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Compilation of Instantaneous Source Functions for Varying Architecture of a Layered Reservoir with Mixed Boundaries and Horizontal Well Completion Part III: B-Shaped Architecture with Vertical Well in the Upper Layer

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Abstract

Two-layered reservoirs with a vertical well in the top layer and with letter 'B' architecture, is encountered very frequently in practice. Instantaneous source functions, which can be utilized in constructing pressure distributions for the purpose of fully characterizing such reservoirs, are derived in this paper.

Results show that sixty-four (64) different variations are possible, as a result of six (6) different external boundaries, which may be considered sealed or constant-pressured. With the interface also considered as a constant-pressure boundary, it is observed that the more the number of constant-pressure external boundaries, the fewer the source functions that could be written and vice-versa. Furthermore, only sources of the kind I(i) can be written for the vertical wells while sources of the kinds I(i), vi(i) and iii(i) are possible for only the x-axes of the horizontal well layer.

Introduction

Part I and II of this series[1-2] derived instantaneous source functions for a two-layered reservoir with letter 'A' and letter 'S' architecture, respectively. In these architectures, horizontal wells were drilled in the layers. In this Part III, the frontiers of Part I and II are extended to letter 'B' architecture but with Layer 2 (top layer) completed with a vertical well. This configuration may result from later-in-life well re-entry with a horizontal well after initial completion with a vertical well in a reservoir initially thought to be singled-layered. It could also result from an oil recovery project, where a horizontal well is drilled to mobilize oil into an already existing vertical well or vice versa, under favourable technical and economic conditions.

Reference 3 derived instantaneous source functions for some selected two-layered reservoir with latter 'B' architecture but with both layers completed with a horizontal wells. Because this architecture is encountered more frequently in practice, this paper explores more of the possible configurations, especially with external constant-pressure applications.

Source and Green's functions in Refs.4 and 5 and Appendix of Ref. 1 are applied in this paper.

Letter 'B' Two- Layered Reservoir Geometry Description

Fig. 1 is a two-layered reservoir bounded on all six external boundaries and with a crossflow interface between its upper and lower boundaries, hence the letter 'B' architecture. The upper layer (Layer 2) is completed with a vertical well while the lower layer is completed with a horizontal well. A vertical well drains in 2D while a horizontal well drains in 3D. In both wells, flow can be governed chiefly by the nature of its reservoir boundaries,

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apart from well completion. An external constant-pressure boundary is capable of bringing flow in either well to ultimate, irreversible steady-state. Therefore, for prolong production of clean oil, well location becomes an important factor. Instantaneous sources and Green's functions will be written down for all possible well location in each layer, for the purpose of deriving the necessary pressure distribution.

Results and Discussion

Several well locations were considered for the wells in the layers in writing relevant instantaneous source functions. The functions showing the effects of critical boundaries, like constant-pressure and interface, are written down, where they exist. Another instantaneous source function that is not affected by boundary of any kind, i.e., the mandatory infinite-acting flow, is also written down for all models considered. Well location does not affect the number of flow directions in the wells but can strongly affect the number of flow periods in the wells especially horizontal wells. For this reason, both central and off-centered horizontal well locations are considered.

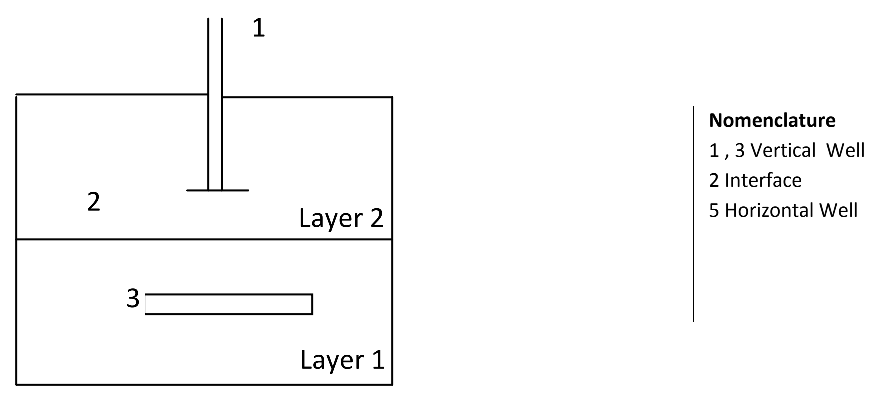

Fig. 1: A-B-Shaped Two-Layered Reservoir Architecture with Vertical Well in the Upper Layer

Table 1 is a tabulation of results obtained. Sixty-four (64) different models emerged. With the interface assumed as a constant-pressure boundary, each layer has three external boundaries that can experience constant-pressure or be sealed.

All the instantaneous source functions for the vertical wells are of the kind I(i) on account of radial flow largely encountered in vertical wells. The constants, E_1, in all the suggested source functions are meant to fully characterize the vertical well flow transients at the inception of an external boundary, which may result in pseudosteady or steady-state flow, after the natural infinite-acting flow. Instantaneous source functions of the kind I(z = f) are suggested to account for interface effect in all the models. Source functions of the kind I(x=0) and I($x=x_e$) are suggested for constant-pressure boundaries along the x-axes, wherever they occur. I(x=0) means that the constant-pressure is at the starting edge of the layer, and I($x=x_e$) means that the constant-pressure is at the finishing end of the layer. However, some factors may prevent the prevalence of these kinds of external boundaries (involving constant-pressure) even if they are physically present.

Given the bounded nature of the lateral boundaries of Layer 1, the horizontal wells in this layer are presumed to experience any of the three kinds of source strengths in the x-axes unless any boundary there is a constant-pressure boundary. These are (1) early time infinite-acting source strength for central well location, (2) an infinite slab source

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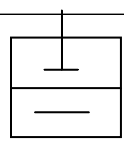
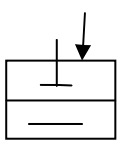
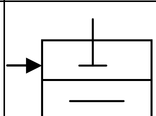
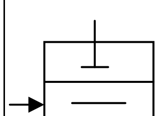
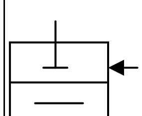
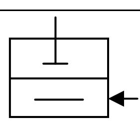
strength in an infinite slab reservoir, and (3) a possible infinite plane source in infinite slab reservoir, owing to off-centered well location. These are source numbers II(i), vi(i), and iii(i), respectively. It is observed that the more the number of external boundaries with constant-pressure, the fewer the number of source functions that can be written down. For example, Models 1 to 7 have more instantaneous source functions than Models 18, 19, 51, etc. this is so because once one constant-pressure boundary is felt, the existence of all other boundaries, whether sealing or another constant-pressure, will not be felt under the same transient regime, if the external fluids have comparatively larger compressibilities than the produced fluids.

All the z-axes source functions at late times are infinite plane sources in infinite slab reservoirs, with an upper constant-pressure interface an lower boundary which may be sealed or constant-pressured. However, at early times, even the z-axes sources are considered to be of the kind I(i) in all models for Layer 1.

In all the models, the y-axes contribute infinite plane sources in infinite reservoirs; that is, the horizontal wells are considered as line sources.

Table 1: Description of Relevant Source Functions

S/N	**Model Diagram**	**Instantaneous Source Function**			
		x-axis	**z-axis**	**Layer 1**	**Layer 2**
1.		Both layers sealed at both ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x).I(z) E_2I(x).I(y) E_2I(y).I(z)
2.		Both layers sealed at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, sealed bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
3.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, sealed ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x).I(z) E_2I(x).I(z=f)
4.		Top layer, sealed ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x).I(z) E_2I(x).I(y) E_2I(y).I(z)
5.		Top layer, constant-pressure at top, sealed bottom. Bottom layer, sealed ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=x_e).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f) E_2I(x=0).I(y)
6.		Top layer, sealed ends. Bottom layer constant-pressure at top, sealed bottom	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x).I(z) E_2I(x).I(y) E_2I(y).I(z)

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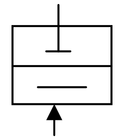
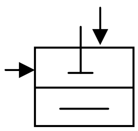
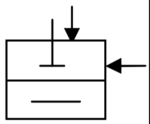
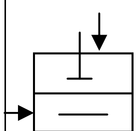
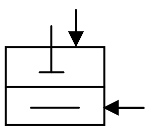
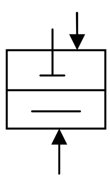
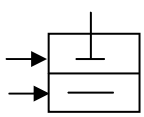
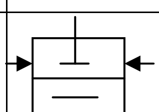
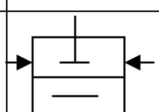
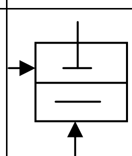
7.		Both layers sealed at both ends	Top layer, sealed top, interface bottom. Bottom layer, constant-pressure at bottom, interface at top	E_1 vii(x).I(y).iv(z) E_1iii(x).I(y).iv(z) E_1iii(x).I(y).I(z) E_1II(x).I(y).I(z)	E_2I(x).I(z) E_2I(x).I(y) E_2I(y).I(z)
8.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, sealed ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, sealed bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=0).I(z=0) E_2I(x=x_e).I(z=f) E_2I(x).I(y) E_2I(x).I(z)
9.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, sealed ends	Top layer, constant-pressure top, interface at bottom. Bottom layer, sealed bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=x_e).I(z=0) E_2I(x).I(z=f) E_2I(x).I(y) E_2I(x).I(z)
10.		Top layer, sealed ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, sealed bottom, interface at top	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
11.		Top layer, sealed ends. Bottom layer, sealed bottom, constant-pressure at top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, sealed bottom, interface at top	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
12.		Both layers sealed at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, constant-pressure at bottom, interface at top	E_1 vii(x).I(y).iv(z) E_1iii(x).I(y).iv(z) E_1iii(x).I(y).I(z) E_1II(x).I(y).I(z)	E_2I(x).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
13.		Top and bottom layers, constant-pressure at bottoms, sealed tops	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(y) E_2I(x).I(z=f) E_2I(x).I(y)
14.		Top layer, constant-pressure at both ends. Bottom layer, sealed ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=0).I(y) E_2I(x=x_e).I(y) E_2I(x).I(z=f) E_2I(x).I(z=0)
15.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, sealed bottom, constant-pressure at top	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(y) E_2I(x).I(z=f) E_2I(x).I(z=f)
16.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, sealed ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1 vii(x).I(y).iv(z) E_1iii(x).I(y).iv(z) E_1iii(x).I(y).I(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(y) E_2I(x).I(z=f) E_2I(x).I(z=f)

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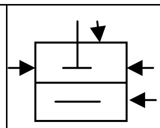
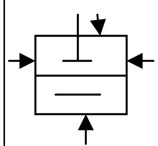
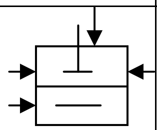
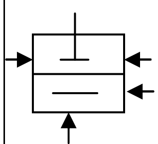
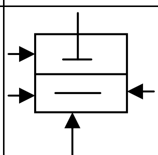
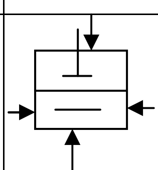
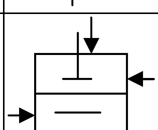
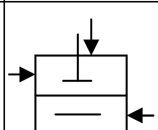
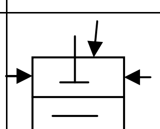
17.		Top layer, constant-pressure at both ends. Bottom layer, sealed bottom, constant-pressure at top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, sealed bottom, interface at top	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(y) E_2I(x=x_e).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
18.		Top layer, constant-pressure at both ends. Bottom layer, sealed ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, constant-pressure at bottom, interface at top	E_1 vii(x).I(y).iv(z) E_1iii(x).I(y).iv(z) E_1iii(x).I(y).I(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(y) E_2I(x=x_e).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
19.		Top layer, constant-pressure at both ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(y) E_2I(x=x_e).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
20.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, constant-pressure at both ends	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_1viii(x).I(y).I(z)	E_2I(x=x_e).I(z=f) E_2I(x).I(y) E_2I(x).I(z=f)
21.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, constant-pressure at both ends	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_1viii(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x).I(y) E_2I(x).I(z=f)
2.		Top layer, sealed ends. Bottom layer, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_1viii(x).I(y).I(z)	E_2I(x=0).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
23.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, constant-pressure at bottom, sealed top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x=x_e).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
24.		Top layer, constant-pressure bottom, sealed top. Bottom layer, sealed bottom, constant-pressure at top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
25.		Top layer, constant-pressure at both ends. Bottom layer, sealed ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=0).I(z=0) E_2I(x).I(y) E_2I(x=x_e).I(z=f) E_2I(x=x_e).I(z=0)

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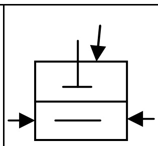
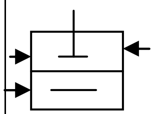
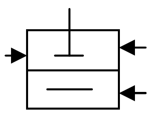
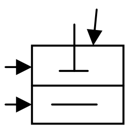
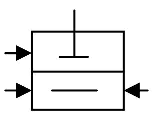
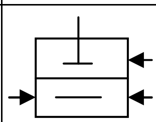
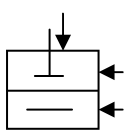
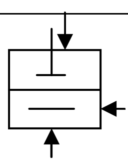
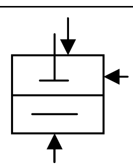
26.		Top layer, sealed ends. Bottom layer, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1viii(x).I(y).v(z) E_1viii(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
27.		Top layer, constant-pressure at both ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x).I(y) E_2I(x=x_e).I(y) E_2I(x=x_e).I(z=f)
28.		Top layer, constant-pressure at both ends. Bottom layer, sealed bottom, constant-pressure at top	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(z=f) E_2I(x).I(y) E_2I(x=x_e).I(y) E_2I(x=x_e).I(z=f)
29.		Both layers, constant-pressure at bottom.	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x).I(y) E_2I(x).I(z=0) E_2I(x).I(z=f)
30.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, constant-pressure at both ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1viii(x).I(y).v(z) E_1viii(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(z=0) E_2I(x).I(y) E_2I(x).I(z=f)
31.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, constant-pressure at both ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1viii(x).I(y).v(z) E_1viii(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=x_e).I(z=f) E_2I(x).I(y)
32.		Both layers, constant-pressure at tops, sealed bottoms	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=x_e).I(z=0) E_2I(x=x_e).I(z=f) E_2I(x).I(y)
33.		Top layer, sealed ends. Bottom layer, sealed bottom, constant-pressure at top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1ix(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i ix(x).I(y).I(z)	E_2I(x).I(z=0) E_2I(x).I(z=f) E_2I(x).I(y)
34.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, sealed ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1 vii(x).I(y).iv(z) E_1iii(x).I(y).iv(z) E_1iii(x).I(y).I(z) E_1II(x).I(y).I(z)	E_2I(x=x_e).I(z=0) E_2I(x).I(z=f) E_2I(x).I(y)

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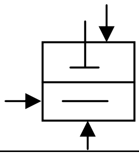
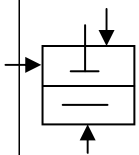
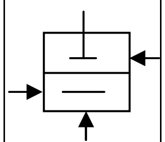
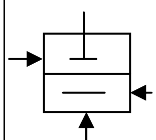
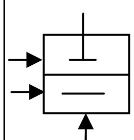
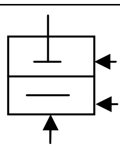
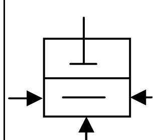
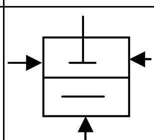
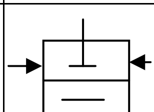
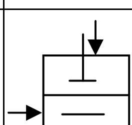
35.		Top layer, sealed ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1x(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i x(x).I(y).I(z)	E_2I(x).I(z=0) E_2I(x).I(z=f) E_2I(x).I(y)
36.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, sealed ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1 vii(x).I(y).iv(z) E_1iii(x).I(y).iv(z) E_1iii(x).I(y).I(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
37.		Top layer, constant-pressure at top, sealed bottom. Bottom layer, constant-pressure at bottom, sealed top	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1x(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i x(x).I(y).I(z)	E_2I(x=x_e).I(z=f) E_2I(x).I(y)
38.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, sealed bottom, constant-pressure top	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1ix(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i ix(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x).I(y)
39.		Both layers, constant-pressure bottoms, sealed tops	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1x(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i x(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x).I(y)
40.		Both layers, constant-pressure tops, sealed bottoms	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1ix(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i ix(x).I(y).I(z)	E_2I(x=x_e).I(z=f) E_2I(x).I(y)
41.		Top layer, sealed ends. Bottom layer, constant-pressure at both ends	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i viii(x).I(y).I(z)	E_2I(x=x_e).I(z=f) E_2I(x).I(y)
42.		Top layer, constant-pressure at both ends. Bottom layer, sealed ends	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1 vii(x).I(y).iv(z) E_1iii(x).I(y).iv(z) E_1iii(x).I(y).I(z) E_1II(x).I(y).I(z)	E_2I(x=x_e).I(z=f) E_2I(x=0).I(z=f) E_2I(x).I(y)
43.		Top layer, constant-pressure at both ends. Bottom layer, sealed ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=x_e).I(z=f) E_2I(x=0).I(z=f) E_2I(x).I(y)
44.		Top layer, sealed ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x).I(z=0) E_2I(x).I(z=f) E_2I(x).I(y)

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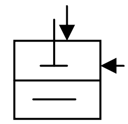
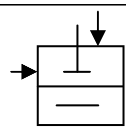
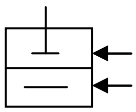
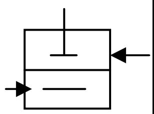
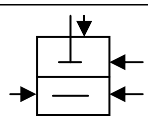
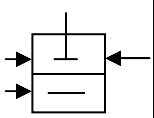
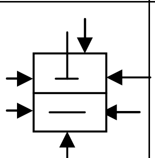
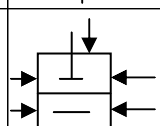
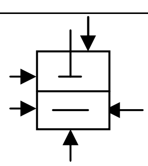
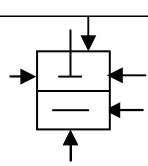
45.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, sealed ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I($x=x_e$).I(z=0) E_2I(x).I(z=f) E_2I(x).I(y)
46.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, sealed ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1vii(x).I(y).v(z) E_1II(x).I(y).v(z) E_1iii(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
47.		Both layers, constant-pressure at tops, sealed bottoms	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1ix(x).I(y).v(z) E_1II(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I($x=x_e$).I(z=f) E_2I(x).I(y)
48.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, constant-pressure, sealed top	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I($x=x_e$).I(z=f) E_2I(x).I(y)
49.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1viii(x).I(y).v(z) E_1viii(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I($x=x_e$).I(z=f) E_2I($x=x_e$).I(z=0) E_2I(x).I(y)
50.		Top layer, constant-pressure at both ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1x(x).I(y).v(z) E_1II(x).I(y).v(z) E_1II(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I($x=x_e$).I(z=f) E_2I(x).I(y)
51.		Both layers, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i viii(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I($x=x_e$).I(z=0) E_2I($x=x_e$).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
52.		Both layers, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1viii(x).I(y).v(z) E_1viii(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(z=f) E_2I($x=x_e$).I(z=0) E_2I($x=x_e$).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
53.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i viii(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
54.		Top layer, constant-pressure at both ends. Bottom layer, sealed bottom, constant-pressure at	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1ix(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i ix(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I($x=x_e$).I(z=0) E_2I($x=x_e$).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)

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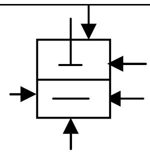
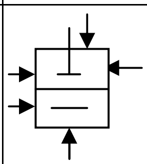
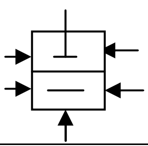
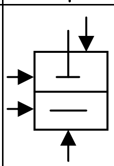
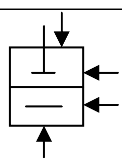
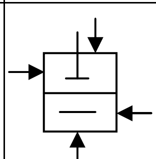
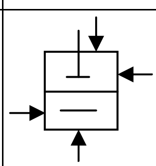
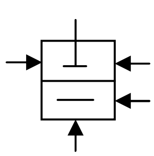
		top			
55.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i viii(x).I(y).I(z)	E_2I(x=x_e).I(z=0) E_2I(x=x_e).I(z=f) E_2I(x).I(y)
56.		Top layer, constant-pressure at both ends. Bottom layer, constant-pressure at bottom, sealed top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1x(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i x(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=x_e).I(z=0) E_2I(x=x_e).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
57.		Both layers, both ends at constant-pressures	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1viii(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i viii(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=x_e).I(z=f) E_2I(x).I(y)
58.		Both layers, constant-pressures at bottom, sealed tops	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1x(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i x(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
59.		Both layers, constant-pressures at tops, sealed bottoms	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1ix(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i ix(x).I(y).I(z)	E_2I(x=x_e).I(z=0) E_2I(x=x_e).I(z=f) E_2I(x).I(y)
60.		Top layer, sealed top, constant-pressure at bottom. Bottom layer, sealed bottom, constant-pressure at top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1ix(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i ix(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
61.		Top layer, sealed bottom, constant-pressure at top. Bottom layer, constant-pressure at bottom, sealed top	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1x(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i x(x).I(y).I(z)	E_2I(x=x_e).I(z=0) E_2I(x=x_e).I(z=f) E_2I(x).I(y)
62.		Top layer, constant-pressures at both ends. Bottom layer, sealed bottom, constant-pressure at top	Top layer, sealed top, interface at bottom. Bottom layer, interface at top, constant-pressure at bottom	E_1ix(x).I(y).iv(z) E_1II(x).I(y).iv(z) E_i ix(x).I(y).I(z)	E_2I(x=0).I(z=f) E_2I(x=x_e).I(z=f) E_2I(x).I(y)

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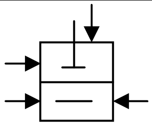
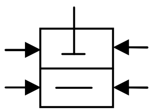
63.		Top layer, constant-pressure at bottom, sealed top. Bottom layer, constant-pressure at both ends	Top layer, constant-pressure at top, interface at bottom. Bottom layer, interface at top, sealed bottom	E_1viii(x).I(y).v(z) E_1viii(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(z=f) E_2I(x=0).I(z=0) E_2I(x).I(y)
64.		Both layers, constant-pressures at both ends	Top layer, sealed top, interface at bottom. Bottom layer, sealed at bottom, interface at top	E_1viii(x).I(y).v(z) E_1viii(x).I(y).I(z) E_1II(x).I(y).v(z)	E_2I(x=0).I(z=f) E_2I(x=x_e).I(z=f) E_2I(x).I(y)

Conclusion

Instantaneous source functions for a two-layered reservoir with letter ‘B’ architecture and with a vertical well in the top layer have been tabulated. The external boundaries were varied with sealing and constant-pressure boundaries. The interface was considered as permeable and therefore behaves as a constant-pressure internal boundary. Compilation of all the possible instantaneous source functions shows that:

1. Sixty-four (64) different models are possible
2. There are six external boundaries defining the two-layered reservoir, which may be sealed or constant-pressured
3. The vertical wells present source functions of the kind I(i) while those of horizontal wells are of the kinds II(i), vi(i) and iii(i) along the x-axes only
4. The more the number of external boundaries with constant-pressure, the fewer the source functions that can be written down, and vice versa

Nomenclature

E_1 Late time flow boundary effects constant for Layer 1

E_2 Late time flow boundary effects constant for Layer 2

(i) Axial flow directions x, y, or z

i Distances in x, y, or z directions, ft

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