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Petrologic and stable isotopic study of the Walloon Coal Measures, Surat Basin, Queensland: peat accumulation under changing climate and base level

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ABSTRACT

The Late Jurassic Walloon Subgroup (recently dated as Oxfordian) is a productive, subbituminous coal seam gas source in the Surat Basin and can be subdivided from bottom to top into the Taroom Coal Measures, the Tangalooma Sandstone, the Lower and Upper Juandah Coal Measures, which have different coal character. The lower Taroom coals are commonly thick, associated with sandstones and interpreted to form as base level is rising, creating sodden anoxic conditions for peat accumulation. The middle Tangalooma to Lower Juandah contains fewer and thinner coals, and transitions upwards from a sandstone to siltstone dominated sequence responding to inundation with the development of floodplain lakes. The strata then coarsen upward in both grain size and coal thickness in the Upper Juandah Coal Measures, which may be eroded by an overlying unit, the Springbok Sandstone. This unconformable surface is basin wide and depending on age, can be tied into global changes in climate and base level.

Existing models for peat growth under changing base level and the variability in terms of the conditions of peat formation through time, as well as throughout the basin, are tested. Environment of peat deposition and changes therein, are investigated by petrographic analysis of the Walloon coals, coupled with high resolution lithotype logging of core and organic stable carbon isotope analysis.

Fine microlayering and abundance of root suberinite, telo- and detrovitrinite indicate precursory peat formation in a mostly herbaceous marsh to fen environment, in which bigger trees are either infrequent or absent, except for the lower seams of the Taroom Coal Measures and the upper seams of the Lower Juandah Coal Measures, where bright bands are thicker (≥10 mm) and more frequent. No extended periods of dehydration-oxidation (<1 vol.% mmf inertinite group macerals) are indicated until the deposition of the Upper Juandah Coal Measures that contain greater amounts (5 to 15 vol.% mmf with rare 68 vol.%) of inertinite group macerals. Suberinite is interpreted to reflect dense root mats that are resistant to decay by microbial activity. They leave behind their suberinised exoderms, which originally helped wetland plants to protect themselves from deleterious solutes or in case of a change to drier conditions provided protection from desiccation. The most common inertinite maceral found in the Upper Juandah Coal Measures is inertodetrinite, associated with detrovitrinite. After bush or swamp fires, pieces of charcoal on dried out peat surfaces are easily blown away by the wind and accumulate with sediment in standing water. Fusinites and semifusinites are mainly associated with telovitrinites and are likely to be the result of desiccation and (fungal) mouldering in addition to fire.

Stable carbon isotopes of coal show a distinct positive shift in the Lower Juandah Coal Measures that sets in well before the increased inertinite content in the Upper Juandah Coal Measures. The enrichment in ^{13}C could be linked to a change in climate during the high stand depositional cycle, marking the onset of late stage falling, where base level begins to drop, later creating exposures and water stress. A shift to a less humid climate in the Upper Juandah Coal Measures could have favoured the conditions for desiccation, mouldering and bush fires, which is reflected in the coal's maceral composition. The Surat Basin $\delta^{13}C$ isotope trend follows the global trend found in marine carbonate samples from the same age interval that corroborates increasing enrichment towards the top of the coal measures (approximately middle Oxfordian), followed by a shift to more negative compositions, which corresponds to the onset of the Springbok Sandstone deposition on an unconformable surface.

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1. Introduction

Over the last decade, interest of energy companies in the Surat Basin's Walloon Subgroup as a coal seam gas source has grown significantly. While the eastern limb of this basin is well studied, there is a gap regarding the characterization of the coals in the western part of the basin and their environment of formation. Furthermore, coal stable carbon isotope analysis in order to reconstruct the conditions of peat accumulation has never been conducted on these Jurassic coals. This study investigates the stratigraphic and lateral variability in the maceral composition of the Jurassic Walloon Coal Measures, and uses organic stable carbon isotopes and fine scale lithotype logging to test existing models of peat accumulation under changing climate and base level. The Walloon coals are vitrinite-rich (62 to 91 vol.% mmf), with abundant liptinite and commonly high mineral matter content (Scott et al., 2007). On a maceral subgroup level, telovitrinite is the most common constituent. Among the liptinite group macerals, suberinite, as well as cutinite is common in these coals. While some authors consider the Walloon coals to have formed in herbaceous and forest swamp environments without any periods of severe dehydration-oxidation (Khavari-Khorasani, 1987; Salehy, 1986), there is evidence that the upper coal measures were subjected to desiccation and fires, indicated by a jump to higher inertinite content within the uppermost coals (Leblang et al., 1981; Scott et al., 2007). If this is caused by changing climatic conditions, the stable carbon isotope compositions of the coals should record this.

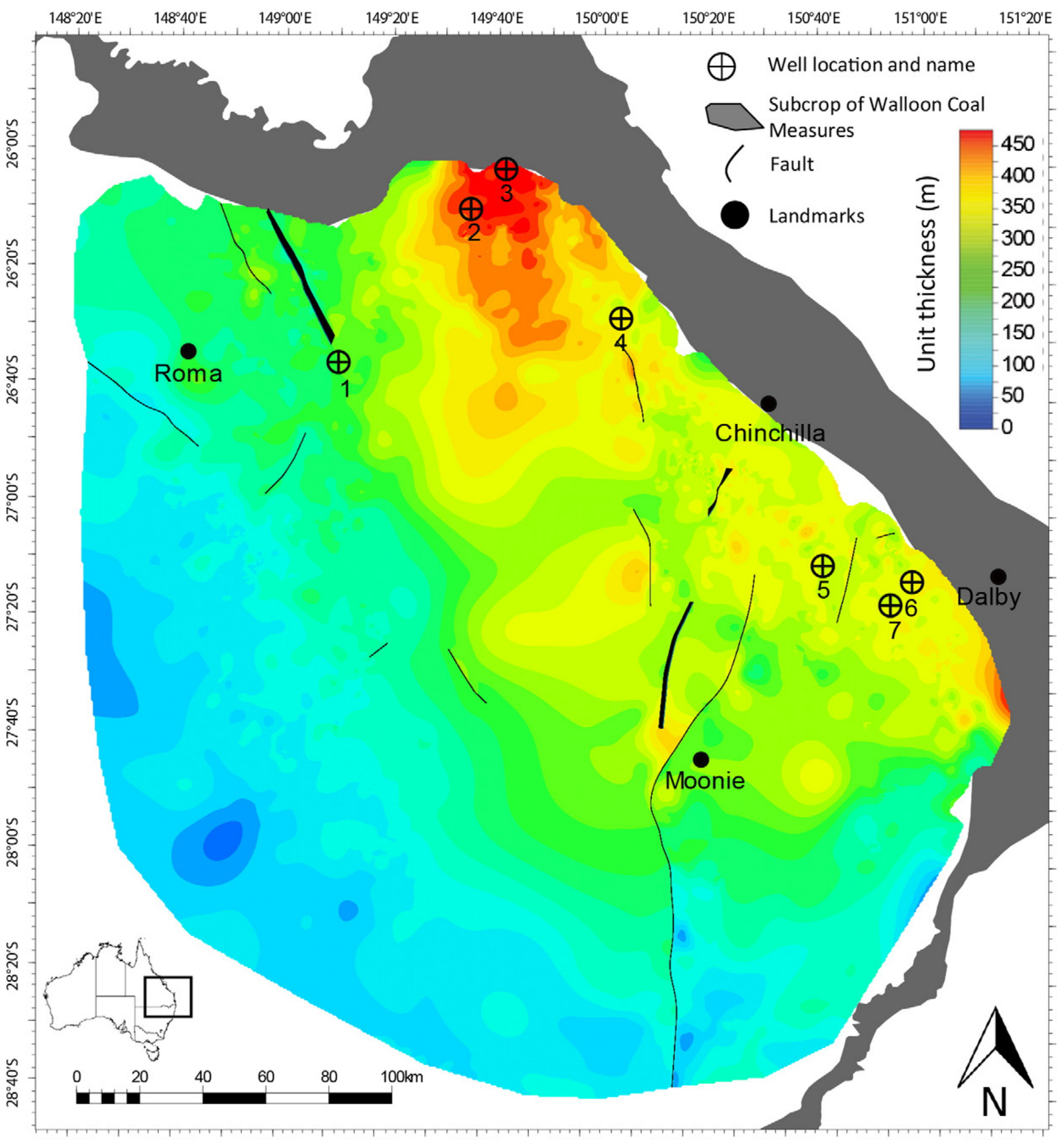

Fig. 1. Thickness map of the Surat Basin's Walloon Coal Measures, showing subcrop of the Walloon Coal Measures and well locations (1–7). Note the measures include non-coal interburden.