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Ordovician stratigraphy of the Junee–Narromine Volcanic Belt in central New South Wales, Australia: conodont studies and regional correlations

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ABSTRACT

This contribution reviews the newly revised biostratigraphy of Middle–Upper Ordovician marine shelf successions from the Junee–Narromine Volcanic Belt in central New South Wales, based on conodont studies from four areas covering the northern, central and southern sectors of the Belt. Seven conodont biozones ranging from the middle Darriwilian (*Histiodella holodentata-Eoplacognathus pseudoplanus* Biozone) to the lower Katian (*Taoqupognathus blandus* Biozone) are recognized in the Billabong Creek Formation exposed in the Gunningbland area. This includes the first known biostratigraphic succession in Australia that extends continuously from the middle Darriwilian to the basal Sandbian. These new data are crucial for a better understanding of the geological evolution of this region in central New South Wales, and for the enhanced correlation of Ordovician rocks throughout the Macquarie Volcanic Province, which hosts substantial porphyry Cu–Au mineral deposits.

Introduction

In central-western New South Wales, the Ordovician to the earliest Silurian Macquarie Volcanic Province occupies the eastern part of the Lachlan Orogen (Fig. 1). It is characterized by a distinctive association of porphyry intrusions, mafic extrusive rocks and volcaniclastic rocks hosting several large porphyry Cu-Au deposits. The Macquarie Volcanic Province is subdivisible into three linear N-S oriented belts separated by contemporaneous deep-water quartz-rich clastic rocks of turbiditic origin. The Junee–Narromine Volcanic Belt (JNVB) is the westernmost belt and consists of >16 discrete igneous complexes within its ~200 km north-south strike (Fig. 1). Establishing a well-calibrated biostratigraphic and chronostratigraphic framework is essential for constraining the temporal and spatial distribution of these igneous complexes and their associated volcanic and volcaniclastic strata. Four magmatic phases are recognized within the Macquarie Volcanic Province (Percival and Glen 2007), with phases 3 and 4 in the Upper Ordovician hosting most of the economic mineralization and being the most prospective for further porphyry Cu–Au exploration (Glen et al. 2007; Zhen et al. 2022). Detailed study of the Ordovician biostratigraphy in the JNVB is crucial, as throughout most of the Middle and Upper Ordovician well-developed marine shelf sedimentary facies are in close association with volcanic facies (Simpson et al. 2005). During the Middle and Late Ordovician, the region now preserved as the JNVB was covered by a shallow tropical sea in which scattered volcanic islands were distributed. Carbonate sediments forming algal and coralline limestones were deposited on narrow shelves fringing the emergent volcanic edifices and were surrounded by siliciclastic sediments that extended offshore into turbidites and submarine fan systems of deep-water settings (Percival et al. 2023).

Revised biostratigraphic framework

Our ongoing studies of the Ordovician conodont biostratigraphy within the JNVB focus on: 1) documentation of the Late Ordovician faunas recovered from an unnamed subsurface formation within the Mingelo Volcanics, intersected in several drill holes located immediately west and northwest of Peak Hill in the northern sector

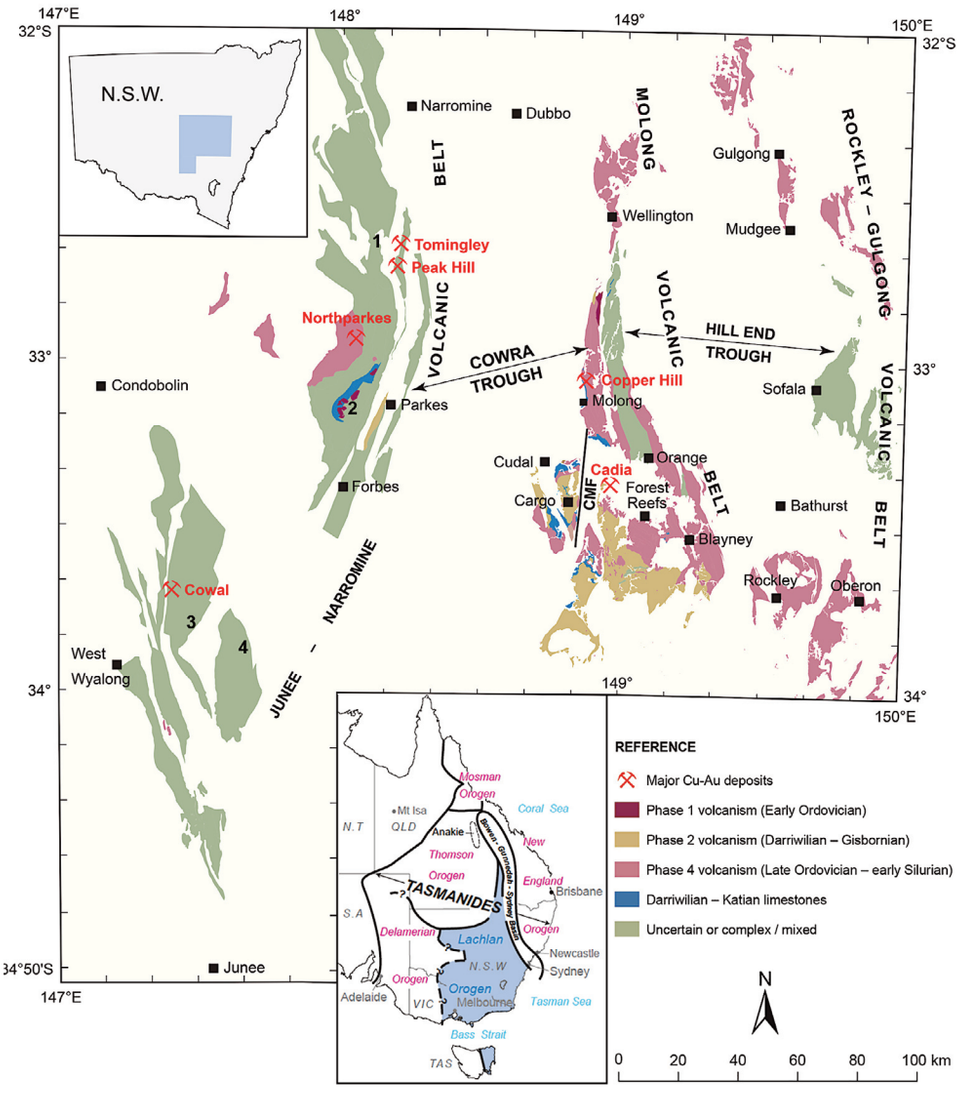

Fig. 1. Map of central New South Wales in eastern Australia showing the four study areas (1 – area immediately W and NW of Peak Hill, 2 – Gunningbland, 3 – Marsden prospect, and 4 – Quandialla) in the Junee–Narromine Volcanic Belt, the major mining sites of Ordovician porphyry copper–gold deposits, and distribution of Ordovician rocks in the three main volcanic belts of the Macquarie Volcanic Province that occupies the eastern part of the Lachlan Orogen (modified from Percival et al. 2023).

(Zhen et al. 2022); 2) re-examination of the Darriwilian and Late Ordovician conodonts from the Billabong Creek and Gunningbland formations in the Gunningbland area west of Parkes (Pickett and Percival 2001; Zhen and Pickett 2008; Zhen, Percival and Smith, unpublished new data); 3) study of limestones within the Lake Cowal Volcanic Complex in the Marsden prospect southeast of the Lake Cowal Gold Mine (Percival et al. 2006) and 4) investigation of a late Sandbian to earliest Katian conodont fauna recovered from an unnamed subsurface formation within the Currumburrama Volcanics of the Quandialla area in the southern sector (Zhen and Percival, unpublished new data). These studies have generated significant new data supporting regional correlations with much improved precision (Fig. 2). More specifically, seven conodont biozones from the middle Darriwilian to the lower Katian are recognized in the Billabong Creek Formation in the Gunningbland area, which represents the first biostratigraphic succession in Australia extending continuously from the middle Darriwilian to the basal Sandbian.

Conodont biofacies

The Middle and Late Ordovician conodont assemblages are preserved in a range of depositional settings reflecting varying water depths. The middle Darriwilian conodont fauna is dominated by *Erraticodon balticus* (44.2%) and *Kirkupodus tricostatus* (36.7%), with *Protopanderodus* species being less common. Based on the abundance of *E. balticus* in the fauna, Zhen and Pickett (2008) interpreted it as representing a shallow-water near-shore facies, consistent with the lithology. Higher in the Billabong Creek Formation, late Darriwilian (Dw3) assemblages are dominated by *Periodon aculeatus* (43.2%), with less common *Pygodus* species (10.9%) and *Ansella robusta* (5.6%), indicative of deeper-water settings in the intermediate to distal shelf.

Upper Ordovician samples are dominated by the species of *Belodina* and *Panderodus*, which inhabited a range of water depths but tend to be more abundant in shallow-water shelf settings. However, the relatively common occurrence of *Phragmodus undatus* in several samples is significant, as this

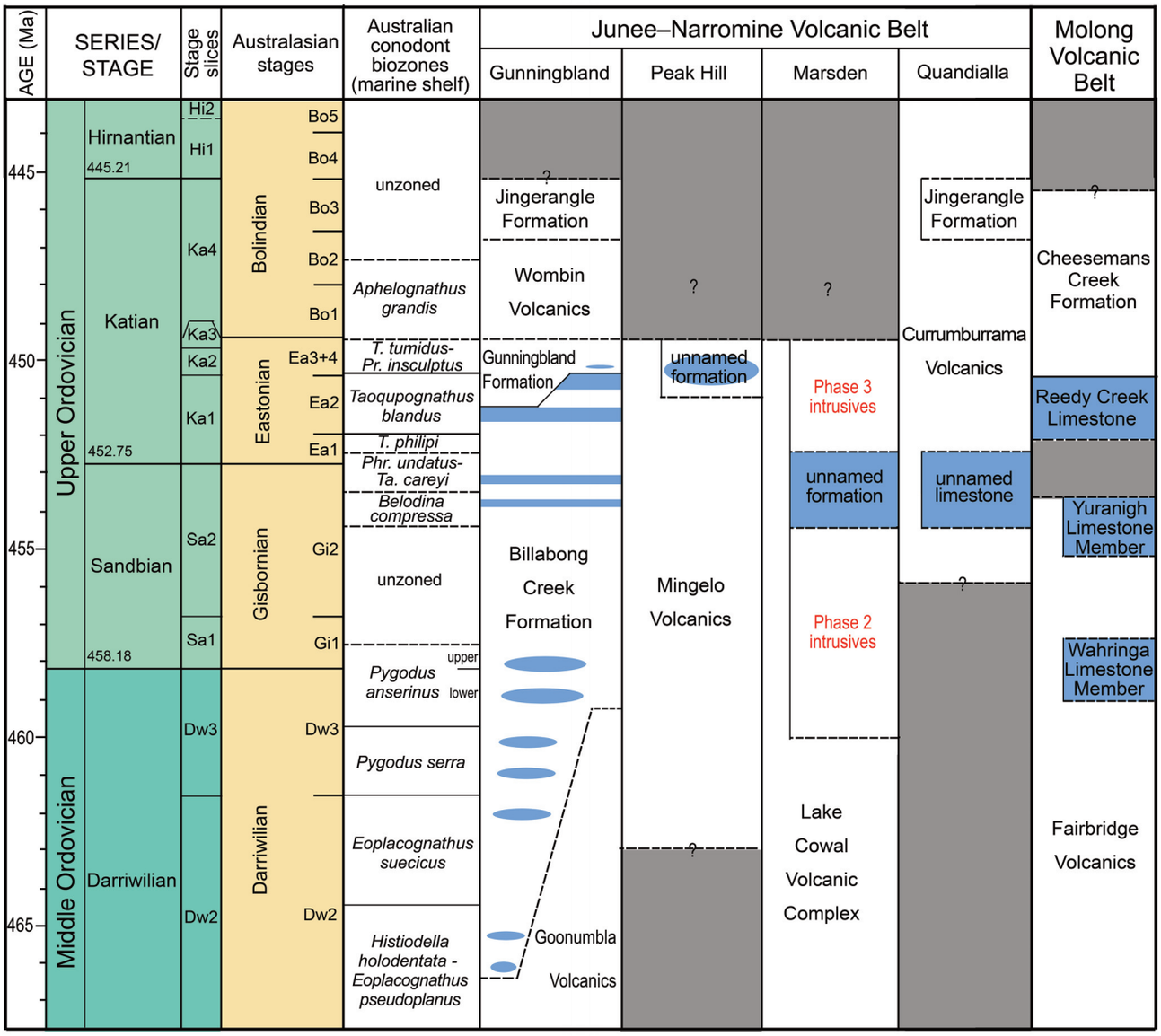

Fig. 2. Correlation of the Middle–Upper Ordovician marine shelf carbonate (in blue) successions from the Junee–Narromine Volcanic Belt in central New South Wales with contemporaneous succession of the northern Molong Volcanic Belt between Molong and Wellington. For localities, refer to Fig. 1.

species characterizes the *Ph. undatus* biofacies, indicative of deep-water settings (Zhen and Webby 1995; Zhen and Percival 2017). This mixture of depth-dependent biofacies may reflect steep volcanic island gradients. In the Peak Hill district of the northern JNVB (Zhen et al. 2022), an early Katian conodont assemblage (*T. blandus* Biozone) has a much higher percentage (45%) of *Ph. undatus*, supporting a more off-shore deeper-water setting (*Ph. undatus* biofacies) for this fauna.

Regional correlations

In the central sector of the JNVB, the Billabong Creek Formation has a maximum estimated thickness exceeding 320 m and is represented by discontinuous exposures in the Gunningbland area, located about 20 km west of Parkes (Fig. 1). Conodont studies confirm that this formation spans a stratigraphic interval from the middle Darriwilian to the lower Katian. Seven conodont biozones are recognized, from the early middle Darriwilian (*Histiodella holodentata-Eoplacognathus pseudoplanus* Biozone) to the earliest Sandbian (upper *Pygodus anserinus* Biozone) age, and from the latter part of the late Sandbian (*Belodina compressa* Biozone) to the early Katian (*Taoqupognathus blandus* Biozone) age (Fig. 2). This conodont succession correlates precisely with the biozonation established in the Upper Ordovician of the Molong Volcanic Belt further east (e.g., Zhen and Webby 1995; Zhen et al. 1999, 2004) in central New South Wales, and in the Gordon Limestone Group of western Tasmania (e.g., Zhen et al. 2010; Zhen and Percival 2017).

In the northern sector of the JNVB, a conodont assemblage of early Katian age (*T. blandus* Biozone) and a succeeding coral and stromatoporoid assemblage, corresponding to the *Taoqupognathus tumidus–Protopanderodus insculptus* conodont Biozone of middle Katian age, were reported from carbonate intervals intersected in three drill holes immediately west and northwest of Peak Hill. These limestones represent the northernmost record of the fossiliferous Ordovician marine shelf successions currently known from the JNVB (Zhen et al. 2022; Fig. 2). In the southern sector of the JNVB,

Percival et al. (2006) reported a conodont assemblage of latest Sandbian to earliest Katian age (*B. compressa* to *Ph. undatus-Tasmanognathus careyi* Biozone) from a carbonate unit intersected in drill core sections located near Marsden, about 20 km SSE of the Lake Cowal Gold Mine (Fig. 1). A Late Ordovician (late Sandbian, *B. compressa* Biozone) conodont assemblage was recently found in a carbonate unit intersected in drill hole CBMD006 located near Caragabal, about 20 km further SE (Zhen and Percival, unpublished new data).

Conclusions

The refined biostratigraphy of carbonate facies within the Billabong Creek Formation in the Gunningbland area west of Parkes comprises seven conodont biozones within a stratigraphic interval extending from the middle Darriwilian (*Histiodella holodentata-Eoplacognathus pseudoplanus* Biozone) to the lower Katian (*Taoqupognathus blandus* Biozone). This includes four successive conodont biozones representing the first biostratigraphic succession in Australia that extends from the middle Darriwilian to the basal Sandbian. New biostratigraphic data from several Ordovician units, including the Northparkes Group, Mingelo Volcanics, Lake Cowal Volcanic Complex, and Currumburrama Volcanics, provide much improved precision for their correlation within phases 2 and 3 in the mineral-rich Macquarie Volcanic Province. This study contributes to an enhanced understanding of the geological evolution of the Macquarie Volcanic Province by interpreting the interplay between volcanic activity and carbonate deposition.

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