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### **Airborne Measurement of Transient Pulses Locates Hydrocarbon Reservoirs**

Author Jackson (2005) recently patented a passive geophysical prospecting method and apparatus that, both in ground-borne mode, and in airborne configuration, have successfully identified hydrocarbon reservoirs by remote sensing of transient electromagnetic pulses. An aircraft the size of a Cessna 206 has typically been used for airborne surveys. Over 30 discovery wells have been documented as being drilled on positive transient-pulse anomalies; to our knowledge, no dry holes have been drilled on any of our positive anomalies.

In blind tests using this prospecting method, Jackson had correctly identified Leduc pinnacle reef reservoirs previously located by author LeSchack using independent geophysical methods, i.e., Magnetic Horizontal Gradient (HG') and passive telluric surveys (LeSchack and Van Alstine, 2002; and LeSchack et al., 2004). This validation encouraged further exploration by Jackson, as well as the preparation of the current paper.

The Jackson method is based on the following theory: An inherent magnetic field of electromagnetic energy is present and can be sensed at the earth's surface, and from low-flying aircraft. Vertical components of this primary field contain transient random impulses of energy varying across a wide frequency range including in the audio-frequency range. Although speculative, it is widely believed that the impulses are related to lightning activity around the Earth that produce "whistlers," among other Audio-Magnetotelluric (AMT) effects (Cummer, 1997; Garcia and Jones, 2002). Regardless of their source, however, the existence of random occurring impulses is recognized. Secondary magnetic fields are associated with the microseepage plumes and accompanying Redox cells over hydrocarbon reservoirs (Pirson, 1969). These secondary fields interact with the random impulses in the primary field and generate secondary impulses.

Jackson first demonstrated to LeSchack that the number of impulses per second over any area is related to the strength of the hydrocarbon-induced secondary magnetic fields. A truck-mounted version of the Jackson tool was used to record transient-pulse density measurements over previously mapped pinnacle reef reservoirs in Alberta associated with the Devonian Homeglen-Rimbey Reef Trend and the Stettler-Fenn-Big Valley atoll. Following the positive ground-borne tests, Jackson then demonstrated that an airborne version of his apparatus, flying typically at 100m above the terrain, could also identify, to within 100m horizontal distance, the location of other pinnacle reef reservoirs mapped by LeSchack. Figure 1 shows a "swarm" of Upper Devonian Leduc pinnacle reefs overlain by Nisku biostrome reservoirs associated with the Stettler-Fenn-Big Valley Atoll in Central Alberta. The colored areas highlight the HG' anomalies caused by pinnacle reef reservoirs as described by LeSchack and Van Alstine (2002). LeSchack et al., 2004, documents the drilling of a well on one such HG' anomaly and finding the predicted oil reservoirs. The blue lines are the flight lines, and the numbers in yellow rectangles are GPS waypoint locations. The analog strip-chart of transient-pulse density recorded

between GPS Points 026 to 028 is presented to the left on Figure 1. Jackson was unaware of LeSchack’s HG’ mapping results at the time of his overflight; nonetheless, his data accurately predicted and validated the earlier mapped Magnetic HG’ survey results.

With the clear success in Alberta obtained by Jackson’s above-discussed transient-pulse methodology, he continued to survey major producing provinces of the U.S., Australia, and New Zealand, further refining the process. To date, he has flown over 100,000 line-miles of surveys. His instrumentation uses an “amplitude detector” with a broad filter that will allow the full transient pulse to pass. Measurements of both E and H fields are made and a magneto-resistive IC sensor with a high-frequency response is used to record the H-field component of the impulse. It has a count-level trigger that will activate a 5-V

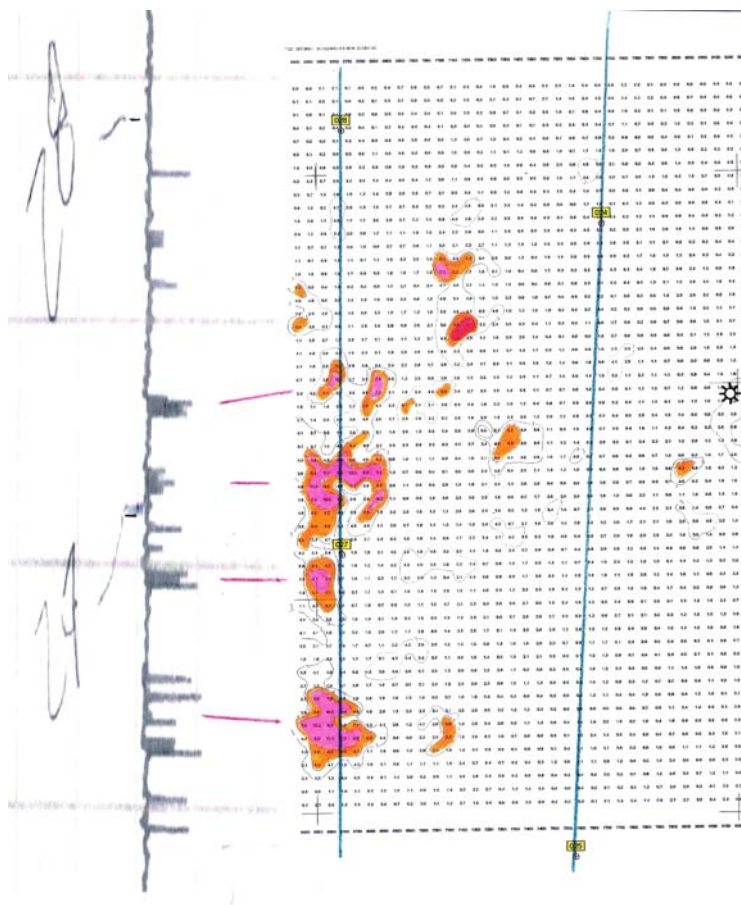


FIGURE 1: Airborne Transient-Pulse trace line (left) is compared with Alberta Leduc pinnacle reef swarm independently mapped. Those reef occurrences were mapped earlier by Magnetic HG’ survey. Mapped area is 2650m X 1600m.

output when a set count number is exceeded within a given time period, and then reset itself for a new count cycle. As the survey begins, the operator sets the threshold count level to the regional baseline. Counts above that baseline are recorded digitally as well as in analog form. Typically, count rate increases exceeding 100 counts/second above baseline have been observed over hydrocarbon reservoirs. The local transient-pulse

density together with associated GPS data is mapped easily, permitting direct interpretation by the geologist.

Figure 2 is a map of the prolific Willamar Oilfield in south Texas in Willacy County. Jackson flew a survey of this field in September 2004. The GPS waypoints are indicated in the numbered yellow rectangles on the map. Below the map is an airborne analog transient-pulse density profile flown across the center of the approximately 3-mile diameter field. As indicated by the transient-pulse density, the field starts approximately at Waypoint 186 and ends at 189.

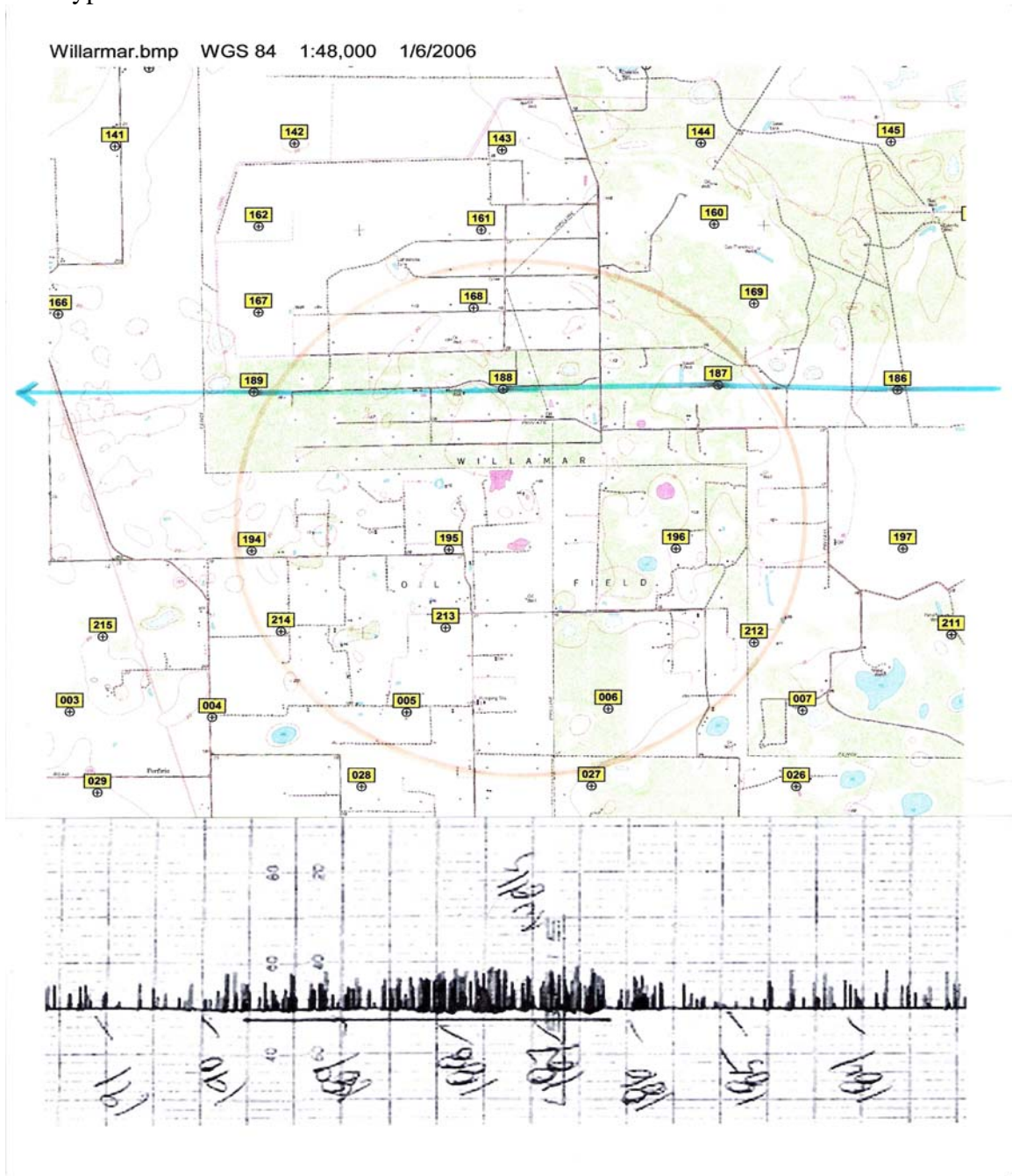


FIGURE 2: Transient-Pulse Density trace across the center of the Willamar Oilfield. The approximate cumulative production for this field is 136,050,000 mcf of gas and 14,500,000 barrels of light oil.

Figure 3 is the Piñon Thrust Gas Field area in Pecos County, Texas, flown in June 2003. That field had already been discovered at the time of the overflight. In this Figure, the number of transient pulses/second above the baseline voltage has been plotted against the corresponding GPS data point. Digital data are recorded in the common “.csv - .txt file” format. Such an automated data stream allows for direct mapping of the survey using standard geological mapping packages. Although the Piñon Thrust Gas Field (eastern anomaly) had already been discovered, a similar transient-pulse density anomaly can be seen just five miles to the west; that anomaly was interpreted to be a similar gas field that had yet to be discovered. Subsequently, four wells were drilled and successfully completed by an operator in the Piñon Thrust Gas Field area on that western anomaly. That operator was not privy to the Jackson survey.

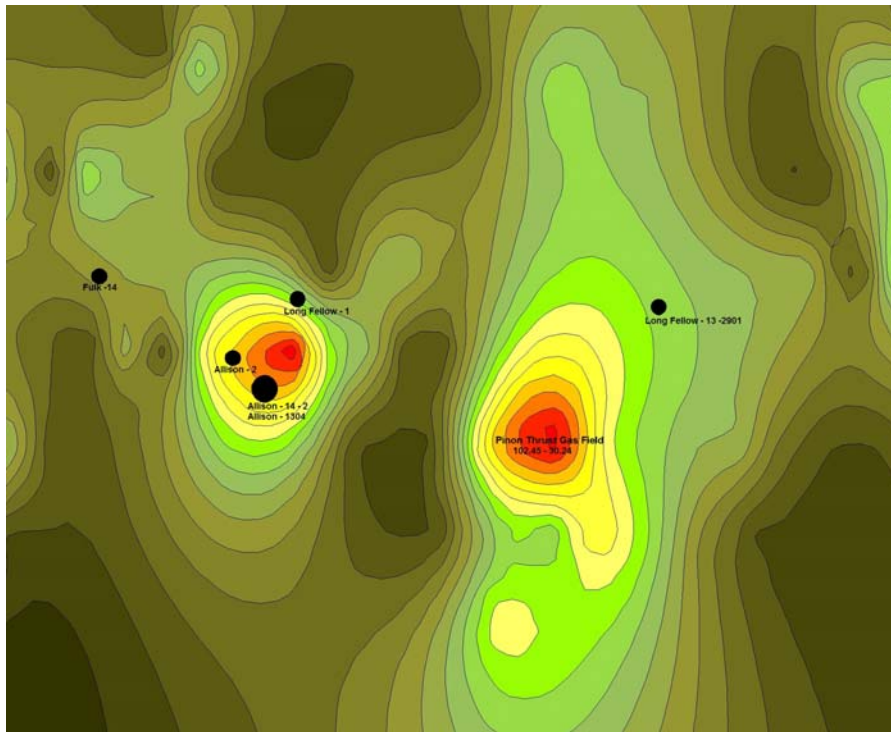


FIGURE 3: Airborne Transient-Pulse Density map of the Piñon Thrust Gas Field. The original Piñon Thrust Gas Field has produced approximately 30 bcf of gas.

Operators who have contracted for Jackson’s recent surveys are clearly impressed, and have told us about successful use of these surveys for their drilling programs; nonetheless, for obvious competitive reasons, they are reluctant to identify themselves. One operator noted, for example, “In the Vicksburg and Wilcox trends of South Texas, your survey, combined with subsequent 3-D seismic, helped us pick 12 locations.” We have received many similar comments, but shall try to illustrate the thrust of these comments from Jackson’s surveys over a variety of areas, and analysis of public well data.

We have included a partial list of commercial producing wells drilled where airborne transient-pulse density surveys *had been conducted prior to drilling*. The list includes wildcat discoveries and development wells drilled on positive anomalies, and only

reflects a sampling of the exploratory wells drilled in areas where surveys have been completed since 2002. We did not extensively research the drill results for all the areas where surveys had been conducted. We have compiled the drill results from [www.drillinginfo.com](http://www.drillinginfo.com), and other informational data bases for areas where surveys had been conducted.

Updated/Corrected 1/06

<b>Well</b>	<b>Location</b>
Madeley 1-H	Shelby County, Texas
Garcia "JA" #1, #11- (multiple wells)	Star County, Texas
Massey 1-H (blow out)	Shelby County, Texas
Krammer 1-H	Shelby County, Texas
Frank Yturria #1	Hildogo County, Texas
Garcia #2	Star County, Texas
Richards G.L. #1	Star County, Texas
Bloomburg-Sam "D" #26 - (multiple wells)	Star County, Texas
Moore "A" #4	Fort Bend County, Texas
Polly "OH" 3-H	Shelby County, Texas
Trinidad-Bridge #2H	Shelby County, Texas
SL17742 #1 (Offshore)	E. Cameron Block 4
Fash #1	Fort Bend County, Texas
Yturria-Greehey #1	Star County, Texas
Sessions #1,#2	Cherokee County, Texas
Long Fellow #1	Pecos County, Texas
Allison #2	Pecos County, Texas
Diaz #1, #6, #5	Star County, Texas
Villareal #1, #2	Star County, Texas
Allison - 14 -2	Pecos County, Texas
Allison #1304, #2	Pecos County, Texas
Long Fellow -13 – 2901	Pecos County, Texas
Temple W. - West #40, #43 - (multiple wells)	Hidalgo County, Texas
Dingle #1	Hidalgo County, Texas
Polly 1-H	Shelby County, Texas

In summary, the Jackson method—especially in its airborne configuration—can reduce the cost of exploration by means of cost-effective reconnaissance surveys, and for high-grading prospective areas for further on-the-ground geochemical and geophysical surveys. The airborne transient-pulse density technology works over land and water. It does not, however, identify the formation depth(s) that are the source of the recorded anomalies. That must be determined by other geophysical means or knowledge of the geology of the area. The airborne transient-pulse density survey method is also valuable for interpretation of seismic features with hydrocarbon content. For example, one Gulf Coast operator worked several months to correct certain problems associated with his seismic data recorded beneath an airborne transient-pulse density anomaly. That work resulted in a successful Yegua Formation discovery that had previously proved elusive.

The present authors believe that both the private and public sectors can benefit from use of the discussed technology. Forward-thinking operators can strongly enhance their reserves positions and lower finding costs. Governments can more effectively enhance their future energy security by employing this mapping procedure as part of their national hydrocarbon resources inventory.

#### References Cited

- Cummer, Steven A., 1997, Lightning and ionospheric remote sensing using VLF/ELF radio atmospherics, A dissertation submitted the Department of Electrical Engineering and the Committee on Graduate Studies of Stanford University, a Ph.D thesis.
- Garcia, Xavier and Alan G. Jones, 2002, Atmospheric sources for audio-magnetotelluric (AMT) sounding, *Geophysics*, Vol. 67, No. 2 (March-April 2002); P. 448-458.
- Jackson, J. R., 2005, U.S. Patent 6,937,190, August 30, 2005.
- LeSchack, L. A., and D. R. Van Alstine, 2002, High-resolution ground-magnetic (HRGM) and radiometric surveys for hydrocarbon exploration: Six case histories in Western Canada, *in* Surface exploration case histories: Applications of geochemistry, magnetics, and remote sensing, D. Schumacher and L.A. LeSchack, eds., AAPG Studies in Geology No. 48 and SEG Geophysical References Series No. 11, p. 67-156.
- LeSchack, L. A, Richard E. Wyman, and John R. Jackson, 2004, Surface Exploration Successful in Finding Alberta Leduc Pinnacle Reefs, AAPG Annual Meeting: April 18-21, 2004; Dallas, Texas.
- Pirson, S.J., 1969, Geological, geophysical, and chemical modifications of sediments in the environment of oil fields, *in* W.B. Heroy, ed., Unconventional methods in exploration for petroleum and natural gas: Dallas, Southern Methodist University, p. 159-186.