



ELSEVIER

GEOSCIENCE FRONTIERS

Supporting Information for

Large earthquakes along slow converging plate margins: a review of Calabrian Arc paleoseismicity based on the submarine turbidite record

Polonia A. (1)*, Melis R. (2), Galli P. (3), Colizza E. (2), Insinga D. (1) and Gasperini L. (1)

¹ Institute of Marine Sciences, National Research Council (ISMAR-CNR), Bologna, Italy

² Dip. di Matematica e Geoscienze, Università degli Studi di Trieste

³ Presidenza del Consiglio dei Ministri, Dipartimento della Protezione Civile, Servizio Rischio Sismico - Roma, Italia

SM1 – Micropaleontology

The micropaleontological analysis of benthic foraminifers were addressed first to differentiate the pelagic sediments from the turbidite layers and later to derive information on sediment source within resedimented deposits. The foraminifers found in the 102 sediment samples comprised 109 benthic species, pertaining to 59 genera; foraminifers pertaining to suborder Rotaliina are better represented. The richness, calculated using the Margalef index, varied from 0 to 11.7 with an average 5.7 and density (as n° specimens/dry sediment weight, in g) from 0 to 362 specimen/g, with a mean of 44. Both values show considerable variation, assuming lower values in correspondence of finer sediments and, viceversa, increasing in accordance with the content of sand. Twenty two levels were totally barren of foraminifers. The foraminiferal species found in the core are well known in the Mediterranean, from infralittoral to bathyal environments (see references in Table 3). *Articulina tubulosa*, *Bolivina dilatata*, *B. variabilis*, *Cassidulina carinata*, *Globocassidulina* are the most frequent taxa, however they do not exceed the mean 10%. Without considering the barren intervals (22 out of 102 levels), no taxa are always present in the studied levels. Using the ecological knowledge of the foraminifers, the association was divided into 4 ecological groups: inner shelf (considering the infralittoral taxa), shelf (considering the taxa living from the infralittoral to the circalittoral), outer shelf - bathyal (considering the taxa living from about 200 to 1000 m) and bathyal (considering taxa living at depths greater than 1000 m) (Table 3).

These ecological groups reach the mean value of 14.3 ± 11.0 , 11.8 ± 9.8 , 34.0 ± 18.3 , $11.3 \pm 13.0\%$, respectively.

SM2 – Tephra layer characterization

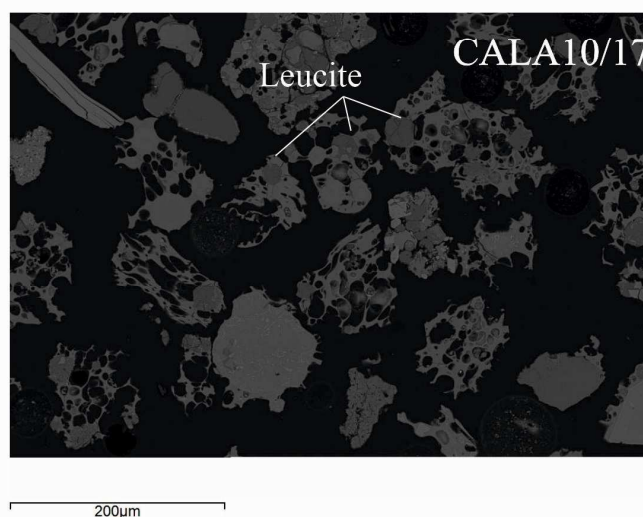
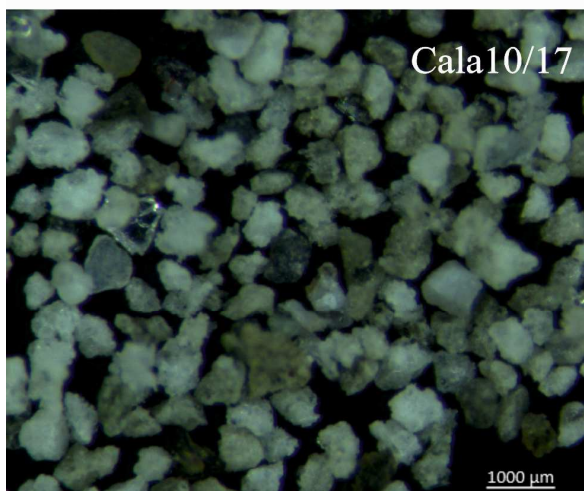
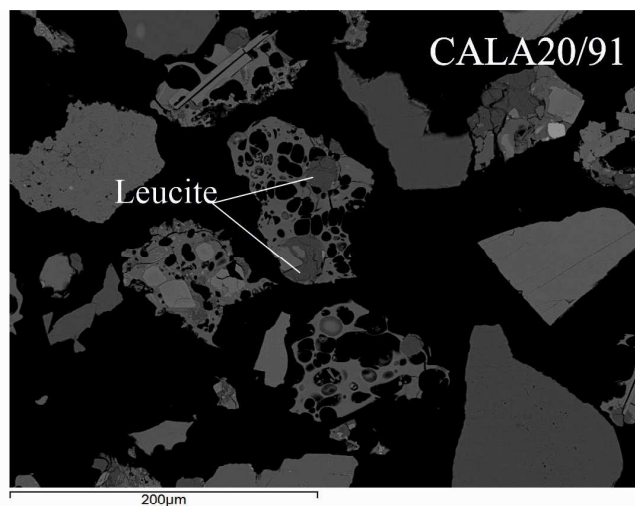
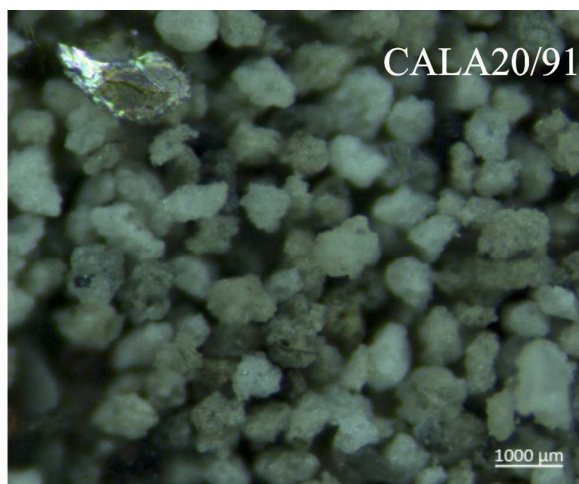
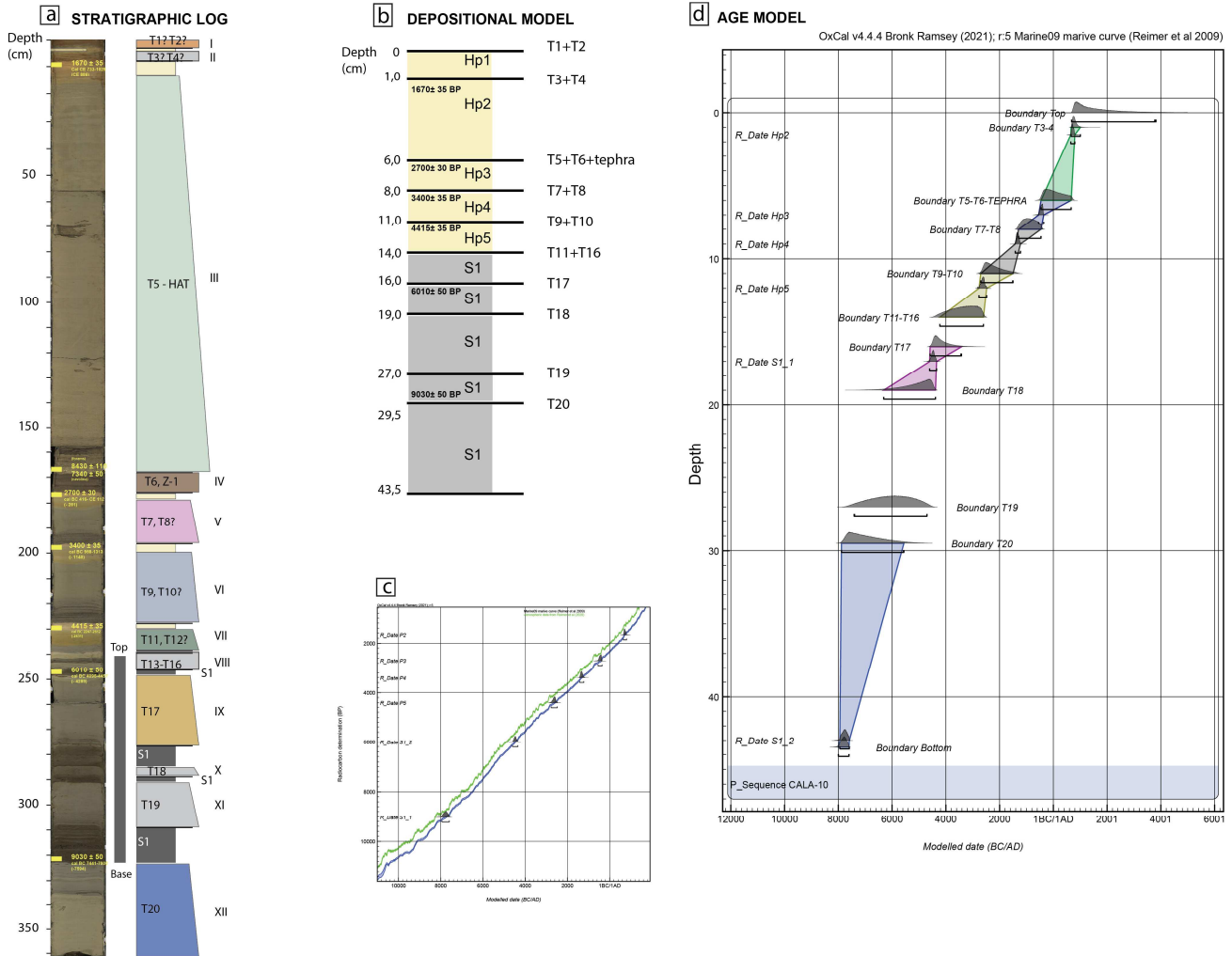


Fig. SM2 - Optical microscope (left) and SEM (right) images to show lithology and leucite crystal occurrence in the two samples representative of the studied tephra.

SM3 – Oxcal age model for core CALA-10



SM3 – Age modelling results for core CALA-10: a) Stratigraphic log, photograph and pelagic units with samples for radiometric datings of core CALA-10; b) Deposition model built subtracting the thickness of the turbidites (instantaneous sedimentary events) from the total core; c) Calibrated radiometric dates (2 σ) of the pelagic units using a ΔR_0 ; d) age model built using the P_Sequence (a Bayesian model of deposition) implemented in the computer program OxCal 4.1 that assimilates sedimentation as a random process following a Poisson law (Bronk Ramsey, 2008). The regularity of sedimentation is determined by the k parameter (here k=3 reflects small variations in sedimentation rate as deduced from radiometric dating analysis. See section 5.5.4). The model finally calculates the age of each corrected depth corresponding to a turbidite and generates the 95.4% probability age ranges (2 σ).

SM4 – Turbidite emplacement time windows for core CALA-20 derived through Oxcal age modeling (k=3).

Name		Unmodelled (BC/AD)			Modelled (BC/AD)			Indices				Select	Page break		
		from	to	%	from	to	%	A _{model} =78	A _{overall} =78.8	A _{comb}	A			L	P
Boundary Top					1510	2376	95.4						97.8	<input checked="" type="checkbox"/> 22	<input type="checkbox"/>
R_Date P1		1491	1664	95.4	1481	1656	95.4		97.6				99.6	<input checked="" type="checkbox"/> 21	<input type="checkbox"/>
Boundary T2					1205	1431	95.4						99.4	<input checked="" type="checkbox"/> 20	<input type="checkbox"/>
R_Date P2		1175	1299	95.4	1180	1300	95.4		100.9				99.7	<input checked="" type="checkbox"/> 19	<input type="checkbox"/>
Boundary T3-4					627	824	95.4						99.2	<input checked="" type="checkbox"/> 18	<input type="checkbox"/>
R_Date P3		616	771	95.4	618	774	95.4		98.7				99.8	<input checked="" type="checkbox"/> 17	<input type="checkbox"/>
Boundary T5					84	674	95.4						98.6	<input checked="" type="checkbox"/> 16	<input type="checkbox"/>
▶ Year-1871					79	80	95.4						100	<input checked="" type="checkbox"/> 13	<input type="checkbox"/>
Boundary T7-T8					41	83	95.4						98.3	<input checked="" type="checkbox"/> 12	<input type="checkbox"/>
R_Date P5		-1451	-1081	95.4	-1355	-973	95.4		62.3				99.2	<input checked="" type="checkbox"/> 11	<input type="checkbox"/>
Boundary T9					-1833	-1258	95.4						98.5	<input checked="" type="checkbox"/> 10	<input type="checkbox"/>
Boundary T10					-1917	-1353	95.4						98.3	<input checked="" type="checkbox"/> 9	<input type="checkbox"/>
R_Date P7		-2176	-1921	95.4	-2220	-1958	95.4		90				99.4	<input checked="" type="checkbox"/> 8	<input type="checkbox"/>
Boundary T11-16					-4547	-2971	95.4						96.4	<input checked="" type="checkbox"/> 7	<input type="checkbox"/>
R_Date PS_2		-4849	-4620	95.4	-4836	-4607	95.4		98.2				99.6	<input checked="" type="checkbox"/> 6	<input type="checkbox"/>
R_Date S1_1		-5511	-5312	95.4	-5508	-5311	95.4		99.3				99.3	<input checked="" type="checkbox"/> 5	<input type="checkbox"/>
Boundary Bottom					-6000	-5409	95.4						95.9	<input checked="" type="checkbox"/> 4	<input type="checkbox"/>
▲ P_Sequence CALA-20														<input checked="" type="checkbox"/> 3	<input type="checkbox"/>
Curve Marine09														<input checked="" type="checkbox"/> 2	<input type="checkbox"/>

SM4 – Age modelling results for core CALA-20. Turbidite age distributions at 2σ are modelled from their stratigraphic depth of emplacement into the background sequence. The Oxcal software derives the sedimentation rate from a modelled time-depth curve for the dated hemipelagic sediments and finds mathematically a representative set of possible ages for each event point in the sedimentary sequence.

SM5 – Turbidite emplacement time windows for core CALA-10 derived through Oxcal age modeling (k=3).

Name	Unmodelled (BC/AD)			Modelled (BC/AD)			Indices				Select	Page break			
	from	to	%	from	to	%	A _{model} =101.2	A _{overall} =101.2	A _{comb}	A			L	P	C
Boundary Top				702	3303	95.4							97.9	<input checked="" type="checkbox"/> 23	<input type="checkbox"/>
Boundary T3-4				666	963	95.4							99.5	<input checked="" type="checkbox"/> 22	<input type="checkbox"/>
R_Date P2	653	802	95.4	650	800	95.4			100.6				99.8	<input checked="" type="checkbox"/> 21	<input type="checkbox"/>
Boundary T5				77	247	95.4							97.5	<input checked="" type="checkbox"/> 20	<input type="checkbox"/>
▶ Year-1871				79	80	95.4							100	<input checked="" type="checkbox"/> 17	<input type="checkbox"/>
R_Date P3	-550	-360	95.4	-541	-361	95.4			101.8				99.6	<input checked="" type="checkbox"/> 16	<input type="checkbox"/>
Boundary T7-T8				-1305	-552	95.4							99.3	<input checked="" type="checkbox"/> 15	<input type="checkbox"/>
R_Date P4	-1418	-1223	95.4	-1420	-1225	95.4			100.3				99.8	<input checked="" type="checkbox"/> 14	<input type="checkbox"/>
Boundary T9-T10				-2713	-1509	95.4							98.4	<input checked="" type="checkbox"/> 13	<input type="checkbox"/>
R_Date P5	-2816	-2487	95.4	-2767	-2481	95.4			100.6				99.5	<input checked="" type="checkbox"/> 12	<input type="checkbox"/>
Boundary T11-T15				-4121	-2579	95.4							98.6	<input checked="" type="checkbox"/> 11	<input type="checkbox"/>
Boundary T16				-4543	-3077	95.4							98.8	<input checked="" type="checkbox"/> 10	<input type="checkbox"/>
R_Date S1_2	-4605	-4347	95.4	-4605	-4349	95.4			99.7				99.8	<input checked="" type="checkbox"/> 9	<input type="checkbox"/>
Boundary T17				-5494	-4366	95.4							98.7	<input checked="" type="checkbox"/> 8	<input type="checkbox"/>
Boundary T18				-7232	-4555	95.4							99	<input checked="" type="checkbox"/> 7	<input type="checkbox"/>
Boundary T19				-7866	-5337	95.4							98.2	<input checked="" type="checkbox"/> 6	<input type="checkbox"/>
R_Date S1_1	-7946	-7596	95.4	-7942	-7592	95.4			99.8				99.3	<input checked="" type="checkbox"/> 5	<input type="checkbox"/>
Boundary Bottom				-8006	-7603	95.4							97.8	<input checked="" type="checkbox"/> 4	<input type="checkbox"/>
▲ P_Sequence CALA-10														<input checked="" type="checkbox"/> 3	<input type="checkbox"/>
Curve Marine09														<input checked="" type="checkbox"/> 2	<input type="checkbox"/>

SM5 – Age modelling results for core CALA-10. Turbidite age distributions at 2σ are modelled from their stratigraphic depth of emplacement into the background sequence. The Oxcal software derives the sedimentation rate from a modelled time-depth curve for the dated hemipelagic sediments and finds mathematically a representative set of possible ages for each event point in the sedimentary sequence.

SM6 – Comparison between turbidite emplacement time windows for core CALA-20 derived through Oxcal age modeling with k=3 (above) and k=1(below).

Name	Unmodelled (BC/AD)			Modelled (BC/AD)			Indices			Select	Page break						
	from	to	%	from	to	%	A _{model} =78	A _{overall} =78.8	A _{comb}			A	L	P	C		
Boundary Top				1510	2376	95.4								97.8	<input checked="" type="checkbox"/>	22	<input type="checkbox"/>
R_Date P1	1491	1664	95.4	1481	1656	95.4				97.6				99.6	<input checked="" type="checkbox"/>	21	<input type="checkbox"/>
Boundary T2				1205	1431	95.4								99.4	<input checked="" type="checkbox"/>	20	<input type="checkbox"/>
R_Date P2	1175	1299	95.4	1180	1300	95.4				100.9				99.7	<input checked="" type="checkbox"/>	19	<input type="checkbox"/>
Boundary T3-4				627	824	95.4								99.2	<input checked="" type="checkbox"/>	15	<input type="checkbox"/>
R_Date P3	616	771	95.4	618	774	95.4				98.7				99.8	<input checked="" type="checkbox"/>	17	<input type="checkbox"/>
Boundary T5				84	674	95.4								98.6	<input checked="" type="checkbox"/>	16	<input type="checkbox"/>
▶ Year-1871				79	80	95.4								100	<input checked="" type="checkbox"/>	13	<input type="checkbox"/>
Boundary T7-T8				41	83	95.4								98.3	<input checked="" type="checkbox"/>	12	<input type="checkbox"/>
R_Date P5	-1451	-1081	95.4	-1355	-973	95.4				62.3				99.2	<input checked="" type="checkbox"/>	11	<input type="checkbox"/>
Boundary T9				-1833	-1258	95.4								98.5	<input checked="" type="checkbox"/>	10	<input type="checkbox"/>
Boundary T10				-1917	-1353	95.4								98.3	<input checked="" type="checkbox"/>	9	<input type="checkbox"/>
R_Date P7	-2176	-1921	95.4	-2220	-1958	95.4				90				99.4	<input checked="" type="checkbox"/>	8	<input type="checkbox"/>
Boundary T11-16				-4547	-2971	95.4								96.4	<input checked="" type="checkbox"/>	7	<input type="checkbox"/>
R_Date PS_2	-4849	-4620	95.4	-4836	-4607	95.4				98.2				99.6	<input checked="" type="checkbox"/>	6	<input type="checkbox"/>
R_Date S1_1	-5511	-5312	95.4	-5508	-5311	95.4				99.3				99.3	<input checked="" type="checkbox"/>	5	<input type="checkbox"/>
Boundary Bottom				-6000	-5409	95.4								95.9	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>
▲ P_Sequence CALA-20															<input checked="" type="checkbox"/>	3	<input type="checkbox"/>
Curve Marine09															<input checked="" type="checkbox"/>	2	<input type="checkbox"/>

Name	Unmodelled (BC/AD)			Modelled (BC/AD)			Indices			Select	Page break						
	from	to	%	from	to	%	A _{model} =94.3	A _{overall} =94.3	A _{comb}			A	L	P	C		
Boundary Top				1484	2412	95.4								99.5	<input checked="" type="checkbox"/>	22	<input type="checkbox"/>
R_Date P1	1491	1664	95.4	1483	1657	95.4				98.1				99.9	<input checked="" type="checkbox"/>	21	<input type="checkbox"/>
Boundary T2				1190	1525	95.4								99.8	<input checked="" type="checkbox"/>	20	<input type="checkbox"/>
R_Date P2	1175	1299	95.4	1178	1300	95.4				100.7				99.9	<input checked="" type="checkbox"/>	19	<input type="checkbox"/>
Boundary T3-4				616	856	95.4								99.5	<input checked="" type="checkbox"/>	18	<input type="checkbox"/>
R_Date P3	616	771	95.4	618	774	95.4				98.9				99.8	<input checked="" type="checkbox"/>	17	<input type="checkbox"/>
Boundary T5				88	676	95.4								99.4	<input checked="" type="checkbox"/>	16	<input type="checkbox"/>
▶ Year-1871				79	80	95.4								100	<input checked="" type="checkbox"/>	13	<input type="checkbox"/>
Boundary T7-T8				-386	83	95.4								97.6	<input checked="" type="checkbox"/>	12	<input type="checkbox"/>
R_Date P5	-1451	-1081	95.4	-1412	-1033	95.4				99.2				99.8	<input checked="" type="checkbox"/>	11	<input type="checkbox"/>
Boundary T9				-1902	-1196	95.4								99.8	<input checked="" type="checkbox"/>	10	<input type="checkbox"/>
Boundary T10				-2067	-1376	95.4								99.7	<input checked="" type="checkbox"/>	9	<input type="checkbox"/>
R_Date P7	-2176	-1921	95.4	-2192	-1938	95.4				98.5				99.9	<input checked="" type="checkbox"/>	8	<input type="checkbox"/>
Boundary T11-16				-4612	-2160	95.4								99	<input checked="" type="checkbox"/>	7	<input type="checkbox"/>
R_Date PS_2	-4849	-4620	95.4	-4844	-4616	95.4				99.9				99.8	<input checked="" type="checkbox"/>	6	<input type="checkbox"/>
R_Date S1_1	-5511	-5312	95.4	-5505	-5309	95.4				98.9				99.9	<input checked="" type="checkbox"/>	5	<input type="checkbox"/>
Boundary Bottom				-6193	-5335	95.4								98.5	<input checked="" type="checkbox"/>	4	<input type="checkbox"/>
▲ P_Sequence CALA-20															<input checked="" type="checkbox"/>	3	<input type="checkbox"/>
Curve Marine09															<input checked="" type="checkbox"/>	2	<input type="checkbox"/>

References:

- Bronk Ramsey, C., 2008. Deposition models for chronological records. *Quaternary Science Reviews* 27, 42-60.
- Reimer, P. J., Baillie, M. G. L., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Burr, G. S., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., McCormac, F. G., Manning, S. W., Reimer, R. W., Richards, D. A., Southon, J. R., Talamo, S., Turney, C. S. M., van der Plicht, J., & Weyhenmeyer, C. E. , 2009. IntCal09 and Marine09 radiocarbon age calibration curves, 0-50,000 years cal BP. *Radiocarbon*, 51(4), 1111–1150.