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Effects of igneous intrusions on thermal maturity of carbonaceous fluvial sediments: A case study of the Early Cretaceous Strzelecki Group in west Gippsland, Victoria, Australia

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ABSTRACT

This study has investigated the effect of small igneous intrusions on Early Cretaceous carbonaceous fluvial sediments of the Gippsland Basin of south-eastern Australia, based on outcrops in the onshore western part of the basin. Vitrinite reflectance measurements, quantitative mineral phases and clay mineralogy were carried out on twenty two samples of organic-rich mudstone up to 25 m east and west of a 1 m wide dyke. Samples of the dyke allowed classification as an alkali-basalt, based on its optical characteristics, and major- and trace-element properties.

Background vitrinite reflectance of 0.75%–0.80% [R_{max}] in the sediments is elevated up to 6.67% [R_{max}] close to the dyke margin, with slightly different patterns on each side of the intrusion. Analysis of seven selected organic-rich mudstone samples shows that they all have very similar XRD patterns, with the main minerals in all cases being quartz, feldspar (mainly plagioclase), chlorite, illite and interstratified illite/smectite. These observations suggest that the thermal maturity of the organic matter in the sediments was locally elevated by heating due to emplacement of the dyke, but no significant changes were observed in host-rock mineralogy that could be related to the heat generated by the dyke and the associated vitrinite reflectance variations.

1. Introduction

Several authors have shown that igneous intrusions may affect the thermal maturity of the organic matter in the surrounding sedimentary rocks (Cooper et al., 2007; Galushkin, 1997; Golab et al., 2007; Gurba and Weber, 2001; Finkelman et al., 1998; Jiang et al., 2011; Karayigit and Whateley, 1997; Singh et al., 2008; Yao et al., 2011). They may also change the physical and chemical structures of the host rocks (Crelling and Dutcher, 1968; Dai et al., 2012; Jiang et al., 2011; Rimmer et al., 2009; Singh et al., 2007; Singh et al., 2008; Singh et al., 2013; Yao and Liu, 2012). Igneous intrusions can also impact on hydrocarbon potential in sedimentary basins (for example: Gurba and Weber, 2001; Saghafi et al., 2008; Yao et al., 2011). Deposition of epigenetic minerals, such as pyrite and carbonates, may also occur as a result of hydrothermal fluid circulation sourced from igneous activity (Cressey and Cressey, 1988; Dai and Ren, 2007; Goodarzi and Cameron, 1990; Querol et al., 1997; Yao et al., 2011; Yao and Liu, 2012).

The width of the area affected by such bodies is typically one or two times the thickness of the intrusion (Dow, 1977; Galushkin, 1997). Some studies, however, have shown that this may vary, due to factors such as thermal conductivity, volume of pore water and maturation of the organic matter (Barker et al., 1998; Raymond and Murchison, 1988; Suchy et al., 2004).

The Gippsland Basin (Fig. 1) is one of the most prolific hydrocarbon provinces in Australia, with production mainly derived from Late Cretaceous to Eocene sedimentary sequences in the offshore area. Mid-Cretaceous uplift and erosion of the Early Cretaceous Strzelecki Group, in the lower part of the basin fill (Fig. 1), was accompanied by extensive igneous activity with the intrusion of plugs and dykes, many of which crop out in the on-shore part of the basin in the west Gippsland region (Barker et al., 1998).

Holdgate and McNicol (1992) provided a comprehensive review of the hydrocarbon prospects of the onshore Strzelecki Group. According to Harrison et al. (2012), overbank and lacustrine shales within the Strzelecki Group sequence may have potential for shale gas. However, the extent of the thermal aureoles produced by igneous activity, and its impact on host-rocks diagenesis and hydrocarbon generation potential in the basin are not well known. Barker et al. (1998) reported elevated levels of organic matter around basalt dykes intruding the Strzelecki Group sediments near San Remo and Inverloch (respectively, about 20 km NW and NE of the present study area). They indicate that about 100 dykes have been recorded, and further suggest that the dykes were intruded in the early-to mid-Cretaceous, after Strzelecki Group deposition and before the cooling of the western Gippsland Basin commenced in the Late Cretaceous.

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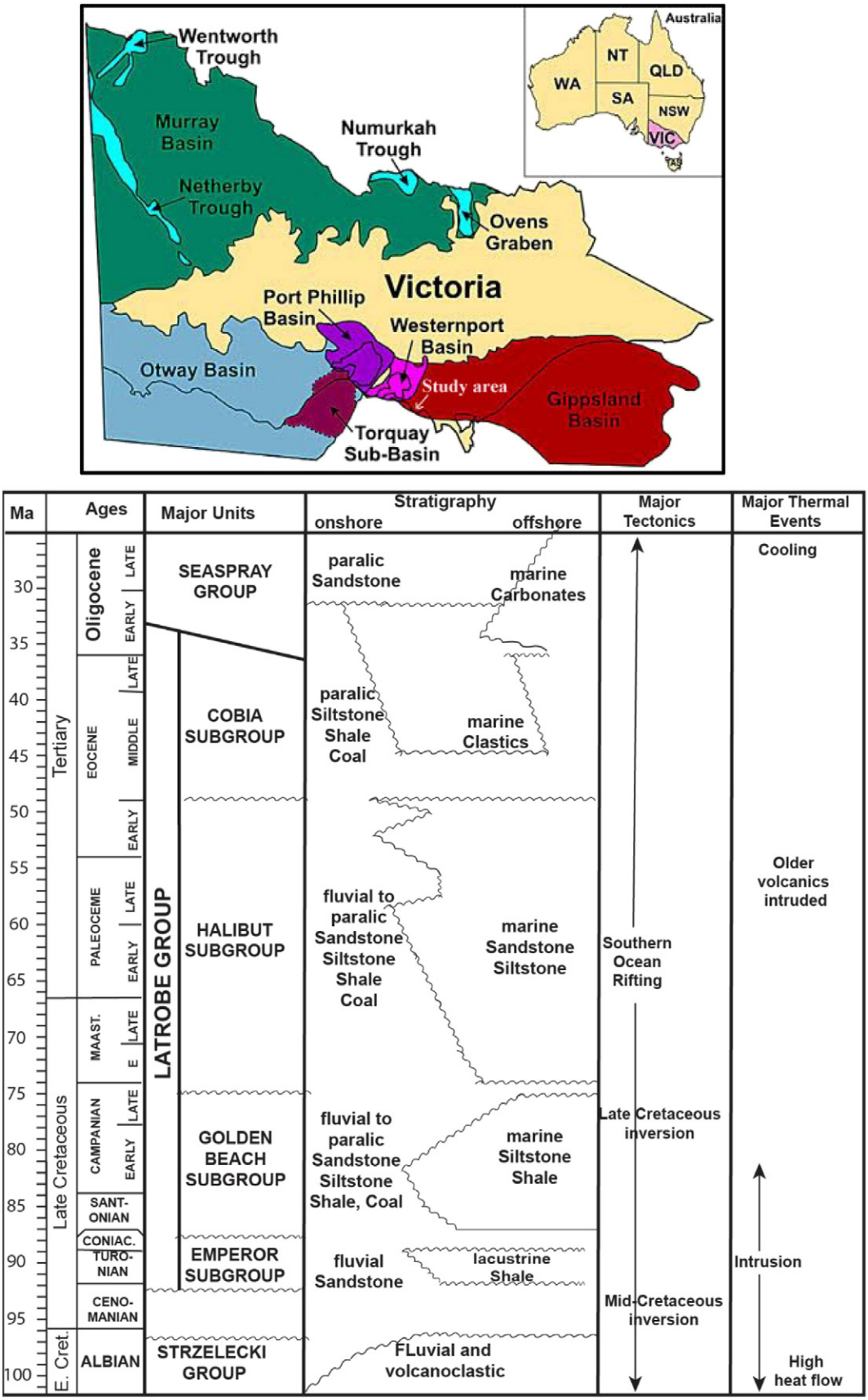

Fig. 1. Location of the study area in the western Gippsland Basin, Victoria, Australia, and simplified stratigraphic column of the Gippsland Basin (modified from Duddy and Green (1992); Barker et al. (1998), and Bernecker and Partridge (2001)).