resolution of the tool due to focusing impairment. The smaller the mud resistance, the larger the effect of such differences in surface layer impedance.

[0005] Thus, the materials used in constructing an electrode-based resistivity logging tool are important considerations, not only due to their tendencies to form surface layers, but also due to their effects on tool assembly and strength. Poorly-chosen materials will limit the tool's strength and prevent it from being used in a drill string or even as part of a large wireline logging assembly.

SUMMARY

[0005a] A first aspect of the present invention provides a resistivity logging tool module, comprising: a mandrel with connector sections at each end and a ring support section between the connector sections; a composite layer disposed around the ring support section; a set of ring electrodes disposed along the ring support section around the composite layer, wherein the composite layer electrically isolates the set of ring electrodes from the ring support section and wherein at least one of the ring electrodes includes an electrode pin slot aligned with an aperture that extends to an interior of the mandrel; and an adapter in an isolation joint configuration with one of the connector sections.

[0005b] A second aspect of the present invention provides a logging string, comprising: a multi-module resistivity logging tool having a plurality of modules, each of the modules having: a mandrel with a connector section at each end and a ring support section between the connector sections; a set of ring electrodes disposed around its ring support section, wherein at least one of the ring electrodes includes an electrode pin slot aligned with an aperture that extends to an interior of the mandrel; and a composite layer disposed around its ring support section, wherein the composite layer electrically isolates its set of ring electrodes from its mandrel, wherein one of the modules of the multi-module resistivity logging tool includes an adaptor in an isolation joint configuration with one of its connector sections.

[0005c] A third aspect of the present invention provides a resistivity logging tool module assembly method, comprising: obtaining a mandrel with connector sections at each end and a ring support section between the connector sections; disposing a composite layer around the ring support section; and moving a set of ring electrodes to a position along the ring support section, wherein the composite layer electrically isolates the set of ring electrodes from the ring support section and wherein at least one of the ring electrodes includes an electrode pin slot aligned with an aperture that extends to an interior of the mandrel. wherein one of the modules of the multi-module resistivity logging tool includes an adaptor in an isolation joint configuration with one of its connector sections.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Accordingly, there are disclosed herein electrode-based resistivity logging tools having a central support mandrel isolated from a set of electrode rings by a layer of composite material, and manufacturing methods therefor. In the drawings:

[0007] Fig. 1 shows an illustrative logging while drilling (LWD) environment.

[0008] Fig. 2 shows an illustrative wireline logging environment.

[0009] Fig. 3 shows an illustrative computer system for managing logging operations.

[0010] Fig. 4A shows a cross-section of various parts of a disassembled resistivity logging tool module.

[0011] Fig. 4B shows a cross-section of an assembled resistivity logging tool module with optional adapter.

[0012] Fig. 5 shows a side view of an assembled resistivity logging tool module with optional adapter.

[0013] Fig. 6 shows an illustrative multi-module resistivity logging tool for a logging string or LWD assembly.

[0014] Fig. 7 shows a flowchart of an illustrative resistivity logging tool module assembly method.

[0015] Fig. 8 shows a flowchart of an illustrative logging string assembly method.

[0016] Fig. 9 shows a flowchart of an illustrative multi-module resistivity logging tool control method.

[0017] It should be understood, however, that the specific embodiments given in the drawings and detailed description thereto do not limit the disclosure, but on the contrary, they provide the foundation for one of ordinary skill to discern the alternative forms, equivalents, and