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VARIABILITY OF DETRITAL ZIRCONS FROM BEACHES AND RIVERS IN THE WESTERN ALGARVE REGION- SOUTH PORTUGAL

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ABSTRACT

Zircon is a common accessory mineral in most rocks and sediments, and although it is ubiquitous, it possesses a considerable petrologic interest. In the scope of CHYNA project, some samples of detrital sediments have been collected in rivers and beaches from Western Algarve region. The present work presents the results of the analyses undergone with the intent to document the existing zircons' variability in these samples. The zircons from 22 samples have been analysed based on their shape, colour and inclusions. There is predominance of rounded and subrounded grains, generally colourless and without inclusions. Systematic differences between beaches and rivers are not observed, indicating that both environments have the same zircon sources.

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INTRODUCTION

Zircon ($ZrSiO_4$) is a common accessory mineral in rocks and sediments, possessing a considerable petrologic interest for being extremely resistant to weathering and having an ample use in radiometric studies (Heimlich *et al*., 1975, Deer *et al*., 1981). However, the analysis of individual zircon grains are potentially able to elucidate on the provenance, the spatial distribution and the ratio of different rock sources that contribute with detrital grains to the draining systems (Weltje and Eynatten, 2004). Denudation and erosion rates of the source area can also be estimated with techniques based on the analysis of individual grains (Weltje and Eynatten, 2004).

In parallel, typology of zircons became to be used since the XIXth century in order to get more detailed information about sediments provenance. This was made especially when the existing assemblages of heavy minerals were monotonous and allowed limited interpretations about the provenance (Schäfer and Dörr, 1997, Heimlich *et al*., 1975).

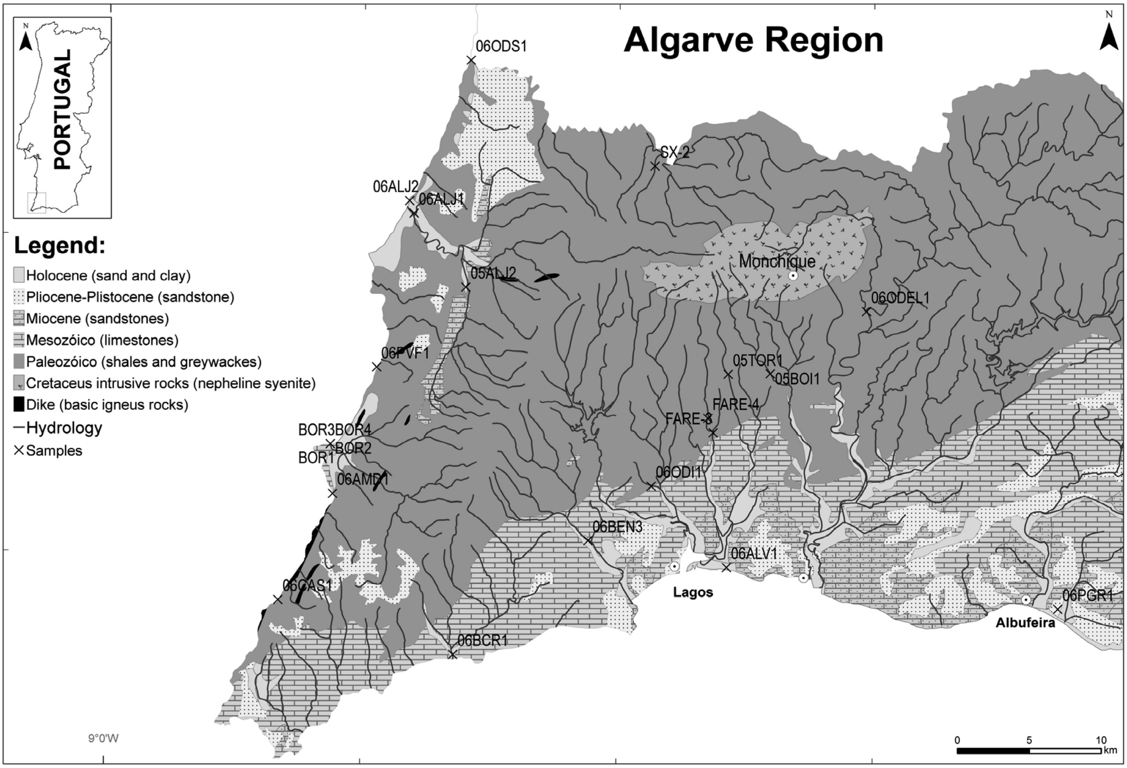

Figure 1:
Sample location and simplified geologic map for the Western Algarve region (Geologic map adapted from Manupella, 1992).

The term provenance has to be understood as the rock source from where grains, that constitute sediments, are derived. The rock source can be igneous, metamorphic or sedimentary. For that reason, some minerals in sediments can already have undergone several sedimentary cycles and others are experiencing their first cycle. Zircon grains in igneous rocks are typically euhedral (Heimlich *et al*., 1975), whereas zircons in metamorphic and sedimentary rocks are frequently rounded because they might already have belonged to some previous sedimentary cycles (Suguio, 2003).

U-Pb dating on individual zircon grains can be used to evaluate whether an individual grain is submitted to a first cycle of erosion or if it underwent previous sedimentary cycles (e.g. Veiga-Pires *et al*. 2006). In accordance with the obtained age, the individual grains can be associated with the rocks from where they derive. Their composition, morphology and structure are also indicative of the petrogenesis and can be used in provenance studies (Morton and Hallsworth, 1999).

Accordingly, the present work intends, in a first phase, to observe and quantify the variations in zircons' characteristics in the heavy mineral assemblages from rivers and beaches of the Western Algarve region. Because of their roundness is generally high, the zircon typology method, which is basically a method for petrogenetic classification of granitic rocks concerning the morphologies of zircons

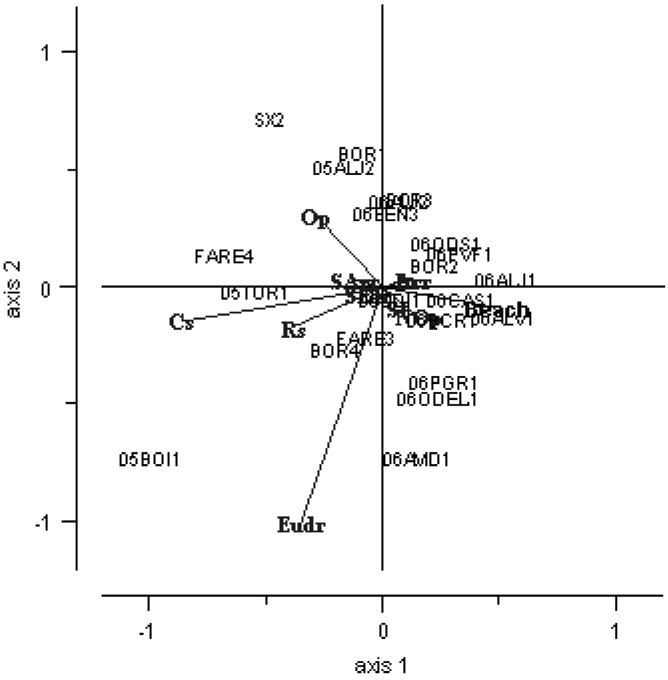

Figure 2:
Correspondence analysis biplot for 22 sediment samples based on 10 morphometric variables from table, with the location factor (beach/river) superimposed. The first axis explains 35.76 % of total variance and the second axis 19.9 %, for a total of 55, 66 % of total variance explained (In-colourless, Cs-brown, Rs-purple, Op-opaque, NOp-non-opaque, Si-without inclusions, Eudr- euhedral, SEdr- subhedral, SArr- subrounded, Arr- rounded).

(Pupin, 1980), has not been analyzed. Zircons have been characterized based on their colour, inclusions and shape. In a second phase, this work will be complemented with dating on the zircon grains and a study of heavy minerals assemblages. The integration of both phases will allow characterizing and determining the sources of actual sediments into the rivers and beaches of the studied region (figure 1).

METHODOLOGY

With the objective to study the assemblage of heavy minerals, several samples of detrital sediments between 3 and 6 kg were collected in small rivers and on beaches from the western Algarve region (figure 1). The samples were washed and sieved with 200 and 63 mesh. Heavy minerals from the sediment fraction between 200 and 63 µm was separated using Methylene Iodide (d=3,32 g.cm^{-3}). All the magnetite minerals were removed with a hand magnet and the remaining heavy minerals were placed in a Frantz Isodynamic Magnetic Separator. The recovered non-magnetic fraction was observed with a binocular microscope. In each sample, 30 zircons were randomly chosen, separated manually and observed under the binocular. Until the moment only 22 samples (figure 1) have a quantity equal or superior to 30 zircons and only these have been considered in the present work. Due to minimize the inherent subjectivity on this process (Heimlich *et al.*, 1975), only one observer grouped the zircons. The zircons were grouped in accordance with their colour,

Table 1:
Colour, Inclusions, and shape for analysed zircons. Values are given as percentage of 30 zircon grains for each sample. The bottom line indicates if the sample was collected on a beach (B) or in a river (R).

Samples	BOR1	BOR2	BOR3	BOR4	05ALJ2	06ALJ1	06ALJ2	FARE3	FARE4	05BOI1	06ODS1	05TOR1	SX2	06BCR1	06PVF1	06ODI1	06ODEL1	06AMD1	06BEN3	06CAS1	06ALV1	06PGR1
Colour																						
Colorless	93	93	93	80	90	97	90	73	60	47	94	60	80	97	93	90	97	93	94	90	90	87
Brown	7	0	0	0	3	0	3	7	20	30	3	17	10	3	0	7	3	0	3	0	3	0
Purple	0	7	7	20	7	3	7	20	20	23	3	23	10	0	7	3	0	7	3	10	7	13
Inclusions																						
Opaque	43	17	33	24	43	13	33	17	37	30	20	30	57	7	7	20	10	7	30	13	7	3
Non-opac	12	0	0	3	7	27	0	0	17	17	7	7	3	20	13	17	13	10	20	20	26	20
whitout ir	45	83	67	73	50	60	67	83	47	53	73	63	40	73	80	63	77	83	50	67	67	77
Shape																						
Euhedral	0	0	0	7	0	0	0	3	0	13	0	0	0	0	0	3	10	13	0	0	0	3
Subhedra	13	13	20	17	20	10	13	10	13	17	0	30	10	37	17	17	7	13	10	17	7	17
Subround	37	34	23	49	43	13	23	24	50	37	30	28	47	33	33	37	36	37	53	20	7	33
Rounded	50	53	57	27	37	77	64	63	37	33	70	42	43	30	50	43	47	37	37	63	86	47
Beach/Rivei	B	B	R	R	R	R	B	R	R	R	R	R	R	B	B	R	R	B	R	B	B	B

the absence or presence of inclusions and their shape. For a better visualization and interpretation of data, a multivariate non-linear statistic analysis has been made, namely a correspondence analysis between the samples and the characteristics of the zircons.

RESULTS AND DISCUSSION

Many types of zircons have been recognized in nature based on colour, shape and inclusions that they have (Carroll, 1953). In the studied area, the only rock forming mineral source of zircons to the rivers, and consequently to the beaches, is the syenitic massive of Monchique (Pereira, 1940, Kraatz-Koschlau, 1967). Some sedimentary formations in the region, in particular the Palaeozoic formations, possess zircons with a high roundness grade (Kraatz-Koschlau, 1967) but they are not rock forming zircons source. These Palaeozoic formations may contribute to the rivers with rounded zircons. The observations based on the colour, inclusions and shape of the zircons of each sample are synthesized in table 1 and represented in figure 2.

The majority of the observed grains are colourless, they do not present inclusions and they are sub-rounded to rounded. However, there are differences between the zircon assemblages of each sample that allow explaining the variance observed in figure 2. Relatively to colour, the observed zircons are in higher percentage colourless, in particular the zircons belonging to samples collected in beaches. Zircons with purple colour are the secondly more frequent followed by brown colour. The samples FARE3, FARE4, 05BOI1, and 05TOR1, collected in rivers that drain the syenite of Monchique massive, together with sample BOR4, from the beach of Bordeira (fig. 1), show a relatively high percentage of purple zircons between 20 and 23% (tab. 1). A significant amount of brown zircons exists in samples FARE4, 05BOI1 and 05TOR1, all collected in rivers that drain the south of the Monchique massive (fig. 1), with respectively 20, 30 and 17% of brown grains (tab. 1). The brown zircons generally have a high radioactivity (Caroll, 1953). Because of that, they have defects in the crystalline mesh and they are thus more instable and susceptible to weathering than the pink or the colourless zircons (Caroll, 1953). For this reason, the absence of brown zircons suggests that they can already have been removed through the weathering and sedimentary processes that affected them in the actual or in previous sedimentary cycle (Caroll, 1953). In such a way, zircons that are supply to the system in the study area, in particular for the Palaeozoic formations (Kraatz-Koschlau, 1967), have a small percentage of brown colour zircons because they have been probably already removed in previous sedimentary cycles. Relatively to the inclusions, there is a high percentage of zircons that do not show any inclusion. When there are inclusions, they are essentially constituted by opaque materials (tab. 1). The samples with high percentage of zircons without inclusions (more than 70 %) do not show any relation with the sampling location, beaches or rivers. Zircons with inclusions, opaque and non-opaque, are also independently distributed between samples collected on beaches or rivers, as it can be verified in figure 2.

Relatively to shape, grains with sub-rounded and rounded shapes are, in general, more abundant. These shapes are probably associated to a contribution of zircons from the Palaeozoic formations (Kraatz-Koschlau, 1967) for river samples, and/or to an effective wave abrasion for beach samples (Twenhofel, 1945). However, once again, there is no evident relation in observed zircons between shape of the grains and sample location, i.e. beach or river (fig. 2). Figure 2 shows that samples are homogeneous in relation to shape of the grains. Only samples that have a high amount of euhedral zircons (05BOI1, 06AMD1 and 06ODEL1) can be distinguished from the remaining samples based on their shape. Among these samples, sample 05BOI1, collected in Boina River, shows a percentage of 13 % of euhedral zircons. River where this sample was collected drains syenite of the Monchique massive, which can be explained this high value as being due to the contribution of not altered zircons from the massive. However, this relation is not unequivocal. In samples collected in rivers that also drain the massive, in particular, the 05TOR1 sample from Torre River (collected 5.5 km away from the massive), the percentage of subhedral zircons is significant (30 %) but there is no euhedral zircon. In parallel, the high value of 13 % of euhedral zircons in a beach sample (06AMD1) can be related with the existing sandstones (consolidated dunes) in the cliff above the beach where the sample was collected. Finally, 06ODEL1 sample, collected in Odelouca River, shows a value of 10 % of euhedral zircons. However it is not possible to state if these derive from the Monchique massive or from a Palaeozoic quartzite crest existing upstream from where sample was collected (fig. 1).

Still in relation to shape, there are great similarities between samples BOR1, BOR2 and BOR3. However, samples BOR1 and BOR2 were collected at Bordeira beach and the sample BOR3 was collected at the mouth of Carrapateira River (fig. 1). In this particular case, it can be assumed that BOR3 can have a component carried from the beach by aeolian transport or by overwash processes. In the same way, sea contributions can be attributed to high percentages of rounded and sub-rounded grains and an absence of euhedral and subhedral zircons in samples collected on the beaches or in the river´s estuaries. The analysis of figure 2 shows that the three analysed characteristics (colour, inclusion and euhedrism) are completely independent between each other but do explain 55 % of the total variance between samples.

CONCLUSIONS

Zircons observed in sediment samples from beaches and rivers from the Western Algarve region show a great variety relatively to their shape, colour and inclusions. In general, studied zircons are: i) colourless, purple being the following more observed colour; ii) without inclusions and when they exist they are mainly opaque; iii) mainly rounded or sub-rounded, independently of the sample belonging to beach or river sediments. However, the roundness of zircon grains in the rivers cannot simply be associated with an actual fluvial transport abrasion because the distances are very short. The roundness, in the present case, is probably associated with a local contribution of rounded zircons originating from the Palaeozoic formations (Kraatz-Koschlau, 1967) or rounded *in situ* through chemical weathering (Carroll, 1953). In the case of beach samples, roundness is probably associated with the work of the waves (Twenhofel, 1945). However, and until the moment, it is not possible to make any type of consistent relation between the observed samples and their provenance. Observation of a larger number of samples from river and beach sediments, as well as datations on individual grains will be done to complement this study. The datations will allow determining if the euhedral zircons belong effectively to the massive of Monchique or to another formation. It will then become possible to establish a relation between the distance to the source and the roundness of zircons.

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