Seismic characterization of fracture barriers

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INTRODUCTION AND MOTIVATIONS

Producing hydrocarbons in karsted and fractured zones is a very risky procedure. This is the case of the source and reservoir Barnett Shale Formation that is overlying the highly karsted and fractured limestone of the Ellenburger Group in the Fort Worth Basin. Typically, karsted and fractured zones had been avoided because of the potential of the faults to connect with the water in the Ellenburger Group. I propose to generate a geological, geophysical and petrophysical model to delineate, characterize and quantify the effects of these karsted and fractures features on the production from the Barnett Shale Formation. Specifically, I will correlate well production to proximity to geohazards and to the elastic properties of the Ellenburger dolomite. Ideally, I will be able to identify areas where the Ellenburger serves as an acceptable barrier to hydraulic fractures.

The field of study is located in Wise County, Texas in the Fort Worth Basin (Figure 1) and will correlate relative amount of water production from wells, to quantify how they are negatively impacted with proximity to drilling hazards such as collapse features and joints.

LOCATION AND GEOLOGICAL BACKGROUND

Initial production in the Boonsville field began September 12, 1950 with a high gas-oil ratio in the Atokan conglomerates (Lower Pennsylvanian). Later on, significant amounts of gas production were found in the deeper Barnett shale (Mississippian) where more than 1,900 bcf of gas were produced with recent proven reserves of more than 31,000 bcf (EIA, 2012). The Barnett Shale Formation is an organic-rich shale and forms an “unconventional reservoir” being both source and reservoir hosting a large gas accumulation. It is the most active exploration and exploitation play in the basin (Airhart, 2005 and Ball et al., 1996). More recent production has been attempted on the Upper Ordovician formation, represented by Ellenburger dolomite group, which consists in a relatively simple carbonate depositional systems but with an intricate diagenetic overprint that has strong spatial heterogeneity inside the reservoir structures (Loucks, 2008). (Figure 2)

Although important water production is attributed to drilling process on heavily karsted zones, the Permian Basin is an excellent example since there had been reported production from the upper Ellenburger group (Kerans, 1990) (Figure 3). Then, and as Figure 4 shows, drilling operations continued to the lower strata, reaching production anywhere between 0 to 900,000 barrels of oil (Kerans, 1988) These new reservoirs were separated by paleocave fill and tight carbonates that were not laterally continuous, since the lateral extent was controlled by the size of the original cave (Loucks, 1999, 2001). The stacked porous brecciated zones could control vertical continuity, as the result of multiple cave passages forming during base-level drop during a cave system is development (Loucks, 2008). This hypothesizes why porosity associated to these intervals and derived from well logs is frequently low (<5%), but permeability from karst-related fracturing may be in the hundreds of millidarcys (Loucks, 2008).

EXPECTED RESULTS

The Barnett Shale is a low permeable tight gas fractured reservoir, similar to the organic-rich Devonian-Mississippian black Woodford Shale, with natural fractures occurring with strikes about N40oE (Jyosyula, 2003). This fracturing patterns are a key contributing factor to the economic success of the Barnett Shale (Thomas, 2003). New interesting targets zones could arise for exploration by understanding these fracture patterns that could be associated with in situ stresses and with the karst collapses in the underlying Ellenburger Group (Thomas, 2003). These may have created unexplored “sweet spots” for the Barnett Shale production.

I will incorporate the structural interpretation, impedance inversion, porosity and facies cubes of the highly karsted Ellenburger Group and determine how they affect the fracture patters of the overlaying formations (Figures 6 and 7). With brittle/ductile analysis, I will be able to determine fracture-prone areas. I will also use the development information to estimate zones that could have similar water production behavior and trace and quantify new “sweet spots”.

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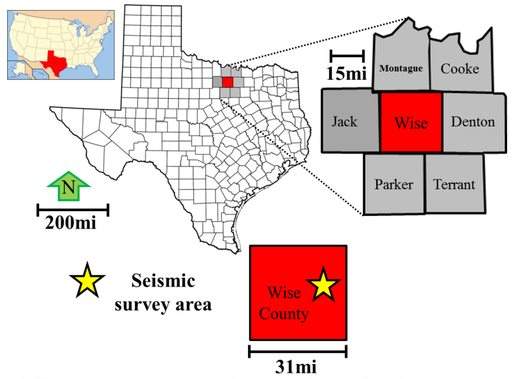


Figure 1. Texas state showing the location of the Wise County, surrounding counties, and the location of the Seismic Survey used in this study.

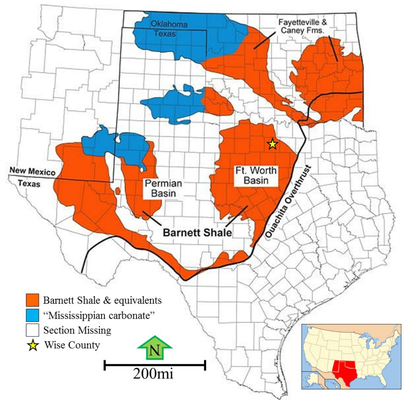
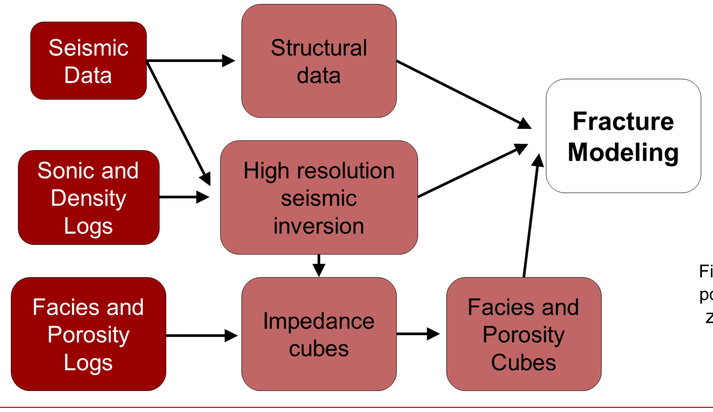


Figure 3. Location of the study area (Star) in the Bend Arch-Fort Worth Basin situated in North-central Texas and surrounded by the Red River/Electra Arch (North), the Muenster Arch (Northeast), the Llano Uplift (South), the Ouachita Overthrust (East), and the Concho Platform (West). (After Airhart, 2005)

Figure 5. Semblance coherence attribute at time slice at 1.2 sec on poststack volume showing the highly karsted dolomitic Ellenburger Group.



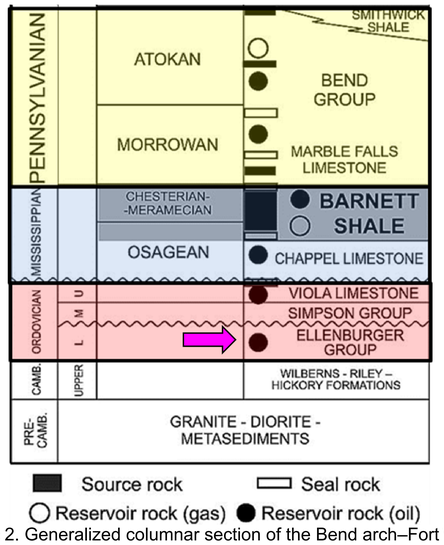


Figure 2. Generalized columnar section of the Bend arch–Fort Worth Basin province showing the principal Groups and Formations with the corresponding petroleum system element (After Pollastro, 2003).

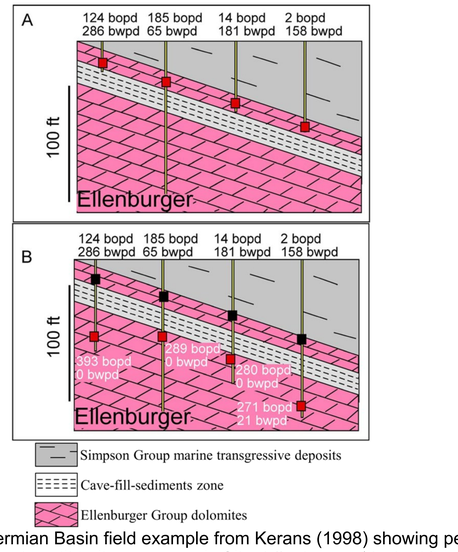


Figure 4. Permian Basin field example from Kerans (1998) showing permeability barrier within the upper part of the Ellenburger (dashed line). (A) Initial completions (before 1977) were above the cave-fill-sediment zone on the upper Ellenburger group strata. (B) The wells were deepened after 1977 and new important hydrocarbon intervals were encountered in the older Ellenburger Group formations. (After Loucks, 2008)

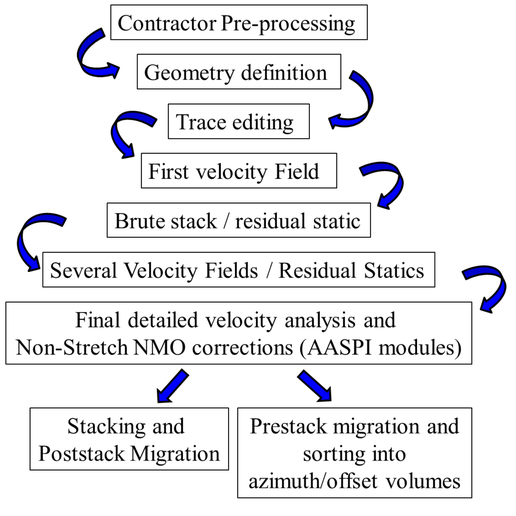


Figure 6 and 7. Proposed seismic data processing workflows and proposed workflow to obtain fracture models related to the brittle/ductile zones that indicate fracture-prone areas (After Ouenes et al., 2008).