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Testing the controls on the seismic sequence stratigraphy of the Eocene–Oligocene boundary in Southern Iran with a Wheeler diagram derived from outcrops, seismic and well logs data

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ABSTRACT

In this study of Southern Iran the timing of the boundary between the Eocene to Oligo–Miocene sections was determined along with a better understanding of the accumulation of the Paleocene to Eocene sediments. This was established by generating Wheeler diagrams from local seismic, well log data and surface data. This boundary was found to be mainly erosional and the time gap between Eocene to Oligo–Miocene displayed by the Wheeler diagram suggests a "degradational vacuity" formed. Relative sea level changes were found to be responsible for the seaward progradational character of the Jahrum Formation sediments. Red sediments and an intraformational conglomerate overlie this erosional boundary between the Paleocene to the Eocene Jahrum Formation and the Oligo–Miocene Asmari Formation.

Long-term lower frequency trends in both regional tectonic and global sea-level curves determined from the Paleocene–Eocene sediments of south Iran, when compared to the coastal plain sediments of US New Jersey and the global coastal onlap chart, suggest that contemporaneous eustastic signals in lower Eocene time produced matching sedimentary patterns.

The results of the study recorded in this paper are intended to be used as the foundation of the study of petroleum related facies and petroleum system components (source, reservoir and seal rocks) in the Tertiary portion of sedimentary section.

1. Introduction

The Zagros fold-thrust belt extends for 2000 km from southeastern Turkey through northern Syria and Iraq to western and south Iran, along the northeastern margin of Arabian plate. This belt encompasses the present day foreland basin of the Persian Gulf and accommodates numerous giant and supergiant oil and gas fields. The Oligo–Miocene carbonate Asmari Formation and Middle-Upper Cretaceous Bangestan Group form reservoirs in the Zagros fold-thrust belt includes one of the largest gas fields of the world, the South Pars, located in the Persian Gulf and sequestered in Permian age sediments. The locally entrapped hydrocarbon highlights the interest of many researchers, especially geologists and other petroleum science workers. These giant hydrocarbon reservoirs coupled to very young tectonic events have led to detailed investigations focused on the region (Lees, 1933; Falcon, 1958; Dunnington, 1967; Stocklin, 1968; Bordenave and Burwood, 1990; Alavi, 1994; Blanc et al., 2003; McQuarrie, 2004; Agard et al., 2005; Bordenave and Hegre, 2005; Hessami et al., 2006). The studies recorded in these papers were mostly focused on oil and gas-related topics and tectonic structure.

The thick sedimentary record contains distinct stratal patterns subdivided by major unconformities forming super-sequences or mega-sequences (James and Wynd, 1965; Berberian and King, 1981; Beydoun, 1991; Motiee, 1993; Alavi, 1994; Grabowski and Norton, 1994; Sharland et al., 2001). The mega-sequences and their correlative unconformities extend across the adjacent regions and are interpreted to be the products of epirogenic movement associated to tectonic events. A study in Zagros Mountains by Heydari (2008) recognized 12 supersequences which were given informal names. These supersequences have been attributed to both eustatic control and tectonic events that affected sedimentation during

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the collision of the Arabian plate and the central Iran microplate through uplift, erosion, and the formation of the Zagros foreland basin in the Tertiary (Heydari, 2008).

The area of the study is located close the Iranian shore of Persian Gulf and includes several oil Fields (Fig. 1). This area was the site of a 2D seismic survey made in 2000 and several wells were drilled from 1965 to the present day. Although the 2D seismic lines differ in length and width, collectively 106,000 line kms have been surveyed. The sedimentary section investigated was primarily formed by the Paleocene–Eocene carbonate Jahrum Formation. Most of this formation accumulated over the Fars platform and the adjacent regions covered by the Persian Gulf. The biostratigraphy of the Jahrum Formation was studied (Wynd, 1965). Lithological and microfaunal characteristics of Jahrum Formation have been defined (Mojab, 1982; Kalantari, 1986; Jalali, 1987; Seyrafian and Mojikhalifeh, 2005) and the biofacies and sequence stratigraphy has been investigated (Vaziri-Moghaddam et al., 2002; Taheri et al., 2008).

Despite the above publication, the seismic character of the Paleocene–Eocene sedimentary section or the controls on Eocene–Oligocene boundary has been little studied. The occurrence of high quality 2D seismic data, well log data and surface data have provided a unique opportunity to examine Paleocene–Eocene sediments of Jahrum Formation and especially the Eocene–Oligocene boundary.

The main goal of this study was to analyze the geometric relationships of the Tertiary sedimentary bodies of the region using Wheeler diagrams (Wheeler, 1958, 1964) to map the Eocene–Oligo–Miocene boundary. Initially a sequence stratigraphic framework was built from the Paleocene to Eocene sediments of the Jahrum Formation. This framework established the stratigraphic order of sediment accumulation. Changes in the trends of the facies were interpreted to have accumulated in depositional settings that ranged from shallow coastal regions to deeper basinal settings. Wheeler diagrams were then tied to this sequence stratigraphic framework and were used to trace relative sea level changes and make studies of the sequence boundaries and unconformities.

Finally to determine if the sedimentary trends of coastal Iran were products of relative or eustatic sea level change and whether the Eocene–Oligocene boundary was local or extended worldwide, the size and timing of relative sea level changes were first established for the study area using Wheeler diagrams and these were then compared to the stratigraphic architecture of the New Jersey coastal plain of the eastern USA and the associated global coastal onlap chart (Hardenbol et al., 1998). The results of this study provide a better understanding of how eustasy and tectonics have affected the sedimentary history of Zagros basin lining the present Iranian coast.

2. Geological setting

The area of study is located close and parallel to the Iranian shore of the Persian Gulf and includes several oil fields (Fig. 1). The Cenozoic history of the Persian Gulf region commenced with a major regression at the end of Maastrichtian. Most of the Persian Gulf including the Arabian Peninsula was then emergent and this surface formed a stratigraphic boundary that extends beneath the overlying Danian section. The exceptions to this were the basinal areas of the Pabdeh basin, also known as the Ras al Khaimah sub-basin, and northern part of the Persian Gulf, or Zagros basin of southwestern Iran (Ghazban, 2007). These two principal troughs, the Zagros and the Pabdeh, represent continuations of the older Cretaceous troughs and were separated by the shallow water Fars Platform (Alsharhan and Nairn, 1977). The Paleogene Pabdeh Formation sediments accumulated in these troughs. Early in the Paleogene, a transgression extended over the northern Arabian Shelf Zagros Trough (Buday, 1980) and the coastal Fars Province of Iran. Early during the course of the Paleocene, a major transgression reestablished widespread marine conditions covering eastern Arabia, the entire northern part of the Arabian shelf, and out over the Taurus–Zagros Trough (Buday, 1980). During

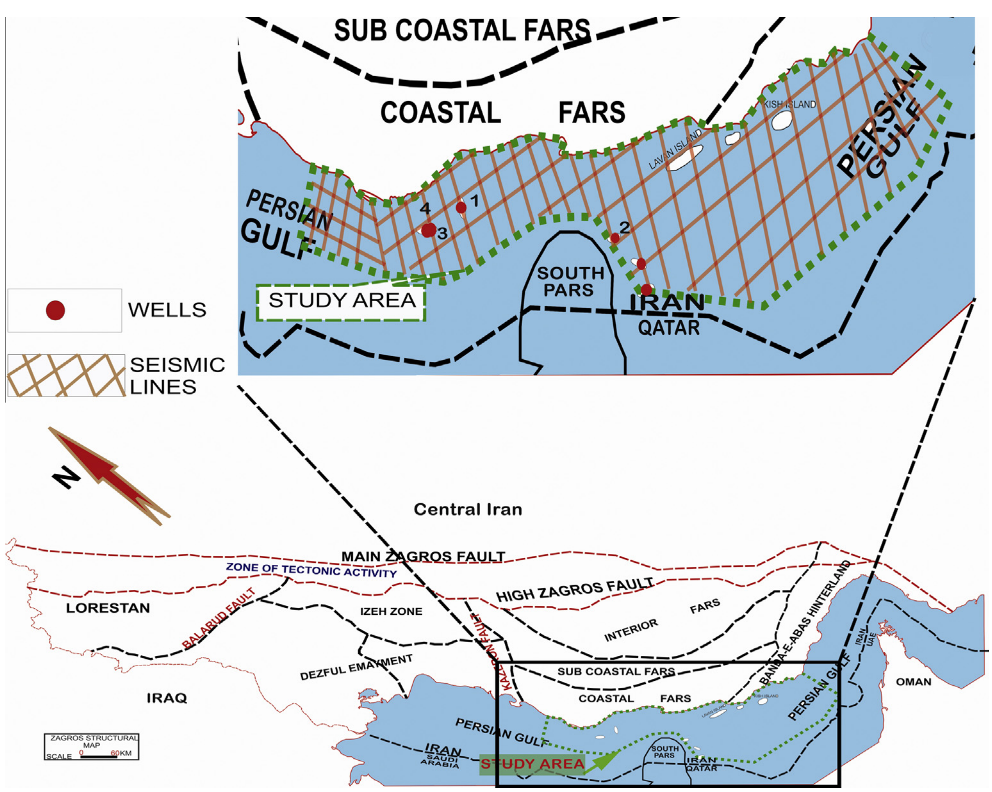

Fig. 1. Location of study area in Persian Gulf.