The Brain Magnetic and Electrical Function in Relation to the Austin Oil & Gas Magnetoelectric Approach for Indications of Oil and Gas Accumulations

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Neuromagnetic and Magnetoelectric Current Flow Comparison

Neuro-electric Current

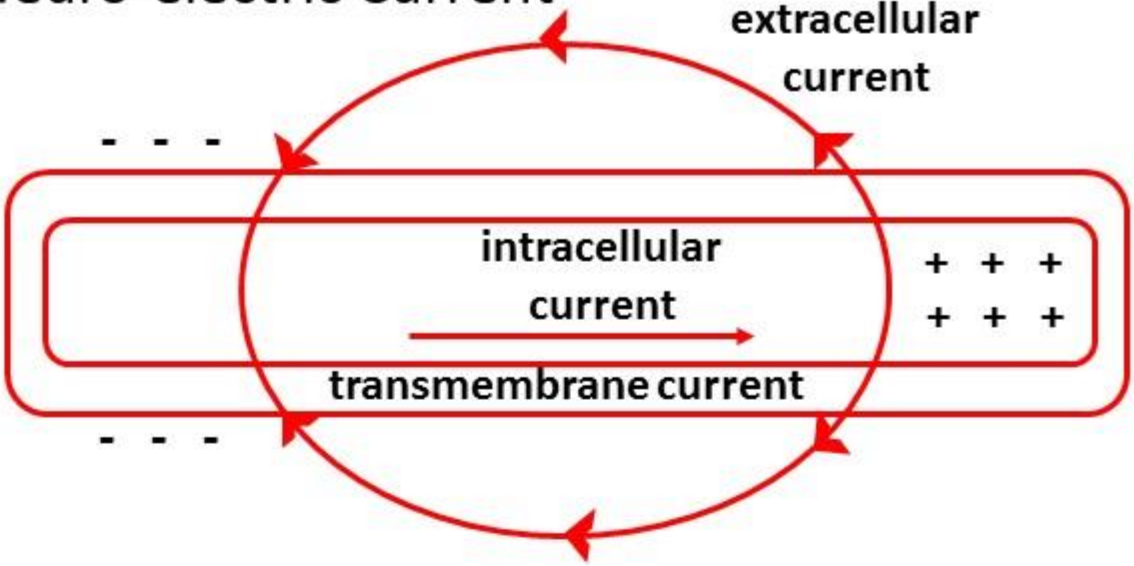

Fig. 1
Current pattern within and near a dendrite exhibiting excitatory postsynaptic activity.

Electro-telluric Current

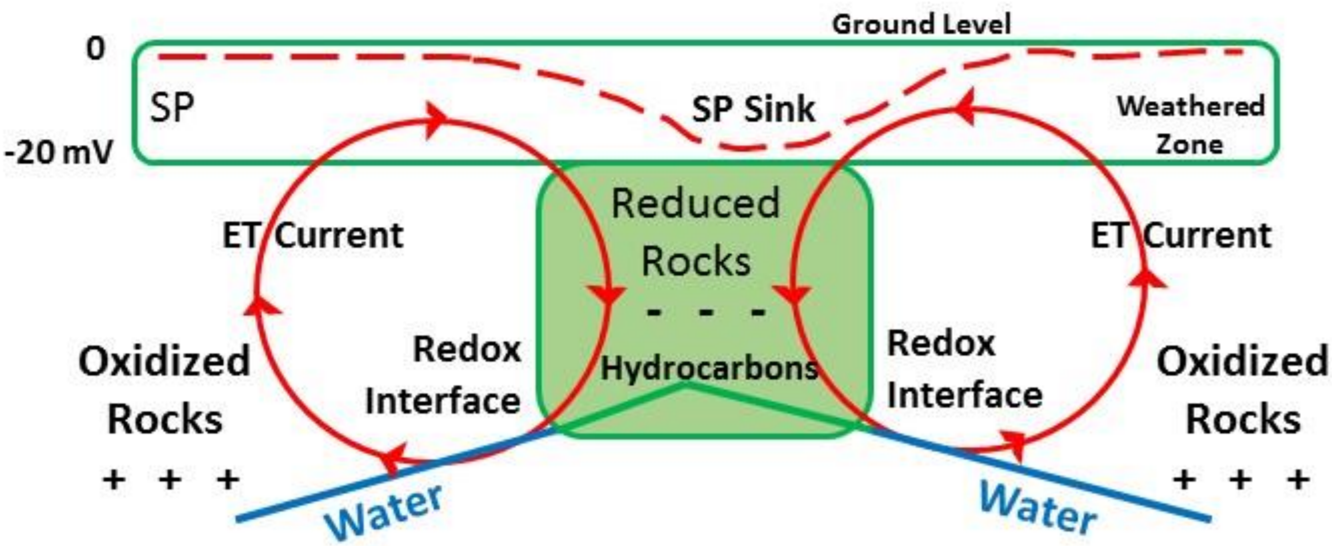

Fig. 2
Current pattern within and near a hydrocarbon accumulation.

SQUIDs are used in MEG systems such as the Neuromag Triux

Neuromagnetic Contributions to Magnetoelectrics through Medical Research

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An area of interest in the relationship between neuromagnetics and magnetoelectrics is the generation of electrical currents and their contribution in developing a localized magnetic field.

In neuromagnetics, cells within the brain produce electrical fields. A dendritic trunk responding to synaptic activity can be used as an illustration for the cellular basis in the generation of electrical currents (Fig. 1).

The resulting change in permeability of the cell membrane allows an influx of positive ions into the cell, leaving a local depletion of positive charge in the extracellular medium (represented by minus signs). The mutual repulsion of the positive ions within the cell produces an axial current (straight arrow) and increasing positive charge near the head of the arrow (positive signs). This in turn repels positive ions in the extracellular medium, resulting in a current directed back toward the negative charge (curved arrow). The extracellular current and oppositely directed intracellular current complete a closed circuit. This current pattern develops within tens of milliseconds, so it is reasonable· to deduce that the intra- and extracellular current pattern is approximately quasi-static. Current continuity insures that the total current in the extracellular backflow equals the intracellular current.

In magnetoelectrics, electrical currents are generated from the redox activity within the subsurface of the earth (Fig. 2).

Hydrocarbon accumulation in the earth, through hydraulic migration, have modified the electrochemical properties of the rocks which immediately overlay those deposits. The rocks above the hydrocarbon accumulation have been more chemically reduced and have an excess of electrons, which relates to the reduced, extracellular medium of the dendrite. The rocks that surround the hydrocarbon accumulation are relatively less reduced, and are oxidized, in that they have a deficiency of electrons. This condition relates to the intracellular medium of the dendrite. A dynamic system of "redox fuel-cells" is manifested from the reduced-oxidized environments. The redox interface as with the cellular transmembrane both give rise to cellular excitation and electric current flow. As the electric currents, called Electrotelluric (ET) currents are generated, they produce a flow pattern very similar to that of the cellular current activity within the brain.

A noticeable self-potential (SP) sink is generally observed over the reduced environment. The ET currents may also cause electrophoretic depletion of certain mineral ions (U, Ra, Th, K) away from the "chimney" above the reduced environment. This may also explain an often noted reduction in radiation over hydrocarbon deposition, which has been observed by subsurface radioactivity mapping of welldefined marker-beds such as shales and silts.

The similarities between neuromagnetics and electromagnetics are not coincidental. They both are based on the same laws and theorems of physics, such as the Biot-Savart law Ampere's law and Stokes' theorem.

According to the Biot-Savart law, any small region of the current pattern shown in both figures, produces a magnetic field. In the neuromagnetic example, it has been shown mathematically that the intracellular current is the generating source for producing a magnetic field consisting of closed loops. This evaluation explains the generation of magnetic fields from ET currents emanating from the oxidized environment.

Ampere's law says that the line integral of the magnetic field around a closed path is proportional to the net current passing through the enclosed area. Ampere's law does not specify which elements of the current enclosed with a path of integration contribute to the field. Basically, polarity and intensity are elements associated with Ampere's "right hand" rule. This rule states that if the thumb of the right hand is pointed in the direction of flow of an existing electric current, the magnetic field generated by such current is directed around it in a closed circuit as pictured by the fingers of the right hand encircling the wire (or chimney) carrying the said current.

In Stokes theorem, it is stated that the line integral of a force field derivable from a potential around a closed circuit is zero. The earth magnetic field, as with the neuromagnetic field, is not fully derivable from a potential function to the extent of 5 to 10 percent. This non-potential part is derived from the intracellular current in neuromagnetics and the electrotelluric current in magnetoelectrics. There is the possibility for noise that can also contribute to the current flow, besides hydrocarbons and cellular fluid medium.

In field magnetics, the only ways to avoid these disturbances are through careful data acquisition and relatively high resolution field measurement.

The instrumentation utilized in measurement of neuromagnetic signals is the SQUID (Superconducting Quantum Interference Device).

The evoked magnetic fields generated by the brain are extremely weak, in the order of 10^{-14} to 10^{-13} tesla, which is about one billionth of the earth's field. A major problem in recording the brain's magnetic field is to extract it from noise caused by the heart, passing vehicles, elevators and other noise that generate fields hundreds or thousands of times larger than the signal. The SQUID depends on the superconducting phenomenon whereby the electrical resistivity of some metals disappears when the temperature approaches absolute zero (-270 degrees C). To maintain this low temperature, the SQUID is bathed in liquid helium.

The instrumentation utilized in measurement of magnetoelectric signals is the magnetometer. A high resolution, vapor pumped magnetometer is generally used for airborne surveys; whereas, ground surveys generally use proton precession magnetometers to provide measurement of the total intensity of the earth's magnetic field. The earth's magnetic field, being in the order of 70,000 gammas does not require the same sensitivities as for brain studies. Generally, sensitivities between .25 to 1 gamma resolution are more than adequate to derive valid data.

The relationships found between neuromagnetics and magnetoelectrics appear to be more similar than dissimilar. Extensive medical research, which is publically available, can be borrowed and utilized by the oil and gas industry as a basis for greater understanding into the scientific principles that apply to both. Through medical research, significant enchancements are being realized in magneto-electric applications for hydrocarbon exploration.

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