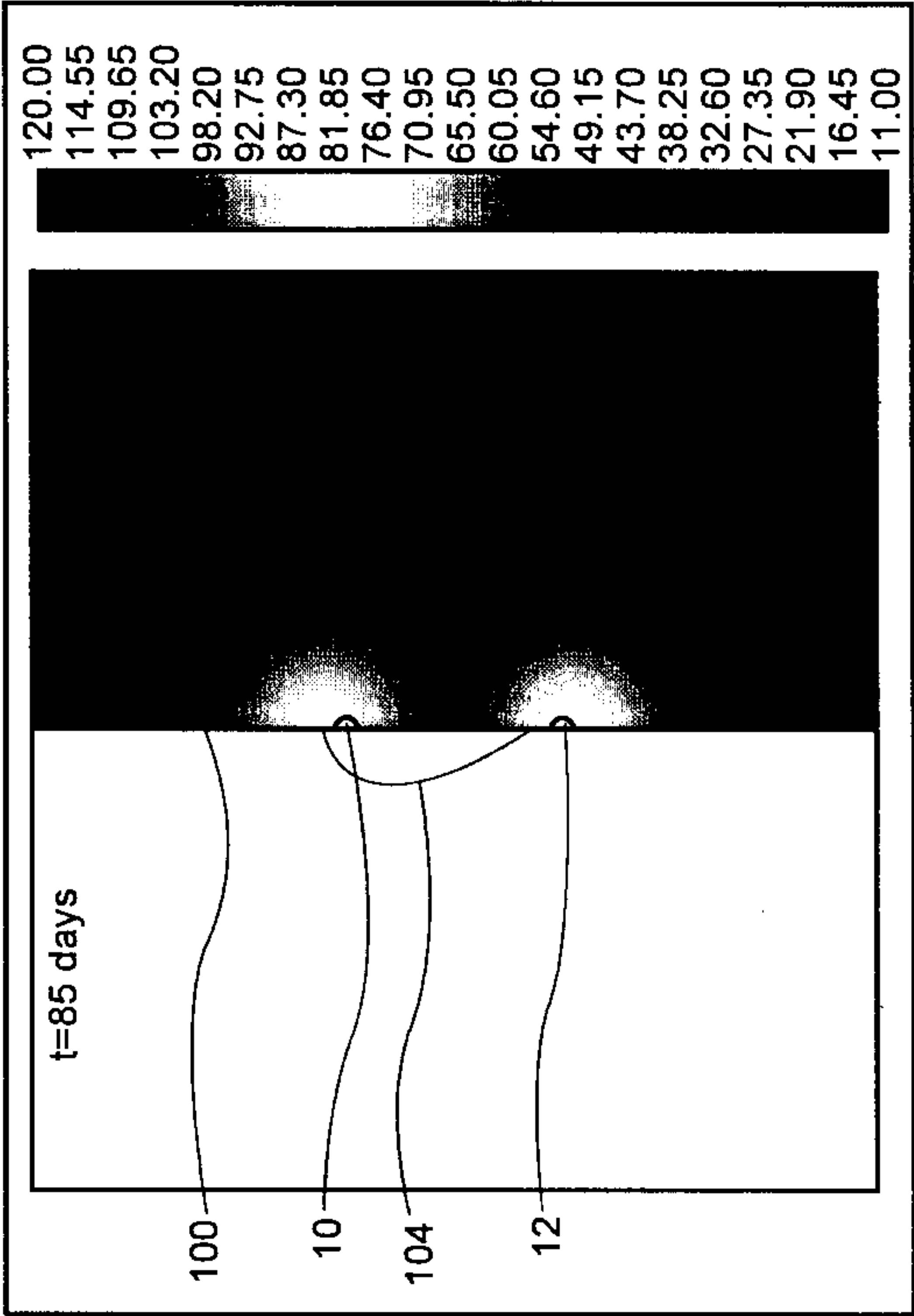


Figure 7b

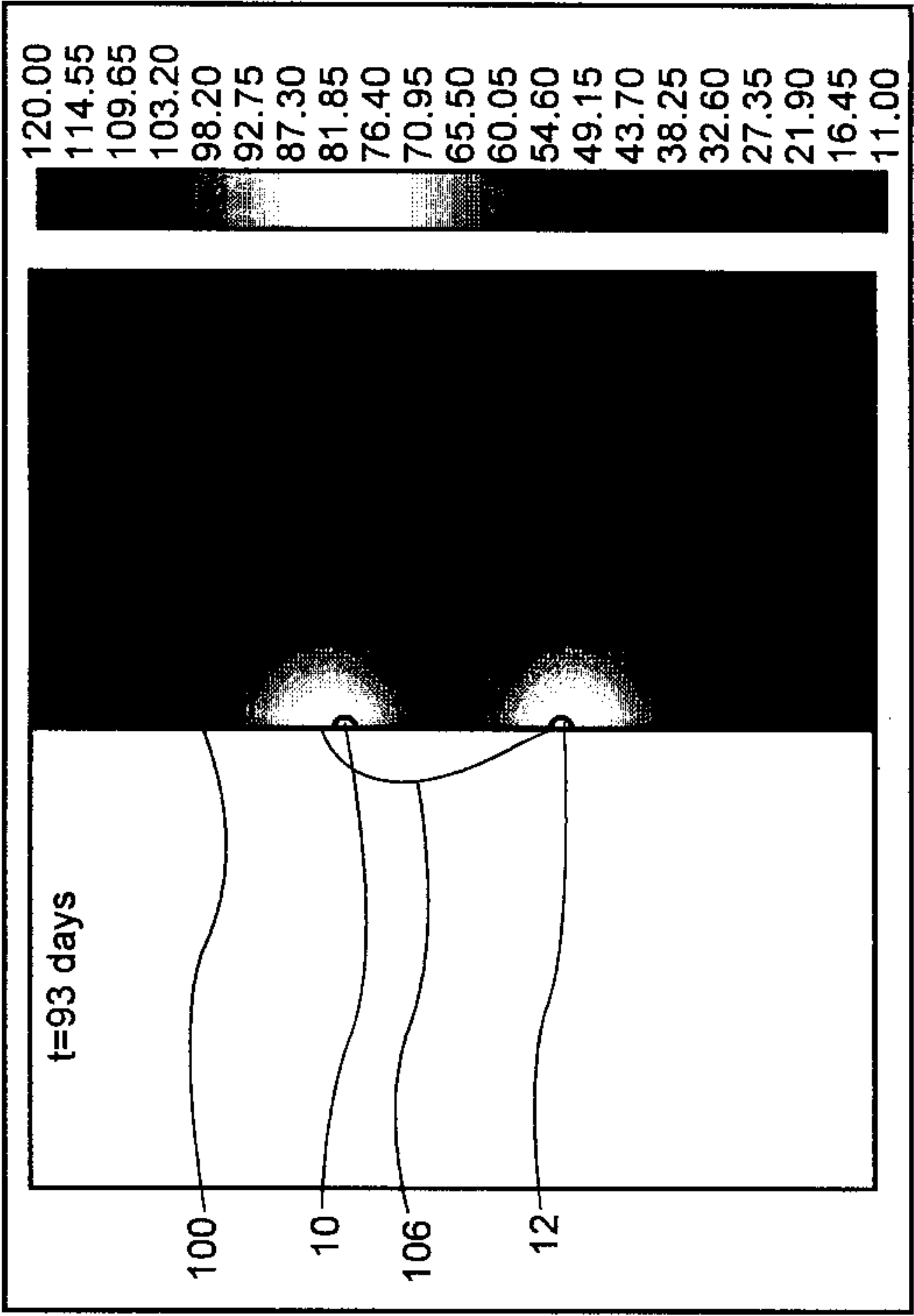


Figure 7c

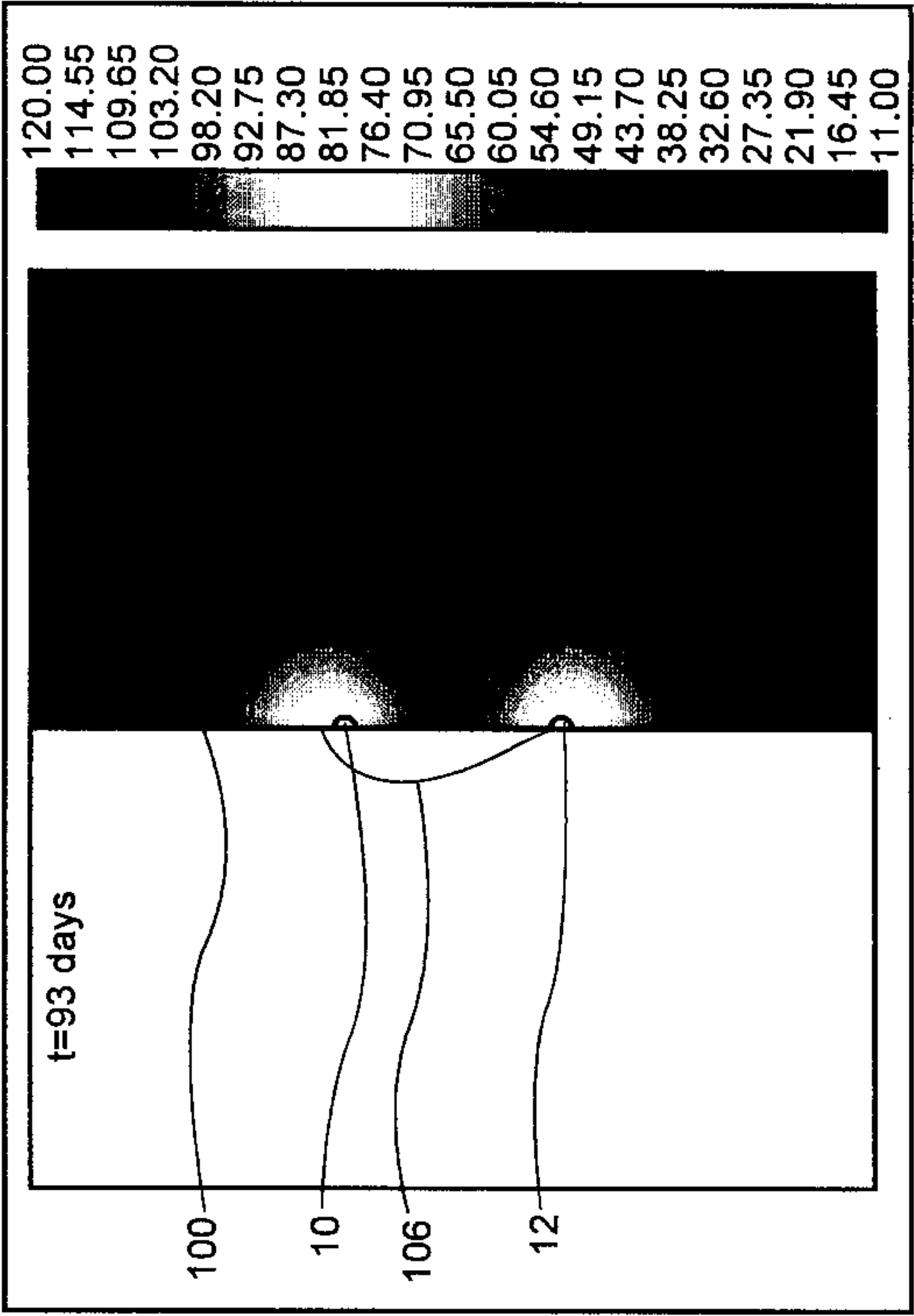


Figure 7d

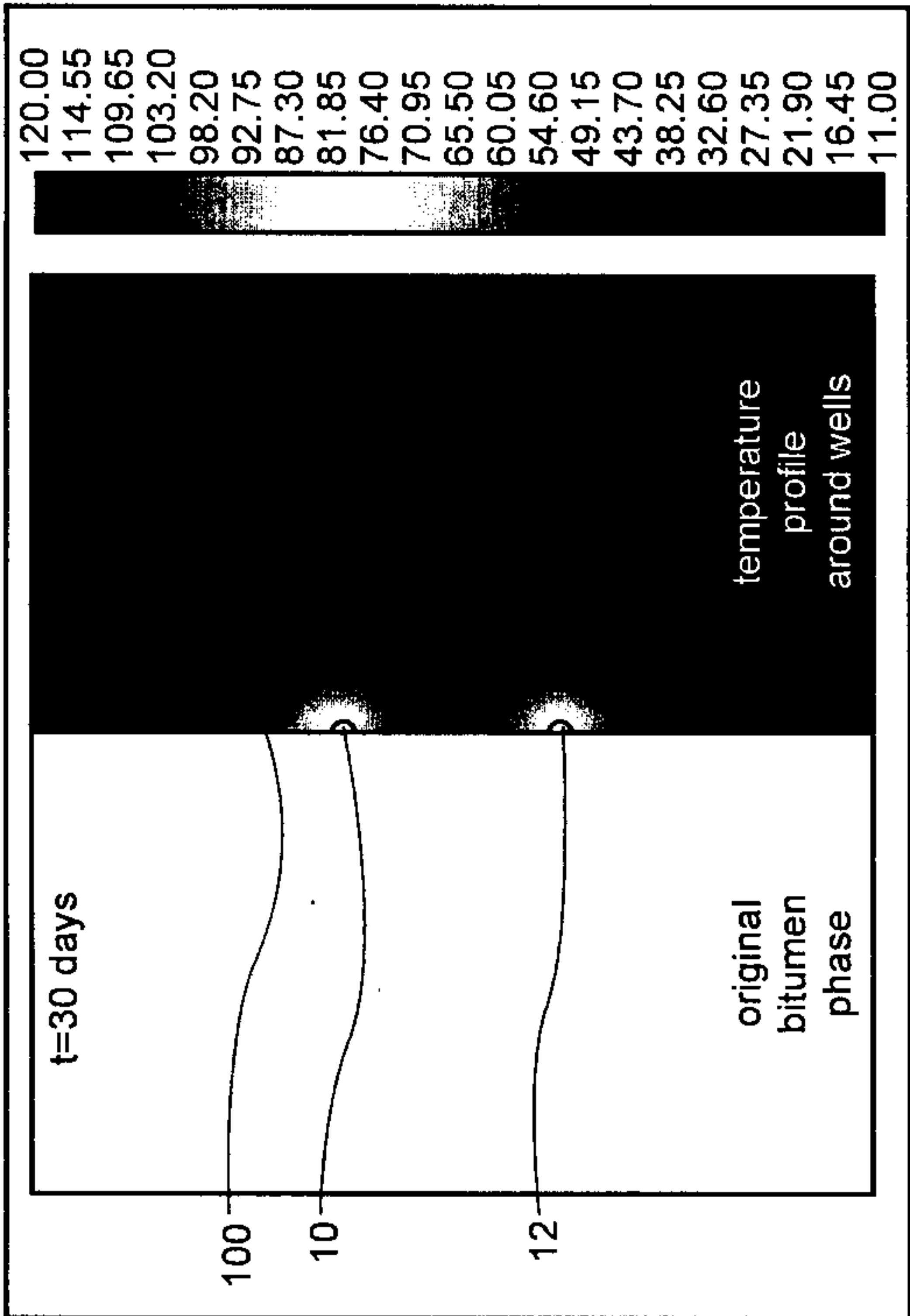
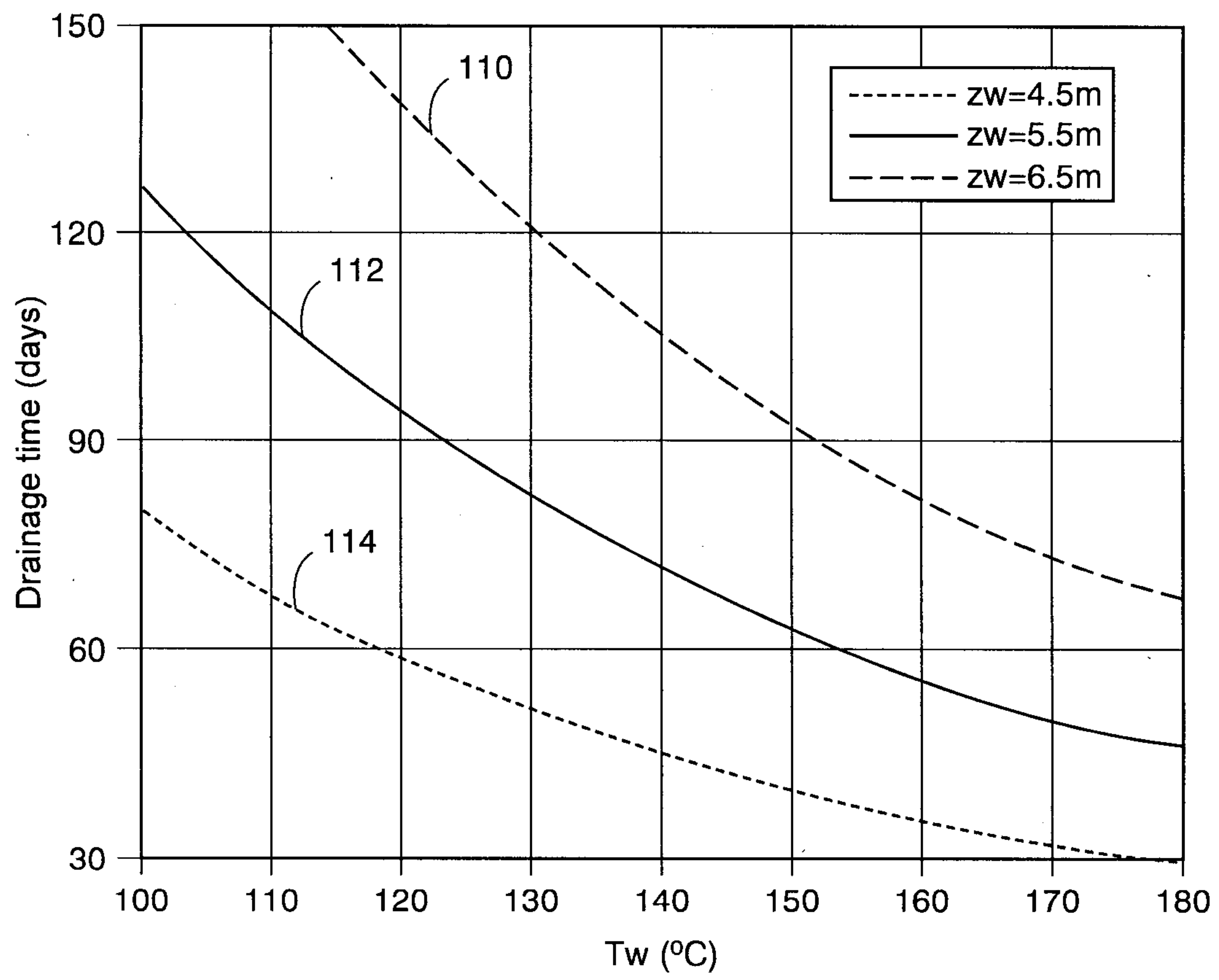
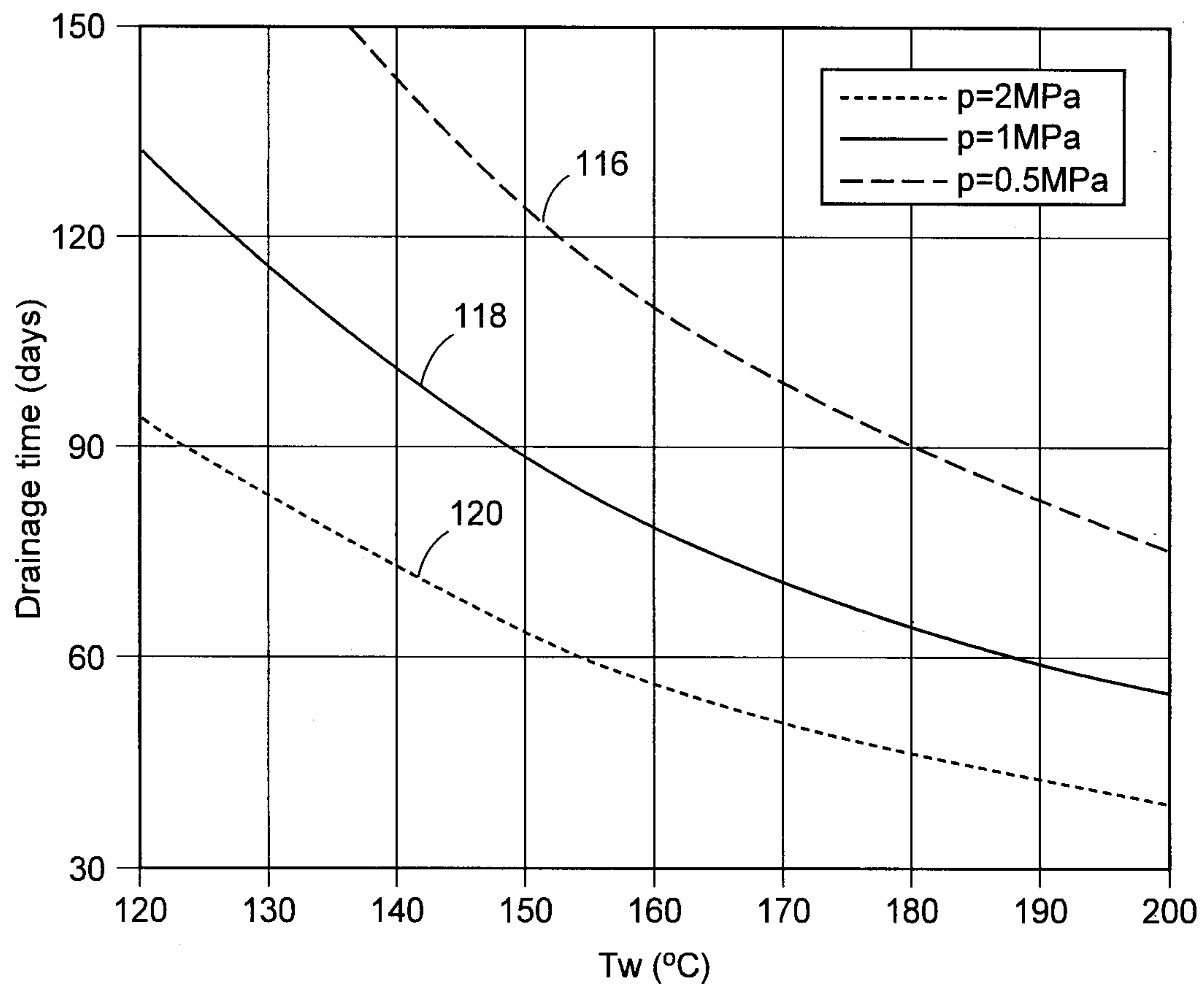


Figure 7e

**Figure 8**

**Figure 9**

