

Potassium feldspar post-IR IRSL dating of uplifted beach-ridges in Mejillones Peninsula, northern Chile

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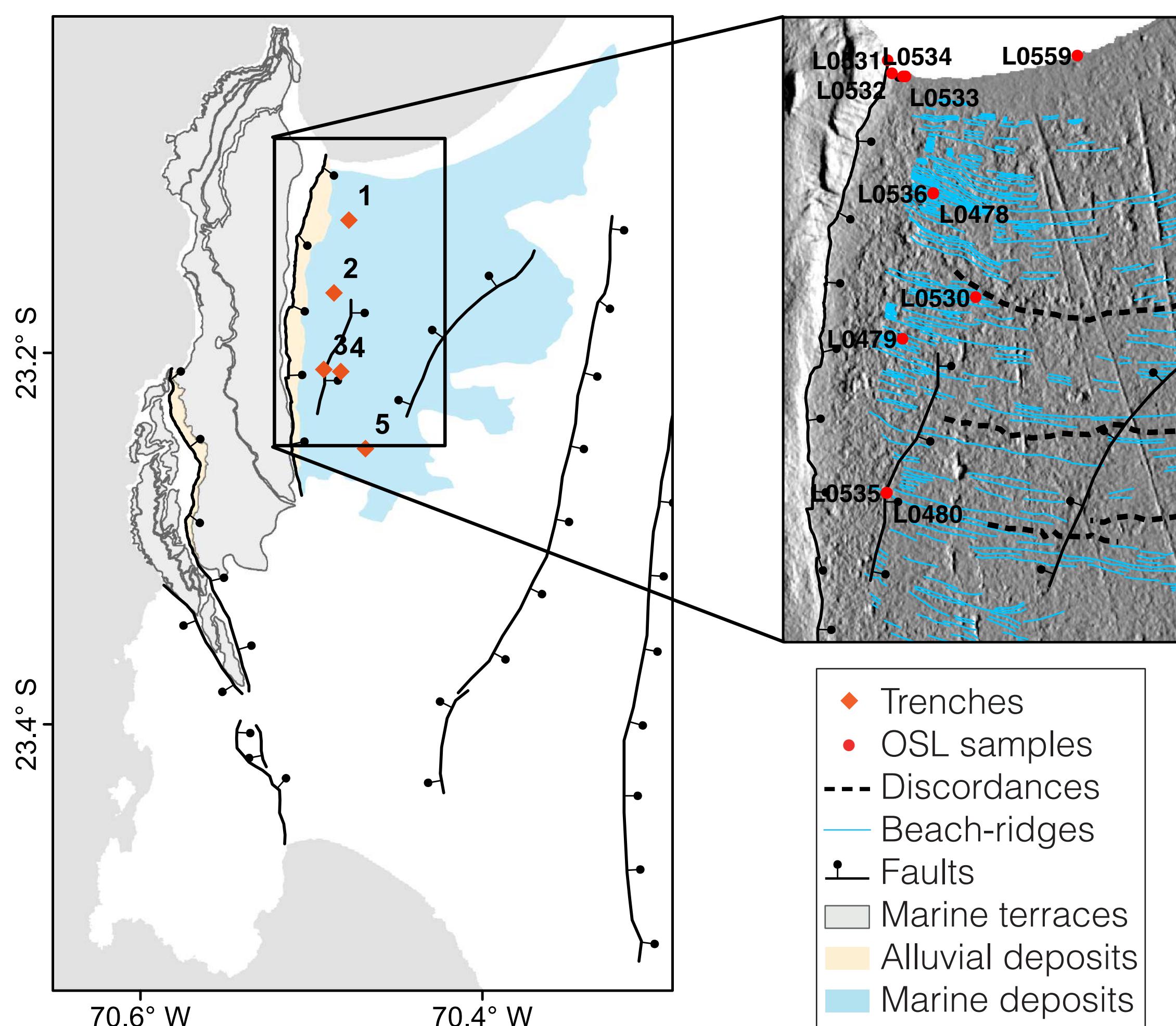
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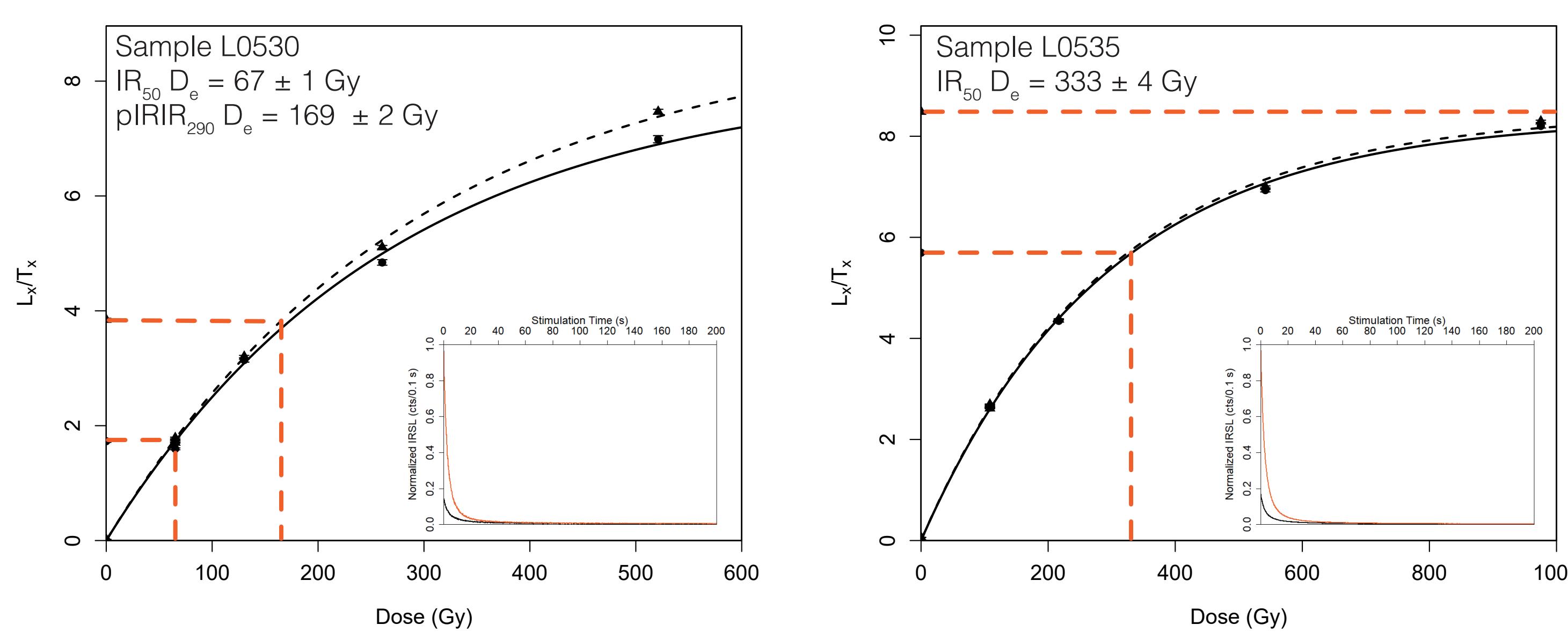
Introduction

Northern Chile is one of the most seismically active zones in the world. Earthquake activity produces uplift of the surface as has been registered by GPS data recorded during subduction earthquakes (references). Pampa Mejillones, in northern Chile, presents a well-preserved set of more than 300 beach-ridges from 20 to 200 m above sea level. The objective of this research is to obtain an uplift rate for the Pampa Mejillones. Also, this is the first time the post-IR IRSL protocol is tested on K-feldspars in the Atacama Desert.

To do this five trenches were excavated to study the deposits and collect samples for luminescence dating. The post-IR IRSL with a second stimulation at 290°C was selected to improve the stability of the IR signal (Buylaert et al., 2012).

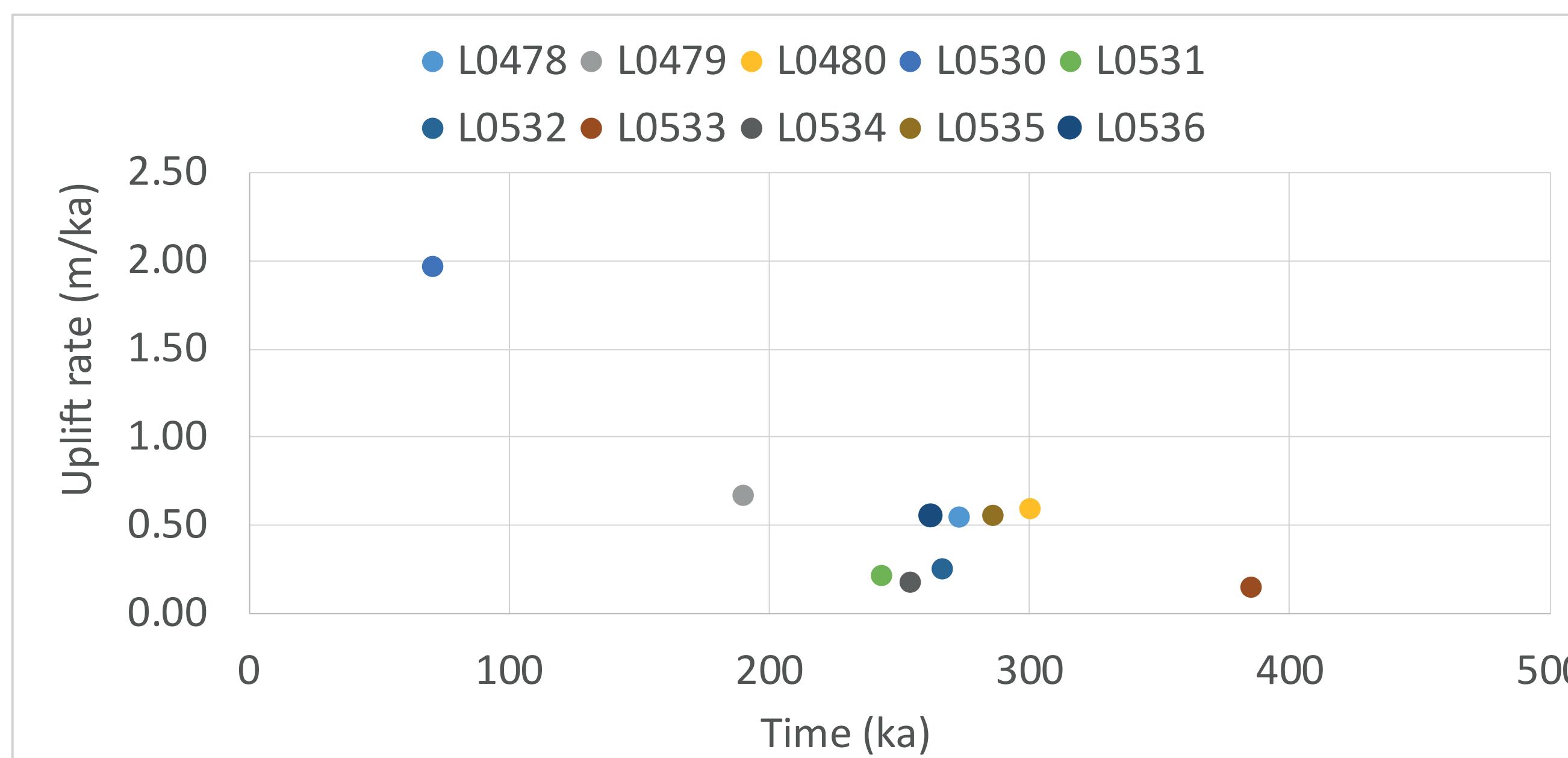


Discussion



Post-IR IRSL signals in saturation suggest this signal is stable over time. Thus, pIRIR signals are considered as reliable. Final ages ranged from 78 to 385 ka which translates to uplift rates from 0.14 to 1.96 m/ka. Overestimation of the ages due to residual doses appears to not be a problem. Modern analogues yielded between 1.8 ± 0.2 to 7.8 ± 0.2 Gy. Given the magnitude of the ages, these residual doses can be considered negligible.

Lower uplift rates (~0.19 m/ka) were yielded by samples extracted from the current coastal cliff (L0531, L0532, L0533 and L0534) which are directly localized over the Mejillones Formation, of age Pleistocene (MIS 9; Ortlieb et al., 1996). Samples extracted directly from the beach-ridge deposits yielded uplift rates slightly larger of ~0.58 m/ka with ages ranging from 286 to 190 ka. The youngest sample (L0530), extracted from the deposit which forms the northernmost discordance, yielded the highest uplift rate with 1.96 ± 0.16 m/ka. These results suggest a progressive acceleration during the Late Quaternary. Said uplift acceleration appears to increase abruptly since the MIS 5e.



Methodology

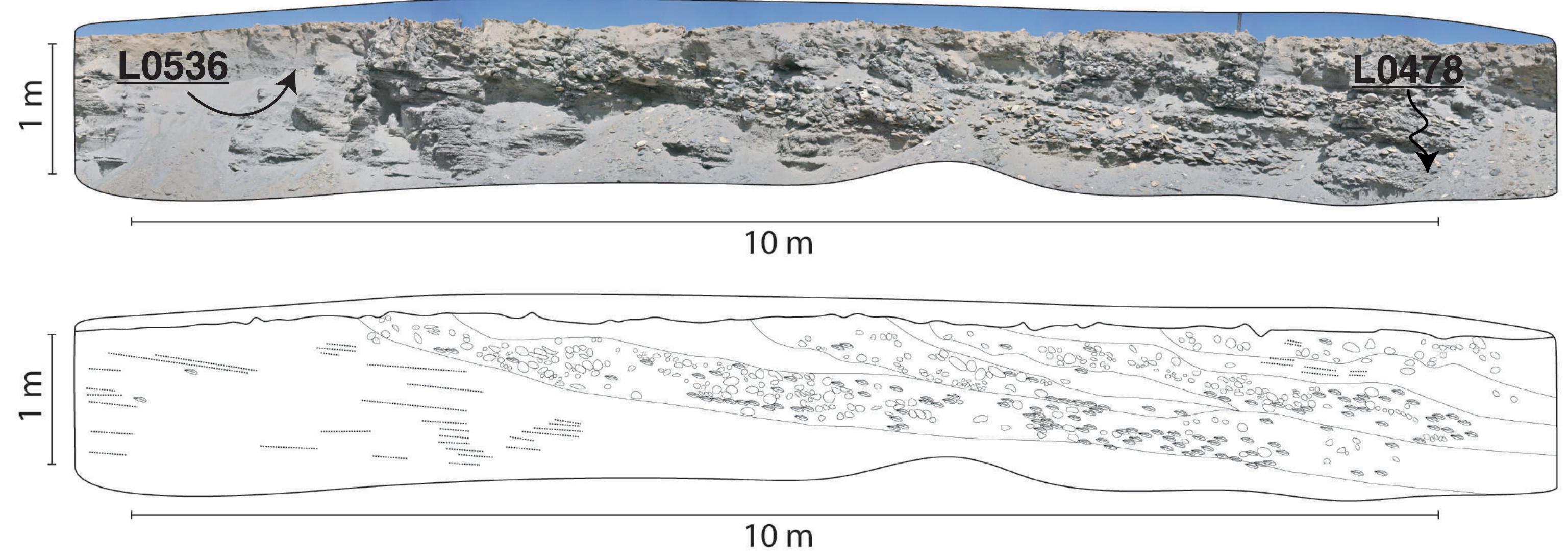
Five trenches of up to 20 m long and 1.5 m depth were dug perpendicular to the gravel outcropping in the surface of the Pampa. Ten samples from the sand deposits underlying the gravel deposits were collected for luminescence dating. Uplift rates were calculated using the relative sea level position for the Quaternary from

K-feldspar grains were sieved and treated with H_2O_2 , HCl (30%) and HF (10%) solutions and isolated by heavy liquids. Luminescence measurements were performed using 11.65 mm stainless steel cups aliquots, on a Risø TL/OSL DA-20 reader system equipped with a $^{90}Sr/^{87}Y$ beta source. Stimulation was done using IR LEDs (870 ± 20 nm) at 90% of its power (~130 mW/cm²) and light detection was conducted in the blue-violet window using a Corning 7-59 and Schott BG-39 filter combination. Post-IR IRSL signals (Buylaert et al., 2012) were integrated using the first 2 s and the last 10 s as background. Final ages were calculated using the Central Age Model (CAM; Galbraith et al., 1999).

Dose rates were determined using high resolution gamma spectrometry. Internal dose rates were calculated assuming a 12.5% K

Results

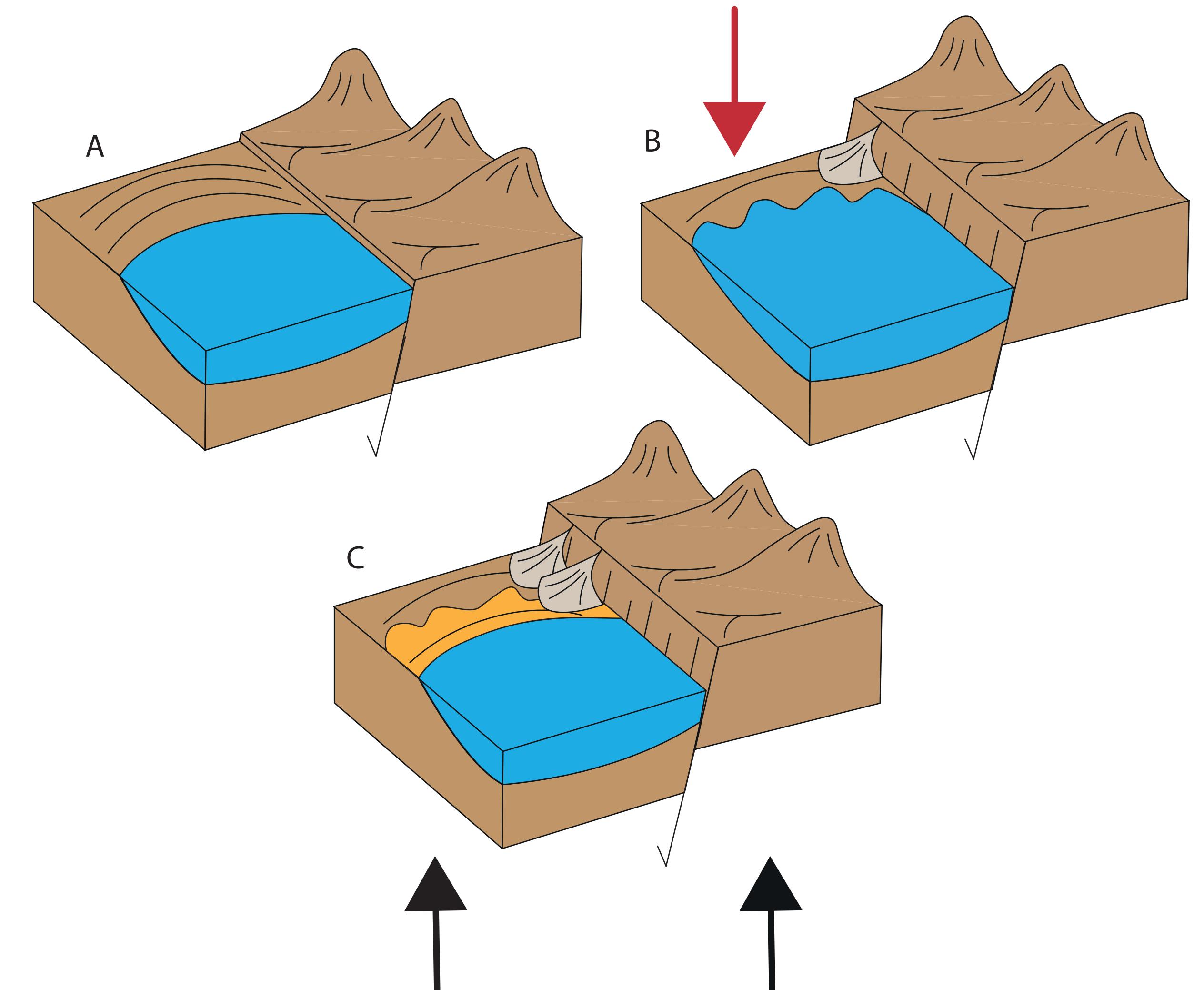
Stratigraphic analysis of the sediments exposed in the wall trenches showed a repetitive sequence of a gravel lens overlying sand deposits (Fig. 2). Gravel lenses showed imbricated clasts oriented to the sea with abundance of valves from genus *Argopecten*. Sand deposits showed parallel lamination and, in some cases, cross lamination. The fauna association found in the trenches changed for the two southernmost trenches to a thermally anomalous molluscan association as indicated by Ortlieb et al., 1996.



Gamma spectrometry analysis yielded dose rates from 2.0 to 3.2 Gy/ka. Dose recovery tests confirmed the ability of the K-feldspar to successfully recover a given dose. Residual doses were studied from a modern analogue sample yielding between 2 to 20 Gy. Given the resulting ages, those residual doses are considered negligible. Six of the 10 samples were found in saturation. Fading tests were performed on 3 aliquots from four of those saturated samples. Those tests yielded inconsistent results as the fading rates were very variable even from measurement to measurement. Thus, a fading rate for the 50°C signal was inferred using the four samples that were not in saturation. This procedure yielded a fading rate of 6.2 ± 0.3 %/decade. Final ages ranged from 78 ka to 385 ka.



A model for the uplift of the Pampa Mejillones can be proposed. Thus, in the first stage (A) the system is stable. The beach-ridges are created solely by the rising and falling of the sea level. In the second stage (B), the reactivation of the Mejillones Fault (red arrow) causes an abrupt rise of the relative sea level, eroding the previously created beach ridges and leaving a scar (i.e. a discordance) at the higher level reached by the sea. In the third stage (C), the whole crustal block (black arrows) is uplifted due to the effect of a subduction earthquake and the beach-ridges are abandoned.



Conclusions

Both IRSL and post-IRIRSL signals present high sensitivity. Some of the post-IR IRSL signals were found in saturation which suggests that they are suitable for dating K-feldspar from sediments of the Atacama Desert without the influence of athermal fading.

The disposition and continuity of the gravel layers observed in the wall trenches suggest that the beach-ridges abandonment corresponds to a continuous process in time more than being produced by discrete events. However, some events as strong storms and, especially, big subduction earthquakes, have a big impact in the uplifting of the coastal deposits.

Uplift rates for the Mejillones Pampa suggest a complex relationship between the tectonic uplift, the activity of the Mejillones Fault and the sea level variation during the Late Quaternary. Moreover, there appears to be an increase in the uplift rate during since the MIS 5e.

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