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Integrated exploration workflow in the south Middle Magdalena Valley (Colombia)

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ABSTRACT

The HC exploration is presently active in the southern part of the Middle Magdalena Valley but only moderate size discoveries have been made up to date. The majority of these discoveries are at shallow depth in the Tertiary section. The structures located in the Valley are faulted anticlines charged by lateral migration from the Cretaceous source rocks that are assumed to be present and mature eastward below the main thrusts and the Guaduas Syncline. Upper Cretaceous reservoirs have also been positively tested. To reduce the risks linked to the exploration of deeper structures below the western thrusts of the Eastern Cordillera, an integrated study was carried out. It includes the acquisition of new seismic data, the integration of all surface and subsurface data within a 3D-geomodel, a quality control of the structural model by restoration and a modeling of the petroleum system (presence and maturity of the Cretaceous source rocks, potential migration pathways).

The various steps of this workflow will be presented as well as the main conclusions in term of source rock, deformation phases and timing of the thrust emplacement versus oil maturation and migration. Our data suggest (or confirm)

(1) The good potential of the Umir Fm as a source rock.
(2) The early (Paleogene) deformation of the Bituima Trigo fault area.
(3) The maturity gap within the Cretaceous source rock between the hangingwall and footwall of the Bituima fault that proves an initial offset of Cretaceous burial in the range of 4.5 km between the Upper Cretaceous series westward and the Lower Cretaceous ones eastward of this fault zone.
(4) The post Miocene weak reactivation as dextral strike slip of Cretaceous faults such as the San Juan de Rio Seco fault that corresponds to change in the Cretaceous thickness and therefore in the depth of the thrust decollement.

1. Introduction

The Middle Magdalena Valley (MMV) is a semi mature exploration area where various medium-to -small scale discoveries have been made. The petroleum system, which consists on Cretaceous Source Rock (SR) and Cretaceous or Tertiary reservoirs (Ramon and Dzou, 1999), is known to work; however facies changes in the reservoirs and early maturation/migration versus trap development may result in dry structures. A multidisciplinary work was carried out in Cepsa to better understand the Bituima area where HC exploration was active. The area of interest is located in the southern part of the MMV (Fig. 1) affected by major transfer faults such as the Ibague fault that separates the MMV from the Upper Magdalena Valley. The timing of the deformation as well as the decollement levels plays a major role in the petroleum system in the area. They have been quantified thanks to paleothermometers and modeling. In addition new seismic data were acquired and a 3D model has been built. This allows us to upgrade the general structural frame of the area published by previous authors (Sarmiento, 2001; Montes et al., 2003; Cortés, 2004; Cortés et al., 2006).

2. Geological setting

The main geological features of Colombia are related to accretion for the Western Cordillera and Western Segment of the Central Cordillera during the Farallon-Nazca Plate subduction followed by the Andean Tectonic phase. This one results in uplift of the Northern Andes (Colletta et al., 1990). The Paleozoic substratum and the basement general characteristics have no key role for oil explora-

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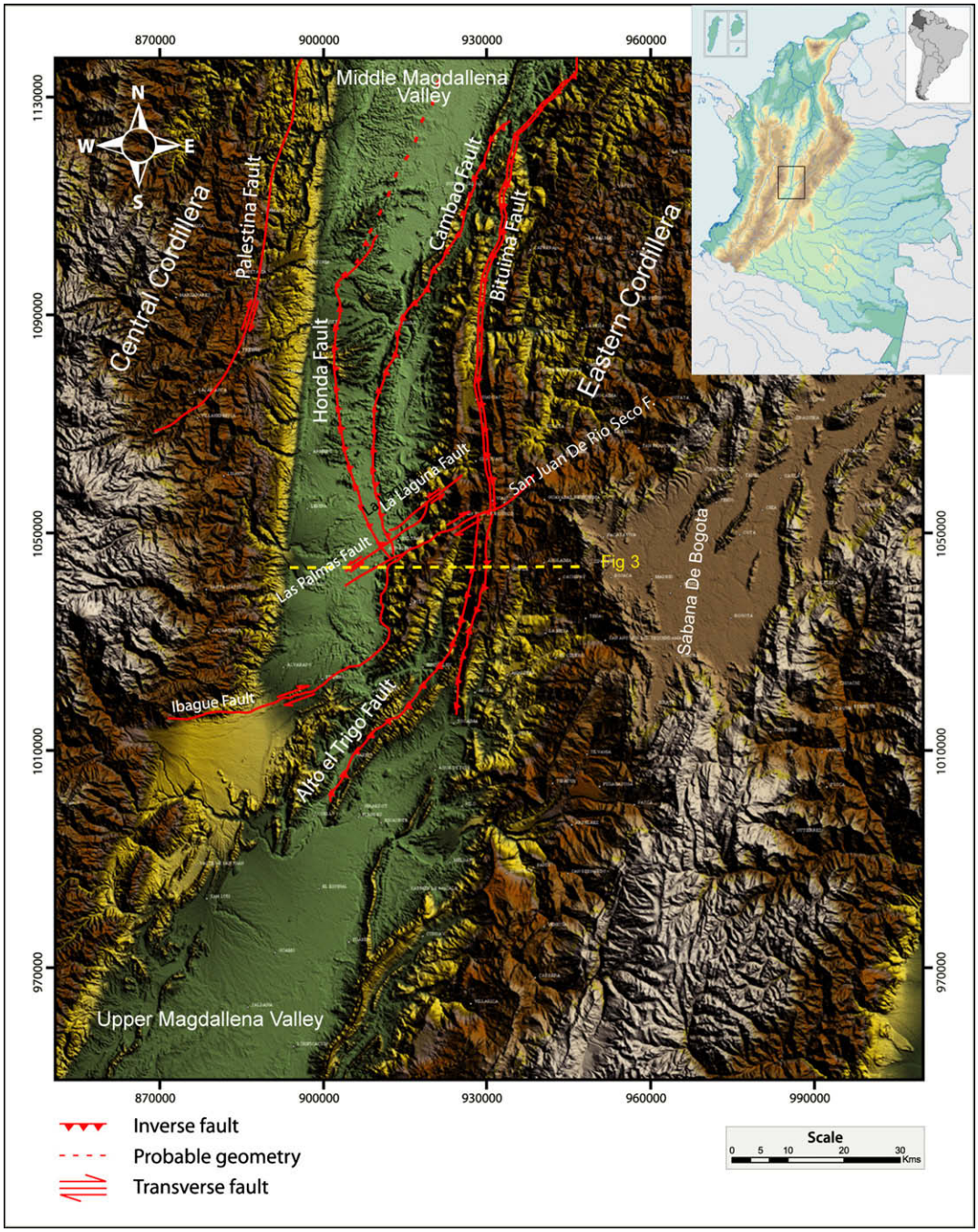

Fig. 1. Geo-morphostructural map showing the Middle and Upper Magdalena Valleys and the major fault on the study area. In background the elevation that ranges from 400 m in the MMV to more than 3500 in the Central Cordillera.

tion in the studied area and will not be described here. Nevertheless, inherited fabrics exist and are reactivated during the recent tectonic phases. During the Early Cretaceous, back arc extension dominated in the area corresponding to the present Eastern Cordillera and resulted in the deposition of a thick Cretaceous sequence. The rift structural inheritage is large and includes thickness variations related to the former tilted blocks and transfer zones between these blocks. All these faults may have been reactivated later (Mora et al., 2008), even if they are not inverted during the compression they likely influence the compressive structure geometry. First accretion started westward at the Aptian (Amaine terrain, now Western Cordillera) whereas subsidence continued eastward (Sarmiento, 2001). Subsequent accretion took place westward at the end of the Maastrichian resulting in the beginning of uplift of the Central Cordillera and the first inversion in the now Magdalena Valley. A compressive regime predominates in the Eastern Cordillera during all the Cenozoic (Casero et al., 1997). After the inversions of the Mesozoic extensional grabens, a more classical thrust regime developed since the Eocene (Bayona et al., 2008). The Eastern Cordillera is a double verging mountain belt: the western flank, in the Magdalena Valley, was initially the more active one but the active compressive front has shifted to the Llanos where the Miocene foreland is nowadays affected by an eastward propagating compression. The Bituima zone study area is located along the S–W border of the Eastern Cordillera; it also corresponds to the western border of the Cretaceous depocenter. The complete stratigraphic column is presented in Fig. 2a but, as sketched below (Fig. 2b), the Cretaceous sequence pinch-out westward.