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Research paper

Sedimentology and depositional architecture of a submarine delta-fan complex in the Durban Basin, South Africa

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A B S T R A C T

The seismic stratigraphy, evolution and depositional framework of a sheared-passive margin, the Durban Basin, of South East Africa are described. Based on single-channel 2D seismic reflection data, six seismic units (A-F) are revealed, separated by major sequence boundaries. These are compared to well logs associated with the seismic data set. Internal seismic reflector geometries and sedimentology suggest a range of depositional regimes from syn-rift to upper slope and outer shelf. Nearshore and continental facies are not preserved, with episodic shelf and slope sedimentation related to periods of tectonic-induced base level fall. The sedimentary architecture shows a change from a structurally defined shelf (shearing phase), to shallow ramp and then terminal passive margin sedimentary shelf settings. Sedimentation occurred predominantly during normal regressive conditions with the basin dominated by the progradation of a constructional submarine delta (Tugela Cone) during sea-level lowstands (LST). The earlier phases of sedimentation are tectonic-controlled, however later stages appear to be linked to global eustatic changes.

1. Introduction

Globally, passive continental margins are defined by broad (~50 km - Shepard, 1963; ~80 km - Helland-Hansen et al., 2012) gently sloping (0.05°; Kennett, 1982) shallow water regions comprising thick sedimentary successions derived from onshore erosion. These have been the object of intense sequence stratigraphic analyses, namely due to their potential hydrocarbon reserves. The sequence stratigraphic analyses of sheared, or structurally controlled passive margins are less conspicuous in the literature (cf. de Lépinay et al., 2016). As de Lépinay et al. (2016) point out, a number of questions arise regarding their evolution in the context of gradient and geodynamic and/or sedimentary setting. It is in this context that the Durban Basin, a portion of the sheared-passive KwaZulu-Natal margin of SE Africa is investigated.

The eastern continental margin of South Africa is unique. It has been subject to prolonged periods of sediment starvation, coupled with tectonic-induced periods of abundant sediment supply (Green, 2011a). It is also dominated by an extremely narrow (~2–12 km) shelf (Martin, 1984; Martin and Flemming, 1986; Green and Garlick, 2011; Cawthra et al., 2012), considered a morphologically inherited feature of the initial shearing phase during margin development (Martin, 1984). In this study, we examine the Durban Basin of the SE African margin, a north-south trending, sediment-filled, sheared-rift basin (Dingle et al., 1978). The basin itself is conspicuous by the development of the Tugela Cone, an anomalous deep-water fan complex of late Cretaceous to Tertiary-age (McMillian, 2003), that occurs beneath and seaward of the present shelf break.

This paper aims to assess the sedimentology and sequence stratigraphic history of the Durban Basin, highlighting controls on sedimentation as the margin evolved from a sheared-rift to drift sequence. We propose a model for the basin, and compare and contrast to the current models for structurally controlled (Martins-Neto and Catuneanu, 2010; Helland-Hansen et al., 2012) and passive margin (Catuneanu et al., 2011) basins.

2. Regional setting

2.1. Geology

The Mesozoic evolution of the Durban Basin is poorly

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documented (Du Toit and Leith, 1974; McMillian, 2003); with work focussed on either low resolution single-channel seismic reflection data (Dingle et al., 1978; Martin, 1984; Goodlad, 1986), or seafloor sediment dynamics, submarine canyon formation and Holocene geology (Green and Garlick, 2011; Cawthra et al., 2012; Green et al., 2013; Wiles et al., 2013). The basin is structurally complex with basement comprising rifted Carboniferous-Jurassic sedimentary and volcanic lithologies of the Karoo Supergroup (Johnson et al., 2006). The basin owes its existence to continental rifting during early Gondwana break-up ~183-159 Ma (Leinweber and Jokat, 2011), bounded to the north by the Naude Ridge, the east by the Mozambique Ridge, and to the south by the Southern Natal Valley (Fig. 1) (Martin et al., 1981; Goodlad et al., 1982). The southern boundary coincides with a major east-west trending fault system that forms the limit of the Agulhas-Falkland Fracture Zone (AFFZ) (Broad et al., 2006). The final stages of rifting in the basin occurred between 115 and 90 Ma Watkeys and Sokoutis (1998), with passive margin conditions prevailing since ~90Ma (Ben Avraham et al., 1993; Watkeys, 2006).

Kimmeridgian to Cenozoic age sediments (Broad et al., 2006) comprise the basin-fill with the main focus of sedimentation occurring within the Tugela Cone (Fig. 1). Based on regional unconformities identified from the biostratigraphy of the Jc-series boreholes and 2D seismic reflection data, Dingle et al. (1978) and McMillian (2003) subdivided the units into syn-rift and drift sequences broadly correlated with the coeval Zululand Group in the onshore Zululand Basin to the north of the study area (Fig. 1) (Broad et al., 2006). Since the late Cretaceous, deposition along the continental shelf is marked by several hiatuses which have resulted in incomplete preservation of the drift stratigraphy (Green, 2011a).

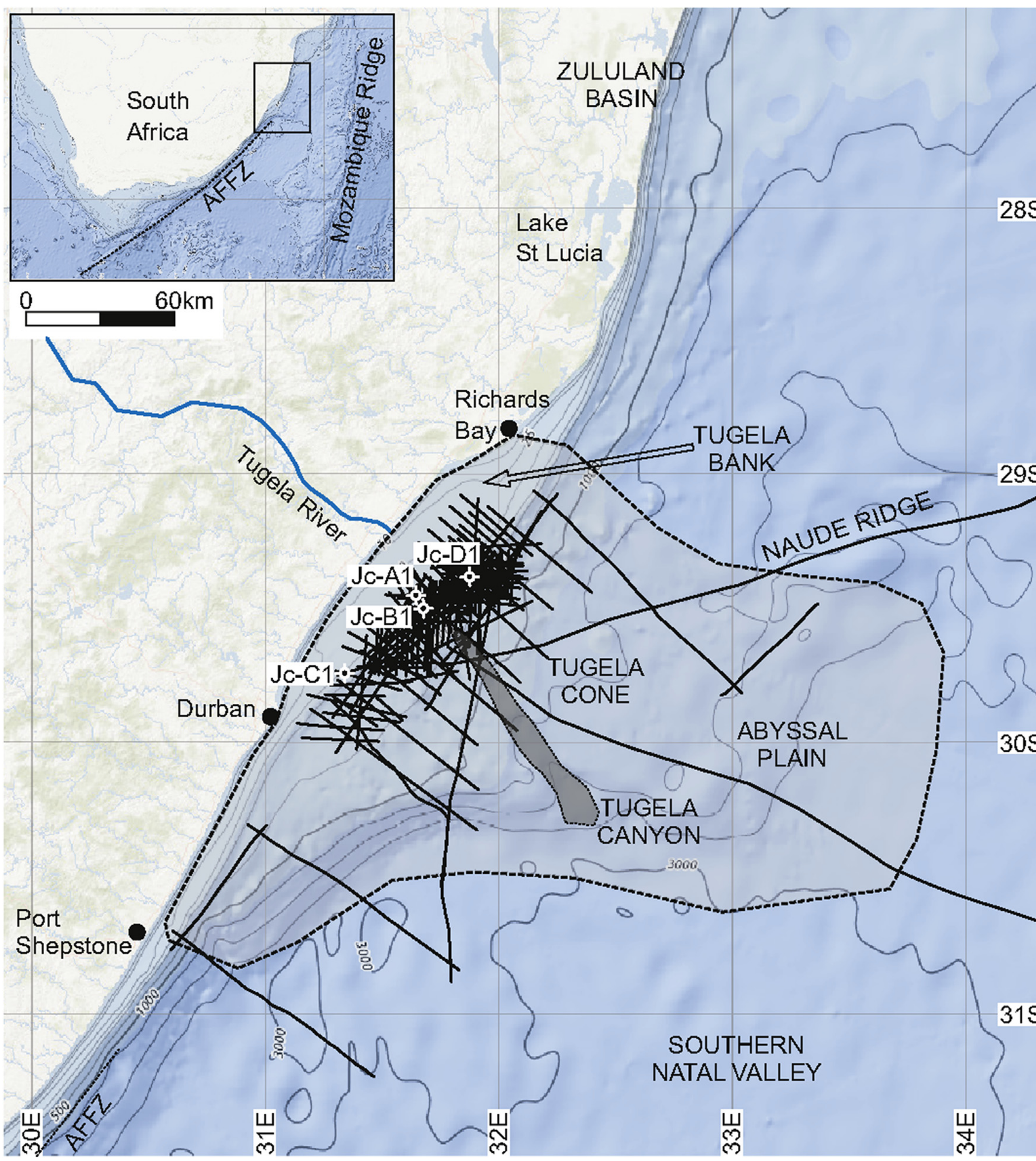

Fig. 1. Locality map detailing study area location with National Oceanic and Atmospheric Administration (1 min grid) UTM showing study area and Indian Ocean bathymetry. The areal extent of the Durban Basin is shown within the shaded polygon. Note the relative position of the Jc-series boreholes drilled on the continental shelf to that of the deep water Tugela Cone and the Abyssal Plain.