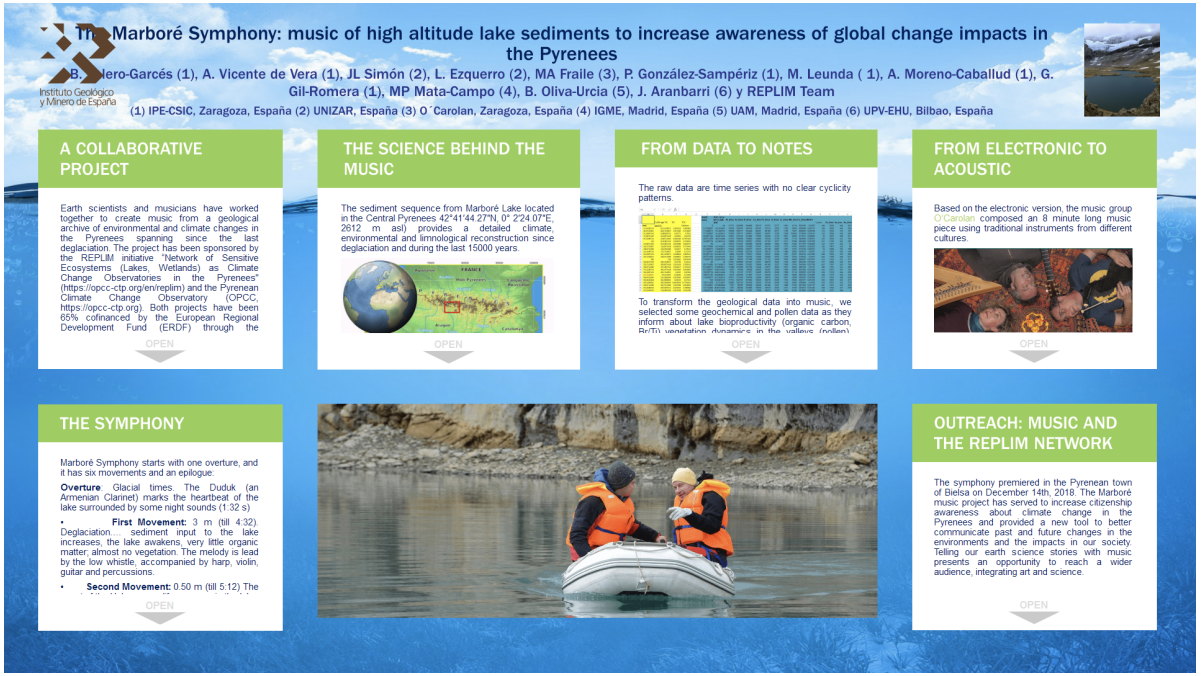
The Marboré Symphony: music of high altitude lake sediments to increase awareness of global change impacts in the Pyrenees



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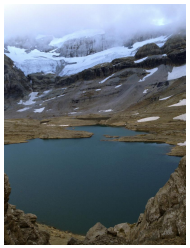
(1) IPE-CSIC, Zaragoza, España (2) UNIZAR, España (3) O´Carolan, Zaragoza, España (4) IGME, Madrid, España (5) UAM, Madrid, España (6) UPV-EHU, Bilbao, España

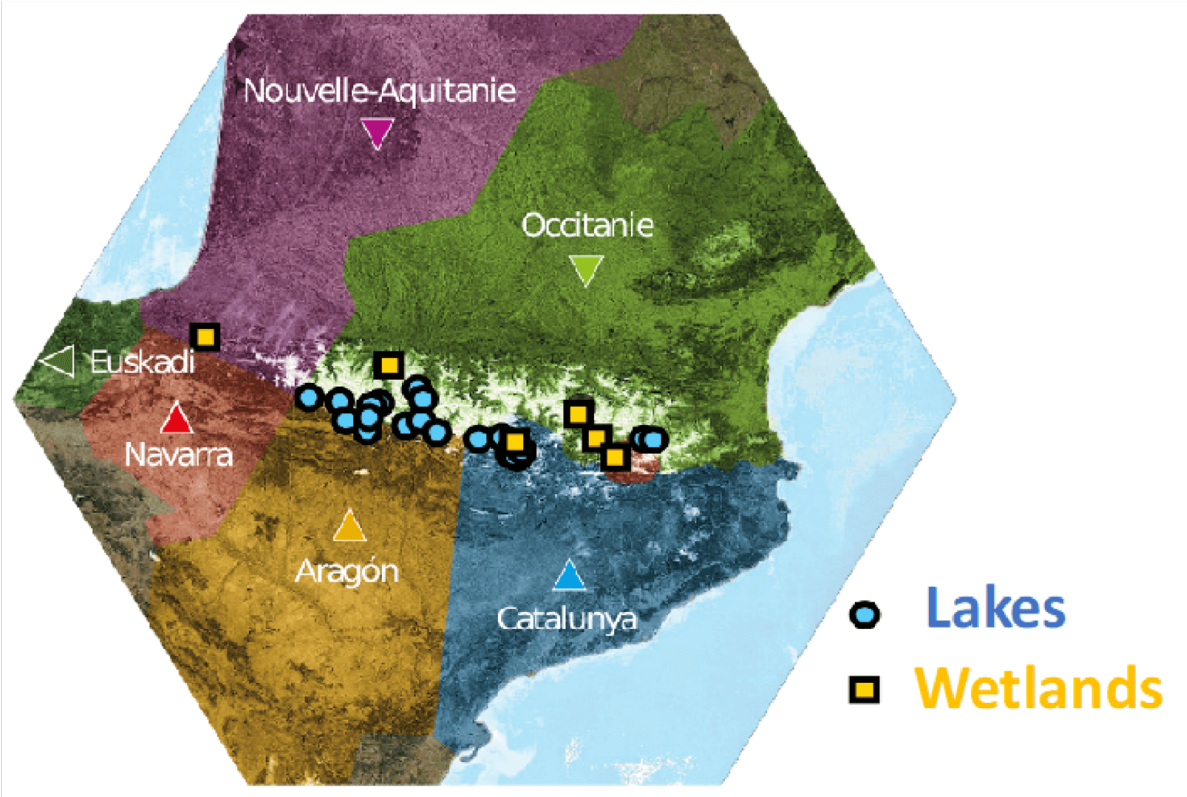


PRESENTED AT:

A COLLABORATIVE PROJECT

Earth scientists and musicians have worked together to create music from a geological archive of environmental and climate changes in the Pyrenees spanning since the last deglaciation. The project has been sponsored by the REPLIM initiative “Network of Sensitive Ecosystems (Lakes, Wetlands) as Climate Change Observatories in the Pyrenees" (https://opcc-ctp.org/en/replim) and the Pyrenean Climate Change Observatory (OPCC, https://opcc-ctp.org). Both projects have been 65% cofinanced by the European Regional Development Fund (ERDF) through the INTERREG V-A Spain France Andorra programme (POCTEFA 2014-2020).

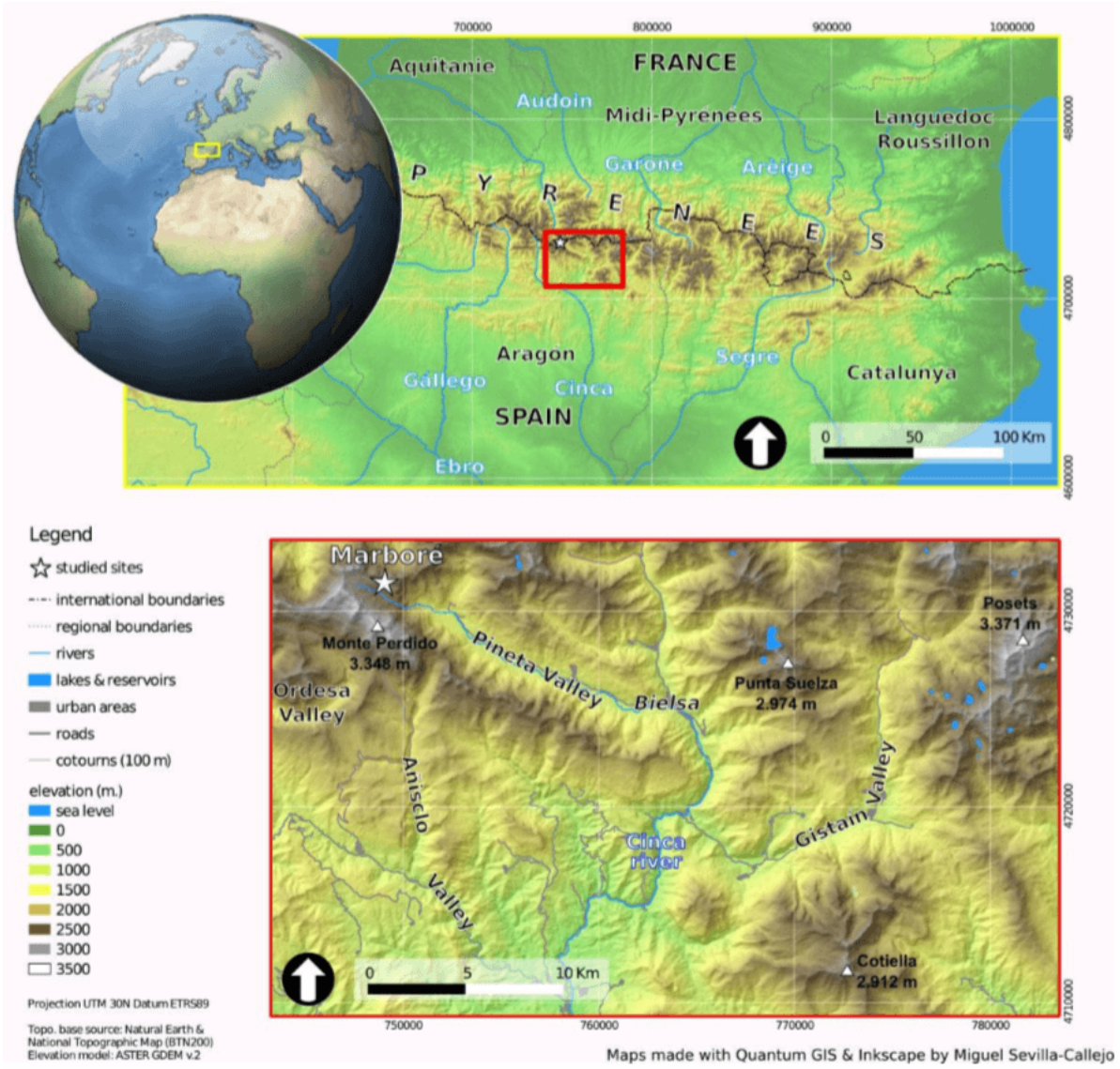
Our goals are to create new materials to improve the networking among scientists, managers, citizens to better convey science, and particularly to educate the public about the concepts of Time and Change, to increase awareness about Climate Change and Human impact in mountain regions and to foster the involvement of citizens living in the territory close to the REPLIM network sites.



Visit the official project web page at www.opcc-ctp.org/replim (http://www.opcc-ctp.org/replim)

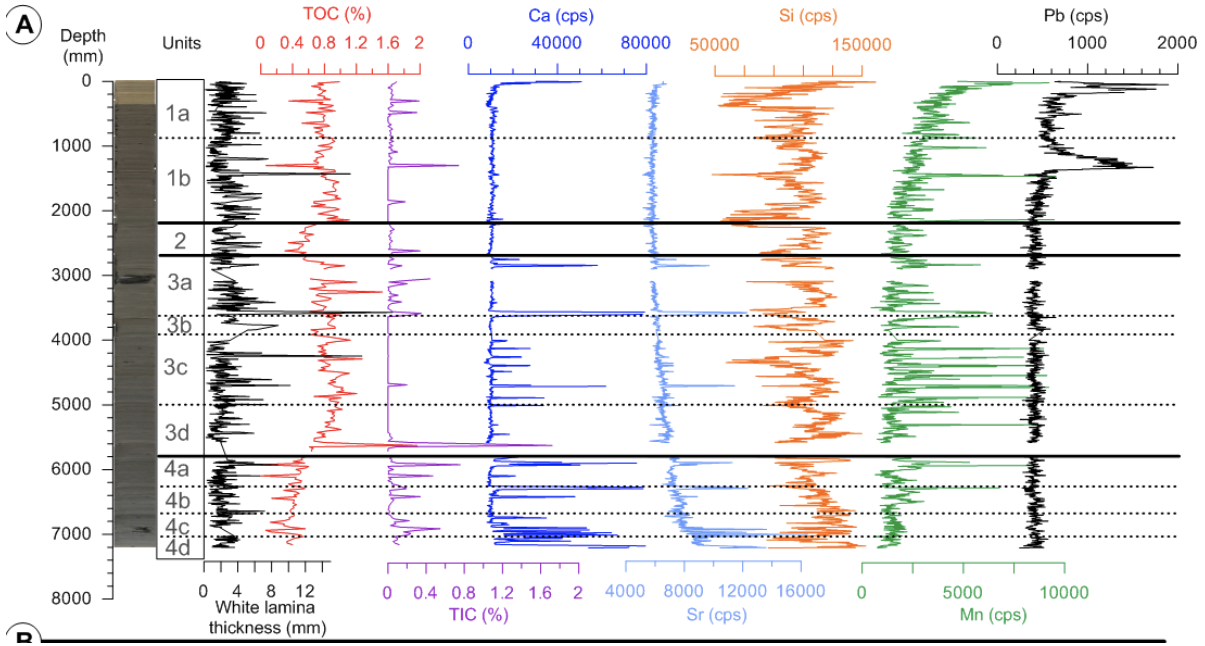
THE SCIENCE BEHIND THE MUSIC

The sediment sequence from Marboré Lake located in the Central Pyrenees 42°41′44.27″N, 0° 2′24.07″E, 2612 m asl) provides a detailed climate, environmental and limnological reconstruction since deglaciation and during the last 15000 years.

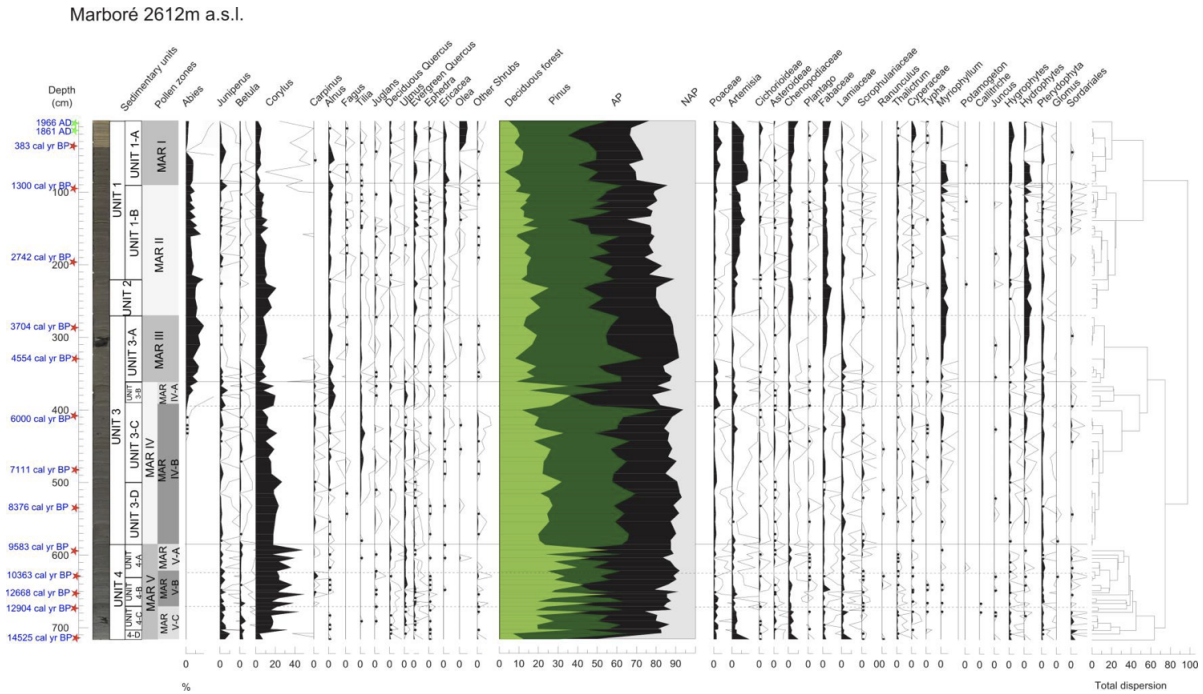


For details, please read our papers: Leunda et al., 2017; Oliva et al., 2018.

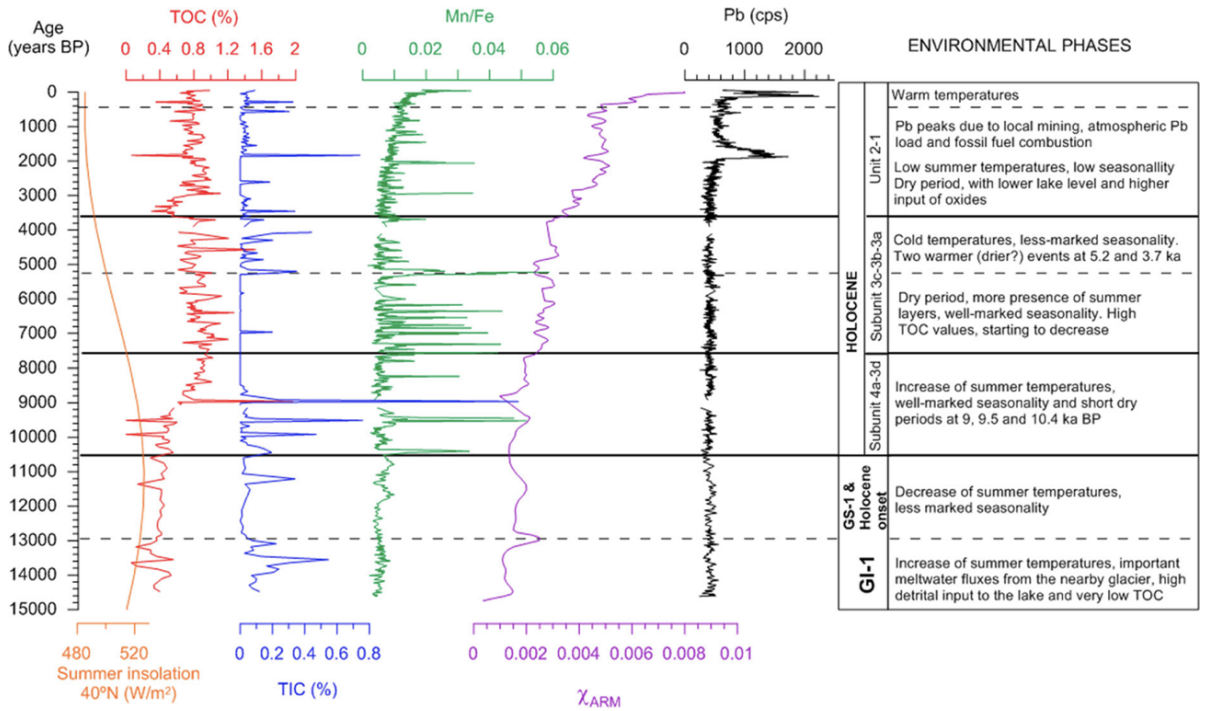
Here there is a summary of the geochemical and sedimentological data for the 7 m long core:



And here the pollen diagram:



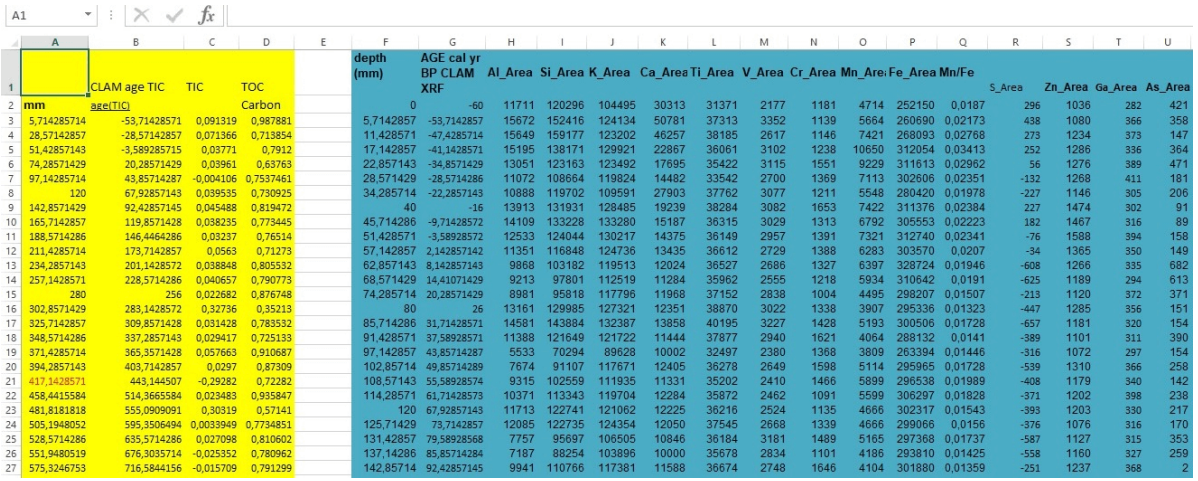
And finally, a summary of Marboré history for the last 15000 years:



Check out this video (https://www.youtube.com/watch?v=l-bBjLxrdi8&fs=1&modestbranding=1&rel=0&showinfo=0) about the Ordesa – Monte Perdido National Park in the Pyrenees and our work in Marboré (from 14:37 – 17:55 min)

FROM DATA TO NOTES

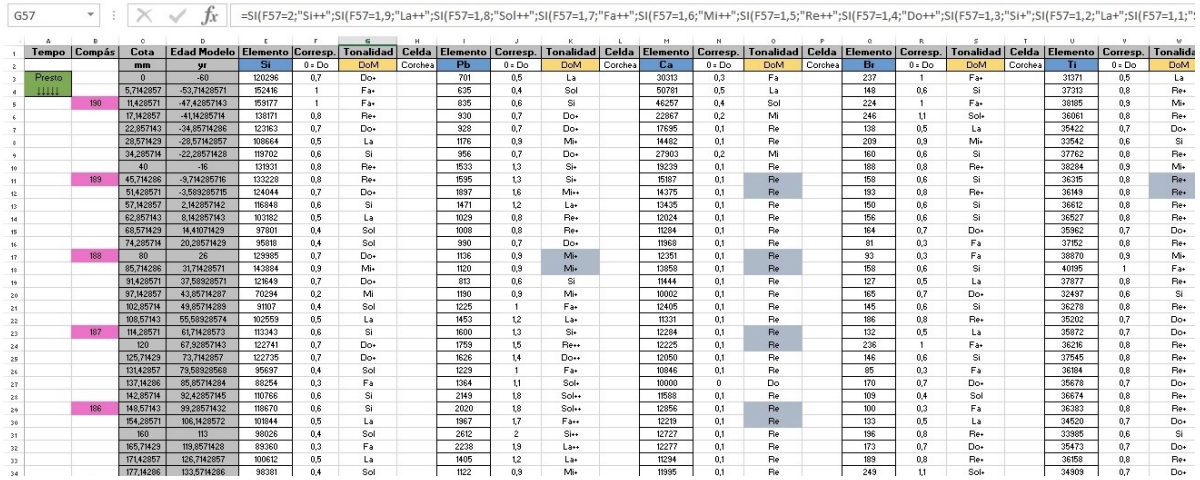
The raw data are time series with no clear cyclicity patterns.



	A	B	C	D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1		CLAM age	TIC	TOC	depth (mm)	AGE cal yr BP CLAM XRF	Al_Area	Si_Area	K_Area	Ca_Area	Ti_Area	V_Area	Cr_Area	Mn_Area	Fe_Area	Mn/Fe	S_Area	Zn_Area	Ga_Area	As_Area
2	mm	age(TIC)		Carbon																
3	5,7142857	-53,71428571	0,091319	0,987881	0	-60	11711	120296	104495	30313	31371	2177	1181	4714	252150	0,0187	296	1036	282	421
4	28,57142857	-28,57142857	0,071366	0,713854	5,7142857	-53,7142857	15672	152416	124134	50781	37313	3352	1139	5664	260690	0,02173	438	1080	366	358
5	51,42857143	-3,589285715	0,03771	0,7912	11,428571	-47,4285714	15649	159177	123202	46257	38185	2617	1146	7421	268093	0,02768	273	1234	373	147
6	74,28571429	20,28571429	0,03961	0,63763	17,142857	-41,1428571	15195	138171	129921	22867	36061	3102	1238	10650	312054	0,03413	252	1286	336	364
7	97,14285714	43,85714287	-0,004106	0,7537461	22,857143	-34,8571429	13051	123163	123492	17695	35422	3115	1551	9229	311613	0,02962	56	1276	389	471
8	120	67,92857143	0,039535	0,730925	28,571429	-28,5714286	11072	108664	119824	14482	33542	2700	1369	7113	302606	0,02351	-132	1268	411	181
9	142,8571429	92,42857145	0,045488	0,819472	34,285714	-22,2857143	10888	119702	109591	27903	37762	3077	1211	5548	280420	0,01978	-227	1146	305	206
10	165,7142857	119,8571428	0,038235	0,773445	40	-16	13913	131931	128485	19239	38284	3082	1653	7422	311376	0,02384	227	1474	302	91
11	188,5714286	146,4464286	0,03237	0,76514	45,714286	-9,71428572	14109	133228	133280	15187	36315	3029	1313	6792	305553	0,02223	182	1467	316	89
12	211,4285714	173,7142857	0,0563	0,71273	51,428571	-3,58928572	12533	124044	130217	14375	36149	2957	1391	7321	312740	0,02341	-76	1588	394	158
13	234,2857143	201,1428572	0,038848	0,805532	57,142857	2,142857142	11351	116848	124736	13435	36612	2729	1388	6283	303570	0,0207	-34	1365	350	149
14	257,1428571	228,5714286	0,040657	0,790773	62,857143	8,142857143	9868	103182	119513	12024	36527	2686	1327	6397	328724	0,01946	-608	1266	335	682
15	280	256	0,022682	0,876748	68,571429	14,41071429	9213	97801	112519	11284	35962	2555	1218	5934	310642	0,0191	-625	1189	294	613
16	302,8571429	283,1428572	0,32736	0,35213	74,285714	20,28571429	8981	95818	117796	11968	37152	2838	1004	4495	298207	0,01507	-213	1120	372	371
17	325,7142857	309,8571428	0,031428	0,783532	80	26	13161	129985	127321	12351	38870	3022	1338	3907	295336	0,01323	-447	1285	356	151
18	348,5714286	337,2857143	0,029417	0,725133	85,714286	31,71428571	14581	143884	132387	13858	40195	3227	1428	5193	300506	0,01728	-657	1181	320	154
19	371,4285714	365,3571428	0,057663	0,910687	91,428571	37,58928571	11388	121649	121722	11444	37877	2940	1621	4064	288132	0,0141	-389	1101	311	390
20	394,2857143	403,7142857	0,0297	0,87309	97,142857	43,85714287	5533	70294	89628	10002	32497	2380	1368	3809	263394	0,01446	-316	1072	297	154
21	417,1428571	443,144507	-0,29282	0,72282	102,85714	49,85714289	7674	91107	117671	12405	36278	2649	1598	5114	295965	0,01728	-539	1310	366	258
22	458,4415584	514,3665584	0,023483	0,935847	108,57143	55,58928574	9315	102559	111935	11331	35202	2410	1466	5899	296538	0,01989	-408	1179	340	142
23	481,8181818	555,0909091	0,30319	0,57141	114,28571	61,71428573	10371	113343	119704	12284	35872	2462	1091	5599	306297	0,01828	-371	1202	398	238
24	505,1948052	595,3506494	0,0033949	0,7734851	120	67,92857143	11713	122741	121062	12225	36216	2524	1135	4666	302317	0,01543	-393	1203	330	217
25	528,5714286	635,5714286	0,027098	0,810602	125,71429	73,7142857	12085	122735	124354	12050	37545	2668	1339	4666	299066	0,0156	-376	1076	316	170
26	551,9480519	676,3035714	-0,025352	0,780962	131,42857	79,58928568	7757	95697	106505	10846	36184	3181	1489	5165	297368	0,01737	-587	1127	315	353
27	575,3246753	716,5844156	-0,015709	0,791299	137,14286	85,85714284	7187	88254	103896	10000	35678	2834	1101	4186	293810	0,01425	-558	1160	327	259
					142,85714	92,42857145	9941	110766	117381	11588	36674	2748	1646	4104	301880	0,01359	-251	1237	368	2

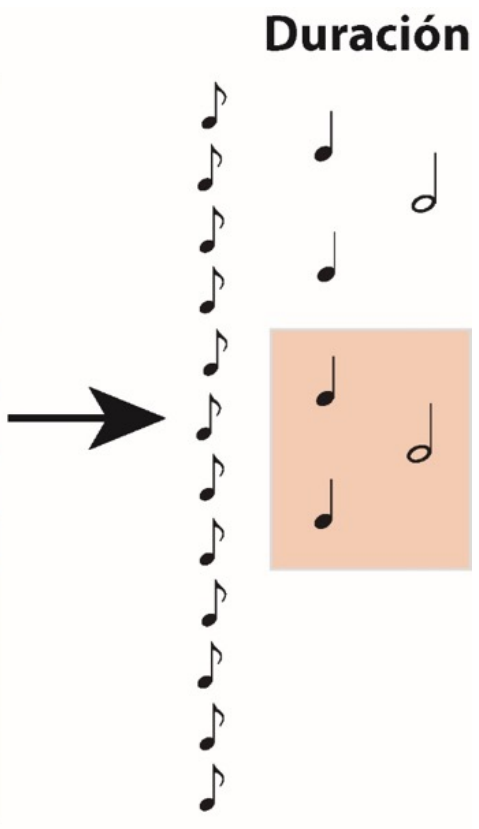
To transform the geological data into music, we selected some geochemical and pollen data as they inform about lake bioproductivity (organic carbon, Br/Ti) vegetation dynamics in the valleys (pollen), sediment influx (Si/Ti) and anthropogenic impact (Pb/Ti).

For the geochemical data, notes were assigned to compositional range intervals.



Tempo	Compás	Cota	Edad Modelo	Elemento	Corresp.	Tonalidad	Celda	Elemento	Corresp.	Tonalidad	Celda	Elemento	Corresp.	Tonalidad	Celda	Elemento	Corresp.	Tonalidad	Celda	Elemento	Corresp.	Tonalidad
		mm	yr	Si	0 = Do	DoM	Corchea	Pb	0 = Do	DoM	Corchea	Ca	0 = Do	DoM	Corchea	Br	0 = Do	DoM	Corchea	Ti	0 = Do	DoM
Presto		0	-60	120296	0,7	Do+		701	0,5	La		30313	0,3	Fa		237	1	Fa+		31371	0,5	La
↓↓↓↓		5,7142857	-53,71428571	152416	1	Fa+		635	0,4	Sol		50781	0,5	La		148	0,6	Si		37313	0,8	Re+
	190	11,428571	-47,42857143	159177	1	Fa+		835	0,6	Si		46257	0,4	Sol		224	1	Fa+		38185	0,9	Mi+
		17,142857	-41,14285714	138171	0,8	Re+		930	0,7	Do+		22867	0,2	Mi		246	1,1	Sol+		36061	0,8	Re+
		22,857143	-34,85714286	123163	0,7	Do+		928	0,7	Do+		17695	0,1	Re		138	0,5	La		35422	0,7	Do+
		28,571429	-28,57142857	108664	0,5	La		1176	0,9	Mi+		14482	0,1	Re		209	0,9	Mi+		33542	0,8	Si
		34,285714	-22,28571428	119702	0,8	Si		956	0,7	Do+		27903	0,2	Mi		160	0,6	Si		37762	0,8	Re+
		40	-16	131931	0,8	Re+		1533	1,3	Si+		19239	0,1	Re		188	0,8	Re+		38284	0,9	Mi+
	189	45,714286	-9,714285715	133228	0,8	Re+		1595	1,3	Si+		15187	0,1	Re		158	0,6	Si		36315	0,8	Re+
		51,428571	-3,589285715	124044	0,7	Do+		1897	1,6	Mi++		14375	0,1	Re		193	0,8	Re+		36149	0,8	Re+
		57,142857	2,142857142	116848	0,6	Si		1471	1,2	La+		13435	0,1	Re		150	0,6	Si		36612	0,8	Re+
		62,857143	8,142857143	103182	0,5	La		1029	0,8	Re+		12024	0,1	Re		156	0,6	Si		36527	0,8	Re+
		68,571429	14,41071429	97801	0,4	Sol		1008	0,8	Re+		11284	0,1	Re		164	0,7	Do+		35962	0,7	Do+
		74,285714	20,28571429	95818	0,4	Sol		990	0,7	Do+		11968	0,1	Re		81	0,3	Fa		37152	0,8	Re+
	188	80	26	129385	0,7	Do+		1136	0,9	Mi+		12351	0,1	Re		93	0,3	Fa		38870	0,9	Mi+
		85,714286	31,71428571	143884	0,9	Mi+		1120	0,9	Mi+		13858	0,1	Re		158	0,6	Si		40195	1	Fa+
		91,428571	37,58928571	121649	0,7	Do+		813	0,6	Si		11444	0,1	Re		127	0,5	La		37877	0,8	Re+
		97,142857	43,85714287	70294	0,2	Mi		1190	0,9	Mi+		10002	0,1	Re		165	0,7	Do+		32497	0,6	Si
		102,85714	49,85714289	91107	0,4	Sol		1225	1	Fa+		12405	0,1	Re		145	0,6	Si		36278	0,8	Re+
		108,57143	55,58928574	102559	0,5	La		1453	1,2	La+		11331	0,1	Re		186	0,8	Re+		35202	0,7	Do+
	187	114,28571	61,71428573	113343	0,6	Si		1600	1,3	Si+		12284	0,1	Re		132	0,5	La		35872	0,7	Do+
		120	67,92857143	122741	0,7	Do+		1759	1,5	Re++		12225	0,1	Re		236	1	Fa+		36216	0,8	Re+
		125,71429	73,7142857	122735	0,7	Do+		1626	1,4	Do++		12050	0,1	Re		146	0,6	Si		37545	0,8	Re+
		131,42857	79,58928568	95697	0,4	Sol		1229	1	Fa+		10846	0,1	Re		85	0,3	Fa		36184	0,8	Re+
		137,14286	85,85714284	88254	0,3	Fa		1364	1,1	Sol+		10000	0	Do		170	0,7	Do+		35678	0,7	Do+
		142,85714	92,42857145	110766	0,6	Si		2149	1,8	Sol++		11588	0,1	Re		109	0,4	Sol		36674	0,8	Re+
	186	148,57143	99,28571432	118670	0,6	Si		2020	1,8	Sol++		12856	0,1	Re		100	0,3	Fa		36383	0,8	Re+
		154,28571	106,1428572	101844	0,5	La		1967	1,7	Fa++		12219	0,1	Re		133	0,5	La		34520	0,7	Do+
		160	113	98026	0,4	Sol		2612	2	Si++		12727	0,1	Re		196	0,8	Re+		33985	0,6	Si
		165,71429	119,8571428	89360	0,3	Fa		2238	1,9	La++		12277	0,1	Re		173	0,7	Do+		35473	0,7	Do+
		171,42857	126,7142857	100612	0,5	La		1405	1,2	La+		11294	0,1	Re		189	0,8	Re+		36158	0,8	Re+
		177,14286	133,5714286	98381	0,4	Sol		1122	0,9	Mi+		11995	0,1	Re		249	1,1	Sol+		34909	0,7	Do+

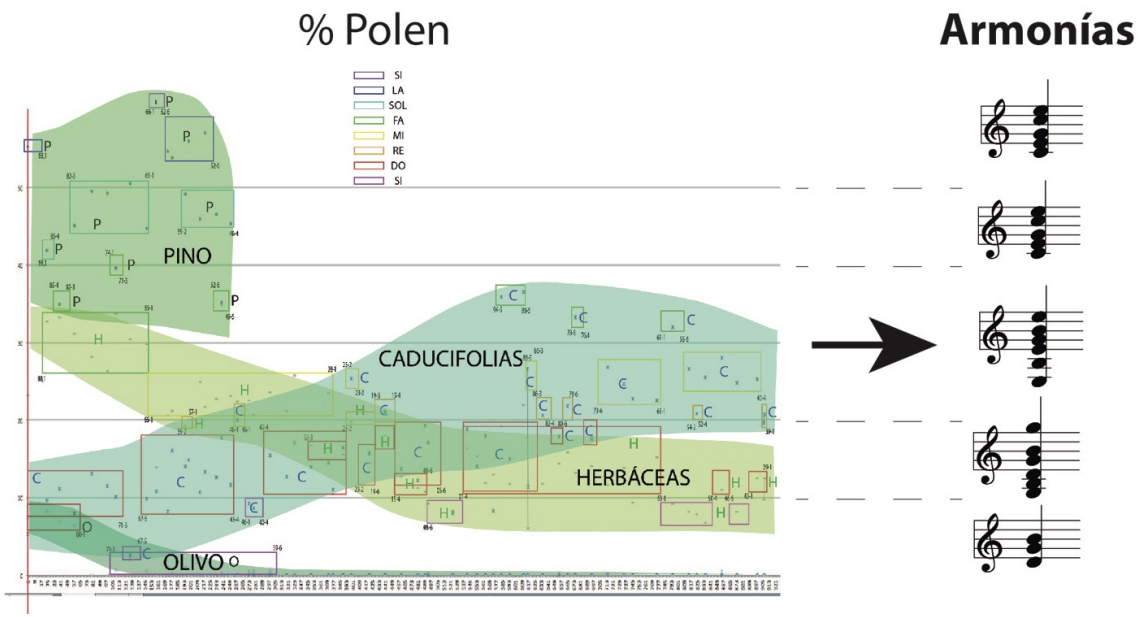
Elem. (ppm)	*Código*	Notación
0,876	0,1	Do
0,890	0,1	Do
0,764	0,1	Do
0,472	0,1	Do
0,968	0,1	Do
0,247	0,1	Do
0,893	0,1	Do
0,540	0,1	Do
3,682	0,4	Si
2,783	0,3	Sol
1,520	0,2	Mi
0,739	0,1	Do



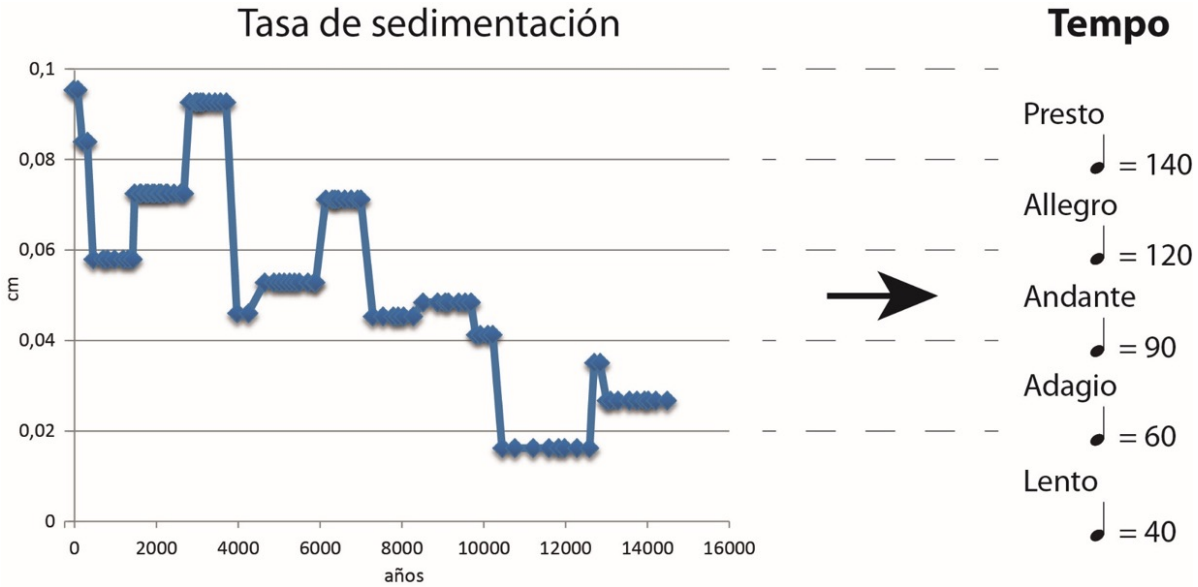
Different melodies and instruments were assigned at each data set. For example, cello (Ti) and double bass (Ca) are used for sediments representing a cool period, while cello (Ti) and violin (Br) play during warm intervals. The silicon (Si) is represented by woodwind instruments, with a piccolo taking the melody in warmer periods, a bassoon in cooler intervals, and a flute in intermediate conditions. The anthropogenic influence represented by the presence of Pb (Roman metallurgy and Industrial Revolution) is marked by the metallic sound of tubular bells.

Data	Variable	Instruments
Si	Sediment influx	**Woodwinds** Flute (intermediate) Piccolo (warmer) Bassoon (cooler)
Br	Warmer periods	**Strings**: Violin
Ti	Cooler periods	**Strings**: Cello
Ca	Cooler periods	**Strings**: Double Bass
TOC	Bioproductivity	**Percussions**: Taiko
TIC	Bioproductivity	**Percussions**: Timpani
Pb	Anthropic influence	**Bells**
Pollen	Vegetation	**Keyboards**

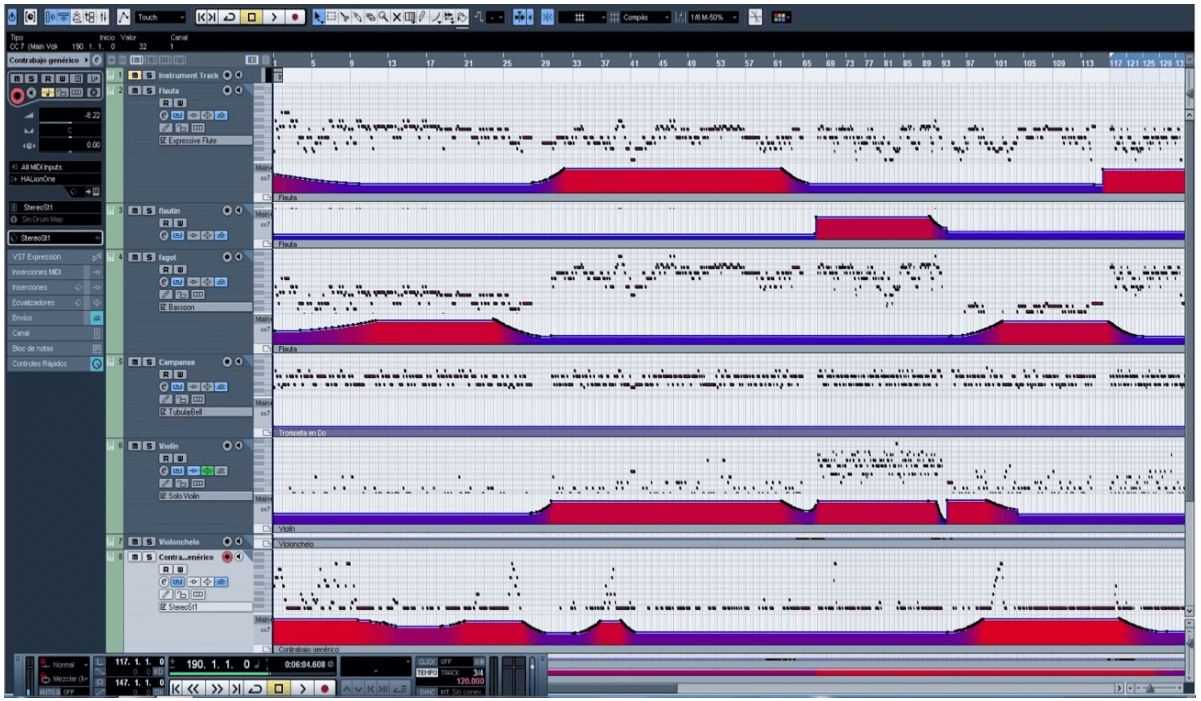
Pollen provide the chords for the harmonies as the background for the melody. Each pollen group represents a chord and each % range within a trend is ascribed to a musical note played by keyboards and organs.



The tempos were defined using sediment accumulation rates.

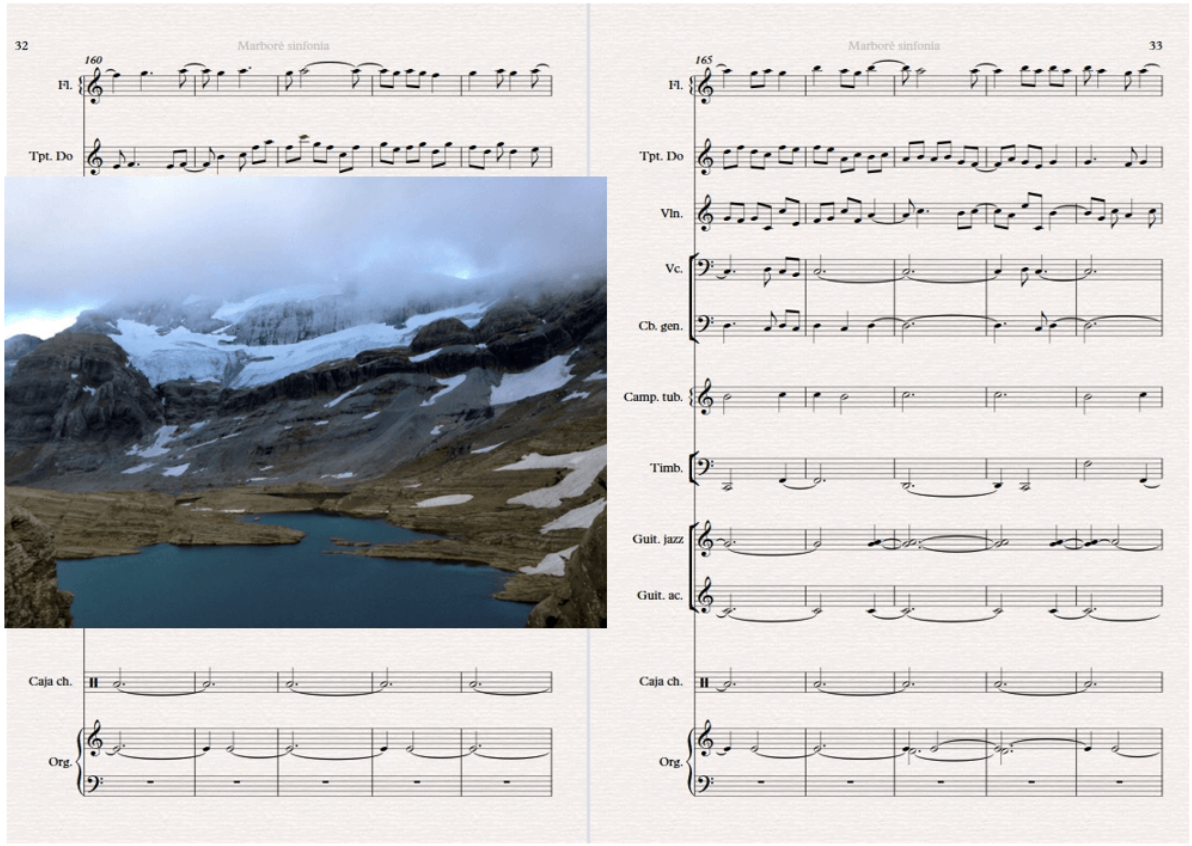


The electronic version of the Marbore Symphony was created by computer software based on the raw data (Fraile and Simón, 2015).



You can listen and download the electronic version of the Marboré Symphony here:

0:00 / 6:22


32
Marboré sinfonía
160
Fl.
Tpt. Do
Caja ch.
Org.
Marboré sinfonía
33
165
Fl.
Tpt. Do
Vln.
Vc.
Cb. gen.
Camp. tub.
Timb.
Guit. jazz
Guit. ac.
Caja ch.
Org.

FROM ELECTRONIC TO ACOUSTIC

Based on the electronic version, the music group O'Carolan (https://www.facebook.com/ocarolan?group_id=0)composed an 8 minute long music piece using traditional instruments from different cultures.

The following music samples show how well the acoustic version captures the raw data through the electronic version:

Sample 1: Glacial times before 12000 yrs BP

0:00 / 0:12

Sample 2: Onset of Neoglacial times around 5000 yrs BP

0:00 / 0:55

Sample 5: End of Neoglacial and onset of warmer times around 4000 years BP

0:00 / 0:22

Sample 6: Anthropocene

0:00 / 0:30

THE SYMPHONY

Marboré Symphony starts with one overture, and it has six movements and an epilogue:

Overture: Glacial times. The Duduk (an Armenian Clarinet) marks the heartbeat of the lake surrounded by some night sounds (1:32 s)

- **First Movement:** 3 m (till 4:32). Deglaciation.… sediment input to the lake increases, the lake awakens, very little organic matter; almost no vegetation. The melody is lead by the low whistle, accompanied by harp, violin, guitar and percussions.

- **Second Movement:** 0.50 m (till 5:12) The onset of the Holocene…. life prospers in the lake, warmer climate. Melody with the uilleann pipe (Irish wind pipe) and violin harp, guitar, percussion.

- **Third movement**: 0.40 minutes. (till 5:50) Life explodes… vegetation increases. Mid Holocene Optimum

- **Fourth movement**: 1 m (till 6:50) Neoglacial brings colder climate. Melody with violin and nykel harpa (Swedish violin)

- **Fifth movement:** 0.30 m (till 7:20) It is warmer again, and the flute comes back

- **Sixth movement.** 1:30 m (till 8:07) The last millennia: Warmer climates and more human impact indicated by mining (Roman times, then medieval, then 20th century) marked by the bells. Fast rhythms for a fast time. Human impact represented by the bells

Final movement...A modern instrument (piano) concludes the symphony and after listening to the long history of Marbore, with changes in climate and the recent human impact and warmer temperatures, the piano music seems to say: “Now it is up to you”.

Here (https://www.youtube.com/watch?v=rp2UeIour7o&t=0s&fs=1&modestbranding=1&rel=0&showinfo=0) you can listen the “Memory of Marboré”

0:00 / 8:30

and you can download it at http://www.ipe.csic.es/proyecto-replim (http://www.ipe.csic.es/proyecto-replim)

MARBORÉ

OUTREACH: MUSIC AND THE REPLIM NETWORK

The symphony premiered in the Pyrenean town of Bielsa on December 14th, 2018. The Marboré music project has served to increase citizenship awareness about climate change in the Pyrenees and provided a new tool to better communicate past and future changes in the environments and the impacts in our society. Telling our earth science stories with music presents an opportunity to reach a wider audience, integrating art and science.

Lessons learned:

• For scientists it is great to work with artists!

• They want to collaborate with us…

• It is easier… and more fun to talk to a general audience about Time, Global Change and Science with music

• Any sedimentary profile (also a non-cyclic or rhythmic one) can be translated into music choosing adequate criteria.

• Quaternary sequences are unique for music as they include time in “human” scales

• Villages, National Park managers and citizens have already used the Marboré Symphony for their own outreach and publicity needs.

DISCLOSURES

HAGA CLIC PARA INGRESAR CONTENIDO

CV

HAGA CLIC PARA INGRESAR CONTENIDO

ABSTRACT

Earth scientists and musicians have collaborated to create music to illustrate the changes in a high altitude (2612 m a.s.l) Pyrenean lake since deglaciation and to increase awareness about global changes in mountains environments. Based on the sediment sequence from Marboré Lake (42°41′44.27″N, 0° 2′24.07″E) we have selected lithological, compositional and pollen data to represent the main climate, environmental and limnological changes in the lake and the region during the last 15000 years. To transform the geological data into music, notes were assigned to compositional range intervals and the tempos were degned using sediment accumulation rates. The electronic version of the Marbore Symphony was created by computer software based on the raw data. Different melodies and instruments were assigned at each data set as they inform about lake bioproductivity (organic carbon, Br/Ti) vegetation dynamics in the valleys (pollen), sediment iniux (Si/Ti) and anthropogenic impact (Pb/Ti). Based on the electronic version, the music group O'Carolan (http://www.ocarolanfolk.com) composed an 8 minutes long symphony with an overture and six movements and using traditional instruments from different cultures. The symphony premiered in the Pyrenean town of Bielsa on December 14th, 2018.

The Marboré music project has served to increase citizenship awareness about climate change in the Pyrenees and provided a new tool to better communicate past and future changes in the environments and the impacts in our society. Telling our earth science stories with music presents an opportunity to reach a wider audience, integrating art and science. The creation of this music composition was undertaken within the framework of the REPLIM project, an INTERREG- POCTEFA – project aimed to develop a network of climate change observatories on lakes and wetlands in the Pyrenees.

You can download the Marboré Symphony at http://www.ipe.csic.es/proyecto-replim.

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