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The 4.2 ka cal BP major eruption of Cerro Blanco, Central Andes

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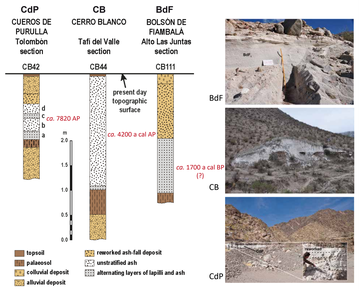
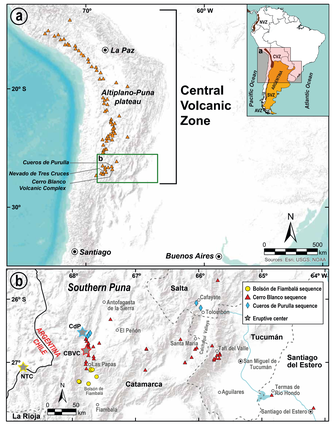
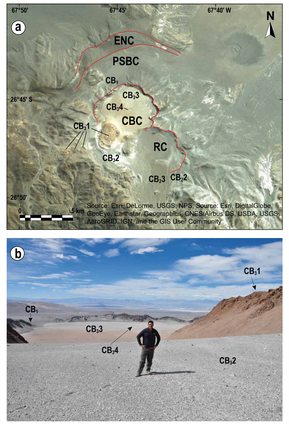
Introduction

The major eruption of the Cerro Blanco Volcanic Complex (CBVC), in the Central Volcanic Zone of the Andes, NW Argentina, dated at 4410–4150 a cal BP, is the most important of the three major Holocene felsic eruptive events identified in the southern Puna (Fernandez-Turiel et al., 2019).





(a) Holocene volcanic centres in the Andean Central Volcanic Zone (data from Global Volcanism Program); NVZ, Northern Volcanic Zone; CVZ, Central Volcanic Zone; SVZ, Southern Volcanic Zone; and AVZ, Austral Volcanic Zone. (b) Studied sections and eruptive centres (CdP, Cueros de Purulla; CBVC, Cerro Blanco Volcanic Complex; NTC, Nevado Tres Cruces).



(a) Cerro Blanco Volcanic Complex showing El Niño Caldera (ENC), Pie de San Buenaventura Caldera (PSBC), Robledo Caldera (RC), and Cerro Blanco Caldera (CBC); (b) stratigraphic units in the Cerro Blanco Volcanic Complex.

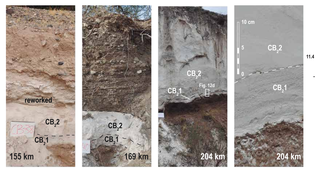
Results

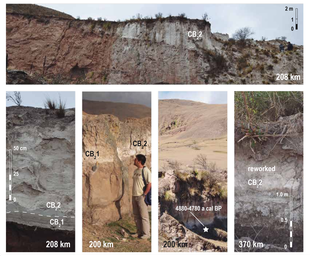
Stratigraphic summary

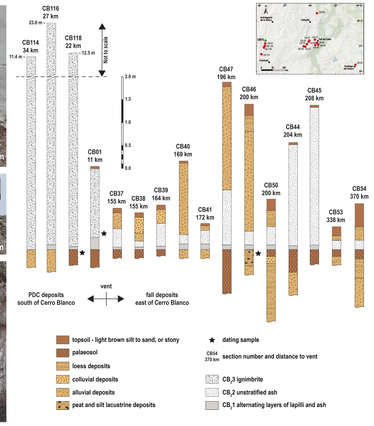
Sequence	Unit	Sub-unit	Lithofacies and interpretation	Mineralogy
Bolsón de Fiambalá	BdF_1		Alternating layers of moderate-poorly sorted, dacitic pumice lapilli and ash. Plinian fall deposit.	glass >> plagioclase, biotite, amphiboles, quartz >> magnetite, ilmenite, apatite, titanite
Cerro Blanco	CB_5 (postcaldera)	4	Alternating layers, 3-30 cm thick, of siliceous sinter. Deposits of hot springs.	amorphous silica
		3	Poorly defined decimetric-scale stratified deposits, poorly to very poorly sorted, with decimetric angular rhyolitic blocks in rhyolitic lapilli and coarse ash matrix deposits. Block-and-ash deposits.	glass >> feldspars, quartz, biotite, magnetite, ilmenite >> apatite, allanite-epidote, zircon
		2	Poorly to well-defined layers, 3-30 cm thick, white, rhyolitic lapilli and ash deposits. Fallout and phreatomagmatic deposits.	
		1	Crystal poor, very vesicular, rhyolite lava domes.	
	CB_3 (syncaldera)	3	Unstratified, matrix-supported, moderate to poorly sorted rhyolitic ignimbrite with clasts dominated by coarse pumice lapilli. Pyroclastic density current (PDC) deposits.	glass >> feldspars, quartz, biotite, magnetite, ilmenite > clinopyroxene, orthopyroxene, amphiboles > allanite-epidote, muscovite, titanite, zircon
		2	Unstratified rhyolitic ash. Plinian fall deposit.	
		1	Alternating layers, 1-3 cm thick, some of lapilli and some of ash. Rhyolitic Plinian fall deposit.	
	CB_1 (precaldera)		Poorly stratified lithic-rich breccia. Block-and-ash deposit.	glass >> feldspars, quartz, biotite, magnetite, ilmenite
Cueros de Purulla	CdP_2	1,2	Unstratified, matrix-supported, moderate to poorly sorted ignimbrite with clasts dominated by coarse pumice lapilli in $CdP_2$1 and lithic-rich $CdP_2$2. Pyroclastic density current (PDC) deposits.	glass >> feldspars, quartz, biotite, magnetite, ilmenite > apatite, allanite-epidote, muscovite, titanite, zircon
	CdP_1		Alternating layers, 1-10 cm thick, some of lapilli and some of ash. Rhyolitic Plinian fall deposit.	glass >> feldspars, quartz, biotite, magnetite, ilmenite > amphiboles, clinopyroxene > apatite, allanite-epidote, muscovite, titanite, zircon

Ignimbrites of Cerro Blanco $CB_3$3 (≈15 km³)

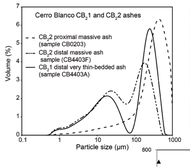
Plinean fall deposits CB_{1-2}3 (≈170 km³)

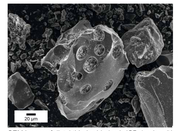




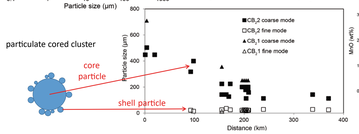


Bimodal particle size



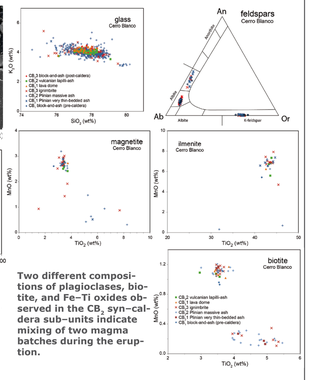


SEM image of distal thin-bedded ash (CB_1 sub-unit)



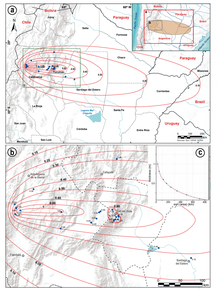
Particle size bimodality is interpreted as evidence of particle aggregation in the eruptive plume, forming cored ash clusters that typically break on impact with the ground. The resulting fallout deposit is made up of core particles of hundreds of microns in size and shell particles of tens of microns in diameter that covered the former.

Geochemistry



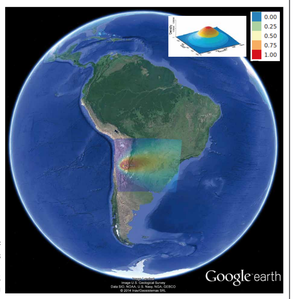
Two different compositions of plagioclases, biotite, and Fe–Ti oxides observed in the CB_2 syn–caldera sub–units indicate mixing of two magma batches during the eruption.

Isopach maps



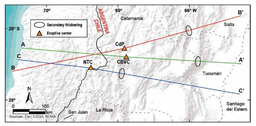
Isopach maps (m) for the CB_{1-2} fall deposits of CBVC: (a) showing up to the inferred area of 0.10 m isopach, and (b) in the sampled area indicating the measured thickness. (c) Semi–log plot of thickness vs. (area)$^{1/2}$ shows the best fit model (Weibull) for isopach adjustment.

Eruption modelling

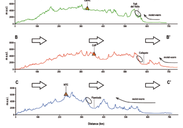


**p (deposition > 1 kg/m²
11,000 daily eruptive events
(~30 years of wind data)
Modelled with Tephra2
Plume height 27,000 m**

Secondary thickening

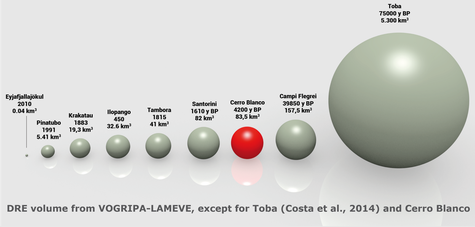


We hypothesized that secondary thickening is related to the effect of the topographically induced turbulences in the disaggregation, e.g., the breaking of lee waves, generated by winds passing over elevated topography beneath the eruption plume, and to a minor effect of upslope moisture transport by easterly atmospheric flow. CBVC, Cerro Blanco Volcanic Complex, CdP, Cueros de Purulla, NTC, Nevado Tres Cruces.



Conclusions

- **These results change the paradigm of Holocene volcanism of southern Puna in the Central Volcanic Zone of the Andes (CVZ).**
- **CBVC generated the largest documented eruption during the past five millennia in the CVZ and around the world.**



DRE volume from VOGRIPA-LAMEVE, except for Toba (Costa et al., 2014) and Cerro Blanco

- **The 4.2 cal ka Cerro Blanco eruption of magnitude 7.0 erupted ~170 km³ tephra over ~500,000 km², and ~15 km³ ignimbrites.**
- **The ash deposits of this eruption are extensive regional chronostratigraphic markers in South America, and the cryptotephra for the South Hemisphere.**
- **Further interdisciplinary research should be performed to analyse impacts in local environments and local communities.**

References

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Acknowledgements

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