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Marine flooding surfaces recorded in Permian black shales and coal deposits of the Main Karoo Basin (South Africa): Implications for basin dynamics and cross-basin correlation

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ABSTRACT

The marine origin of black shales in the context of the Permian postglacial development of the Karoo Basin, South Africa, is subject of an ongoing controversial discussion. Here, we present and discuss palynological and sedimentological data providing evidence of a transgressive event during the early Guadalupian. Palynofacies assemblages of the black shales of the southern basin include marine phytoplankton that exhibit peak abundance within the Whitehill shales and which also occur within siltstones and glauconitic sandstones on top of the No. 5 coal seam of the north-eastern basin. Palynostratigraphic control makes this marine signal a powerful tool for cross-basin correlation. Moreover, palynofacies analysis demonstrates a facies transition from terrestrial lacustrine and fluvio-deltaic in the northeast to deep marine in the south-western parts of the basin.

1. Introduction

Previous works on Permian Karoo black shales provide sedimentological and palaeontological evidence for their marine origin (e.g., Haughton et al., 1953; Du Toit, 1954; Rilett, 1963; Hart, 1964, 1969, 1970; Ryan, 1968; McLachlan and Anderson, 1973; Teichert and Rilett, 1974; Stanistreet et al., 1980; Oelofsen, 1987; Visser, 1987, 1989, 1992, 1993, 1994; Visser and Young, 1990; Smith et al., 1993; Johnson et al., 1997, 2006; Scheffler et al., 2006; Buatois et al., 2010; Götz, 2015). Despite this, there is ongoing controversy and discussion concerning the marine or lacustrine origin in the context of the postglacial development of the Karoo Basin (e.g., Cole and McLachlan, 1991; Faure and Cole, 1999; Herbert and Compton, 2007; Chukwuma and Bordy, 2016; Schulz et al., 2016). This discussion includes the palaeoecology of the famous Permian mesosaurs (Oelofsen, 1981; Oelofsen and Araújo, 1983), interpretations ranging from freshwater, brackish, coastal, lagoonal, hypersaline to normal marine (see Modesto, 2006; Piñeiro et al., 2012; Silva et al., 2017 and references therein). Marine condensed sections have been described from black shales of the Prince Albert and Whitehill formations and interpreted to represent postglacial highstand phases corresponding to coal-forming delta deposits of the north-eastern coalfields (Visser, 1992, 1993, 1995). More recently, a cross-basin correlation of the marine Prince Albert and Whitehill shales and fluvio-lacustrine coal deposits using palynological data was presented by Ruckwied et al. (2014). Glauconitic sandstones, indicative of marine transgressions, are documented from coalfields in the north-eastern part of the basin on top of distinct coal seams (Van Vuuren, 1981, 1983; Cadle, 1982; Cairncross, 1986; Cadle et al., 1993), the most prominent being at the top of the No. 5 coal seam in the Witbank and Highveld coalfields (Hancox and Götz, 2014). From this background and in view of the recent interest in Karoo shales as unconventional gas resource (Decker and Marot, 2012; Mowzer and Adams, 2015), new data from recently drilled deep boreholes in the southern Karoo, as well as published borehole and outcrop data from Karoo black shales and coal deposits are discussed to pinpoint marine transgressions and flooding surfaces on a basin scale. Ultimately, the complexity of basin dynamics within a postglacial setting and related implications for cross-basin correlations are highlighted.

2. Geological setting

The Main Karoo Basin (Fig. 1) comprises a continuous sedimentary succession from the Pennsylvanian to Middle Jurassic known as the Karoo Supergroup (Johnson et al., 2006). It documents the postglacial climate history of central Gondwana marking the transition from the late Palaeozoic Icehouse to the Triassic Hothouse extremes (Montañez

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