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# Mineralogy of the volcanic-influenced Great Northern coal seam in the Sydney Basin, Australia

Lei Zhao [a,*], Colin R. Ward [a], David French [b], Ian T. Graham [a]

[a] School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney 2052, Australia
[b] CSIRO Energy Technology, PO Box 52, North Ryde 1670, Australia

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ABSTRACT

The mineralogy of the individual coal plies and intra-seam claystone bands in the Great Northern seam of the Sydney Basin has been evaluated using optical and scanning electron microscopy, and quantitative X-ray diffraction techniques. The uppermost two claystone bands are tonsteins, consisting mainly of well-ordered kaolinite with graupen to vermicular textures. Idiomorphic crystals of K-feldspar within these tonsteins may represent members of the anorthoclase–sanidine series or a sodic sanidine, and indicate an acid to intermediate volcanic ash input. In contrast, the lowermost parting was largely derived from epiclastic sediment, admixed with minor volcanic material such as high-temperature quartz and a different type of K-feldspar component.

The mineral fraction of the coals, especially in the middle and upper parts of the seam, is dominated by authigenic kaolinite with a very low abundance of quartz. Apart from the tonsteins, authigenic processes therefore appear to be the dominant mechanism of mineral matter formation. Authigenic K-feldspar also occurs in the lower few metres of the seam, with a variety of modes of occurrence including cell and cleat infillings, cross-cutting veins, and thin laminae parallel to the organic matter and detrital clay bands. A late syngenetic low-temperature hydrothermal fluid injection process is suggested for formation of the feldspar veins. The origin of the fluid is uncertain, but is most likely associated with contemporaneous volcanic activity.


## 1. Introduction

Minerals in coal provide information about the depositional conditions and thus the geologic history of coal-bearing sequences, along with the regional sedimentary and tectonic history (Ren, 1996; Ward, 2002). Knowledge of the mineral matter in coal is important in understanding both the inorganic processes associated with coal formation (Ward et al., 2001) and aspects such as materials handling, boiler erosion, ash formation, and slagging in coal processing or utilisation (Gupta et al., 1999; Ward, 1984).

The Late Permian Newcastle Coal Measures is one of several stratigraphic units in the Sydney Basin of eastern Australia (Figs. 1, 2) from which significant resources of bituminous coals are currently extracted. As discussed more fully by Agnew et al. (1995), the uppermost part of the sequence, the Moon Island Beach Subgroup (Fig. 2), includes a number of coarse pebble conglomerates, with associated sandstones and shales, derived from erosion of older strata immediately to the north, in what was then the tectonically active orogen of the New England Fold Belt (Fig. 1), and deposited by alluvial fan and braided river systems in a foreland basin setting (Agnew et al., 1995; Bocking et al., 1988; Branagan and Johnson, 1970; Diessel and Hutton, 2004; Herbert, 1980). However, the upper part of the Newcastle Coal Measures (including the Moon Island Beach Subgroup) also contains a number of tuffaceous units (Fig. 2), representing products of contemporaneous volcanism associated with the New England Orogen, transported into the basin by ash fall and ash flow processes (Agnew et al., 1995; Diessel, 1965, 1985; Grevenitz, 2003; Kramer et al., 2001; Loughnan and Ray, 1978). The coal seams of the upper Newcastle Coal Measures were thus deposited under conditions that were influenced by two different types of non-coal sediment input, and these, along with authigenic processes associated with peat accumulation, may both have impacted on the mineral matter in the individual coal beds.

The Great Northern seam is one of the principal economic coal seams in the Moon Island Beach Subgroup. It is exposed in coastal outcrops at Catherine Hill Bay, 30 km SSW of Newcastle (Fig. 1), and is mined from a number of underground collieries in the area to the north and west. The seam is underlain by the Awaba Tuff, an extensive tuffaceous unit which commonly shows cross-stratification (Kramer et al., 2001) and may in part represent ash flow or reworked ash fall material. It is partly interbedded with alluvial channel deposits, and overlain mainly by the Teralba Conglomerate, a sequence of sandstone and conglomerate also formed by fluvial channel processes (Agnew et al., 1995). Another volcanic unit, the Booragul Tuff, also overlies the Great

* Corresponding author. Tel.: +61 430166280; fax: +61 93851558.
*E-mail address:* lei.zhao@y7mail.com (L. Zhao).

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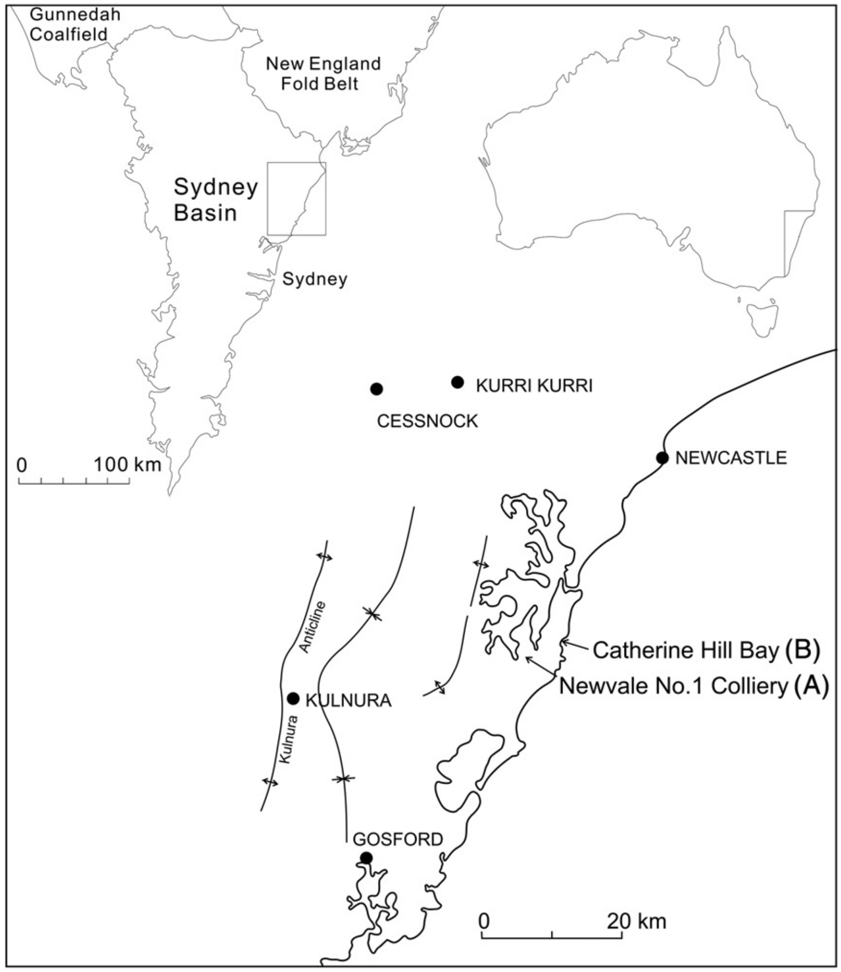


**Fig. 1.** Locations of Great Northern seam sections at Newvale (A) and Catherine Hill Bay (B) in the northern Sydney Basin.

Northern seam in the eastern part of the coalfield, occurring in places between the coal and the Teralba Conglomerate interval.

Like other seams in the upper Newcastle Coal Measures (Warbrooke, 1987), the coal of the Great Northern seam is relatively rich in inertinite. Agnew et al. (1995) indicated around 43% vitrinite, 53% inertinite and 4% liptinite for typical Great Northern seam products on a mineral-free basis. Coal from the seam is used as a fuel source in both domestic and international markets.

This study aims to investigate the characteristics and vertical variation in the mineral matter of the Great Northern seam and associated strata, including the immediate roof and floor rocks and a number of thin intra-seam claystone bands, as well as the different individual layers of coal (coal plies) within the seam section. Such a study provides an opportunity to assess the mineralogical characteristics of both the coal and non-coal strata in a major and economically-important coal seam, with an emphasis on evaluating the role of the different inorganic processes and sedimentary inputs that may be associated with coal formation.

## 2. Sampling and methodology

A series of 13 coal and associated non-coal rock samples from the Great Northern seam at Newvale No. 1 Colliery, located approximately 35 km SSW of Newcastle (Fig. 1), were supplied for this study from a sample bank maintained by CSIRO Energy Technology. An additional set of 18 samples, including coal, claystone partings and roof and floor materials, was taken from an outcrop of the Great Northern seam at Catherine Hill Bay (Fig. 1). The seam section at each location is illustrated in Fig. 3, which also shows the variation in abundance of dull and bright lithotypes in the individual coal plies. The contact between the conglomerate and the underlying coal seam at Catherine Hill Bay is disconformable, and in one part of the outcrop a thick layer of mudstone overlain by a thin bed of coal occurs between the conglomerate roof and the main part of the coal seam. This section is illustrated separately (Fig. 3). A tentative correlation between the two sections is also indicated in Fig. 3. The Great Northern seam at Newvale is thinner than that exposed at Catherine Hill Bay; correlation of the two sections suggests that this is probably due to contemporaneous erosion of the upper part of the coal bed by processes associated with deposition of the Teralba Conglomerate. Although the organic matter of the coal is affected by weathering, the exposure at Catherine Hill Bay allows a more extensive study of the sediments deposited in the area before and after the peat swamp was established.

The samples were ground to less than 200 mesh using either a zirconia mill (Newvale) or a ceramic mortar and pestle (Catherine Hill Bay), and split into representative portions for analysis. Use of the zirconia mill was intended to facilitate study of the trace element components, but discussion of these is outside the scope of the present paper. All the coal samples were subjected to low-temperature oxygen-plasma ashing, using techniques described by Standards Australia (2000), and the percentage of low-temperature ash (LTA) was determined in each case. Other samples of coal from Newvale were ashed at 815 °C; these ashes, and also samples of the powdered non-coal rocks from both locations, were fused into borosilicate disks (Norrish and Hutton, 1969) and analysed by X-ray fluorescence (XRF) spectrometry, using a Philips PW2400 XRF system, to determine the