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Revisiting the Intermediate Sediment Repository Concept Applied to the Provenance of Zircon

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Abstract: This paper revisits the intermediate sediment repository (ISR) concept applied to provenance, using a comparison of the detrital zircon population of Holocene beach sand from the southwest Portuguese coast with populations from their potential source rocks. The U–Pb age of detrital zircon grains in siliciclastic rocks allows for the interpretation of provenance by matching them with the crystallization ages of igneous source (protosource) rocks in which this mineral originally crystallized or which was subsequently recycled from it, acting as ISRs. The comparative analysis of the Precambrian, Paleozoic, and Cretaceous ages using recent statistical tools (e.g., kernel density estimator (KDE), cumulative age distribution (CAD), and multidimensional scaling (MDS)) suggests that the zircon age groups of Carboniferous, Triassic, and Pliocene-Pleistocene ISRs are reproduced faithfully in Holocene sand. Furthermore, the recycling of a protosource (Cretaceous syenite) in a sedimentary system dominated by ISRs is evaluated. It is argued that the ISR concept, which is not always taken into account, is required for a better understanding of the inherent complexity of local provenance and to differentiate sediment recycling from first- cycle erosion of an igneous rock.

Keywords: zircon U–Pb dating; provenance; sediment recycling; siliciclastic rocks; plutonic rocks; protosource

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1. Introduction

1.1. Zircon

Zircon crystallizes from magma that is saturated in zirconium, and it may undergo the dissolution and recrystallization associated with magmatic and metamorphic processes [1–3]. The composition of the magma and the temperature of crystallization affect the morphology of zircon, which may present different external forms [1]. Zircon formed by distinct processes shows a wide variety of internal patterns which can only be identified efficiently by using cathodoluminescence images [2,3]. Magmatic zircon may have a structure corresponding to a single crystallization event, or it may be composite, representing more than one crystallization event as indicated by the core and rim patterns [4]. In the latter case, the core may represent an early stage of crystallization or older zircon that derived from the host rocks [5,6]. Zircon that grows during metamorphism tends to form growths surrounding the older (inherited) grains or appear to be non-composite grains, representing a unique growth event [4].

Zircon is common in most sedimentary systems associated with the deposition of siliciclastic rocks because it is extremely resilient in the face of erosion, which makes it invaluable for provenance studies. At present, the U–Pb age of detrital zircon may be determined with precision and accuracy by using a laser ablation inductively coupled plasma mass spectrometer (LA-ICP-MS), sensitive high-resolution ion microprobe (SHRIMP), and thermal ionization mass spectrometry (TIMS) [4,7,8]. These have all been used as a proxy for the age of the source (magmatic, metamorphic, or sedimentary) rock from which it was sourced [9].