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U-Pb dating of detrital zircons of placer deposits from the Seufzergründel near Hinterhermsdorf (Elbsandsteingebirge, Sachsen)

U-Pb-Datierung detritischer Zirkone aus Seifenablagerungen im Seufzergründel bei Hinterhermsdorf (Elbsandsteingebirge, Sachsen)

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Abstract

For determining the crystallisation age of a mafic rock body covered with loess, 69 zircons were dated using LA-ICP-MS (Laser Ablation-Inductive Coupled Plasma-Mass Spectrometry) U-Pb analysis. These zircons were taken from a heavy mineral placer in the spring area of the Seufzergründel creek close to Hinterhermsdorf (Saxony Switzerland, Germany). The placer consists of volcanic rock minerals, eroded loess particles as well as Cretaceous sandstone grains. While almost all analyses give ages that are older than ~ 230 Ma (Sonntag 2007) two large zircon grains yielded a concordia age of 30.5 ± 0.58 Ma. As these grains have been too heavy for Pleistocenian aeolian transportation, an origin from the loess cover can be excluded. Therefore, the young zircon most likely date the crystallisation of the mafic rock body which crosscuts the granitic basement rocks and the overlying Cretaceous sandstone. The magmatism is related to a widespread tectonic rifting event in Central Europe during the Oligocene.

Kurzfassung

Zur Bestimmung des Intrusionsalters eines mit Löss bedeckten mafischen Gesteinskörpers wurden an 69 Zirkonen mittels LA-ICP-MS (Laserablation verbunden mit einem Massenspektrometer mit induktiv gekoppeltem Plasma) U-Pb-Analysen durchgeführt. Diese Zirkone wurden einer Schwermineralseife im Quellbereich des Seufzergründelbächleins nahe Hinterhermsdorf (Sächsische Schweiz, Deutschland) entnommen. Die Seife besteht hauptsächlich aus einem Gemisch von Mineralen vulkanischen Ursprungs, erodierten Lössmineralen und kretazischen Sandsteinkörnern. Während nahezu alle Altersgruppen älter als ~ 230 Ma (Sonntag 2007) sind, ergibt sich für zwei Zirkonkörner ein konkordantes Alter von 30.5 ± 0.58 Ma. Diese Körner sind zu groß für einen äolischen Transport während des Pleistozäns, daher kann eine Herkunft aus der Lössdeckschicht ausgeschlossen werden. Der mafische Gesteinskörper durchstößt das granitische Grundgebirge und den darüberliegenden kretazischen Sandstein. Die Zirkone scheinen die damit einhergehende vulkanische Eruption zu datieren, welche sich vermutlich während des Oligozäns im Zuge des weitläufigen tektonischen Riftings in Zentraleuropa ereignete.

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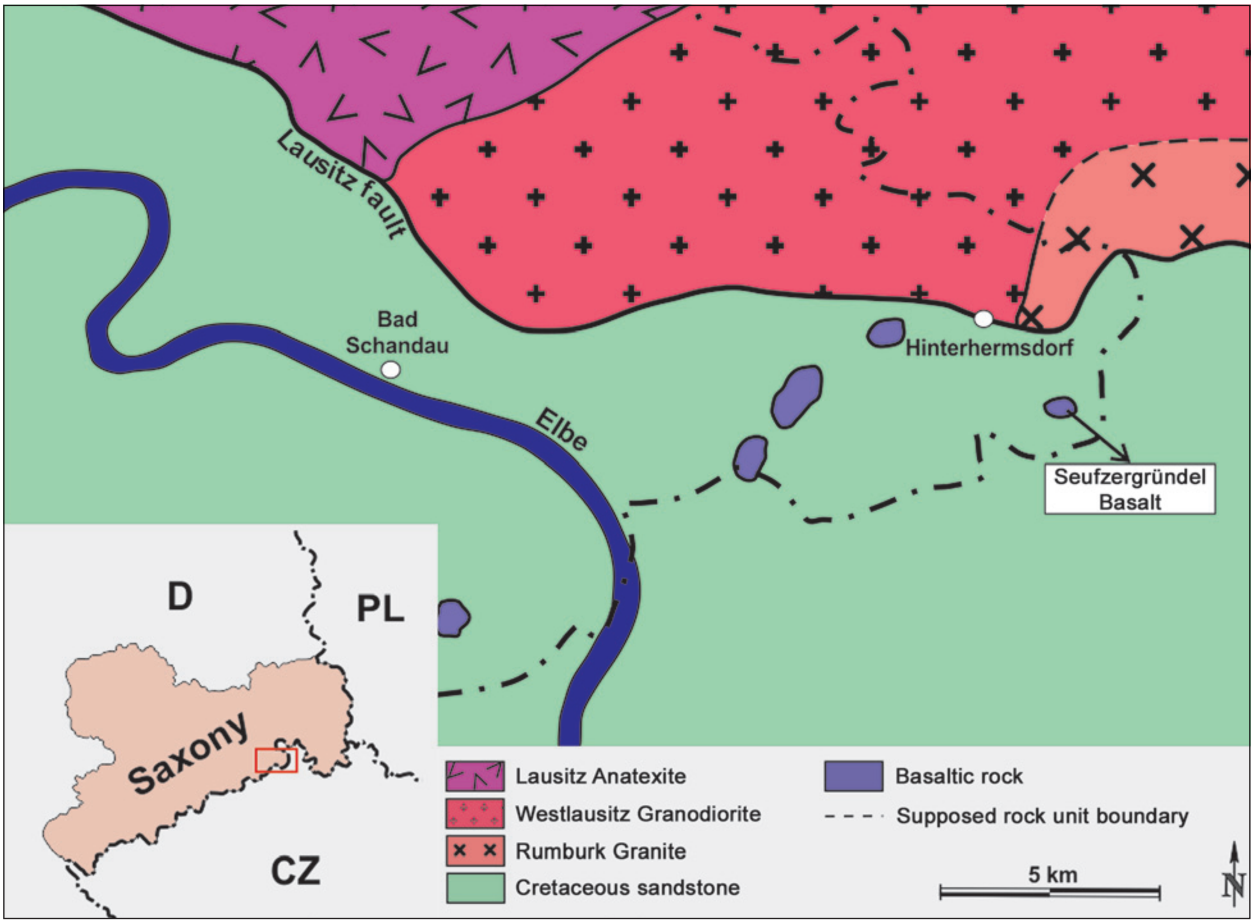

Fig. 1. Overview map showing the location of the investigation area (red rectangle) in Saxony and simplified geological map of the Seufzergründel area (based on Linnemann 2003).

Abb. 1. Übersichtskarte zur Lage des Untersuchungsgebietes (rotes Rechteck) in Sachsen und vereinfachte geologische Karte des Seufzergründelgebietes (basierend auf Linnemann 2003).

1. Introduction

The Seufzergründel near Hinterhermsdorf (Elbsandsteingebirge/Germany) shows a heavy mineral placer in the spring area of the Seufzergründel creek. Findings of gems larger than 5 mm in length led to the installation of a gemstone mining in the 16th century (Wiedemann 1961a). Due to economic inefficiency the mining activities already stopped shortly after. Concerns according to origin and age of these heavy minerals arose a long time later and are still a topic of interest today.

After Pietzsch (1962) the bedrock in the investigation area is assumedly composed of the Westlausitz Granodiorite with an age of ~ 540 Ma (Linnemann 2003) and the eastward adjacent Rumburk Granite, which intruded ~ 490 Ma ago (Linnemann 2003). On top of these igneous rocks Upper Cretaceous sandstone units have been deposited with several hundred meters in thickness. The stratigraphic position of these sandstones was determined by using particular index fossils (mainly inoceramid bivalves; Tröger 2003, 2004). These sandstone layers have been intersected by an ellipsoidal mafic rock body of ~ 700 m length and ~ 260 m width (see Fig. 1). The latter is mainly composed of a heterogenic polymictic basalt breccia. With exception of small areas this volcanic rock is below the surface. Nevertheless, where it can be observed the entire mafic rock body is strongly weathered to several ten metres in depth (Bautsch & Vollstädt 1983, 1985). The Cretaceous sandstone units and the crosscutting mafic rock body are covered by a up to 2 m thick Pleistocenian loess layer (Wiedemann 1961b).

The heavy minerals of the placer were determined by X-Ray microanalyses (Seifert 2006) and by EDX analyses (Sonntag 2007). An overview of all heavy minerals occurring in the Seufzergründel placer is given in Tab. 1. A large portion of these heavy minerals is basaltic in origin (e.g., Augite and Diopside). Other minerals (e.g., Pyrope) indicate high pressure and high temperature forming conditions that point to an origin from lower crust or upper mantle. In total, EDX-analyses reveal more than 20 different heavy minerals.

Furthermore, the placer is known for containing large zircon grains. Supposing this zircon is related to the pipe-shaped mafic rock body its age will constrain the time of crystallisation.

Table 1. Overview of heavy minerals occuring in the Seufzergründel placer, based on Seifert 2006 and Sonntag 2007).

Tabelle 1. Überblick über die in der Seufzergründelseife auftretenden Schwerminerale, basierend auf Seifert 2006 und Sonntag 2007).

Fe-Ti-oxides	Magnetite, Titanomagnetite, Ilmenite, Haematite	
Pyroxenes	Clinopyroxenes	Augite, Aegirin-Augite, Ti-Augite, Diopside, Cr-Diopside
	Orthopyroxenes	Enstatite, Bronzite, Hypersthene
Amphiboles	Hornblende	
Spinels	Spinel, Ceylonite, Picotite	
Accessory minerals	Zircon, Apatite, Olivine, Garnet (Pyrope, Almandine, Spessartin), Rutile, Monazite, Cerianite, Coelestine, Andalusite	

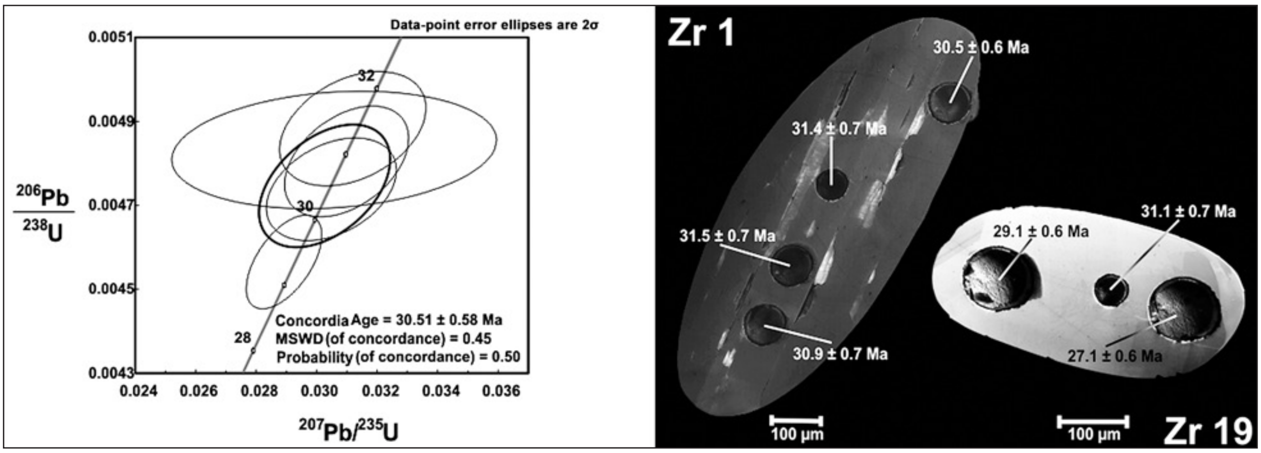

Fig. 2. Age of two Seufzergründel zircons (Zr 1 and Zr 19). Five laser spots yielded a concordia age of 30.51 ± 0.58 Ma (left); the U-Pb ages of all seven measured spots are presented in the CL image (right).

Abb. 2. Alter zweier Zirkone aus dem Seufzergründel (Zr 1 und Zr 19). Fünf Laserspots ergaben ein konkordantes Alter von 30.51 ± 0.58 Ma (links); die U-Pb-Alter aller sieben Messungen sind im CL-Bild dargestellt (rechts).

2. Methods

In the separated material of the samples BLS1 and BLS2 from the Seufzergründel heavy mineral placer, two different types of zircon grains were identified and analysed by LA-ICP-MS (Laser Ablation-Inductive Coupled Plasma-Mass Spectrometry). The first type is represented by small needle-shaped grains observed within the fraction ranging from 0.063 mm to 0.4 mm. Larger rounded grains showing a length between 0.4 mm and 3 mm characterize the second type. At least 69 zircon grains of the placer were dated using U-Pb LA-ICP-MS method. In this study only the results of just two of the larger zircon grains (from sample BLS2 – 14° 22′ 449″ E, 50° 54′ 118″ N) will be presented and discussed herein (for further results and details, see Sonntag 2007). In total the two grains were analysed with seven laser spots using different spot diameter. Prior to analyses the zircon grains were picked from the heavy mineral fraction, obtained by standard magnetic and heavy liquid separation, mounted in epoxy resin, polished to half their thickness, and imaged by SEM CL (cathodoluminescence) at the Senckenberg Naturhistorische Sammlungen Dresden. LA-ICP-MS U-Pb analyses and age calculations were made at Goethe-Universität Frankfurt am Main. A detailed description of the method can be found in Gerdes & Zeh (2006, 2009).

3. Results and discussion

Both zircon grains investigated within this study are well rounded and thus do not reveal a euhedral crystal shape typical for magmatic crystallisation, except of the elongation. The CL images of the two grains, Zr 1 and Zr 19, show rather homogeneous luminiscence with only faint evidence for an internal occilatory zoning typical for magmatic growth (Fig. 2). The rounded crystal shape imply either fluvial abrasion or resorption in a hot magma, whereas the homogenous zoning can be explained by either metamoprhic zircon recrystallisation or by homogenous distribution of elements (e.g., U, Y, REE) commonly responsible for the luminiscence in zircon.

Seven spots were measured on the larger zircon grains Zr 1 and Zr 19 (Tab. 2); five of these spots yielded within uncertainty equivalent and concordant Pb-U data corresponding to a concordia age of 30.5 ± 0.6 Ma (± 2 σ; $MSWD_C$: 0.45; Fig. 2). All measurements of the smaller needle-shaped grains produced Cretaceous ages and older (Sonntag 2007).

As the mafic body intersects granitic basement rocks as well as Createceous sandstone units its crystallisation age must be younger than ~ 65 Ma. Furthermore, the grain size of the two dated zircon grains is incompatible with an aeolian transport leading to the deposition of a

Table 2. LA-ICP-MS U, Pb and Th data of zircon grains Zr 1 and Zr 19 from the Seufzergründel mafic rock body.
Tabelle 2. Mittels LA-ICP-MS analysierte U-, Pb- und Th-Werte der Zirkone Zr 1 und Zr 19 aus dem mafischen Gesteinskörper vom Seufzergründel.

	Spot	^{207}Pb (cps)	U[a] (ppm)	Pb[a] (ppm)	Th[c]/U	^{206}P/^{204}Pb	^{206}Pb[e]/^{238}U	2 σ (%)	^{207}Pb[e]/^{235}U	2 σ (%)	^{207}Pb[e]/^{206}Pb	2 σ (%)	Rho[d]	^{206}Pb/^{238}U	2 σ (Ma)	^{207}Pb/^{235}U	2 σ (Ma)	^{207}Pb/^{206}Pb	2 σ (Ma)
zr1	1	1872	33	4.6	0.78	115	0.00488	2.3	0.0312	6.3	0.04639	5.9	0.36	31.4	0.7	31.2	1.93	18	141
zr1	2	1205	30	4.6	0.78	565	0.00490	2.3	0.0308	6.1	0.04561	5.6	0.37	31.5	0.7	30.8	1.84	-23	136
zr1	3	1027	24	4.6	0.68	256	0.00480	2.2	0.0310	5.4	0.04685	4.9	0.42	30.9	0.7	31.0	1.64	42	117
zr1	4	1170	29	4.6	0.78	162	0.00474	2.1	0.0305	5.7	0.04674	5.3	0.37	30.5	0.6	30.5	1.72	36	127
zr19	5	281	22	0.5	0.65	606	0.00483	2.4	0.0306	14.2	0.04597	14.0	0.17	31.1	0.7	30.6	4.30	-4	338
zr19	6	1895	20	0.8	0.67	1890	0.00456	2.0	0.0290	3.5	0.04604	2.9	0.57	29.4	0.6	29.0	1.00	0	69
zr19	7	2392	20	1.3	0.50	1930	0.00420	2.3	0.0269	6.5	0.04642	6.1	0.35	27.1	0.6	27.0	1.74	19	147

[a] Within-run background-corrected mean ^{207}Pb signal in counts per second
[b] U and Pb content and Th/U ratio were calculated relative to GJ-1 and are accurate to approximately 10%
[c] Corrected for background, mass bias, laser induced U-Pb fractionation and common Pb (if detectable, see analytical method) using Stacey & Kramers (1975) model Pb composition. ^{207}Pb/^{235}U calculated using ^{207}Pb/^{206}Pb/(^{238}U/^{206}Pb × 1/137.88). Errors are propagated by quadratic addition of within-run errors (2SE) and the reproducibility of GJ-1 (2SD)
[d] Rho is the error correlation defined as err^{206}Pb/^{238}U/err^{207}Pb/^{235}U.

Pleistocenian loess cover overlying the mafic rock complex. The age obtained on the two zircon grains is best interpreted as dating their magmatic crystallisation and as they derived from the mafic body, also the crystallisation of the latter. The rounded shape suggest that the crystals were resorbed in the magma after recrystallisation, which is in line with the high solubility of Zr in mafic magmas. Thin section observations gave no evidence for the presence of any zircon within the fine-grained basaltic matrix but within the coarse-grained breccia which is amalgamated with the fine-grained material (Sonntag 2007). So it is likely that large zircon grains from the coarse-grained breccia were taken up from a subsequent batch of the magma and somewhat resorbed by it. The zircon age therefore date the crystallisation of the Seufzergründel mafic body. The intrusion age of the mafic rock body corresponds to the so-called Rupel-Transgression (Oligocene). A very large part of the crust was reactivated as well as thinned and a marine transgression flooded huge parts of Central Europe (Ziegler 1993). This extension of the lithosphere was accompanied by extensive mafic to ultra-mafic magmatism in Central Europe and the intrusion of the Seufzergründel mafic rock body is supposed to be linked to that important tectonomagmatic event.

4. Conclusions

With evaluating seven LA-ICP-MS U-Pb measurements of two zircon grains larger than 0.4 mm from the Seufzergründel placer, the intrusion age of the related mafic rock body could be determined and assigned to a widespread tectonic rifting during the Oligocene. Nevertheless, the exact reason (mantle plume or volcanism related to Alpine orogeny and subduction processes or something else?) for this extensive rifting in Central Europe is still strongly discussed. Consequently, the detailed evolution and development of the mafic rock body remains mostly unclear.

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