CA-IDTIMS and biostratigraphy: Their impact on exploration

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SUMMARY

Uranium-Lead dating of Zircon using the Chemical Abrasion-Isotope Dilution Thermal Ionisation Mass Spectrometry (CA-IDTIMS) technique has largely overcome the problem of radiogenic lead loss, and has greatly improved the precision of the dating. That improvement in precision and the plethora of tuffs throughout the Permian and Triassic successions in eastern Australian basins (Tasmania, Sydney, Gunnedah, Bowen and Galilee) permits the recalibration of the Australian spore and pollen palynostratigraphic scheme directly to the numerical timescale, obviating the need for a multi-step process of correlation. The Permian recalibration has, for example, shown the base of the *Dulhuntyispora parvithola* (APP5) Zone to be about 6 million years younger than previously calibrated, and in the Triassic, the base of the *Polycingulatisporites crenulatus* (APT5) Zone could be about as much as 10 million years younger than previously calibrated.

Key words: CA-IDTIMS, Permian, Triassic, palynostratigraphy, geochronology.

INTRODUCTION

Because of the huge coal reserves present, the Sydney, Gunnedah and Bowen basins have been intensively studied (Figure 1). However, because much of the stratigraphic succession was deposited in non-marine environments, stratigraphic correlation is difficult even within a basin, and the most useful biostratigraphic scheme is based on largely endemic spores and pollen.

Until the development of Chemical Abrasion-Isotope Dilution Thermal Ionisation Mass Spectrometry (CA-IDTIMS), one of the major problems with Uranium-Lead dating of zircons was that of radiogenic lead loss, which gave ages significantly younger than that of crystallisation. Several techniques were developed to try to overcome this problem, including physical abrasion, mild HF leaching and neither of these have been entirely successful. The 'chemical abrasion' method, developed by Mattinson (2005), entailed annealing, followed by digestion in concentrated and pressurised HF over an extended period, and it seems to have largely overcome the problem of lead loss (Figure 2).

METHOD AND RESULTS

Previous techniques gave 95% confidence intervals of 1% or worse, whereas CA-IDTIMS can deliver 95% confidence intervals of 0.1% or better. This has major implications for the correlation of strata. Previous techniques allowed the dating of formations, subgroups or groups, but we can now date individual beds in a succession and provide a much better understanding of the timing of volcanic events and sedimentation rates. However, perhaps the most important facet of this new technique is the ability to date biostratigraphic zones. Previously, zones were calibrated against the numerical timescale often by a three-stage correlation. For instance, in the Permian, eastern Australian palynological zones were correlated with Western Australian palynological zones, on the assumption that they were coeval. Then limited Western Australian conodont or ammonoid occurrences were used to correlate to northern hemisphere zonal schemes, which form the basis for the international Geologic Time Scale. Each of these steps added a degree of uncertainty that is rarely, if ever, quantifiable. The result is essentially presented as the best available estimate. Where ash beds are common, and they are very common in the eastern Australian coal basins, the new technique allows robust calibration of biostratigraphic schemes directly to the numerical timescale, thus obviating the need for the three-stage, imprecise correlations previously used.

The recalibration of the Guadalupian and Lopingian (middle and late Permian) have been completed (Laurie et al., 2016), based on 34 CA-IDTIMS dates and demonstrate that (see Figure 2): the *Playfordiaspora crenulata* and *Protohaploxypinus microcorpus* (APP6) zones are most likely Triassic in age rather than Changhsingian (i.e. their base being about 2.5 million years younger than previously calibrated); the base of the *Dulhuntyispora parvithola* (APP5) Zone is about 6 million years younger; the base of the *Dulhuntyispora dulhuntyi* (APP4.3) about 7 million years younger; the base of the *Didecitriletes ericianus* (APP4.2) Zone is about 2 million years younger; the base of the *Dulhuntyispora granulata* (APP4.1) Zone is about 1.8 million years younger; and the *Microbaculispora villosa* (APP3.3) Zone is about 3 million years younger. Preliminary results from the Cisuralian (early Permian) are also available (Bodorkos et al., 2016) and indicate that: the base of the *Praecolpatites sinuosus* (APP3.2) Zone is about 2.6

million years younger; the base of the *Phaselisporites cicatricosus* (APP3.1) is about 3.5 million years younger; the base of the *Microbaculispora trisina* (APP2.2) Zone is at about the same age; the base of the *Pseudoreticulatispora pseudoreticulata* (APP2.1) Zone is about 2.3 million years older; and the base of the *Pseudoreticulatispora confluens* (APP1.22) Zone is about 1.4 million years older.

Currently, only seven CA-IDTIMS dates have been determined for Triassic biozones. Of these, five are from eastern Australia, and two from New Zealand. A very preliminary recalibration of eastern Australian Triassic biozones based on these few preliminary dates is given in Figure 3. While most of the new dates are confidently assigned to palynozones (Bomfleur et al., 2014; Smith et al., 2015), one sample, from the Brisbane Tuff of the Clarence-Moreton Basin (Queensland) is not based on direct palynostratigraphic dating, but on a correlation of the Brisbane Tuff with the base of the Ipswich Coal Measures (de Jersey & Hamilton, 1965). It provides an age of 227.08 ± 0.10 Ma for the *C. rotundus* biozone. This suggests that the base of APT4 may need to be recalibrated to approximately 10 million years younger than previously.

Such dramatic changes in the calibration will, of course, have a significant effect on age-depth curves and the resultant geohistory analyses.

CONCLUSIONS

CA-IDTIMS is a more precise technique for Uranium-Lead dating of Zircons. The eastern Australian Permian and Triassic successions contains numerous tuffs throughout. This permits a more precise and accurate calibration of the largely endemic spore-pollen zonation, than has hitherto been possible. It has demonstrated that the calibration obtained from the previous method of multi-step correlations needs revision.

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Figures

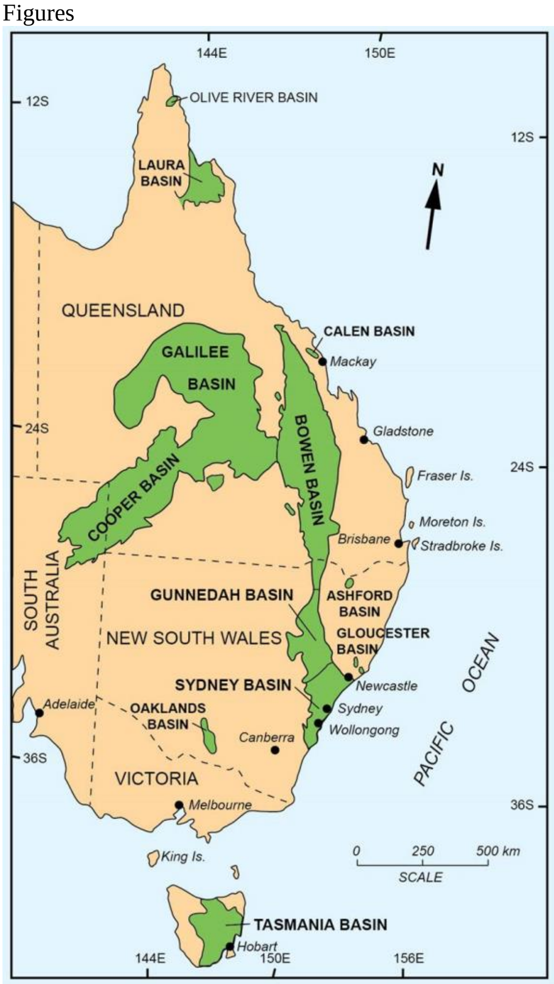

Figure 1. Permian-Triassic Basins in Eastern Australia. Most of the CA-IDTIMS dates used herein have been obtained from the Tasmania, Sydney, Gunnedah, Bowen and Galilee basins (Figure modified from Metcalfe et al., 2015).

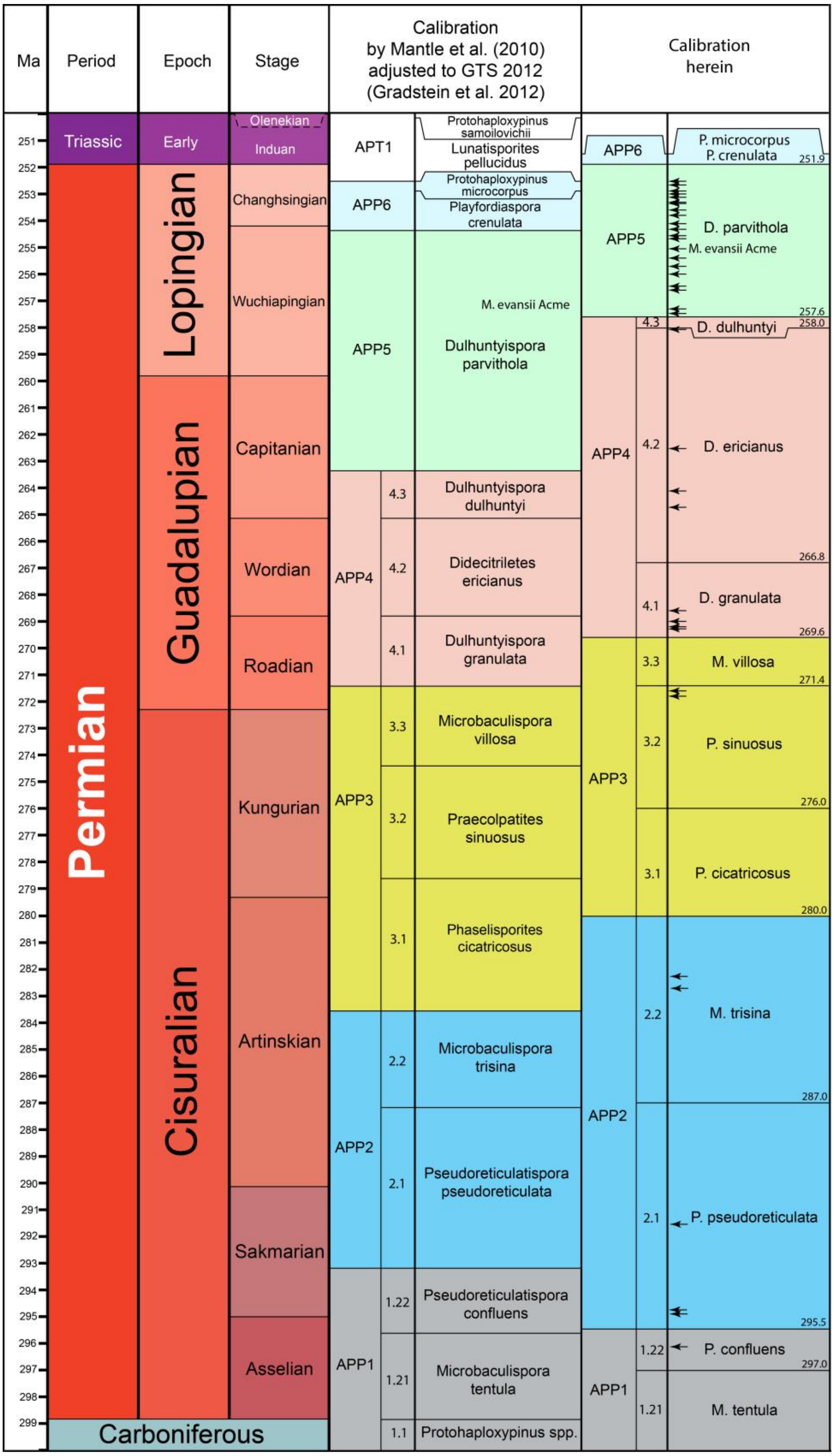

Figure 2. Recalibration of the Australian Permian palynostratigraphic scheme from that of Mantle et al. (2010), based on Laurie et al. (2016) for the Guadalupian and Lopingian, and unpublished data for the Cisuralian.

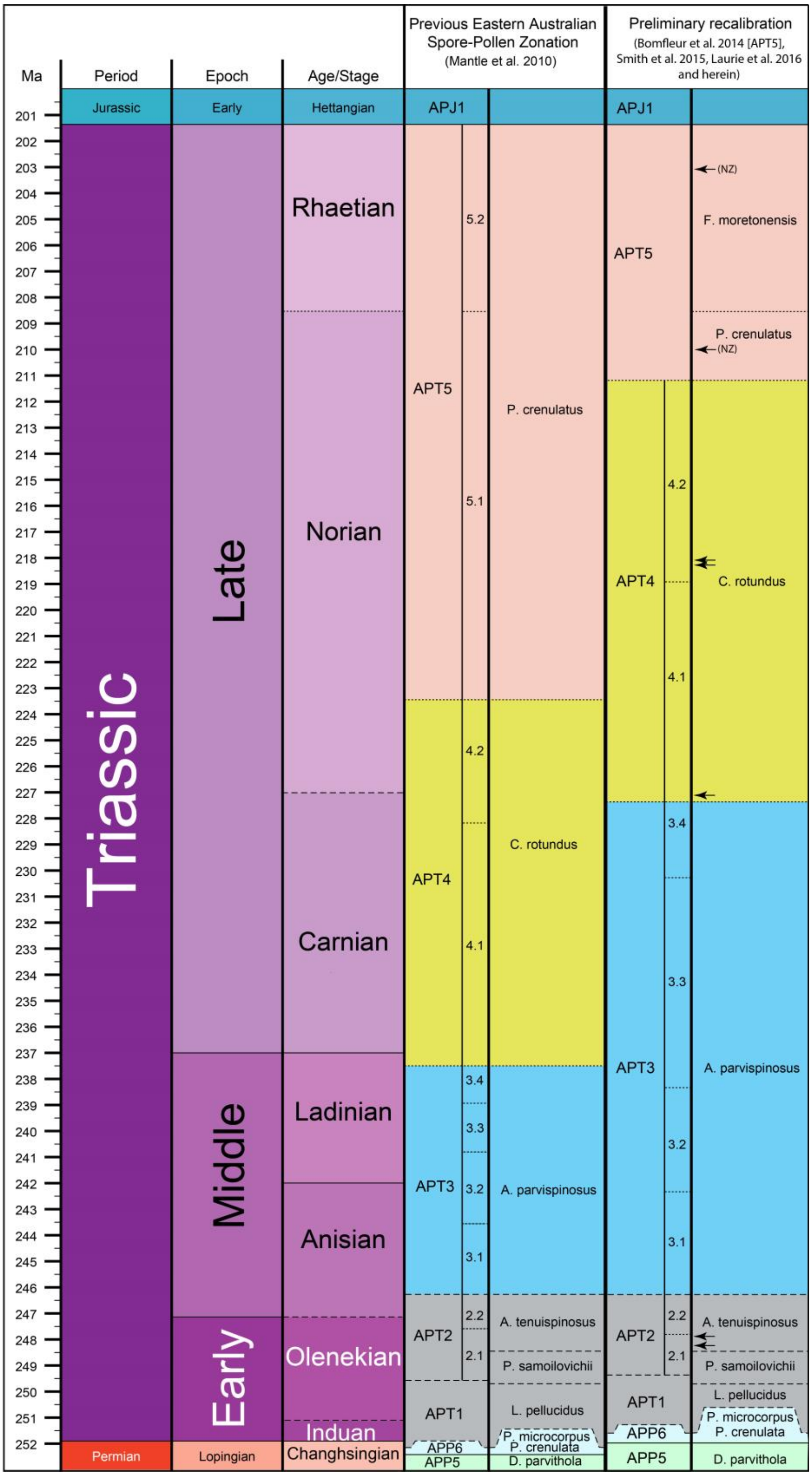

Figure 3. Recalibration of the Australian Triassic palynostratigraphic scheme from that of Mantle et al. (2010), based on Bomfleur et al. (2014), Smith et al. (2015), Laurie et al. (2016), and unpublished data.