Figure DR1. Astronomical tuning (La2004 precession index) of the Maiella composite section (Sampalmieri et al., 2010) and the Morgia 1 borehole (re-drawn from Progetto ViDEPI, 2009-2010). This tuning shows the occurrence of 20 precession index cycles from 5.96 Ma to 5.56 Ma, giving a 20.0 ± 1.6 k.y. average duration per cycle in this interval (see Data Repository for explanation of the error calculation).

Figure DR2. Provisional tuning of the Maccarone section to La2004 summer-half year insolation at 65º North (*Analyseries 2.0.4.2*; Paillard et al., 1996). Clays rich in organic matter, Fe-dolomites, and Colombacci limestones record arid climate conditions thus correlate to insolation minima. Insolation maxima correlate with intervals of high sedimentation rate (increased precipitation/runoff), predominant low in the section; upsection replacement of dark clay/lignites with Colombacci limestones is accompanied by an overall declining sedimentation rate. The tuning indicates 9.5 insolation cycles from 5.5320 ± 0.0082 Ma to 5.332 ± 0.005 Ma, i.e., a 21.1 ± 3.1 k.y. average duration per sedimentary cycle in this interval. c = clay; m = marl; s = sandstone; v = volcanic ash layer; ca = carbonates. Yellow star indicates the position of the MKB. Legend: 1) p-ev1 clays, with intercalations of thin sandstone layers; 2) clays rich in organic matter and plant remains, with intercalations of thin Fe-dolostone layers; 3) ash layer (MKB); 4) p-ev2 clays, with intercalations of thin sandstone layers; 5) marls; 6) lacustrine limestones ("Colombacci"); 7) deep water marine clays.

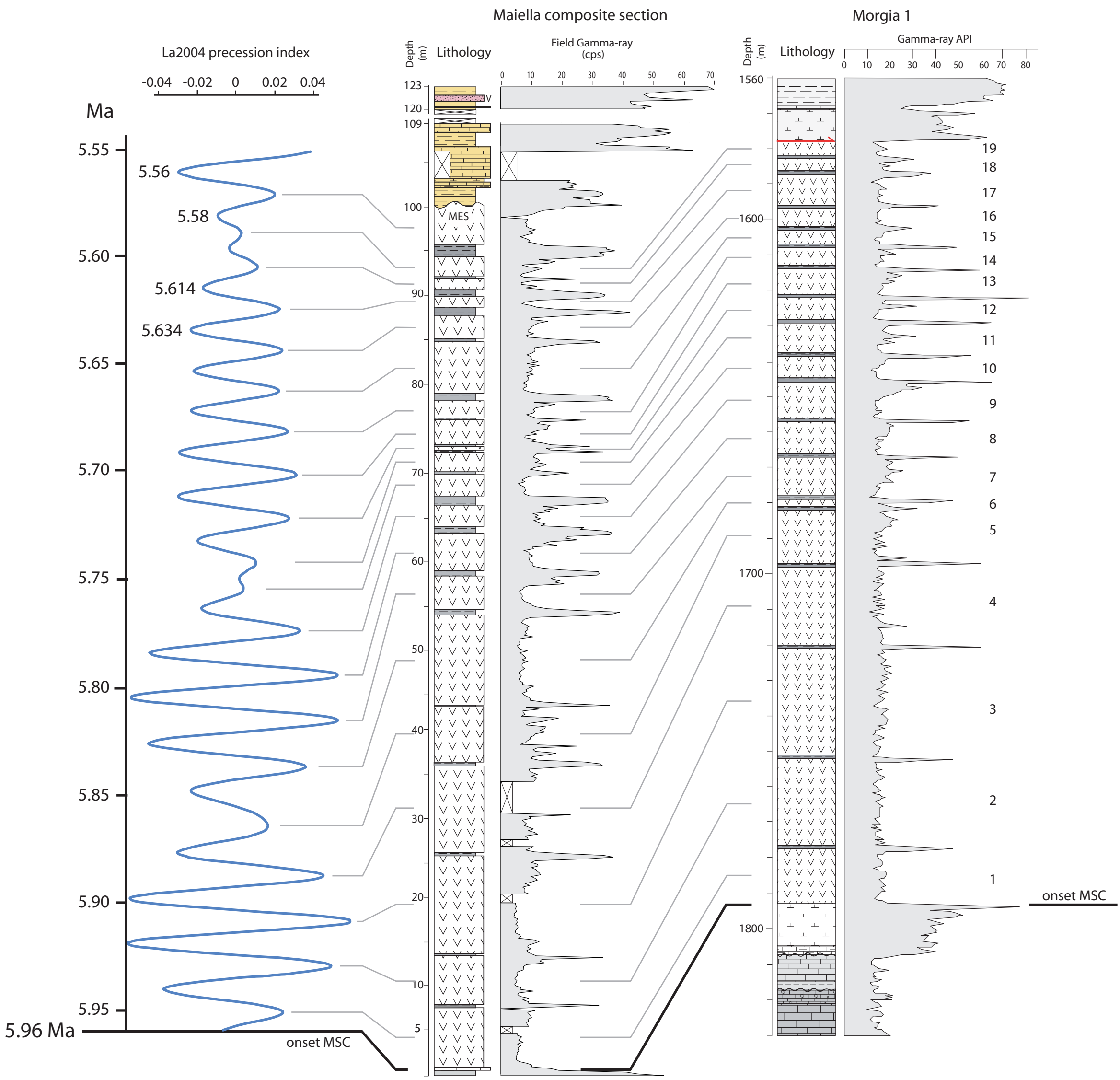

Figure DR1 - Cosentino et al.

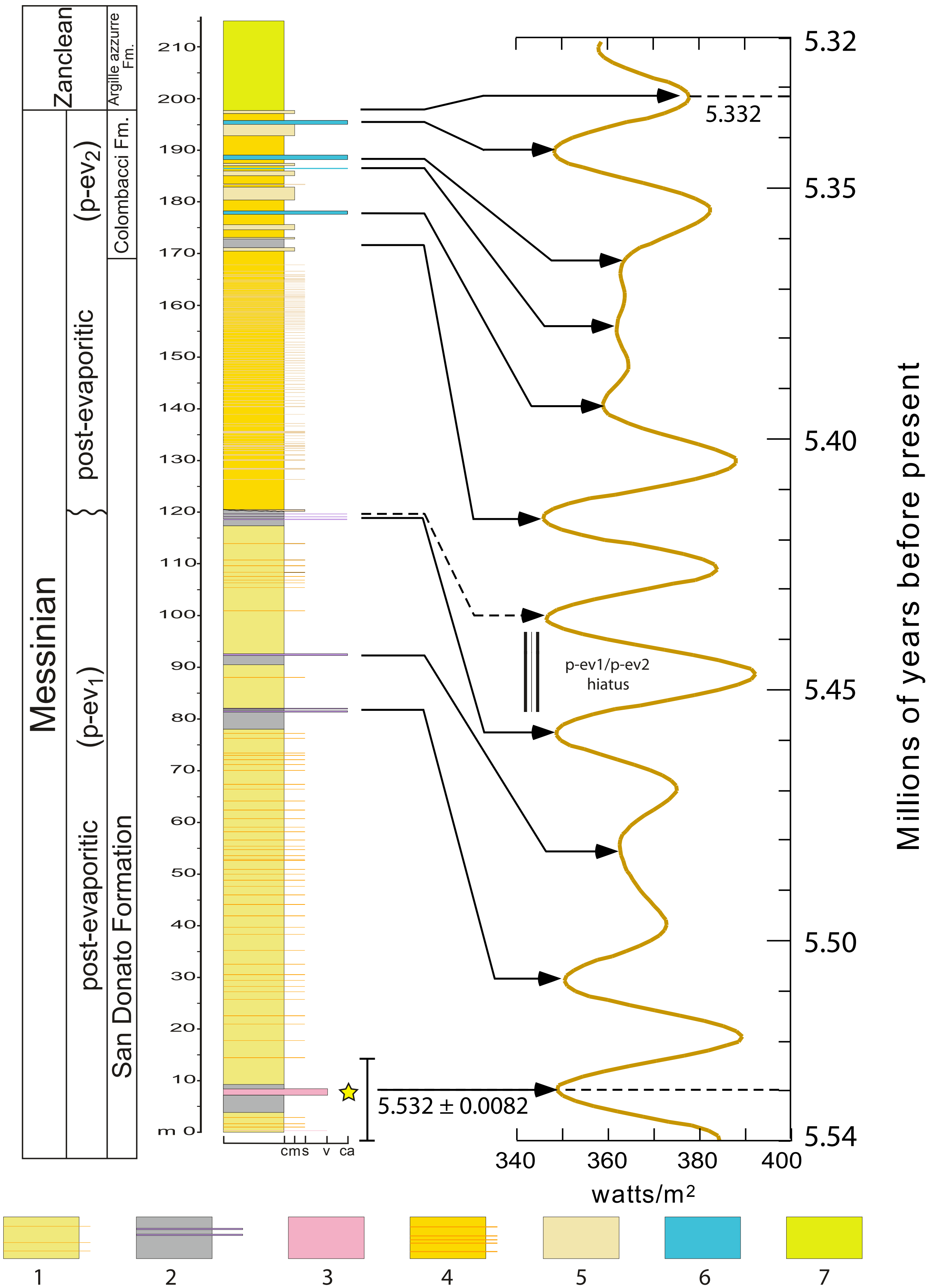

Figure DR2 - Cosentino et al.

Methods of Error Calculation

Astronomical Tuning Errors

All reported astronomical ages include a $\pm$5 k.y. error due to uncertainty in the season of insolation forcing. We consider this error to represent a 95% (2σ) confidence interval. Additional errors in accuracy can be derived from modeling uncertainties: 1 k.y. too old due to the La1993 astronomical target (Laskar et al., 1993) used in Messinian tuning (e.g., Hilgen et al., 2007) compared with the La2004 target (Laskar et al., 2004), and up to 2 k.y. too old due to uncertainty in tidal dissipation (Lourens et al., 2004).

Errors on the Difference Between Two Dates

In calculating the error on the duration of time between two dates, we first follow standard error propagation for subtraction or addition:

$$(1)\quad \sigma^2_{(A-B)} = \sigma^2_A + \sigma^2_B$$

Eq. 1 can be rewritten as:

$$(2)\quad \sigma_{(A-B)} = \sqrt{\sigma^2_A + \sigma^2_B}$$

For all calculations of the error on the durations, we use 5 k.y. as the 2σ confidence level on the astronomical ages, and we use the Z error term in the zircon U-Pb reported errors as the 2σ confidence level, which includes the decay constant error. For sample Mc 16a, the Z error term is 8.2 k.y. (2σ).

The error on the duration of the deposition of a sedimentary succession is equal to $\sigma_{(A-B)}$. The 9.5 sedimentary cycles deposited between the Messinian Key Bed Mc 16a and the Zanclean flooding event yield a $\sigma_{(A-B)}$ value of 4.8 k.y. (σ_A = 2.5 k.y. and σ_B = 4.1 k.y.), or a 2$\sigma_{(A-B)}$ value of 9.6 k.y.

Errors on Durations of Sedimentary Cycles

We next calculated the error on the duration of each cycle (σ_{cycle}) within the succession by the following:

$$(3)\quad \sigma_{cycle} = \sqrt{\frac{1}{n}\sigma^2_{(A-B)}}$$

where *n* is the number of cycles in the succession. Within the 9.5-cycle succession of post-evaporitic sediments in the Maccarone section, Eq. 3 yields a σ_{cycle} value of 1.56 k.y. (2σ_{cycle} is 3.1 k.y.). The same calculation method yields a 2σ_{cycle} value of 1.6 k.y. for the 20-cycle succession of the Lower Evaporites that occurs between 5.96 and 5.56 Ma, assuming σ_A = 2.5 k.y., σ_B = 2.5 k.y., and calculating $\sigma_{(A-B)}$ to be equal to 3.5 k.y..

TABLE DR1: Isotopic data along with details of fractionation and blank corrections.

	Composition			*Isotopic Ratios*								*Dates [Ma]*						
Fraction	Th/U [a]	Pbc [b] [pg]	Pb*/Pbc [c]	$^{206}Pb/^{204}Pb$ [d]	$^{208}Pb/^{206}Pb$ [e]	$^{206}Pb/^{238}U$ [e,f]	±2σ [%]	$^{207}Pb/^{235}U$ [e]	±2σ [%]	$^{207}Pb/^{206}Pb$ [e,f]	±2σ [%]	$^{206}Pb/^{238}U$ [f,g]	±2σ [abs.]	$^{207}Pb/^{235}U$ [g]	±2σ [abs.]	$^{207}Pb/^{206}Pb$ [f,g]	±2σ [abs.]	Corr. coef.
CV-6: Zircon																		
z8	0.46	0.8	2.68	180.9	0.151	0.000855	0.54	0.00546	6.91	0.046282	6.702	5.511	0.030	5.524	0.38	11.27	161.2	0.43
z9	0.45	0.5	2.11	146.9	0.146	0.000857	0.63	0.00548	8.85	0.046390	8.632	5.520	0.035	5.546	0.49	16.86	207.4	0.40
z15[h]	0.36	0.5	7.16	464.9	0.118	0.000893	0.20	0.00562	2.39	0.045712	2.346	5.751	0.011	5.694	0.14	-18.64	56.7	0.32
z16[h]	0.59	0.5	5.01	312.3	0.191	0.002382	0.26	0.01541	3.39	0.046937	3.331	15.335	0.039	15.524	0.52	44.95	79.6	0.27
z18	0.59	0.5	1.71	118.2	0.192	0.000857	0.71	0.00575	9.43	0.048656	9.287	5.524	0.039	5.821	0.55	130.24	218.5	0.26
z19	0.61	0.4	4.39	273.5	0.199	0.000858	0.32	0.00565	3.80	0.047744	3.741	5.529	0.018	5.717	0.22	85.54	88.7	0.28
z20	0.57	0.4	3.97	251.8	0.186	0.000860	0.35	0.00554	4.25	0.046746	4.184	5.542	0.019	5.610	0.24	35.21	100.2	0.26
z21[h]	0.39	0.4	3.30	221.7	0.127	0.000898	0.39	0.00612	5.07	0.049501	4.942	5.784	0.023	6.200	0.31	170.60	115.4	0.39
z22	0.60	0.5	2.97	191.4	0.195	0.000859	0.43	0.00565	5.56	0.047711	5.477	5.537	0.024	5.721	0.32	83.88	129.9	0.26
z102	0.50	0.7	4.86	309.7	0.163	0.000859	0.29	0.00560	3.40	0.047306	3.347	5.535	0.016	5.671	0.19	63.61	79.7	0.28
z103	0.50	0.7	3.30	215.8	0.163	0.000858	0.40	0.00565	5.11	0.047764	5.006	5.528	0.022	5.718	0.29	86.54	118.7	0.33
z105	0.49	0.5	3.25	213.2	0.160	0.000859	0.39	0.00569	4.99	0.048089	4.903	5.536	0.022	5.765	0.29	102.60	115.9	0.28
Mc16a: Zircon																		
z2	0.44	0.9	2.37	163.1	0.142	0.000861	0.51	0.00553	7.39	0.046603	7.258	5.546	0.028	5.598	0.41	27.83	174.0	0.31
z3	0.42	0.9	5.05	327.5	0.138	0.000860	0.30	0.00564	3.78	0.047575	3.698	5.541	0.017	5.709	0.22	77.10	87.9	0.35
z5	0.45	0.8	3.36	223.0	0.146	0.000858	0.48	0.00549	6.54	0.046416	6.300	5.526	0.026	5.556	0.36	18.23	151.3	0.56
z6	0.39	0.4	3.89	259.0	0.128	0.000857	0.36	0.00546	5.06	0.046215	4.930	5.524	0.020	5.529	0.28	7.78	118.7	0.42
z6a	0.43	0.9	3.40	226.0	0.139	0.000862	0.38	0.00571	4.83	0.048102	4.730	5.552	0.021	5.783	0.28	103.22	111.8	0.33
z9	0.52	0.5	7.92	490.9	0.169	0.000857	0.23	0.00542	2.45	0.045883	2.385	5.522	0.013	5.487	0.13	-9.62	57.6	0.43
z13	0.47	0.5	4.36	281.8	0.154	0.000859	0.30	0.00563	3.67	0.047508	3.612	5.538	0.016	5.698	0.21	73.78	85.9	0.27
z14	0.49	0.4	5.84	369.4	0.159	0.000859	0.24	0.00562	2.78	0.047508	2.737	5.536	0.013	5.695	0.16	73.78	65.1	0.27
z15	0.51	0.3	4.35	278.5	0.166	0.000857	0.31	0.00544	4.20	0.046073	4.119	5.520	0.017	5.509	0.23	0.37	99.3	0.34
z101	0.56	0.7	5.57	347.7	0.181	0.000858	0.26	0.00545	3.05	0.046119	3.000	5.528	0.015	5.522	0.17	2.75	72.3	0.28
z102	0.59	1.1	2.77	180.4	0.192	0.000858	0.46	0.00562	5.98	0.047496	5.886	5.531	0.026	5.690	0.34	73.17	139.9	0.27
z103	0.52	1.3	2.31	156.0	0.170	0.000859	0.52	0.00573	6.80	0.048376	6.703	5.536	0.029	5.799	0.39	116.61	158.1	0.25
z104	0.44	0.4	5.51	354.4	0.143	0.000858	0.24	0.00555	2.92	0.046919	2.881	5.529	0.013	5.619	0.16	44.05	68.9	0.25
z105	0.55	0.5	5.08	319.2	0.178	0.000859	0.28	0.00560	3.29	0.047257	3.232	5.537	0.015	5.667	0.19	61.16	77.0	0.28

Pb Blank isotopic composition: $^{206}Pb/^{204}Pb$ = 18.42 ± 0.35; $^{207}Pb/^{204}Pb$ = 15.36 ± 0.23; $^{208}Pb/^{204}Pb$ = 37.46 ± 0.74

(a) Th contents calculated from radiogenic ^{208}Pb and the $^{207}Pb/^{206}Pb$ date of the sample, assuming concordance between U-Th and Pb systems.

(b) Total mass of common Pb.

(c) Ratio of radiogenic Pb (including ^{208}Pb) to common Pb.

(d) Measured ratio corrected for fractionation and tracer contribution only.

(e) Measured ratios corrected for fractionation, tracer, blank, common Pb is lab blank, U blank = 0.1 pg; Mass fractionation correction of 0.25%/amu ± 0.04%/amu (atomic mass unit) was applied to single-collector Daly measurements

(f) Corrected for Initial Th/U disequilibrium using radiogenic ^{208}Pb and Th/U [magma] = 2.8

(g) Isotopic dates calculated using the decay constants λ_{238} = 1.55125E-10 yr^{-1}, λ_{235} = 9.8485E-10 yr^{-1} (Jaffey et al. 1971), and for the $^{238}U/^{235}U$ = 137.818 ± 0.045 (Hiess, J. et al. 2012)

(h) fraction excluded from age calculation

corr. coef. = correlation coefficient

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