Proposal for High-Grading the Barinas-Apure Basin of Venezuela (and Environs) Using Airborne Transient Pulse (A-EM) Surveys*

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Abstract

The Barinas-Apure Basin of Venezuela (Figure 1) appears to be a good candidate for cost-effective exploration and evaluation of hydrocarbon potential by means of Airborne Transient Pulse (A-EM) Surveys and follow-on Surface Geochemically-based Exploration. Callejon and von der Dick, (2002) in their paper, 'Numerical Identification of Microseeps in Surface soil Gases of Western Venezuela, and its Significance for Hydrocarbon Exploration,' sets the stage for an aggressive, potentially highly cost-effective exploration program in the Barinas-Apure Basin region of Venezuela. LeSchack (2012) showed that Airborne Transient Pulse Surveys Identify Subtle Stratigraphic FDD Channel Sand Reservoirs in Australia, Namibia and South Africa, Leonard A. LeSchack, #40905 (2012).

Using Airborne Transient Pulse (E-EM) surveys, followed by geochemical analyses of soil samples strategically gathered to ascertain that live hydrocarbons are microseeping vertically upwards from promising Airborne Transient Pulse (A-EM) anomalies, I have outlined a methodology that worked for identifying on-shore reservoirs for clients in Namibia and South Africa and suggested that the Fluvial Dominated Deltaic (FDD) reservoir i.e., channel sands, are likely found on continental land masses around the world. The Callejon and von der Dick (2002) paper, discusses in detail the observed geologic section and description and age of the rocks that are the setting of the Barinas-Apure Basin in Venezuela, a basin that already produces oil. After examining the Barinas-Apure geology, and the patterns of known producing areas, as well as their observed geochemical leads, I compared it with the geology and type of 'Muddy Sands' fields discussed in (Dolson, et. al., 1991). I believe that there are sufficient similarities, so that Table 1 in the Dolson paper, which lists numerous fields, their geology, reservoir, type of trap and environment, as well as their production, can be compared with the geology as presented in Callejon and von der Dick (2002). Similarities can be found, such that the LeSchack (2012) methodology could be applicable at Barinas.

Introduction

Callejon and von der Dick, (2002) in their paper, "Numerical Identification of Microseeps in Surface soil Gases of Western Venezuela, and its Significance for Hydrocarbon Exploration," sets the stage for an aggressive, potentially highly cost-effective exploration program in the

Barinas-Apure Basin region of Venezuela, and likely even beyond to the northwest into Colombia (Figure 2). They also discuss in detail the observed geologic section, Figure 3, and description and age of the rocks that are the setting of the Barinas-Apure Basin in Venezuela, a basin that already produces oil.

Discussion

The present author, after examining the Barinas-Apure geology, and the patterns and shapes of known producing areas, as well as their observed "geochemical leads," has compared it favorably with the geology and type of "Muddy Sands" fields discussed in (Dolson, et. al., 1991). Further, he expects that there are sufficient similarities, so that Table 1 in the Dolson paper, which lists numerous fields, their geology, reservoir, type of trap, and depositional environment, as well as their production, can be used as a guide to compare with the geology as presented in Callejon and von der Dick (2002).

Dolson, et. al. (1991) in their Table 1 shows that the majority of the 47 fields included in their study were stratigraphic traps with the remainder being either wholly structural or a combination of stratigraphic traps enhanced by structure. From the description in the Callejon and von der Dick (2002) paper, it appears that several of the oilfields discovered at Barinas were combination traps, i.e., structurally enhanced stratigraphic traps. This is likely to be also the case with the potential onshore oilfields in Australia, South Africa and Namibia as mapped by Airborne Transient Pulse Surveys, such that the LeSchack (2012) methodology as discussed below could be applicable at Barinas and perhaps the nearby fields to the northwest. LeSchack (2012) showed that Airborne Transient Pulse (A-EM) Surveys Identify Subtle Stratigraphic FDD Channel Sand Reservoirs in Australia, Namibia and South Africa, Leonard A. LeSchack, #40905 (2012).

In that paper, the author observed that, "The Fluvial-Dominated-Deltaic (FDD) Reservoir is the most common and important onshore reservoir in the United States, and is responsible for the majority of its oil and gas production from sandstone reservoirs in the US (Johnson, 2001). Further, he continued, it is quite possible that this may be true for other countries in similar Continental areas also, for we see such reservoirs elsewhere." Typically, FDD reservoirs are subtle stratigraphic traps, which are not easily found by seismic exploration unless subsequent tectonic action has structurally enhanced the channel-sand reservoirs, as is the case for the "combination fields," as seen in Table 1, from Dolson, et. al. (1991).

However, Airborne Transient Pulse Surveys can readily identify all these kinds of reservoirs, if those airborne data are properly recorded, processed, and mapped using appropriate Kriging parameters. Finally, these survey maps must be interpreted by a petroleum geologist familiar with oilfield maps of FDD reservoirs, i.e., production maps, isopach maps, or isopotential maps of typical channel sand reservoirs, similar to, for example, the Booch Delta and the Hawkins Field of Eastern Oklahoma, as shown in LeSchack (2012). Once the Kriged Airborne Transient Pulse Survey maps are prepared, the petroleum geologist needs to "connect the dots," that is, do a geological interpretation that fits for FDD shoestring sands and channel sand oil and gas fields. Examples of these interpretations are shown by "penciled in" channels drawn by the present author (a petroleum geologist), after, LeSchack (2012). A good example of such penciled in channels are those shown for an already productive area in South Australia, the Cooper Basin. That interpreted Airborne Transient Pulse Survey map, along with a geological description, Hamlin et. al. (1996), is presented below to aid the reader understand the value of a properly mapped and interpreted Airborne Transient Pulse Survey of a known producing area.

Using Airborne Transient Pulse (A-EM) surveys (Figure 4), followed by geochemical analyses of soil samples strategically gathered to ascertain that live hydrocarbons are microseeping vertically upwards from promising Airborne Transient Pulse (A-EM) anomalies, the present author outlined a methodology that worked for identifying on-shore reservoirs for clients in Namibia and South Africa and suggested that the Fluvial Dominated Deltaic (FDD) reservoir i.e., Channel Sands, are likely found on continental land masses around the world.

While I originally postulated the Barinas Apure Basin maps and geological description suggested FDD reservoirs, Eissa, et. al. (2009) was explicit in their paper, “Seismic petrophysical analysis for thin sandstone reservoirs in Colombia's Guajira Basin.” In that paper, they observed, “This study incorporates well logs, production, temperature, pressure, fluid properties, sidewall core report, and pre-stack seismic data into the analysis. The zones of interest are two fluvial sandstone packages (i.e., FDD reservoirs) of the Lower Upper Miocene.”

From a geologist's point of view, if the Barinas fields are stratigraphic and/or combination traps as defined in Dolson, et. al., (1991) and the gas field in Colombia's Guajira Basin is an FDD reservoir, as indicated in the Eissa et. al., (2009) study (Figure 5), then it is reasonable to suggest from Figure 2, considering the obvious trend from Barinas to the Guajira Peninsula in Colombia, that the fields from Barinas to the Guajira Peninsula may, in fact, all have been formed in the same depositional environment and, therefore, all be some combination of stratigraphic and structural traps as defined by Dolson et. al. (1991), and therefore likely to be identified from an Airborne Transient Pulse (A-EM) Survey, as were the onshore oil fields in South Africa, and as were the onshore fields in Namibia, as described in LeSchack, (2012). The juxtaposition, and the similar shapes of the oil and gas fields in Figure 2, leads to the speculation that such similarity may have been enabled by the same depositional environment, modified by similar, but subsequent tectonic events for the entire area.

With regard to oil field shapes, it is instructive to look at the Bell Creek oilfield in Montana, the first and largest field listed in Table 1 (Dolson, et. al., (1991). It is a stratigraphic trap. Figure 6 shows an isopach map of the Bell Creek oilfield. That field has a shape remarkably similar to the largest oilfield in Zulia Province in Venezuela as seen in Figure 2. Also shown in Figure 6 is one of our Airborne Transient Pulse (A-EM) maps of an FDD oilfield in Namibia, which so well modeled the Bell Creek Oilfield, that once that A-EM map was oriented so that a visual comparison could easily be made, our client felt that our Airborne maps of this area in Namibia, coupled with the production statistics of the Bell Creek Field were a likely guide to the production potential of the rest of this mapped area in Namibia.

The Barinas-Apure Basin of Venezuela, and its now seeming likelihood of continuation to the northwest to include the entire swath of oil and gas fields to, and including the onshore Guajira Basin up to Punta Gallinas, Colombia, appear to be a good candidate zone for cost-effective exploration and evaluation of hydrocarbon potential by means of Airborne Transient Pulse (A-EM) Surveys and follow-on on-the-ground Surface Geochemically-based Exploration as discussed in LeSchack (2012). There is much room in this zone between Barinas and the Peninsula de Guajira to discover missed oil pools.

Conclusion

The Barinas-Apure Basin of Venezuela, and its seeming continuation to the northwest to include the entire swath of oil and gas fields to and including the onshore Guajira Basin up to Punta Gallinas, Colombia appears to be a good candidate zone for cost-effective exploration and evaluation of hydrocarbon potential. It is also a good candidate for discovering overlooked reservoirs in this swath, by means of Airborne Transient Pulse (A-EM) Surveys and follow-on Surface Geochemically-based Exploration as discussed in LeSchack (2012).

Selected References

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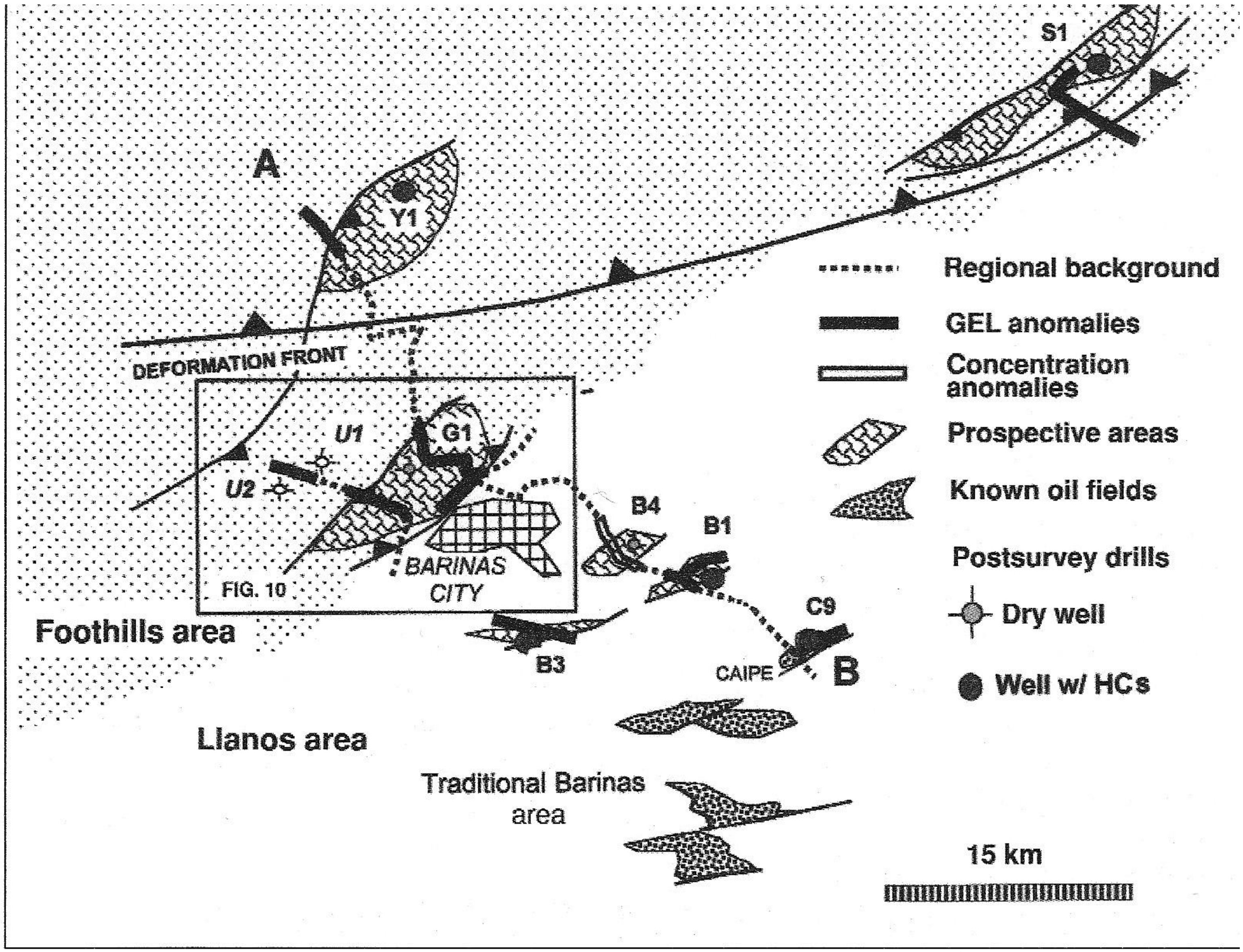


Figure 1. This is the base map of the Barinas, Venezuela oil fields as described in Callejon and von der Dick (2002). It is Figure 9 in that paper.

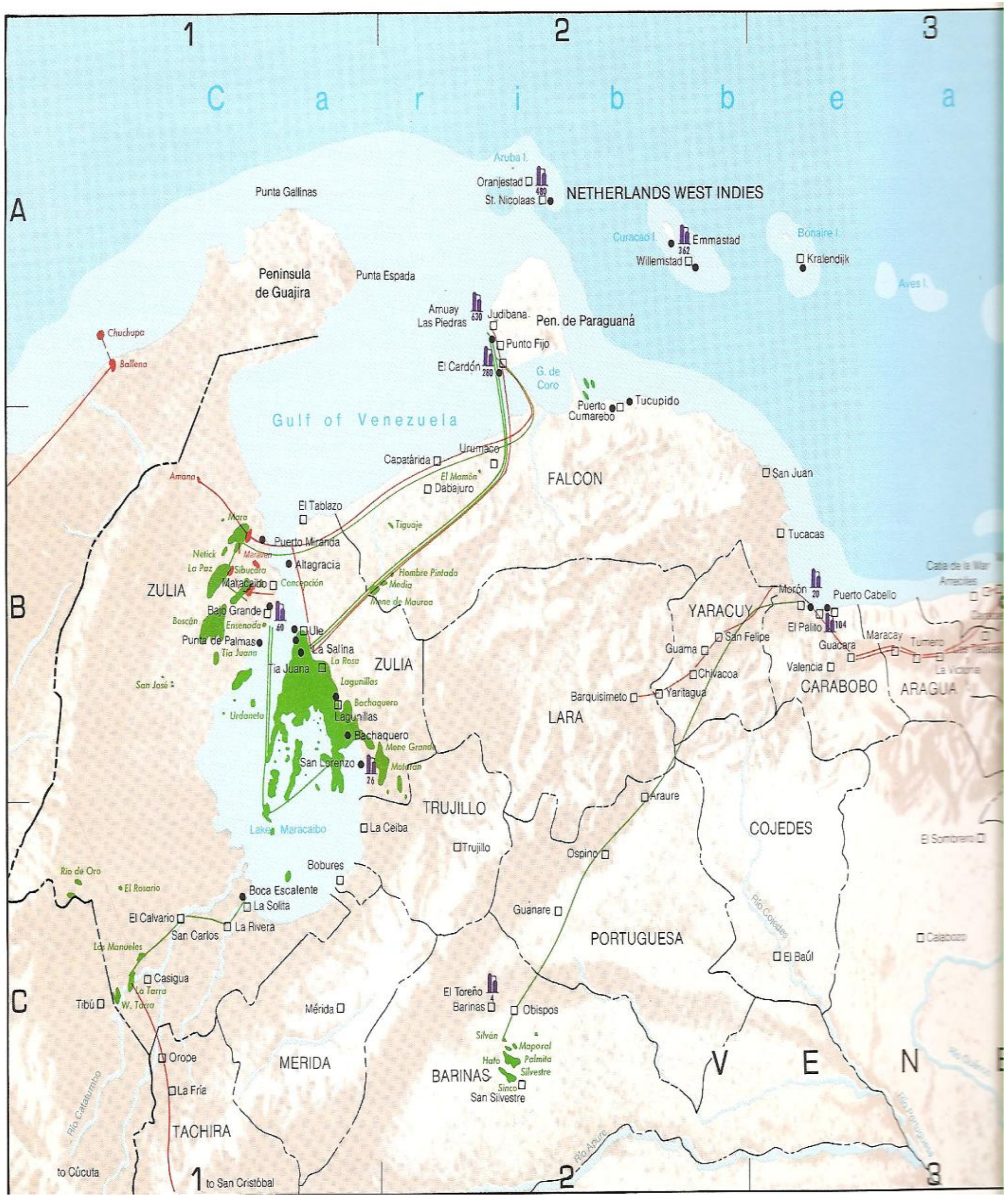


Figure 2. Oil and gas map from Pennwell International Petroleum Encyclopedia 1983, shows the Callejon and von der Dick (2002) Barinas area at the center bottom of the map and several larger fields trending to the Northwest up to Colombia's Guajira Basin.

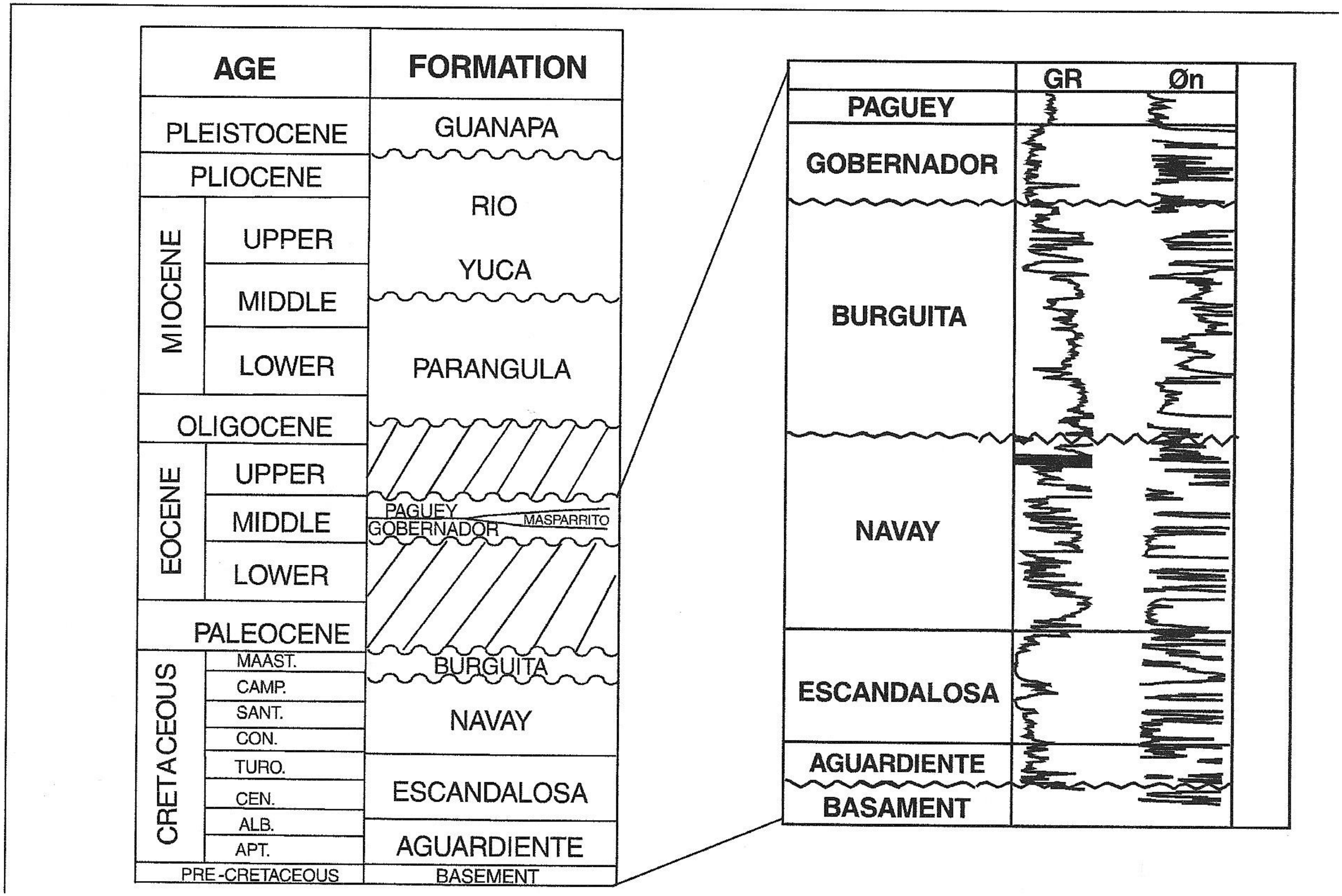


Figure 3. Geologic section of Barinas-Apure Basin in Venezuela.

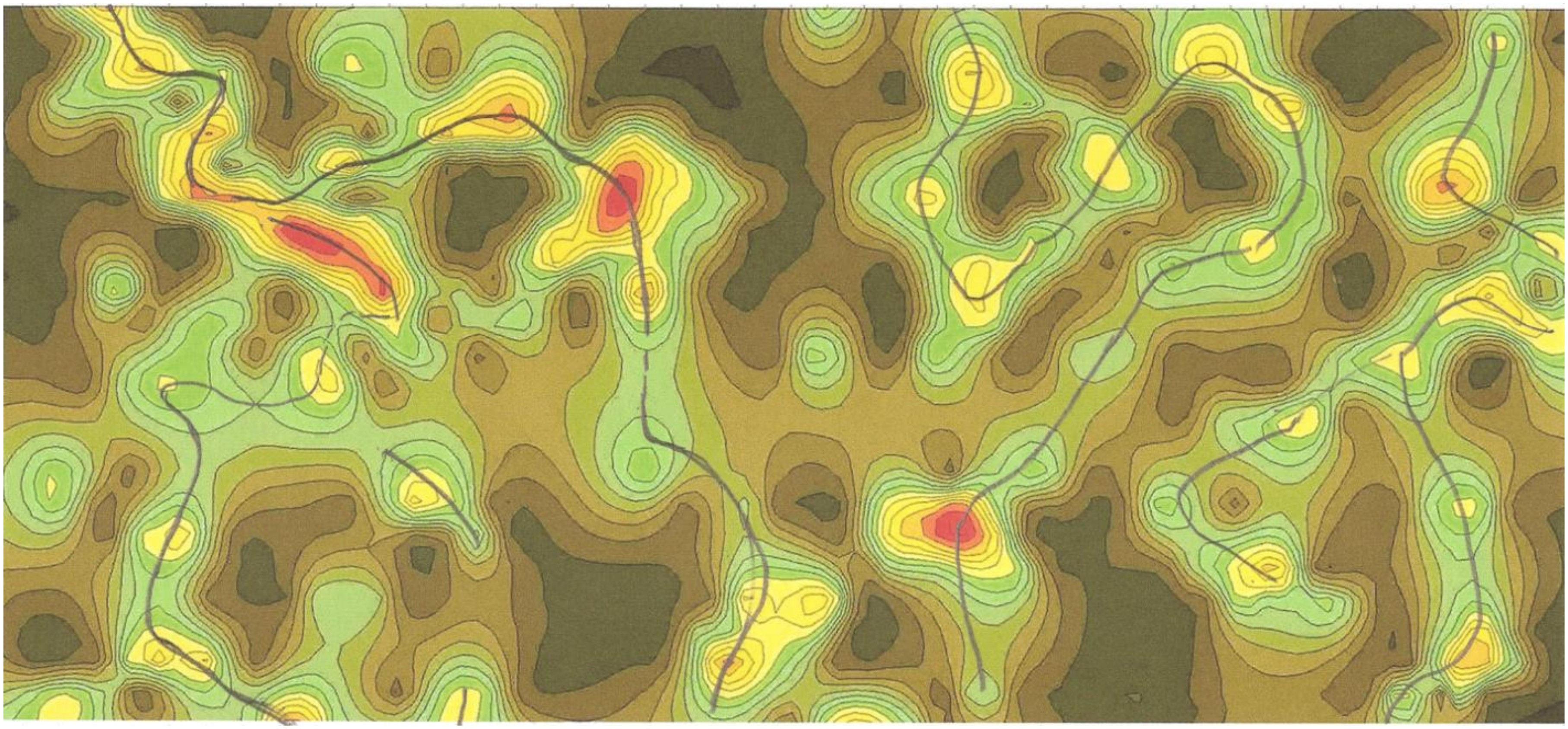


Figure 4. An Airborne Transient Pulse Survey (LeSchack and Jackson, 2006), maps a 45 by 90 NM area over the Cooper Basin, South Australia where more than 80% of the oil in this basin is contained in the Early Permian braid delta and braided stream sandstone reservoirs found here (Hamlin, et. al., 1996). This means an FDD paleo-environment has governed the deposition of the productive Tirrawarra Sandstone. It is therefore likely that the typical channel-fill stream systems seen penciled in here are Tirrawarra stratigraphic reservoirs that generally show little or no seismic expression, unless they have been subsequently modified by faulting. The reds, oranges and yellows indicate the likeliest areas to produce hydrocarbons. The Tirrawarra Sandstone contains 146 million bbl of oil in the Tirrawarra Field. Although many FDD Reservoirs are stacked one above the other, in the Cooper Basin braided channel sandstones are overlain by lenticular meandering channel sandstones, which appear to be exactly what is imaged on this map.

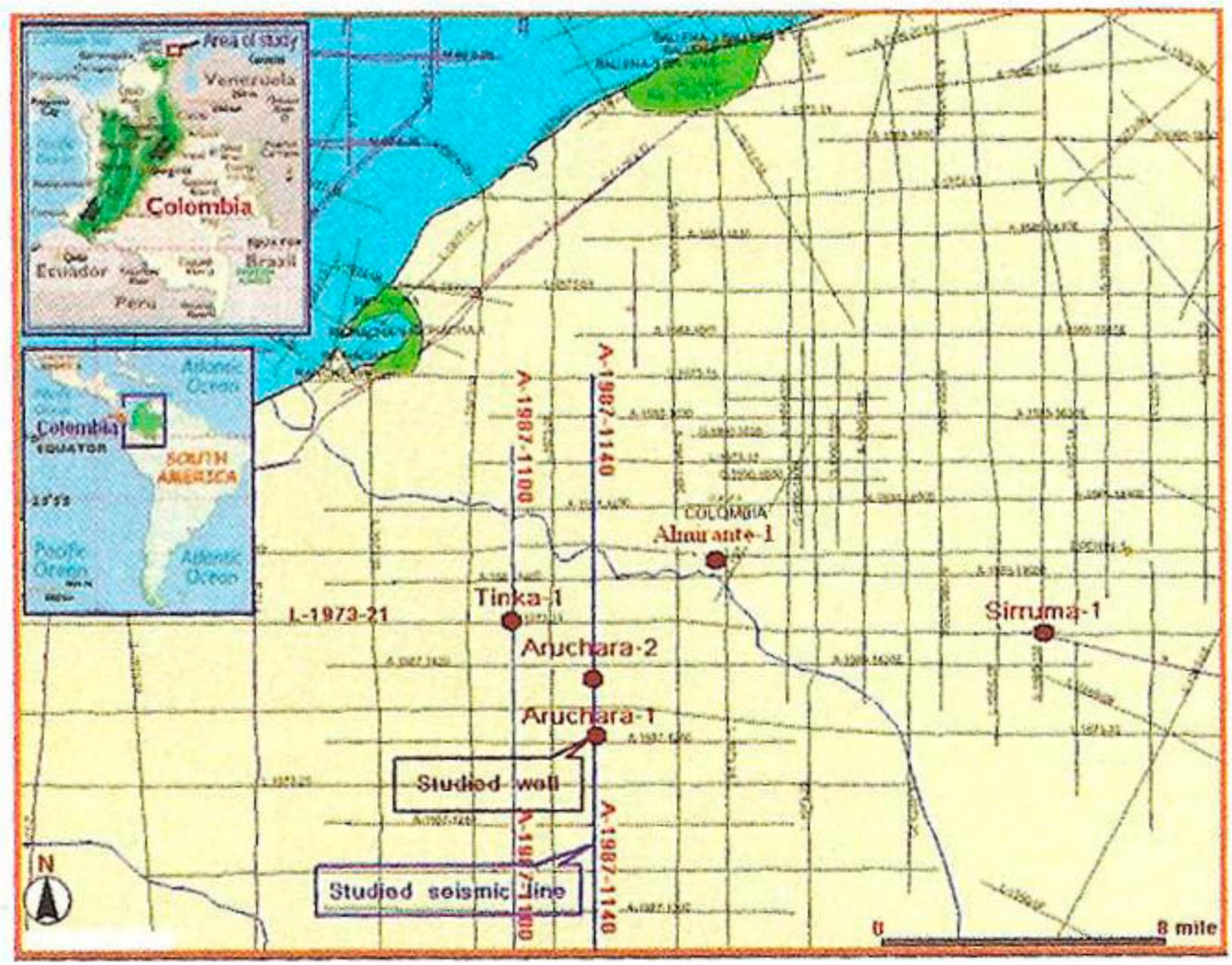
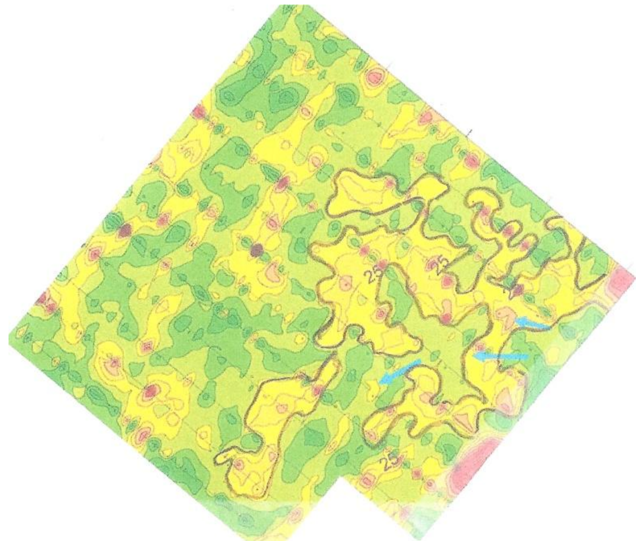
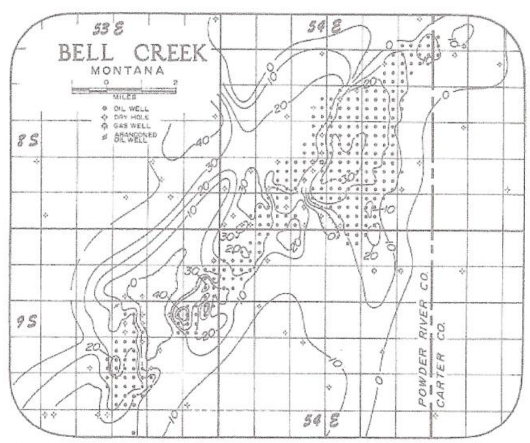


Figure 5. This is the location of the Eissa et. al. (2009) study showing the specific area in Colombia where they identified "fluvial sandstone packages (see upper left-hand corner of their Figure 1, where the tiny red rectangle identifies their study location).



Bell Creek Field, Montana: A Rich Stratigraphic Trap 135



. 9.—Isopach map of gross thickness of Muddy Sandstone in Bell Creek field; based on data available mid-April 1968. CI = 10 ft.

Figure 6. The NE corner of the first Namibia Airborne Transient Pulse Map, as above, has been rotated and its scale changed so that it may be directly compared to the FDD Bell Creek oilfield in Montana (McGregor and Biggs, 1970). The shape of the Bell Creek Field seems well modeled by the Namibian Airborne Survey #1 when compared at the same scale. The Bell Creek look-a-like in Namibia is outlined in black on the airborne map. The shape similarity should not be surprising, however, since similar FDD paleo-environments around the world might be expected to create similar-shaped reservoirs. The Bell Creek Field in 1967 produced 50,000 b/d with an average well producing 500 b/d of 34 API oil, and as of 1988 had produced 124 million bbls of oil and 39 bcf of gas.