The Impact of CA-IDTIMS on the Understanding of Permian and Triassic Lithostratigraphy and Correlation in Eastern Australian Coal Basins*

Robert S. Nicoll¹, John R. Laurie², Simon Bodorkos², Jim Crowley³, and Tegan E. Smith²

Search and Discovery Article #51209 (2015) Posted January 18, 2016

*Adapted from oral presentation given at AAPG/SEG International Conference & Exhibition, Melbourne, Australia, September 13-16, 2015

With the exception of the Commonwealth Coat of Arms and where otherwise noted, this product is provided under a Creative Commons Attribution 4.0 International Licence. http://creativecommons.org/licenses/by/4.0/legalcode

Abstract

In recent years, numerous correlations of the Permian and Triassic successions in the eastern Australian coal basins (Sydney, Gunnedah, Bowen and Galilee basins) have been attempted based on broad scale lithostratigraphy, sequence stratigraphy and biostratigraphy. However, detailed correlation of these successions has proved difficult. The development of Chemical Abrasion-Isotope Dilution Thermal Ionisation Mass Spectrometry (CA-IDTIMS), with its dramatically increased precision, has allowed more precise correlations to be obtained. This is in part because of the large number of tuffs in these eastern Australian basins, which range from the lowest Permian to the middle Triassic and number in the several hundred. The new correlations have resulted in numerous revisions to the ages of important units in eastern Australian basins. For example, the uppermost coal successions in the Sydney Basin (Newcastle Coal Measures, Illawarra Coal Measures) extend to very near the Permian-Triassic boundary and have a shorter duration than previously thought. The underlying Tomago Coal Measures/Whittingham Coal measures, rather than extending from the basal Wordian to earliest Wuchiapingian extend from the middle Capitanian to middle Wuchiapingian. Similarly, the top of the Greta Coal Measures, rather than being middle Kungurian are now known to be middle

^{**©} Commonwealth of Australia (Geoscience Australia) 2016.

¹Research School of Earth Science, Australian National University, Canberra, ACT, Australia (bob.nicoll@ga.gov.au)

²Resources Division, Geoscience Australia, Canberra, ACT, Australia

³Department of Geosciences, Boise State University, Boise, ID, United States

Roadian. In the Gunnedah Basin, the top of the Millie Group was basal Wordian, but is now considered middle Capitanian, while the overlying Brothers Subgroup, which was thought to extend up to the middle Capitanian is now known to be middle Wuchiapingian. The overlying Coogal Subgroup has been dramatically shortened in duration, and now lies entirely within the middle Wuchiapingian. In the Bowen Basin, the changes are similar, with the base of the Peawaddy Formation changed to late Wuchiapingian rather than middle Wordian, the base of the overlying Black Alley Formation now being latest Wuchiapingian rather than late Capitanian, and the base of the Bandanna Formation reassigned to earliest Changhsingian, rather than early Wuchiapingian. This recalibration of stratigraphy allows for a much improved understanding of basin history and the correlations between stratigraphic units, within and between eastern Australian basins.

Reference Cited

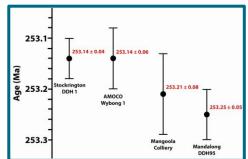
Price, P.L., 1997, Permian to Jurassic palynostratigraphic nomenclature of the Bowen and Surat basins, *in* P. Green, ed., The Surat and Bowen Basins, southeast Queenslan, Queensland.Department of Mines and Energy, Brisbane, p. 137-178.

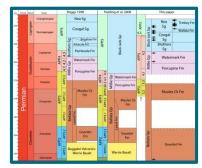


The impact of CA-IDTIMS on the understanding of Permian and Triassic lithostratigraphy and correlation in eastern Australian coal basins







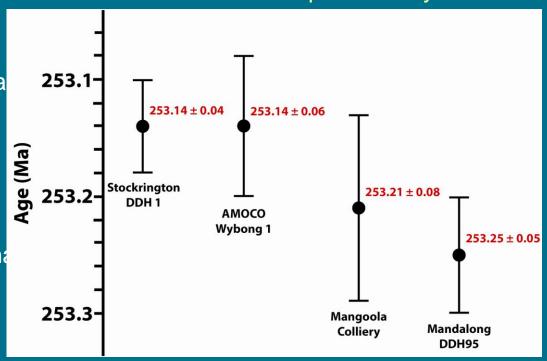


Bob Nicoll, John Laurie, Simon Bodorkos, Jim Crowley & Tegan Smith

CA-IDTIMS

Chemical Ablation Isotope Dilution Thermal Ionisation Mass Spectrometry

- Zircon crystals from volcanic a
- Radiometric U-Pb dating
- High precision (e.g. ± 100 ky)
- Some Limitations
 - Dwell time of zircons in ma



CA-IDTIMS

- Multiple applications
 - regional & international correlation
 - timing of tectonic events
 - tying tuff beds to their volcanic source
 - depositional rates

Best results obtained with a sequence of dates

The technique be used throughout the stratigraphic column, give us an ash bed with zircons, we can probably date it!

Volcanic eruptions

Plinian eruptions create extensive ash beds, providing a time horizon across a broad area



Tuffs in coals

Volcanic ash deposits over peat swamps create distinctive geological layers

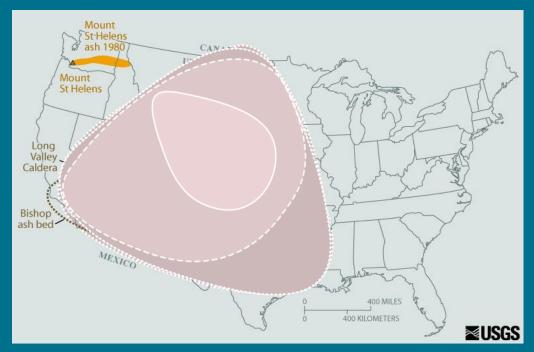




These types of layers are abundant in the Eastern Australian coal basins

Extent of Yellowstone eruptions relative to Eastern

Australia





http://volcanoes.usgs.gov/volcanoes/yellowstone/yellowstone_sub_page_91.html

Tying tuff beds to their volcanic source



Numerous Tuffs around the same age:

- Trinkey Formation 254.57
- Trinkey Formation 254.65
- Trinkey Formation 254.67
- Wybong 1 254.82
- Huntley Claystone 254.86
- Trinkey Formation 254.87
- Nobby's Tuff 254.88



Wandsworth volcanics:

 254.66 ± 0.14 (at Attunga Creek)

• 254.85 ± 0.28

Dating tuffs in the Gunnedah and Sydney basins

In the Newcastle Coalfield

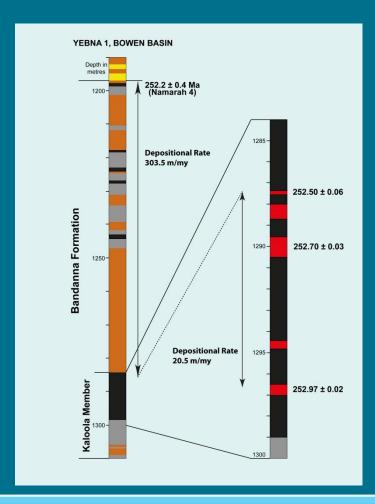
More than 10 major tuff beds in the Newcastle Coal Measures

In the Hunter Coalfield

124 tuff beds in 350-450 m of Newcastle Coal Measures (8 beds more than 1 m thick)

29 tuff beds in the Wittingham Coal Measures (6 beds more than 1 m thick)





Depositional rates

Yebna 1, Bowen Basin

Bandanna Formation including Kaloola Member

Depositional rate of Kaloola Member 20.5 m/my

Depositional rate of remainder of Bandanna Formation 303.5 m/my

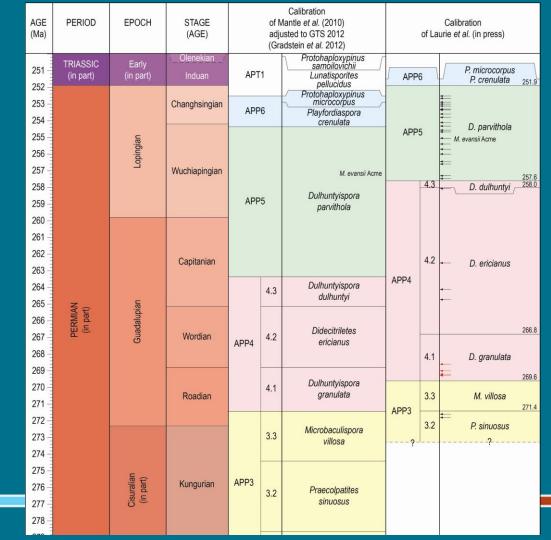
Price et al. 1997 biozones

1990 nomenclature Current nomenclature Pre-1985 (Filatoff and Price, 1990; Period (Filatoff and Price. Index forms usage Draper and others, 1990) 1991: Price, 1994) Triassic APT1 Tr1b APT1 Lunatisporites pellucidus (sp.92) APP6 Tr1a APP6 Triplexisporites playfordii (sp. 805) 5006 Lycopodiumsporites "crassus" (sp. 1083) Late Permian 5005 Micrhystridium evansii Acme Zone ('P3c horizon') 5.0.3 Microreticulatisporites bitriangularis "bireticularus" (sp. 1079) Upper APP5 5004 Consistent A. villosus* APP5 stage 5 Dulhuntvispora stellata radians (sp. 312) 5003 Dulhuntyispora spongia Dulhuntyispora spongia (sp. 277 and 309) 5.0.2.2 5.0.2 5002 U5a Dulhuntyispora (large forms) (sp. 1141, 313 and 308) 5.0.2.1 5001 501 Dulhuntyispora granulata Dulhuntvispora parvitholus (sp. 339) 432 L5c 4.3 43 Dulhuntyispora sp. cf. D. parvitholus (sp. 298) 431 Lower APP4 APP4 Dulhuntvispora dulhuntvi (sp. 6) stage 5 L5b 4.2 42 Didecitriletes ericianus (sp. 7) L5a 4.1 41 Dulhuntyispora granulata 3322 3.3.2 332 Lopadiospora vermithola (sp. 205) 3.3 33 3321 U4b Lopadiospora pannosus (sp.1379) 3.3.1 331 Acanthotriletes villosus (sp. 5) 322 Acanthotriletes "baculatus" (sp. 251) 3214 APP3 Granulatisporites sp. ct. M. Indica (sp.4) APP3 Stage 4 3.2 32 321 3213 Permian Propinquispora praetholus (sp. 206) U4a 3212 Granulatisporites trisinus "subtlis" (sp. 3781) 3211 Praecolpatites sinuosus "corona" (sp. 21) 3102 3.1 31 Granulatisporites trisinus "microsubtlis" (sp. 4549) Early 3101 L4 Phaselisporites cicatricosus (sp. 63) 2222 Praecolpatites spp. 222 Granulatisporites "parvus" (sp. 4610) 2.2 22 2221 3b Gondisporites ewingtonensis (sp. 4569) APP2 APP2 221 Stage 3 Granulatisporites trisinus (sp.671) 212 3a 2.1 21 Striatopodocarpites fusus (sp. 1181) 211 Pseudoreticulatispora pseudoreticulata (sp. 1595) 122 Pseudoreticulatispora confluens (sp. 194) 1212 1.2 12 APP1 121 Stage 2 APP1 Granulatisporites micronodosus (sp. 46) 1211 Granulatisporites tentula (sp. 276) 1.1 11 Late Protohaploxypinus spp. 4.2 42 Carboni-Stage 1 APL4 APL4 Diatomozonotriletes birkheadensis (sp. 1612) 4.1 ferous Pontonieisporites spp. NOTE: * APP4 forms, including A. villosus, P. cicatricosus 13-7216-1

After Price et al. 1997

Revised palynostratigraphy for the Guadalupian and Lopingian

Arrows indicate CA-IDTIMS dated samples with palynological control



Revised Permian palynostratigraphy

Ма	Period	Epoch	Age/Stage	ı	1				
250 -	Triassic	Early	Olenekian Induan	APP6 251.9	Playfordiaspora crenulata, Protohaploxypinus microcorpus,				
-	`E		Changhsingian APP5		Triplexisporites playfordi				
255 -		Lopingian	Wuchiapingian	257.6	Dulhuntyispora parvithola Dulhuntyispora dulhuntyi				
			vvuciliapiligiaii	APP4.3					
260 -			Capitanian	APP4.2	Didecitriletes ericianus				
265 —		Guadalupian	Wordian	266.8 APP4.1	266.8 Dulhuntyispora granulata				
070			Wordian	269.6					
270 -	an		Roadian	APP3.3	Microbaculispora villosa				
	Permian			APP3.2	Praecolpatites sinuosus				
275 -	P		Kungurian	APP3.1	Phaselisporites cicatricosus				
280 -				280.0	280.0				
285		Cisuralian	Artinskian	APP2.2	Granulatisporites trisinus				
290				290.0	290.0				
230			Colemanian	APP2.1	Pseudoreticulatispora pseudoreticulata				
295 -	snc		Sakmarian	295.0 APP1.22	295.0 Pseudoreticulatispora confluens				
	ifero		Asselian	297.0	297.0				
300 -	uoc l		, locollan	APP1.21	Granulatisporites tentula				
300 -	Carboniferous	Late Penn.	Gzhelian						





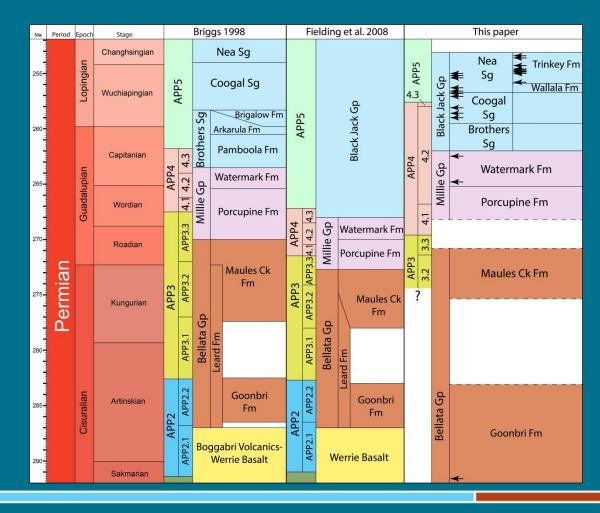




Tadros 1997 correlation

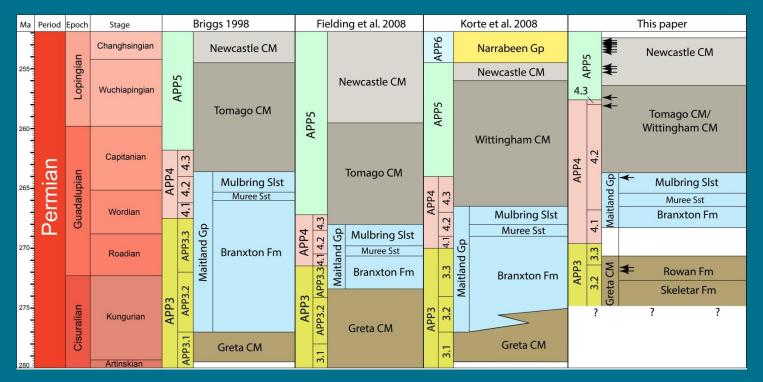
	C	iunnedah Basin	Hunter Coalfield			Newcastle Coalfield		Western Coalfield		Southern Coalfield				
	Deriah Formation											Wianamatta Group		
	Napperby Formation						Hawkesbury Sandstone				Hawkesbury Sandstone			
	Digby Formation				Narrabeen Group			Narrabeen Group		Narrabeen Group		Narrabeen Group		
	Nea Sg	ত্ত্ব Trinkey Formation			Wollombi C.M.		Ne	wcastle C.M.		Wallerawang Subgroup		Cuda au		
	\vdash	Wallala Formation	4		Watts Sandstone	<u> </u>		Waratah Sandstone	e S		res	Sydney		
۵	II Sç	Benelabri Fm			Denman Fm		l	Dempsey Formation	Measures	Baal Bone Fm	asnı	Bargo Claystone		
Black Jack Group	Coogal Sg	Clare Sandstone Hoskissons Coal		C.M.	Jerrys Plains Sg	То	mago)	Coal Me	Charbon Subgroup	Coal Measures	Subg	roup	
Jack			Supergroup	Jham C.	Archerfield Ss	Co	آ			Cullen Bullen Subgroup	ပ္ခ်	•		
ack		Brigalow Fm Arkarula Fm	Singleton		Bulga Fm		Coai	Kulnura Marine Tongue		Marrangaroo Cgl	llawarra	Erins Va	le Formation	
Big	Brothers Sg	D 1 1 5		Whittingham	Vane Subgroup	Me	easure	25	Illav	Nile Subgroup	Illav	Cumberland Subgroup		
	Pamboola Formation			> varie subgroup				₫	Budgong Sandstone		Budgong Sandstone	Gerringong Volcanics		
_			В			அ Mulbring Siltstone			l or	Berry Siltstone		Berry Si	Itstone	
dn	Watermark Formation			٨	Mulbring Siltstone		M	Mulbring Siltstone				Nowra Sandstone		
Great					Muree Sandstone		N	Muree Sandstone	Shoalhaven Group		Group	Wandrawandian Siltstone		
Millie Group	Porcupine Formation			Ві	Branxton Formation		Bra	anxton Formation		Snapper Point Formation	ven Gro	Snapper Point Formation		
Сp	Maules Creek Formation		Maules Creek Formation		Greta Coal Measures				Shoalhaven	Yarrunga				
Bellata	Leard & Goonbri Formations			S	keletar Formation		Greta	a Coal Measures			Sho	C.M.	Pebbley	
ă	8				Farley Formation	을 Farley Formation					Yadboro	Beach		
					Boggabri Volcanics & Werrie Basalt Siles Rutherford Allandale F		therford Formation	Farley Formation Rutherford Formation					& Tallong	Formation
	Boggabri Volcanics &			Allandale Formation		Dalwood	All	landale Formation				Cgls		
	Werrie Basalt				ochinvar Formation	Lochinvar Formation					Clyde Pige	eon Wasp use Sist Head Fm		
					Seaham Formation			Seaham Formation				Talaterang C		

Gunnedah Basin



Northern Sydney Basin

Hunter and Newcastle coalfields



Galilee–Bowen transect

AGE	ERA	PERIOD	EPOCH	STAGE	PALYNO	STRATIGRAPHIC ZONES		GALILEE BASIN		BOWEN BASIN							
AGE (Ma)	LIVA	PERIOD	EFOOII	(AGE)	Pric F	ce et al.,1985; Price, 1997	NORTH-EASTERN AREA	EASTERN (incl. Koburra Trough	N AREA (Aberfoyle Syncline)	DENISON TROUGH REGION	SOUTH-WESTERN TAROOM TROUGH & ROMA SHELF	SOUTH-EASTERN TAROOM TROUGH	CENTRAL TAROOM TROUGH	NORTH-CENTRAL TAROOM TROUGH	NORTHERN TAROOM TROUGH		
230			Late (in part)	Carnian		APT4 (in part)											
E	(in part)	SiC	Middle	Ladinian		APT3.4	Moolayember Formation	·····		***************************************		····					
240	MESOZOIC	TRIASSIC (in part)			APT3	APT3.3 APT3.2	4	Moolayember Formation		Moolayember Formation	Moolayember Formation	Moolayember Formation		Moolayember Formation	Moolayember Formation		
E	ME			Anisian	APT2	APT3.1 APT2.2	Warang Sandstone	Clematis	Group 2	Clematis Group	Showgrounds Sandstone	Clematis Group	2	Clematis Group	Clematis Group		
250			Early	Olenekian Induan		APT2.1 APT1 APP6		Rewan Group Dunda beds		Rewan Group	Rewan Group	Rewan Group	Rewan Group	Rewan Group	Rewan Group		
Ē			Lopingian	Changhsingian Wuchiapingian		APP5	Betts Creek beds	Betts Creek beds	Bandanna Formation Peawaddy Formation	Bandanna Formation Peawaddy Formation	Bandanna Formation Tinowon Formation	Baralaba Coal Measures	Burngrove Formation Fairhill Formation	Fort Cooper Coal Measures	Fort Cooper Coal Measures		
260				rraciiapingian		APP4.3	••••	Black A	lley Shale Colinlea Sandstone	Black Alley Shale Catherine Sandstone	Black Alley Shale Muggleton Formation	Wiseman Formation Burunga Formation	Rangal Coal Measures Macmillan Formation	Rangal Coal Measures Moranbah Coal Measures	Rangal Coal Measures Moranbah Coal Measures		
E			Guadalupian		APP4	APP4.2			Catherine Sandstone Ingelara Formation Freitag Formation	Ingelara Formation Freitag Formation "upper Aldebaran Sandstone"		Banana Formation Flat Top Formation Barfield Formation	German Creek Formation Maria Formation Freitag Formation	German Creek Formation Blenheim Formation	Exmoor Formation Blenheim Formation		
270				Wordian Roadian		APP4.1 APP3.3		"upper Aldebaran Sa	"upper Aldebaran Sandstone"	"lower Aldebaran Sandstone"		Oxtrack Formation	"upper Aldebaran Sandstone" "lower Aldebaran Sandstone"	Gebbie Formation			
	art)	IAN	Cisuralian		APP3	APP3.2				Sirius Mudstone Member		Buffel Formation	Cattle Creek	Tiverton Formation	Collinsville Coal Measures		
200	OIC (in p	PERMIAN		Kungurian		APP3.1		7		Cattle Creek Formation	····›		Blair Athol Coal Measures	tion			
280	ALEOZOIC	Snc		Artinskian	APP2	ADD2 2		Aramac Coal		• bed am			- Super		•		
E	Δ.					APP22		Measures		~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	Arbroath beds				••		
290		NIFER(n part)	hvanian cart)	Sakmarian		APP2.1		E GROI	my			Camboon Volcanics		Lizzie Creek Volcanic Group	Lizzie Creek Volcanic Group		
E		CARB(Pennsylv (in pa	Asselian		APP APP1.2.2	-7	Edie Tuff Member				:			80		
300		1	ate	Gzhelian	APP1 (in part)	1.2 APP1.2.1		Jochmus Formatio	n Zz		Combarngo Volcanics				000		
E			2	Kasimovian		APP1.1 (in part)			}						W VIOLEN		

Summary

Whole new appreciation of stratigraphic sequence

Real control on depositional rates

Confirmation on lateral correlation within and between basins

Time control on event stratigraphy





Thank you

Bob Nicoll

Phone: +61 2 6249 9484

Web: www.ga.gov.au

Email: bob.nicoll@ga.gov.au

Address: Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609

Postal Address: GPO Box 378, Canberra ACT 2601