resolution of the tool is also a function of the height of the receive antenna and (due to the tool's motion) the number of measurements that are combined. Existing logging tools have to find a feasible tradeoff between vertical resolution and SNR and hence are not able, under normal operating conditions, to provide a high vertical resolution together with a high SNR.

SUMMARY

According to an aspect of the present invention, there is provided a nuclear magnetic resonance (NMR) logging method that comprises: establishing a static magnetic field with a tool positioned along a borehole through a formation; concurrently driving a plurality of antenna cells to produce a radio frequency field in said formation; measuring an individual response from each antenna cell as NMR relaxation occurs in the formation; combining individual responses, wherein said combining involves selectively excluding at least one of the measured individual responses due to tool motion; and determining at least one characteristic relaxation time of the formation based at least in part on the combined individual responses.

According to another aspect of the present invention, there is provided a nuclear magnetic resonance (NMR) logging tool that comprises: an arrangement of one or more magnets that generates a static magnetic field in a formation penetrated by a borehole containing said tool; plurality of antenna cells attached to the tool body, each cell having at least one coil antenna; and circuitry that drives the plurality of antenna cells concurrently to produce a radio frequency field in said formation, wherein the circuitry further measures an individual response from each antenna cell as NMR relaxation occurs in the formation, and wherein the circuitry combines individual responses and selectively excludes at least one of the measured individual responses due to tool motion.

DESCRIPTION OF THE DRAWINGS

A better understanding of the various disclosed embodiments can be obtained when the following detailed description is considered in conjunction with the following drawings, in which:

Fig. 1 shows an illustrative environment for logging while drilling ("LWD");

Fig. 2 shows an illustrative environment for wireline logging;

Fig. 3 shows an illustrative environment for tubing-conveyed logging;

Fig. 4 shows an illustrative NMR logging tool;

Fig. 5 shows illustrative antenna cell arrangements;

Fig. 6 shows a first illustrative antenna cell;

Fig. 7 shows a second illustrative antenna cell;

Fig. 8 is a diagram of illustrative transmit/receive circuitry;

Fig. 9 shows illustrative transmit currents for an antenna cell;

Fig. 10 is a function block diagram of an illustrative NMR logging tool;

Fig. 11 shows a time-space relationship for antenna cell measurements;

Fig. 12 shows a time-space relationship for a rapidly moving tool;

Fig. 13 is a flow diagram of an illustrative NMR logging method; and

Figs. 14-17 show illustrative magnet configurations for alternative tool embodiments.