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Short communication

Azorella compacta's long-term growth rate, longevity, and potential for dating geomorphological and archaeological features in the arid southern Peruvian Andes

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ABSTRACT

We determine the long-term growth rate and longevity of an *Azorella compacta* growing on Misti volcano, near Arequipa, Peru to investigate the species' capacity as a geochronological resource. Using ^{14}C dating on stem pieces sequestered within the plant's cushion, which grows larger through time, we obtain ages of 15 ± 15 ^{14}C yrs BP and 165 ± 15 ^{14}C yrs BP at depths of 15 cm and 29 cm below the cushion's living surface, respectively. Applying a mixed calibration curve with a Bayesian growth model yields calendar age ranges of 1948–1958 CE and 1802–1935 CE for our ^{14}C dates, respectively. Such ages provide sufficiently precise constraints for investigations requiring dating during the last few hundred years when individual ^{14}C dates yield imprecise calendar age ranges. We infer a long-term growth rate of 1.3–3.5 mm yr^{-1}, corroborating published maximum short-term growth rates. Extrapolating our growth model to the *A. compacta*'s core suggests that it began growing as early as 1462–1830 CE. At such age it lived through myriad important geological and historical events, including regional earthquakes, volcanic unrest at Misti, decades to centuries of the Little Ice Age, and a broad transect of Peruvian history possibly beginning during the Inca Empire. *A. compacta* may provide another important geochronological resource in the arid Central Andes that can be applied to date volcanological, glacial, mass-movement, and archaeological features, especially where dendrochronology and lichenometry are not possible.

1. Introduction

Long-lived organisms, such as trees and certain genera of lichens are important geochronological resources to constrain the ages of archaeological and geomorphological features. Such biological techniques can be applied to surfaces or deposits that are hundreds of years old and are particularly important in the Andes for dating surfaces or deposits from the last several centuries when ^{14}C dating is difficult (Rodbell et al., 2009). Yet many parts of the arid Central Andes lack trees and despite successes, lichenometry has inherent limitations that complicate its wide-spread application (Armstrong, 2016). Misti volcano (5822 m asl) near Arequipa, Peru (Fig. 1), for example, has only scant trees growing below ~4000 m asl and lacks appropriate surfaces for calibrating lichen growth rate. *Azorella compacta*, however, is another possibly long-lived species that grows on Misti's slopes from ~4100 to 5000 m asl whose potential as a geochronological resource has never been explored.

A. compacta, known locally as *yareta*, may offer a yet untapped wealth of geochronological information that can be applied to dating archaeological and geomorphological surfaces similarly to more established biological dating methods such as dendrochronology and lichenomentry (e.g., Yamaguchi et al., 1990). As the plants grow outward from their central root systems, compact cushions form from accumulated dead leaves and stems that are progressively overgrown by their tight-knit canopies (see Fig. 2 in Pugnaire et al., 2020). *A. compacta* grows widely at elevations of 3950–5250 m asl in the volcanic, glaciated, seismically active, and archaeologically rich arid Central Andes (Ralph, 1978; Kleier et al., 2015; Pugnaire et al., 2020) and may expand our capacity to date surfaces into areas where other biological dating methods are not feasible. Previous work suggests that the species' growth rate and maximum size are sufficiently slow and large that the

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