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Sefidrud delta and Quaternary evolution of the southern Caspian lowland, Iran

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ABSTRACT

The southern Caspian Sea lowland in Iran forms a thick sedimentary prism produced by interactions of marine, deltaic, and fluvial processes during the Late Neogene and Quaternary. Deltaic and fluvial deposits have been developed mainly by the Sefidrud, which is the largest river of the country. Its drainage area (ca. 61,600 km^2) includes nearly the entire Alborz mountain range and forms deep valleys, gorges, and a large delta at the southern coast of the Caspian Sea. The Sefidrud delta is so large that it covers one third of the large Guilan–Mazanderan plain, both from an aerial and volumetric point of view. Consequently, the drainage network of the Sefidrud represents the Quaternary evolution of northern Iran and can be used to test the hypothesized evolution of the region. The Sefidrud delta has been investigated using many short and long cores, satellite images, and lithofacies maps, and the results show that this delta complex (1680 km^3) consists of a covered lower part and exposed upper deltaic sequences. The lower and upper parts of the complex were formed during the Early Pleistocene and Late Pleistocene, respectively. The upper exposed alluvial and deltaic sediments represent a total progradation of approximately 50 km forming three separate delta subsequences (D1-3) of which the last one (D3) is the modern Sefidrud delta. The modern delta is a wave-dominated, blanket-like sediment cover (ca. 30 m thick and 1550 km^2) produced during the last three millennia. It was formed by 30 km progradation of six juxtaposed lobes; each lobe corresponds to a long-term sea-level fluctuation of the Caspian Sea. The active lobe (ca. 50 km^2) has been forming since 1550 AD. Late Pleistocene deltaic sequences (D1-3), particularly the modern one (D3), were produced by relatively fast deposition due to high volume sediment load of the Sefidrud. It is suggested that they were produced after the opening of the Rudbar gorge by river capture that in turn six times enlarged the drainage area. Previous deltaic progradation and marine transgressions were relatively slow and the development of the whole lowland at the southern Caspian Sea lasted ca. 1–1.2 Ma BP.

1. Introduction

The Caspian Sea is one of the most studied sedimentary basins of the world because of hydrocarbon reservoirs and offers excellent examples of the influences of water-level changes on both environments and deposition (Kosarev and Yablonskaya, 1994; Mansimov and Aliyev, 1994; Kaplin and Selivanov, 1995; Seddletskii and Baikov, 1997; Arpe et al., 2012). Recently its water level has risen up by > 2 m in between 1977 and 1995, resulting in inundation of large populated areas around the sea, despite its decreasing levels between 1925 and 1976 (CEP, 1998; Kroonenberg et al., 2000; Schrader, 2001). Transgressions and regressions were significant, particularly within the last 30 ka (Leroy et al., 2007; Svitoch, 2009). Except for time-interpretations, all previous studies agree that Caspian Sea was subject to the periodic raising and falling of water levels (Mamedov, 1997; Rychagov, 1997; Kroonenberg et al., 2000; Chepalyga, 2002, 2007; Svitoch, 2009). In addition, some authors argue that water-level oscillations were characteristic of the Caspian Sea not only in Late Pleistocene, but also during the whole of the Pleistocene and even back to Messinian times (Svitoch et al., 2000; Krijgsman et al., 2010; Kakroodi et al., 2012). The Caspian Sea was connected to the Black Sea and the Mediterranean Sea with moderate sea-level rise (Kosarev and Yablonskaya, 1994; Svitoch et al., 2000; Cordova et al., 2009; Dolukhanov et al., 2010). However, there is no agreement on number and times of transgressions and regressions due to the absence of a full and accessible sedimentary record (Badyukova, 2007; Kakroodi et al., 2012). In addition, theoretical models do not support the idea that water level oscillations in

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the Black and Caspian seas have always taken place in parallel (Thom, 2010). On the other hand, recent studies indicate that Late Pleistocene transgressions were recorded within marine sedimentary sequences in the Iranian Caspian region (Kazancı et al., 2004; Kalani et al., 2008). A series of transgressions and regressions formed large coastal lowland called the Guilan–Mazanderan plain that recorded significant Quaternary sea-level oscillations. It also contains the large Sefidrud* and its delta (*Sefidrud is a unified name. Rud means "river") (Fig. 1). The Sefidrud delta (delta complex) found in the middle of these lowlands seems to have resisted marine transgressions (Figs. 2, 3). Moreover, the subaerial and submarine morphology of the delta prism reaching from 50 m asl to −700 m water depth inspires a long duration delta development on the southern Caspian Sea based on bathymetry (Fig. 1). A recent submarine seismic survey supports this idea (Fig. 5). As result, it is possible to say that this delta complex represents the Quaternary evolution of the southern Caspian Sea included marine incursions and catchment development. The aim of this study is to describe the Sefidrud delta complex in detail in order to present the above-mentioned development. In addition, this delta complex could serve as a possible analogue for hydrocarbons reservoirs of Pliocene in the mid and northern Caspian basin.

The Sefidrud is one of the three largest rivers that carry a high volume of water and sediments into the Caspian Sea (others are Volga and Kura; for details see Kroonenberg et al., 1997, 2004; Hoogendorn et al., 2005; Krasnozhon and Kovalev, 2005; Lahijani et al., 2008). It starts in the Zagros Mountains and passes through the Alborz mountains in deep gorges and transports sediments of central Iran to the Caspian Sea (Fig. 2); however, there seems to be an imbalance between sediment discharge and deltaic progradation for the Sefidrud. Few references provide information about the delta, but those that do have focused primarily on its recent development (Kousari, 1986, 1992; Krasnozhon et al., 1999; Khoshraftar, 2005). Lack of data about initiation (=age) of the delta and particularly the timing and mechanism of gorge development, prevents the description of a realistic paleogeography for the southern Caspian region. The second purpose of this study is to present the Quaternary evolution of the coastal lowland, including the Sefidrud delta, and to describe its paleogeography (Fig. 1). To achieve this goal, a large area was re-mapped and 48 cores from the delta plain were re-interpreted (Figs. 4, 6, 7).

As a last note, the name of the Caspian Sea was derived from Casps, an ancient human society that lived in Transcaucasia. It is the Hyrcanian Ocean and Khvalyn Sea in ancient Persian and Russian cultures respectively. The Mazanderan Sea is the present name within people of Iran; however Turkish societies called it the Hazar Sea due to the Hazara civilization in the north (Grand Larousse, 1969).

2. Geologic and geographic setting

The geology of the study area is not only interesting but also very complicated, as it contains many rock sequences of Palaeo-, Neo- (Alborz belt), and Para-tethys (Caspian Sea successions) in addition to being actively seismic (Berberian and King, 1981; Berberian and Walker, 2010; Djamour et al., 2010). Except for the Quaternary, a full geologic history of the region is beyond scope of this study and instead a brief summary is given below.

2.1. Geological background

The Iranian Caspian coast is bordered by the Talesh Mountains and/or the Alborz belt which is composed of metamorphic,

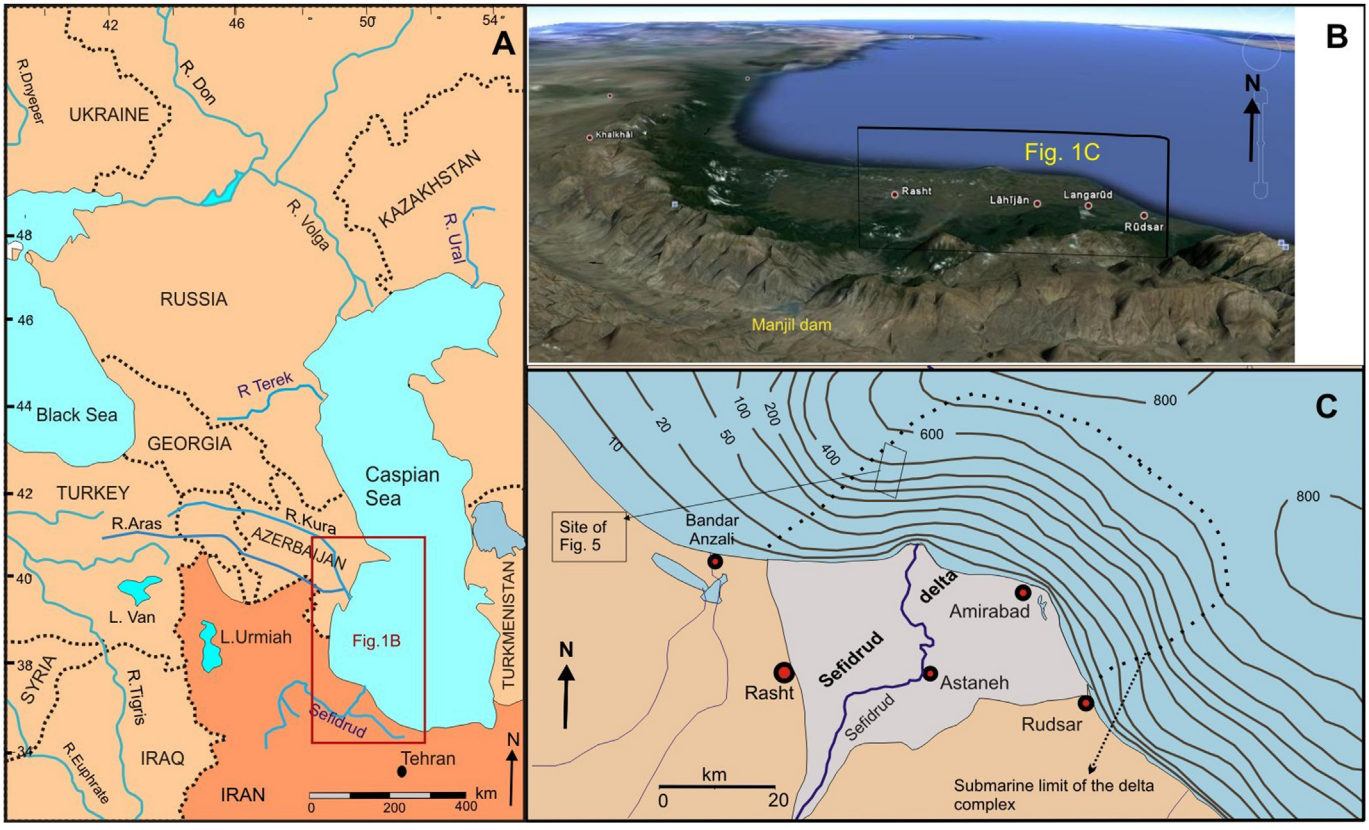

Figure 1. Study area in SW Asia. A: Southern Caspian Sea and site of the Sefidrud delta; B: 3D morphology of the Guilan – Mazanderan plain by Google Earth; C: Bathymetry of the southern Caspian coastal zone included the Sefidrud delta (from Kosarev and Yablonskaya, 1994).