

Multi-proxy detrital accessory mineral analysis reveals the age and origin of eroded basement: a case study from the western Magura Nappe, Outer Western Carpathians, Poland

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The Magura Nappe is the largest unit in the Outer Western Carpathians. However, there are limited single-grain provenance data from the Magura Nappe and so far only from Paleocene-Eocene sedimentary rocks, with no single-grain provenance information from Mesozoic rocks. Here we present the first multi-proxy U-Pb and trace-element analysis of detrital minerals (zircon, rutile and apatite) from the Upper Cretaceous 'Biotite Sandstones' of the Jaworzynka Formation in the Magura Nappe. The data show that in the western part of the Magura Nappe the eroded crystalline basement to the Biotite Sandstone (Jaworzynka Formation) was predominantly high-grade felsic metamorphic and igneous rocks, with subordinate detritus from mafic protholiths. Detrital rutile and apatite ages correspond with the main peak seen in detrital zircon spectra and record late Variscan (320–330 Ma) tectonomagmatic activity. The Campanian Biotite Sandstone represent an episode of rapid basement erosion, transport and sedimentation, as well as rapid burial, that led to excellent preservation of primary rock-forming minerals (biotite). We envisage a depositional setting on the slopes of the North European Platform and the Moldanubicum (Hostýn Ridge) as the sediment source. The similarity of the multi-proxy U-Pb spectra in Late Cretaceous and Eocene sediments implies that sediment routing system (with sourcing from the northwest) was relatively long lived.

Key words: Outer Western Carpathians, detrital zircon, rutile, apatite, U-Pb dating, Alpine tectonics.

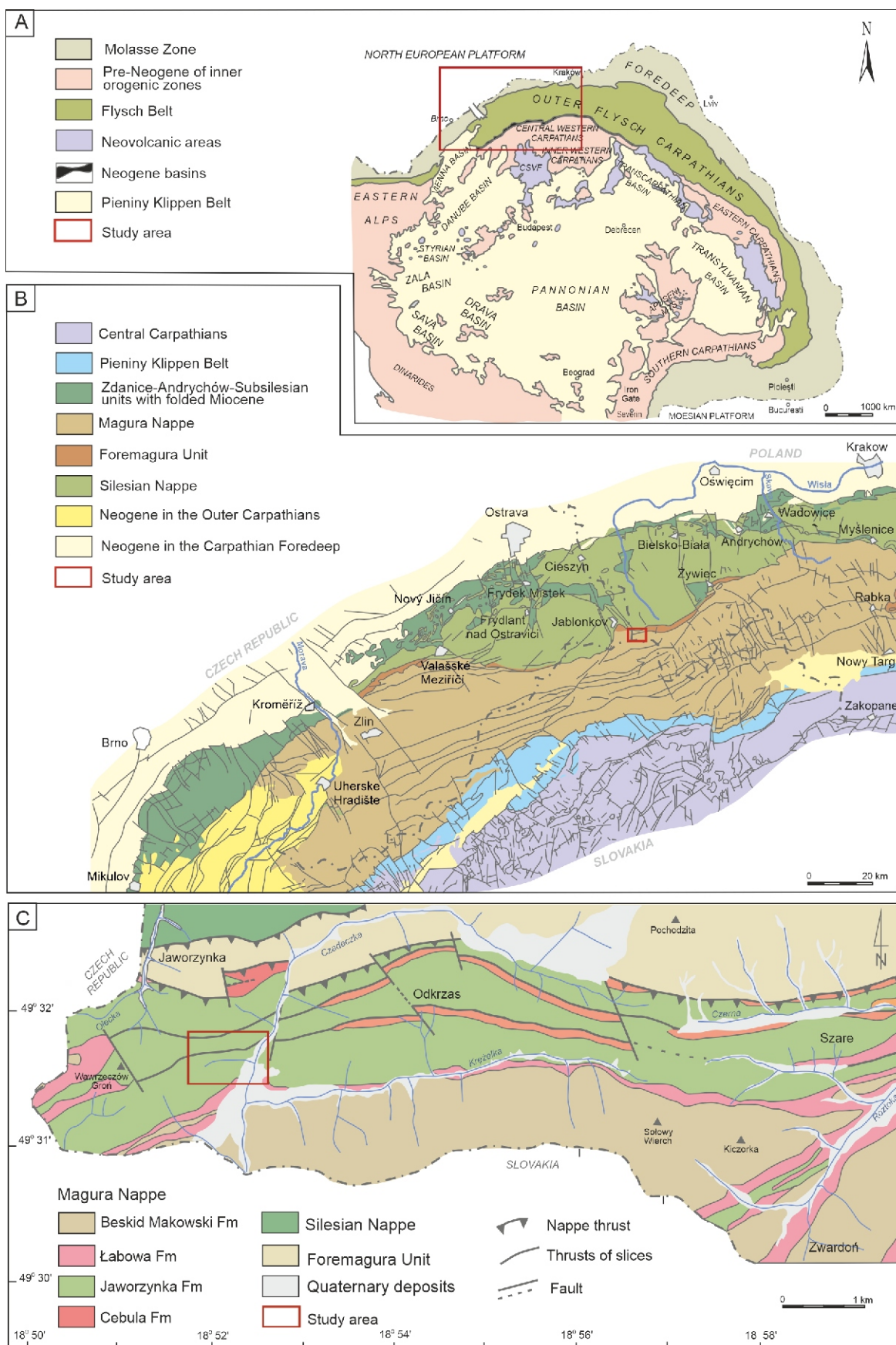
INTRODUCTION

The Magura Nappe is the largest tectonostratigraphic unit in the Outer Western Carpathians (Fig. 1A, B). Most of the provenance information to date has come from exotic crystalline blocks, which are comprised of diverse igneous lithologies (from granitoids to gabbros) as well as metamorphic clasts (Budzyń et al., 2011; Gawęda et al., 2019, 2021, 2023). These exotic blocks are not abundant and are only found in Eocene sedimentary rocks (see Gawęda et al., 2019, 2021, 2023), while single-grain accessory mineral provenance studies are restricted to the Slovakian portion of the Rača Unit (Eocene Makovica

sandstones; Bónová et al., 2016, 2019) and the Menilite and Krosno Formations (Oligocene to Lower Miocene; Nawrocki et al., 2024). Almost all published single-grain provenance data from the Magura nappe are therefore from Cenozoic sedimentary rocks, contemporaneous with turbiditic sedimentation related to Alpine tectonics and there are almost no provenance data from Upper Cretaceous rocks in the Magura Nappe. The exceptions are the detrital rutile geochronology study of de Doliwa-Zieliński et al., (2025) and a preliminary detrital zircon study by Pańczyk et al. (2023) that focused on Caledonian and Cadomian inherited sources. The regional pre-Alpine palaeogeographic and sediment routing systems are thus not constrained.

Modern sedimentary provenance studies predominantly employ single-grain analysis (geochronology, thermochronology, trace-element characterization and isotopic analysis applied to detrital grains), often on accessory minerals (see von Eynatten and Dunkl, 2012 for a comprehensive review). The

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most common accessory mineral employed in single-grain provenance studies is zircon, primarily because of its amenability to U-Pb geochronology. However, zircon predominantly crystallizes in intermediate to felsic magmatic rocks and high-grade metamorphic rocks and is highly refractory in magmatic and metamorphic rocks and sedimentary routing systems, meaning it can survive multiple tectonothermal cycles or several phases of sedimentary recycling. These fertility biases, its refractory behaviour in crystalline basement and propensity to undergo multiple episodes of sedimentary recycling often that provenance interpretations based on U-Pb zircon geochronology datasets are non-unique (Chew et al., 2020 and references therein).

Rutile, a TiO_2 polymorph, is very stable in sedimentary systems and its trace element geochemistry carries information about the temperature of crystallization and the nature of the metamorphic/igneous protolith (Zack et al., 2004; Triebold et al., 2012; O'Sullivan et al., 2016). Rutile can crystallize in HP mafic intrusives (typically at pressures >1.2 GPa), in granitoids and pegmatites, particularly with metamorphic or hydrothermal overprints (Giere, 1990), but is also a common accessory mineral in medium- to high-grade metamorphic rocks. In metapelitic and metamafic rocks rutile is stable above 0.7 GPa (Chambers and Kohn, 2012). Its relatively high U contents make rutile a useful U-Pb geochronometer (Cherniak, 2000). Its trace elements systematics (Cr/Nb ratios, Fe contents) are indicative of the nature of the protolith (metabasic or metapelitic), while Zr contents allow estimation of the temperature of rutile crystallization (Zack et al., 2004; Watson et al., 2006; Triebold et al., 2012). These different analytical approaches make rutile very useful in provenance studies.

While zircon has a closure temperature for Pb of $>900^\circ\text{C}$ and thus records high temperature processes, rutile has a lower limit for Pb-diffusion of $\sim 490\text{--}500^\circ\text{C}$ and an upper temperature limit of $640\text{--}700^\circ\text{C}$ (Pereira et al., 2020). Both minerals are extremely stable in sedimentary systems (Chew et al., 2020 and references therein), while apatite is prone to dissolution in acid meteoric waters, but very persistent during diagenesis (Morton and Hallsworth, 1999). Its closure temperature for the U-Pb system is $\sim 375\text{--}550^\circ\text{C}$ (Cherniak 2000).

In this study, we apply single-grain provenance analysis of the accessory minerals zircon, rutile and apatite, together with major element analysis of biotite and muscovite grains, to discuss the age, provenance and nature of the source region, which is the main goal of this study. Additionally, we aim to constrain the depositional setting of the "Biotite Sandstones", representing the lowermost Jaworzynka Formation within the Siary Zone, Magura Nappe (Figs. 1C and 2). Finally, we discuss potential source area(s), integrating existing literature, including palaeotransport directions and the broader palaeotectonic context of the Late Cretaceous Tethys Ocean and surrounding regions.

GEOLOGICAL SETTING AND SAMPLING

THE OUTLINE OF THE OUTER WESTERN CARPATHIANS GEOLOGY AND PALAEOGEOGRAPHY

The Carpathian Belt formed during continental collision between the North European Platform (East and West European plates) and a composite terrane known as the Apulian Plate (Stampfli, 2005; Golonka et al., 2018), leading to the closure of the Western Tethys Ocean. The internal part of the orogen consist of Neoproterozoic–Paleozoic crystalline basement massifs, covered partly by pre-Neogene (mainly Mesozoic) nappes and basins with several kilometres of sedimentary fill (Golonka et al., 2021 and references therein; Fig. 1A, B). The Outer Carpa-

thians were deformed during the Alpine orogeny in the Miocene and consist of an accretionary complex comprising several nappes (e.g., Koszarski et al., 1974; Cieszkowski et al., 2006; Poprawa et al., 2006; Golonka et al., 2019). The structurally highest is the southernmost Magura Nappe, which has the largest present-day outcrop in the Outer Carpathians (Fig. 1B).

Each nappe represents a distinct sedimentary system (Nemčok et al., 2001; Książkiewicz, 1965, 1977; Żytko et al., 1989). Deposition started in the Late Jurassic and occurred within two distinct domains that were not connected: the Silesian Domain in the north and Magura Domain in the south. The Magura Domain constituted the northwestern part of the Alpine Tethys, bordered by the Czorsztyn Ridge to the south, and the North European Platform and Silesian Ridge to the north. The margin of the North European Platform was uplifted, forming the Pavlov and Silesian ridges. The external Silesian Domain was located to the north of Silesian Ridge (e.g., Oszczypko et al., 2006; Golonka et al., 2019, 2021 and references therein). The ridges bordering the Magura domains, were the most important highs, active from the Jurassic to the Oligocene and serving as an important source of clastic material (e.g., Książkiewicz, 1965, 1977; Unrug, 1968; Eliáš, 1979; Golonka and Picha, 2006, 2021 and references therein). The Pavlov Ridge was transformed into the Hostýn Ridge during Late Cretaceous times (Golonka et al., 2019), while southern part of Silesian ridge formed the Foremagura Ridge.

DETAILED GEOLOGICAL DATA AND SAMPLING

Within Magura group of nappes, six lithologically different tectonic zones can be distinguished, which are from north to south: Siary, Rača, Bystrica, Krynica, Hulina and Bile Karpaty, (e.g., Koszarski et al., 1974; Oszczypko et al., 2015; Golonka et al., 2019 and references therein).

The Siary Zone is the outermost zone of the Magura Nappe. The lithological record in the Siary Zone begins with Santonian variegated shales of the Malinowa and Cebula formations (e.g., Cieszkowski et al., 2006; Oszczypko and Oszczypko-Cloves, 2009; Golonka et al., 2019). The variegated deposits are overlain by turbidite deposits of Jaworzynka Formation. This formation was deposited during the initial phase of turbidite sedimentation from the Campanian to the Paleocene (e.g., Burtan et al., 1973a, b; Cieszkowski et al., 2006; Waśkowska et al., 2021). Depositional conditions, as well as the supply of sediment, varied over time, leading to significant lithological diversity. In the type area, four distinct lithological packages have been distinguished: Biotite sandstone and shale (I), shale (II), the Mutne Sandstone Member (III), and thin-bedded turbidites (IV; Waśkowska et al., 2021). The Jaworzynka Formation is overlain by the variegated shale of the Łabowa Formation with hemipelagic mudstone and claystone deposits as the primary lithosome (Fig. 2).

The lowest unit of the Jaworzynka Formation, the Biotite Sandstone and shale (Fig. 2), the first true turbiditic deposit in the succession, is the focus of our study. According to foraminiferal biostratigraphy, it was deposited during the Middle Campanian to the earliest Maastrichtian, with a thickness of 150 m in the stratotype area. It is composed of thick- to medium-bedded fine- and medium-grained sandstones, with fewer coarse-grained or conglomeratic sandstones (Fig. 3A, B).

These are interlayered with thin dark grey or greenish-grey clayish shales and with decimetre- to metre-thick packages of thin-bedded sandstone-shale sequences (Sikora and Żytko, 1960; Burtan, 1973a, b; Waśkowska et al., 2021). The transport directions are from the north and are suggested to be perpendicular to the ridge, which was the sediment source (Książkiewicz, 1962; Ryłko, 1992; Cieszkowski et al., 2007).

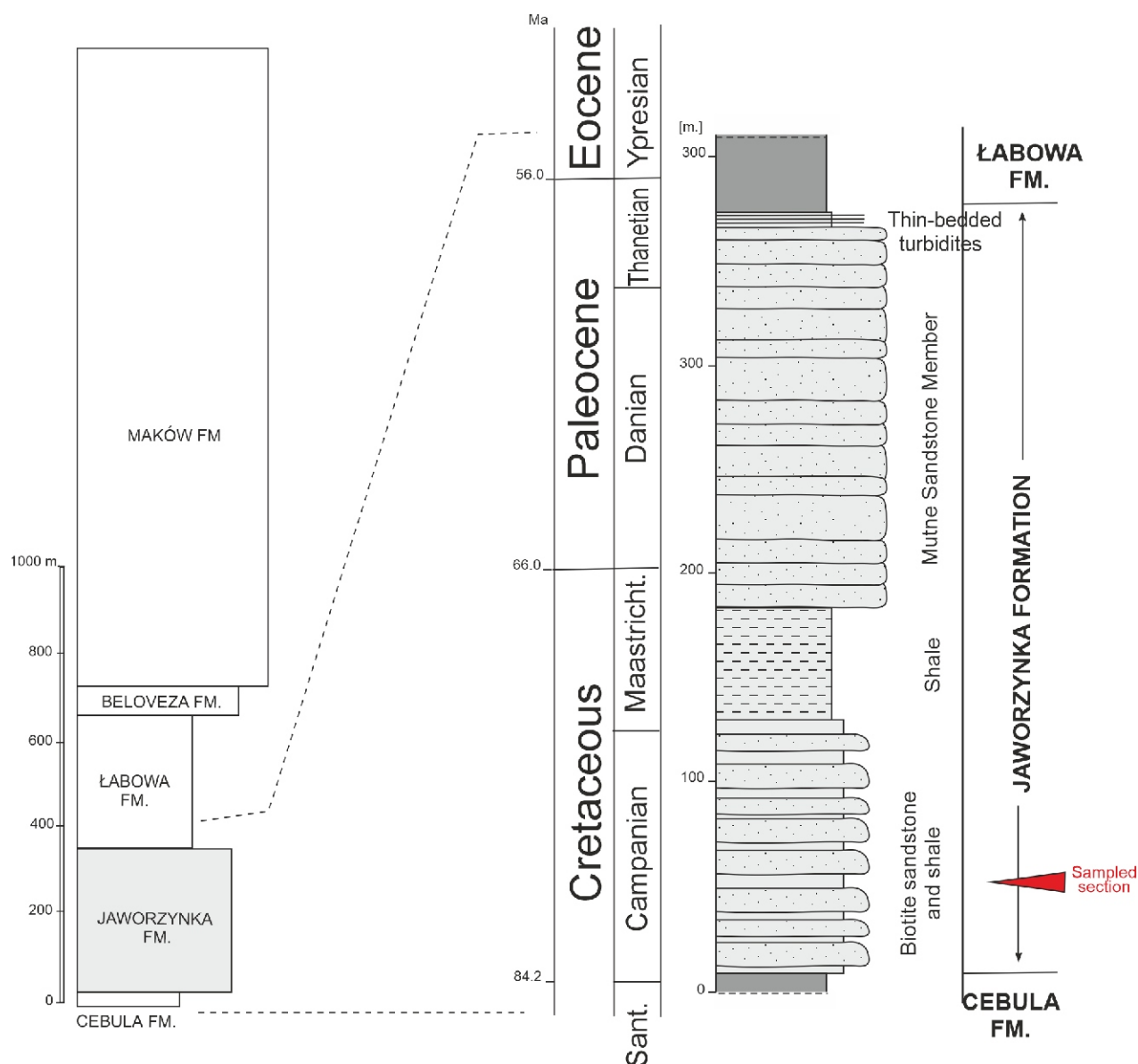


Fig. 2. Lithostratigraphy of the Jaworzynka Formation after Waśkowska et al. (2021)

Biotite Sandstone and shale is the most distinctive unit in the Outer Carpathians due to its unique mineral composition and presence of non-altered or weakly altered clastic biotite (Fig. 3C–F). This occurrence is so unique that it defines the unit name. Initially, they were referred to as the “Biotite-feldspar beds” by Sikora and Žytko (1960), who first identified them, and later as the “Biotite beds from Jaworzynka,” a term introduced by Burtan (1973a, b).

Samples weighting from 4 to 8 kg each were collected for laboratory analyses from the type area of the Jaworzynka Formation, in the village of Jaworzynka, near the Poland-Czech Republic-Slovakia triple-border on the left-bank tributary of the Czadeczka Stream (Fig. 1C; coordinates: 49°32'09.3"N 18°53'19.9"E). Sampling was undertaken along the stream with sampling points located every 1–2 metres.

Two main lithologies were sampled: 1) coarse-grained sandstone (MAG 1) and 2) medium-grained sandstone (MAG 2, MAG 3 and MAG 4). They differ in grain size, but not in petrographic character of the grains and matrix.

EXPERIMENTAL METHODS

MICROSCOPY AND ELECTRON PROBE MICRO-ANALYSES (EPMA)

Petrographic analyses of thin sections were undertaken at the Faculty of Earth Sciences in the University of Silesia using Olympus BX-51 and SX-10 microscopes to constrain textural and microstructural relationships and to determine the presence of accessory minerals. From each sample two thin sections were examined.

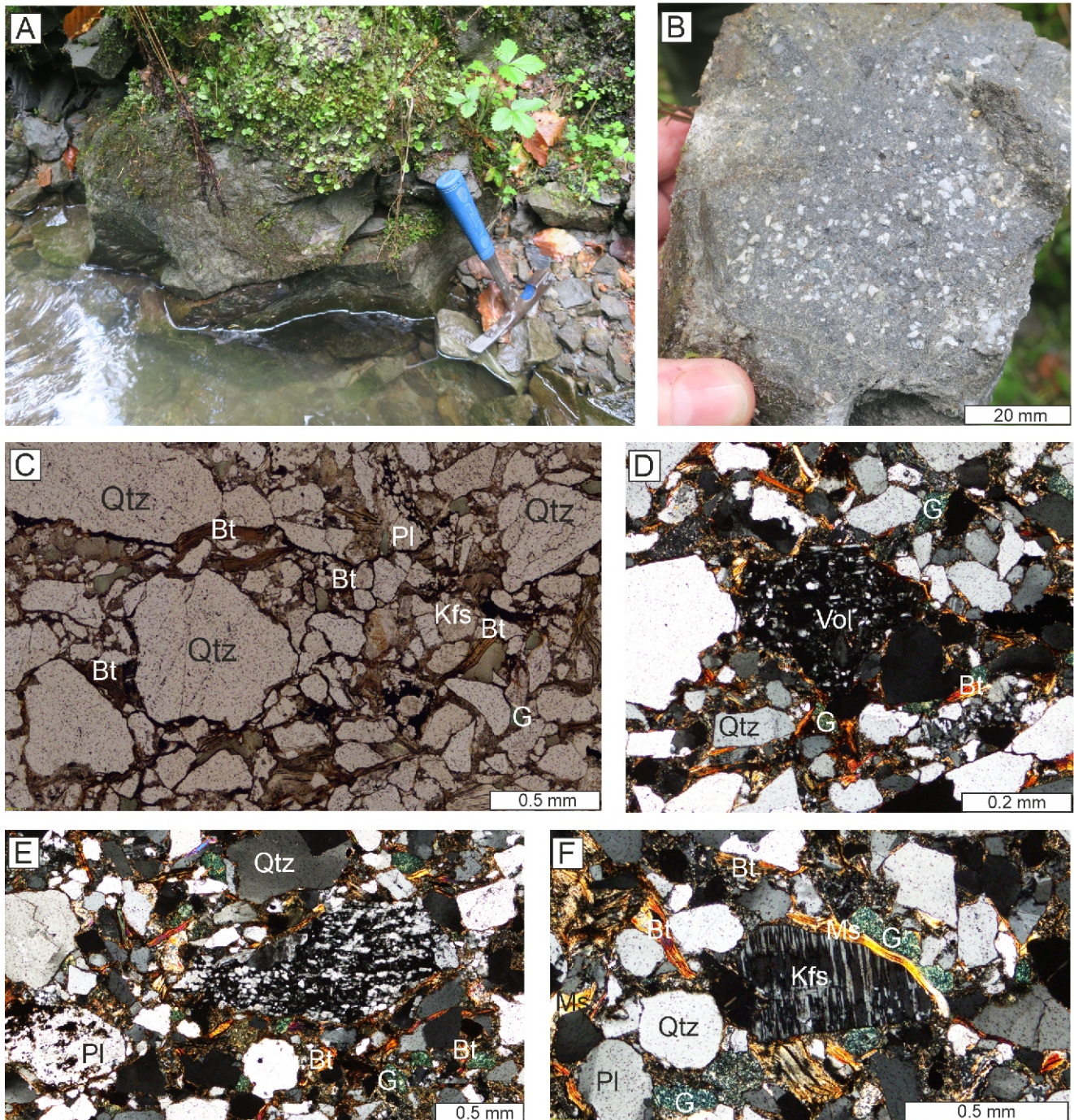


Fig. 3. Photographs and optical photomicrographs from the study area

A – field photograph showing the sampling locality in the Czadeczka stream, geological hammer as a scale; **B** – coarse-grained biotite-rich sandstone MAG 1; **C** – photomicrograph (plane-polarized light) of coarse-grained biotite sandstone; **D–F** – photomicrographs (crossed polars) of **D** – a volcanic clast within biotite sandstone, **E** – a metamorphic clast and clasts of quartz, feldspar, biotite and **F** – a non-altered clast of microcline. Abbreviations: Qtz – quartz, Pl – plagioclase, Kfs – K-feldspar, Bt – biotite, Ms – muscovite, Vol – volcanic clast, G – glauconite

Microprobe analyses of the main rock-forming and accessory minerals were carried out at the Laboratory of Electron Microscopy, Microanalysis and X-Ray Diffraction (Faculty of Geology, University of Warsaw, Poland), using a *CAMECA SX-100* electron microprobe. The analytical conditions employed an accelerating voltage of 15 kV, a beam current of 20 nA, counting times of 20–30 s for peak and 10–15 s for background and a beam diameter of 1–5 mm. Reference materials, analytical

lines, diffracting crystals, mean detection limits (in wt.%) and uncertainties were as follows: rutile – Ti (K, PET, 0.03, 0.05), diopside – Mg (K, TAP, 0.02, 0.11), Si – (K, TAP, 0.02, 0.21), Ca – (K, PET, 0.03, 0.16), orthoclase – Al (K, TAP, 0.02, 0.08), and K (K, PET, 0.03, 0.02), albite – Na (K, TAP, 0.01, 0.08), hematite – Fe (K, LIF, 0.09, 0.47), rhodonite – Mn (K, LIF, 0.03, 0.10), phlogopite – F (K, TAP, 0.04, 0.32), tugtupite – Cl (K, PET, 0.02, 0.04), Cr₂O₃ – Cr (K, PET, 0.04, 0.01),

ZirconED2 – Zr (L, PET, 0.01, 0.01), Nb₂O₃-MAC – Nb (L, PET, 0.09, 0.01), V₂O₅ – V (K, LIF, 0.02, 0.01), YPO₄ – Y (L, TAP, 0.05, 0.05), CeP₅O₁₄ – Ce (L, LPET, 0.09, 0.02), NdGaO₃ – Nd (L, LIF, 0.31, 0.24), ThO₂ – Th (M, LPET, 0.09, 0.09), UO₂ – U (M, LPET, 0.16, 0.13).

MINERAL SEPARATION AND IMAGING

Rutile, zircon and apatite grains from the “biotite sandstones” were separated using standard density separation techniques (crushing, sieving, washing and panning). This separation was carried out at the Institute of Geological Sciences at the Polish Academy of Sciences, Kraków, Poland. Minerals prepared for dating were hand-picked under a binocular microscope, cast in 25 mm diameter epoxy resin mounts, and then ground and polished to expose the grain interiors. Internal mineral textures were then imaged using back-scattered electron (BSE) and cathodoluminescence (CL) detectors on a FET Philips 30 scanning electron microscope with a 15 kV accelerating voltage and a beam current of 1 nA at the Faculty of Natural Sciences, University of Silesia in Katowice, Poland.

Cathodoluminescence (CL) imaging was performed at the Faculty of Natural Sciences in the University of Silesia in Katowice, Poland, using a C/TL Mk5 cold-cathode CL unit operating at maximum 30 kV, 0.003 mbar and 250 mA of beam voltage, vacuum, and current, respectively. Typical operating conditions for the sample analysis were 10 kV and 280–300 mA. The CL unit was mounted on a Nikon Eclipse optical microscope.

LA-ICP-MS U-Pb DATING

LA-ICP-MS U-Pb age data were acquired using a Photon Machines Iridia 193 nm ArF excimer laser-ablation system with a Cobalt 2-volume ablation cell coupled to an Agilent 7900 ICPMS at the Department of Geology, Trinity College Dublin. The instruments were tuned using NIST612 reference material glass to yield Th/U ratios of unity and low oxide production rates (ThO⁺/Th⁺ typically <0.15%). A repetition rate of 11 Hz and a circular spot of 24 µm were employed. A quantity of 0.4 L min⁻¹ He carrier gas was fed into the laser cell, and the aerosol was subsequently mixed with 0.6 L min⁻¹ Ar make-up gas and 11 mL min⁻¹ N₂.

Data reduction of the raw U-Pb isotope data was performed through the “VizualAge” and “VizualAge_UcomPbine” data reduction schemes (Petrus and Kamber, 2012; Chew et al., 2014) in the IOLITE v 4.10 package (Paton et al., 2011). Sample-standard bracketing was applied after the correction of downhole fractionation to account for long-term drift in isotopic or elemental ratios by normalizing all ratios to those of the U-Pb reference material. Final age calculations were made using the Isoplot add-in for Excel (Ludwig, 2012) and IsoplotR (Vermeesch, 2018).

ZIRCON LA-ICP-MS U-Pb DATING

Eleven isotopes (⁴⁹Ti, ⁹¹Zr, ¹⁷⁵Lu, ²⁰²Hg, ²⁰⁴Pb, ²⁰⁶Pb, ²⁰⁷Pb, ²⁰⁸Pb, ²³²Th, ²³⁵U and ²³⁸U) were acquired during each analysis, which comprised 27 s of ablation and 12 second washout, the latter portions of which were used for the baseline measurement. 91500 zircon (²⁰⁶Pb/²³⁸U TIMS age of 1065.4 ±0.6 Myr; Wiedenbeck et al., 1995, 2004) was used as the primary U-Pb calibration reference material. The secondary reference mate-

rial GZ-7 zircon (²⁰⁶Pb/²³⁸U TIMS age of 530.26 ±0.05 Myr; Nasdala et al., 2018), Plešovice zircon (²⁰⁶Pb/²³⁸U TIMS age of 337.13±0.37 Myr; Sláma et al., 2008) and WRS 1348 zircon (²⁰⁶Pb/²³⁸U TIMS age of 526.26 ±0.70 Myr; Poinçon et al., 2012) yielded LA-ICPMS ages of 532.0 ±2.2 Myr, 337 ±1.6 Myr and 528.4 ±3.2 Myr, respectively.

LA-ICP-MS U-Pb RUTILE DATING AND TRACE ELEMENT ANALYSES

All data reduction was performed offline using the IOLITE data reduction package using the Vizual Age_UcomPbine data reduction scheme (Chew et al., 2014). R10 (1090 ±5 Myr; Luvisotto et al., 2009) was employed as the primary reference material (yielding 1096.2 ±7.5 Myr), and R19 (ID-TIMS date of 489.5 ±0.9 Myr; Zack et al., 2011) and R13 (U-Pb SHRIMP age of 504 ±4 Myr, Schmitt and Zack, 2012) were employed as secondary reference material and treated as unknowns during data reduction, and yielded weighted average ²⁰⁷Pb-corrected ages of 489.4 ±2.6 Myr and 508.5 ±6.6 Myr, respectively. Ages were calculated using the Isoplot plug-in for Excel (Ludwig, 2012). Common (non-radiogenic) Pb in the primary and secondary standards was corrected with a ²⁰⁷Pb-based correction method using a known initial ²⁰⁷Pb/²⁰⁶Pb ratio; common Pb in the detrital unknowns was corrected using an initial estimate of the ²⁰⁷Pb/²⁰⁶Pb ratio generated using the terrestrial Pb evolution model of Stacey and Kramers (1975) employing an iterative approach (Chew et al., 2011; Bracciali et al., 2013). Due to the use of the ²⁰⁷Pb-based correction, rutile U-Pb analyses could not be conventionally assessed for discordance, but sometimes the high common Pb to radiogenic Pb ratios resulted in undesirably large age uncertainties. Grains with large age uncertainties were therefore filtered (Mark et al., 2016; O’Sullivan et al., 2016) and only grains with 2 uncertainties <15% RSD were accepted.

LA-ICP-MS U-Pb APATITE DATING AND TRACE ELEMENT ANALYSES

Twenty-nine isotopes (³¹P, ³⁵Cl, ⁴³Ca, ⁵¹V, ⁵⁵Mn, ⁸⁸Sr, ⁸⁹Y, ⁹⁰Zr, ¹³⁹La, ¹⁴⁰Ce, ¹⁴¹Pr, ¹⁴⁶Nd, ¹⁴⁷Sm, ¹⁵³Eu, ¹⁵⁷Gd, ¹⁵⁹Tb, ¹⁶³Dy, ¹⁶⁵Ho, ¹⁶⁶Er, ¹⁶⁹Tm, ¹⁷²Yb, ¹⁷⁵Lu, ²⁰⁴Pb, ²⁰⁶Pb, ²⁰⁷Pb, ²⁰⁸Pb, ²³²Th and ²³⁸U) were acquired for apatite. NIST612 standard glass was used as the apatite trace-element reference material with ⁴³Ca employed as an internal elemental reference material, and a crushed aliquot of Durango apatite that has been characterized by solution quadrupole-ICP-MS analyses (Chew et al., 2016), was used as the apatite trace-element secondary reference material. For U-Pb apatite analyses, the Madagascar natural mineral standard (Thomson et al., 2012) was used as the primary age reference material, using a ~1 cm sized crystal of Madagascar apatite which has yielded a weighted average ID-TIMS concordia age of 473.5 ±0.7 Myr (unpublished data from the study of Cochrane et al., 2014). McClure Mountain syenite apatite (total Pb/U isochron age of 525.3 ±1.7 Myr; Krestianinov et al., 2021) and Durango apatite (linear 3-D isochron age of 32.683 ±0.050 Myr; Paul et al., 2021) were used as secondary reference materials and yielded ²⁰⁷Pb-corrected ages of 522.9 ±56.8 Myr (MSWD = 1.8) and 32.49 ±0.94 Myr (MSWD = 1.4) respectively, using a ²⁰⁷Pb/²⁰⁶Pb value of 0.874 derived from an apatite ID-TIMS total U-Pb isochron (Krestianinov et al., 2021) and a ²⁰⁷Pb/²⁰⁶Pb value derived from the Stacey and Kramers (1975) terrestrial Pb evolution model at 32.68 Myr. Age calculation was made using the IsoplotR software (Vermeesch, 2018).

Table 1

Representative microprobe analyses of detrital biotite grains and their crystal-chemical formulas recalculated for 22 O²⁻ and computed temperatures according to Henry et al. (2005) geothermometer

Component	LoD	Bt-1	Bt-2	Bt-3	Bt-4	Bt-5	Bt-6
SiO ₂	0.04	37.49	37.47	37.44	37.44	37.19	37.45
TiO ₂	0.06	3.88	4.05	5.30	5.31	5.33	5.36
Al ₂ O ₃	0.03	13.46	13.04	13.85	13.84	13.74	13.86
Cr ₂ O ₃	0.01	0.11	b.d.l	0.05	0.14	0.07	0.17
FeO	0.08	17.58	19.45	14.09	14.98	13.55	15.06
MgO	0.02	12.71	11.77	14.80	14.79	15.07	14.39
MnO	0.02	0.33	0.25	0.33	0.08	0.03	0.17
Na ₂ O	0.04	0.14	0.11	0.43	0.52	0.44	0.53
K ₂ O	0.05	9.25	9.38	8.84	8.80	8.78	8.87
BaO	0.01	0.25	0.12	0.74	0.78	0.75	0.67
F	0.25	1.64	0.69	0.68	0.50	0.38	0.37
Cl	0.02	0.31	0.31	0.23	0.22	0.23	0.21
H ₂ O*		3.01	3.49	3.61	3.73	3.75	3.79
Total		100.07	100.20	100.14	101.06	99.45	100.83
O=F,Cl		0.76	0.36	0.34	0.26	0.21	0.20
Total		99.31	99.84	99.80	100.80	99.24	100.63
Si		5.81	5.77	5.63	5.58	5.59	5.59
Al ^{IV}		2.19	2.23	2.38	2.42	2.41	2.41
Al ^{VI}		0.27	0.13	0.08	0.01	0.03	0.02
Ti		0.45	0.47	0.60	0.60	0.60	0.60
Cr		0.01	–	0.01	0.02	0.01	0.02
Fe		2.28	2.50	1.77	1.87	1.71	1.88
Mg		2.94	2.70	3.32	3.29	3.38	3.20
Mn		0.03	0.04	0.01		0.02	0.01
Na		0.04	0.03	0.13	0.15	0.13	0.15
K		1.83	1.84	1.69	1.67	1.68	1.69
Ba		0.02	0.01	0.04	0.05	0.04	0.04
F		0.80	0.34	0.33	0.24	0.18	0.17
Cl		0.08	0.08	0.06	0.06	0.06	0.05
#mg		0.56	0.52	0.65	0.64	0.66	0.63
T_{H2005}		734	730	789	784	792	784

#mg = Mg/(Fe+Mg+Mn) ; b.d.l. – below detection limit ; * – computed values

RESULTS

PETROGRAPHY, MINERAL CHEMISTRY AND CLASSIFICATION OF THE BIOTITE SANDSTONE

The sandstone clasts range in size from 0.1–3.0 mm (Fig. 3A, B) and are comprised of quartz, sericitized plagioclase, perthitic K-feldspar, biotite (to some extent chloritised), muscovite and abundant zircon and rutile; apatite and magnetite are rare. Lithics include quartzo-feldspathic micro-clasts which together with monomineralic clasts of quartz and feldspar make ~75% of the rock by volume, while the fine-grained clay-quartz matrix comprises ~10% by volume. Volcanic and metamorphic micro-lithoclasts are sometimes found, ranging from 1.2 to 0.6 mm in size (Fig. 3D, E). The volcanic micro-clasts are composed of an aphanitic matrix and remnants of plagioclase (Fig. 3D) while the metamorphic micro-clasts, show an oriented fabric and are mainly quartzites (Fig. 3E). Glauconite fragments are also present (Fig. 3C–F). Biotite is enriched in F and is Mg-rich (F = 0.17 – 0.96 a.p.f.u.; #mg = 0.52–0.66). Application of the Henry et al. (2005) Ti-in-biotite geothermometer yielded temperature ranges of 709–792°C (Table 1). Two generations of muscovite grains differing in the phengite component and with #mg ranging from 0.59–0.79 were recognized: Ms1 with Si [a.p.f.u] of 6.63–6.83, and Ms2 with Si [a.p.f.u] from 6.20–6.42 (Table 2). On the basis of the clasts character and mineral composition the rocks are classified as arkosic arenites.

RUTILE MORPHOLOGY, TRACE ELEMENTS CHARACTERISTICS, GEOTHERMOMETRY AND U-Pb DATING

The rutile grains from two rock-types were analysed: the coarse grained MAG 1 sandstone and medium-grained MAG 2 and MAG 4 sandstones. Two types of rutile grains were found: 1) rounded, isometric, anhedral, dark-brown in transmitted light and 2) long-prismatic, brick-red crystals, that are commonly broken (Fig. 4A).

Sixty-three rutile grains from the MAG 1 sample yielded a Tera-Wasserburg age of 327.4 ± 4.4 Myr (MSWD = 2.9), with 55 analyses yielding ²⁰⁷Pb corrected ages with 2 uncertainties <15% (Appendix Table 1a; Fig. 5A–C). 93 rutile grains from the MAG 2 sample yielded a Tera-Wasserburg age of 346.2 ± 4.8 Myr (MSWD = 3.3), with 62 points yielding ²⁰⁷Pb corrected ages with 2 less 15%, (Appendix Table 1a; Fig. 5E, F). 32 rutile grains from the MAG 4 sample yielded a Tera-Wasserburg lower intercept age of 375 ± 18 Myr (MSWD = 0.71), with 4 concordant grains yielding a concordia age of 377.9 ± 8.8 Myr (MSWD = 0.14: Appendix Table 1a; Fig. 5H, J). Two concordant Neoproterozoic grains and one Lower Paleozoic are noted (Appendix Table 1a).

Zr-in rutile geothermometry after Zack et al. (2004) [Z04] and Tomkins et al. (2007) [T07] shows a division into two populations: 124 isometrical rutile grains from mostly MAG 1 and MAG 2 samples define a high temperature (HT) population, yielding temperatures [Z04] in the range of 601°C to 977°C (mean temperature of 786°C), or [T07] temperatures of 602°C

Table 2

Representative microprobe analyses of muscovite grains and their crystal-chemical formulas recalculated for 22 O²⁻

Component	LoD	Ms-1	Ms-2	Ms-3	Ms-4	Ms-5	Ms-6
SiO ₂	0.04	46.61	46.94	48.22	51.93	51.11	47.15
TiO ₂	0.06	0.07	0.10	0.11	0.06	0.10	0.07
Al ₂ O ₃	0.03	37.29	36.21	32.98	28.87	28.93	36.13
Cr ₂ O ₃	0.01	b.d.l.	b.d.l.	0.04	0.05	0.05	b.d.l.
FeO	0.08	0.25	0.54	0.90	2.17	2.20	0.49
MgO	0.02	0.34	0.67	1.97	2.61	2.50	0.64
MnO	0.02	b.d.l.	0.08	0.05	0.03	b.d.l.	b.d.l.
Na ₂ O	0.04	0.14	0.17	0.10	0.06	0.04	0.14
K ₂ O	0.05	10.88	10.70	10.48	9.41	9.41	10.36
BaO	0.01	0.05	0.09	0.05	b.d.l.	b.d.l.	0.05
H ₂ O*		4.54	4.54	4.51	4.56	4.51	4.53
Total		100.17	100.04	99.41	99.75	98.85	99.56
Si		6.14	6.20	6.41	6.83	6.80	6.23
Al ^{IV}		1.86	1.80	1.59	1.17	1.20	1.77
Al ^{VI}		3.93	3.84	3.38	3.31	3.33	3.87
Ti		0.01	0.01	0.01	0.01	0.01	0.01
Cr		—	—	—	0.01	0.01	—
Fe		0.03	0.06	0.10	0.24	0.25	0.06
Mg		0.07	0.13	0.39	0.51	0.50	0.13
Mn		—	0.01	0.01	—	—	—
Na		0.04	0.04	0.03	0.02	0.01	0.04
K		1.83	1.81	1.78	1.58	1.60	1.75
Ba		—	0.01	—	—	—	—
#mg		0.71	0.66	0.79	0.68	0.67	0.70

For explanations see Table 1

– 950°C (mean temperature 764°C), with Cr/Nb ratios ranging from 0.002–1.764; U ranging from 0.59–86.5 ppm and Hf from 4.48–142.8 ppm (Appendix Table 1b). 32 elongated rutile grains from MAG 4 sample yielded temperatures of 317–686°C. Considering the lower calibration limit of the geothermometers is ~430°C, the lowest values (six grains) were removed from calculations yielding a mean value of 592 °C [Z04] or 573°C [T07]. The Cr/Nb ratio in this population ranges from 0.003–0.900, U from 0.28–24.3 ppm and Hf from 0.43–11.71 ppm (Appendix Table 1b).

ZIRCON MORPHOLOGY, CATHODOLUMINESCENCE FEATURES AND U-Pb DATING

Detrital zircon grains from four sandstone samples were separated and analysed. They are translucent, white to yellow, and are both idiomorphic with well-developed long to short prismatic morphologies, and mechanically abraded, with rounded edges (Fig. 4B, C). Both the idiomorphic and sub-idiomorphic grains have sometimes a coating of host-rock minerals (most commonly chlorite/biotite) and contain mineral inclusions or pits representing inclusions removed during polishing (Fig. 4B, C). Most of grains show oscillatory and sector zonation and moderate grey CL colours, sometimes containing inherited cores that are either CL-dark or bright (Fig. 6A). Two grain size population were analysed separately: grains 100 µm long (marked as D) and grains 100 µm long (up to 450 µm – marked as G; Fig. 4B, C).

From sample MAG 1 both G and D populations were analysed: 131 grains from G population (two of them discordant) and 140 grains from the D population (16 discordant). Sample MAG 2 contained only population D (150 grains analysed, 14 discordant). In sample MAG 3 114 grains of the D population (13 discordant) and 52 grains of G population were analysed (1 discordant), while in sample MAG 4 55 grains of the G popu-

lation were analysed (11 discordant). Considering all samples together, the ages are dominantly Variscan, with a subordinate (~11%) pre-Variscan population, representing mostly inherited cores (Fig. 7A).

The concordant ages from MAG 1(G) cover the range of 306–951 Myr, with the majority (122) in the range of 306–361 Myr and only seven Neoproterozoic ages (Appendix Table 2a; Fig. 7A). Concordant ages from the MAG 1(D) population range from 299–2737 Myr, again with majority (97) ranging from 299–350 Myr with 27 older ages (either inherited cores or single crystals; Appendix Table 2a; Fig. 7B).

In the MAG 2(D) the concordant zircon age population yielded two inherited Paleoproterozoic cores of 1881 Myr and 1988 Myr, twelve grains ranging from 553–1018 Myr, eight early Paleozoic inherited cores (502–406 Myr) along with the dominant population Variscan ages (314–364 Myr). Two Permian rims (292 Myr and 280 Myr) were detected (Appendix Table 2b; Fig. 7C).

Fifty-one concordant zircon grains from MAG 3(G) population yielded a narrow spectrum of Variscan ages (317–352 Myr; Fig. 7C), while the 101 concordant grains of the MAG 3(D) population yielded two inherited Paleoproterozoic cores (1942 Myr and 2011 Myr), ten Neoproterozoic cores (559–772 Myr), seven early Paleozoic cores (507–441 Myr) and a dominant Variscan population (312–382 Myr; Appendix Table 2c; Fig. 8C). The MAG 4(G) concordant population yielded one inherited pre-Variscan core (452 Myr), and a Variscan population ranging from 307–357 Myr (Appendix Table 2d, Fig. 7D).

APATITE MORPHOLOGY, CATHODOLUMINESCENCE PATTERNS, TRACE ELEMENTS CHARACTERISTICS AND U-Pb DATING

Detrital apatite grains from the MAG 1 and MAG 2 samples show mostly well-developed short- to long-prismatic hexagonal morphologies and range from 60–200 µm in length (Fig. 4A). The grains exhibit prism-perpendicular fractures and slight mechanical abrasion. The grains are characterised by yellow, grey-yellow, violet and blue colours in CL and minor oscillatory zonation. The grey-yellow apatite grains show homogeneous or patchy internal textures (Fig. 6B).

In both samples apatite grains with violet CL have SREE from 2107–10 695 ppm (mean = 6835 ppm), Eu/Eu* = 0.04–0.66, Ce_N/Yb_N = 1.64–34.15, while for two blue apatites SREE is 4529 ppm and 1451 ppm, Eu/Eu* = 0.04 and 0.70 and Ce_N/Yb_N = 1.31 and 26.28 (Appendix Table 3). The mean Mn content is lowest and Sr is highest in the violet luminescing apatites (Mn_{mean} = 409 ppm; Sr_{mean} = 573 ppm). They plot in the IM fields on the support vector machine (SVM) classification diagram after O'Sullivan et al. (2020; Fig. 8A). The yellow luminescing and zonal apatites have REE ranging from 1918–10 371 ppm (mean = 4112 ppm) and Eu/Eu* = 0.03–0.83 and Ce_N/Yb_N = 1.11–36.71, while unzonal grey-yellow apatites are characterised by REE in the range of 73–6572 ppm (mean value = 3236 ppm), Eu/Eu* = 0.10–0.64 and Ce_N/Yb_N = 1.15 to 14.47 (Appendix Table 3).

The grey-yellow and yellow-luminescing apatite show the highest mean Mn content (336 ppm and 324 ppm), while the CL-yellow ones are characterised by the highest mean Y contents (1833 ppm). They plot mostly in the S-type granite (S), high-grade metamorphic (HM) and I-type granitoids and mafic igneous (IM) fields on the SVM diagram, together with two CL blue grains. One analysis of CL grey-yellow apatite and one of CL yellow plot in LM field with one CL yellow in UM field

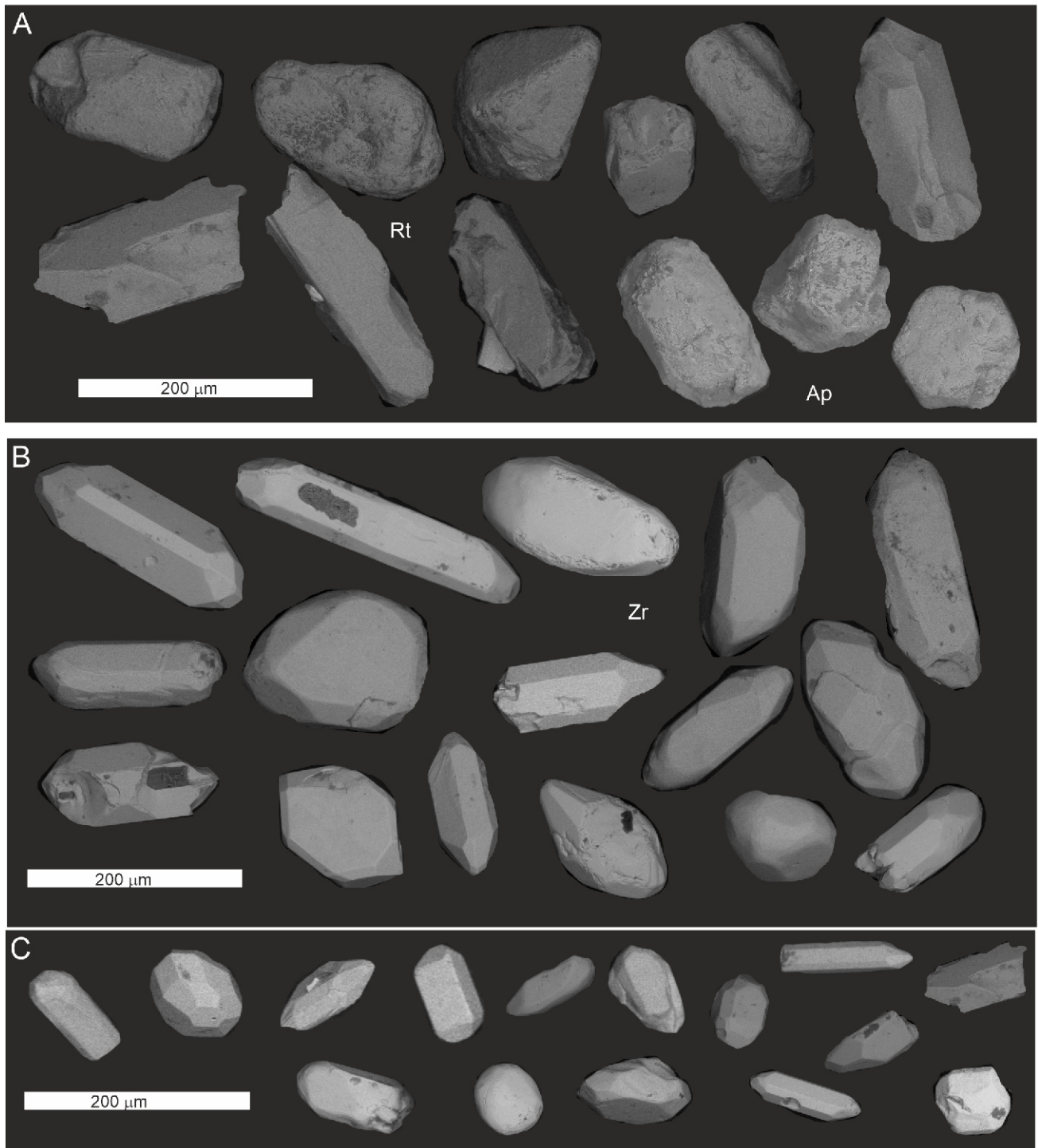


Fig. 4. Representative scanning electron microscopy (SEM) images

A – rutile (Rt) and apatite (Ap); **B** – zircon grains (G population), >100 μm; **C** – zircon grains (D population), <100 μm

(Fig. 8A). The Tera-Wasserburg lower intercept ages of the MAG 1 grains is $317.8 \text{ Myr} \pm 9.5/14.7 \text{ Myr}$ (MSWD = 2.2). Six CL violet grains from this sample yielded a Tera-Wasserburg lower intercept age of $315 \pm 13 \text{ Myr}$ (MSWD = 0.32) while the CL yellow to grey-yellow grains yielded a lower intercept age of $314.4 \pm 7.3 \text{ Myr}$ (MSWD = 2.2; Fig. 9A–C). All apatite grains from the MAG 2 sample yielded a lower intercept age of 320.4

$\pm 4.2/6.6 \text{ Myr}$ (MSWD = 2.4; Fig. 9D). Ten violet-luminescing crystals from this sample yielded a lower intercept age of $321 \pm 12 \text{ Myr}$ (MSWD = 0.3) and the CL yellow/grey-yellow grains yielded a lower intercept age of $320 \pm 9 \text{ Myr}$ (MSWD = 0.81; Fig. 9E, F). All apatite sub-populations subdivided by CL colour just yield identical ages considering age uncertainty.

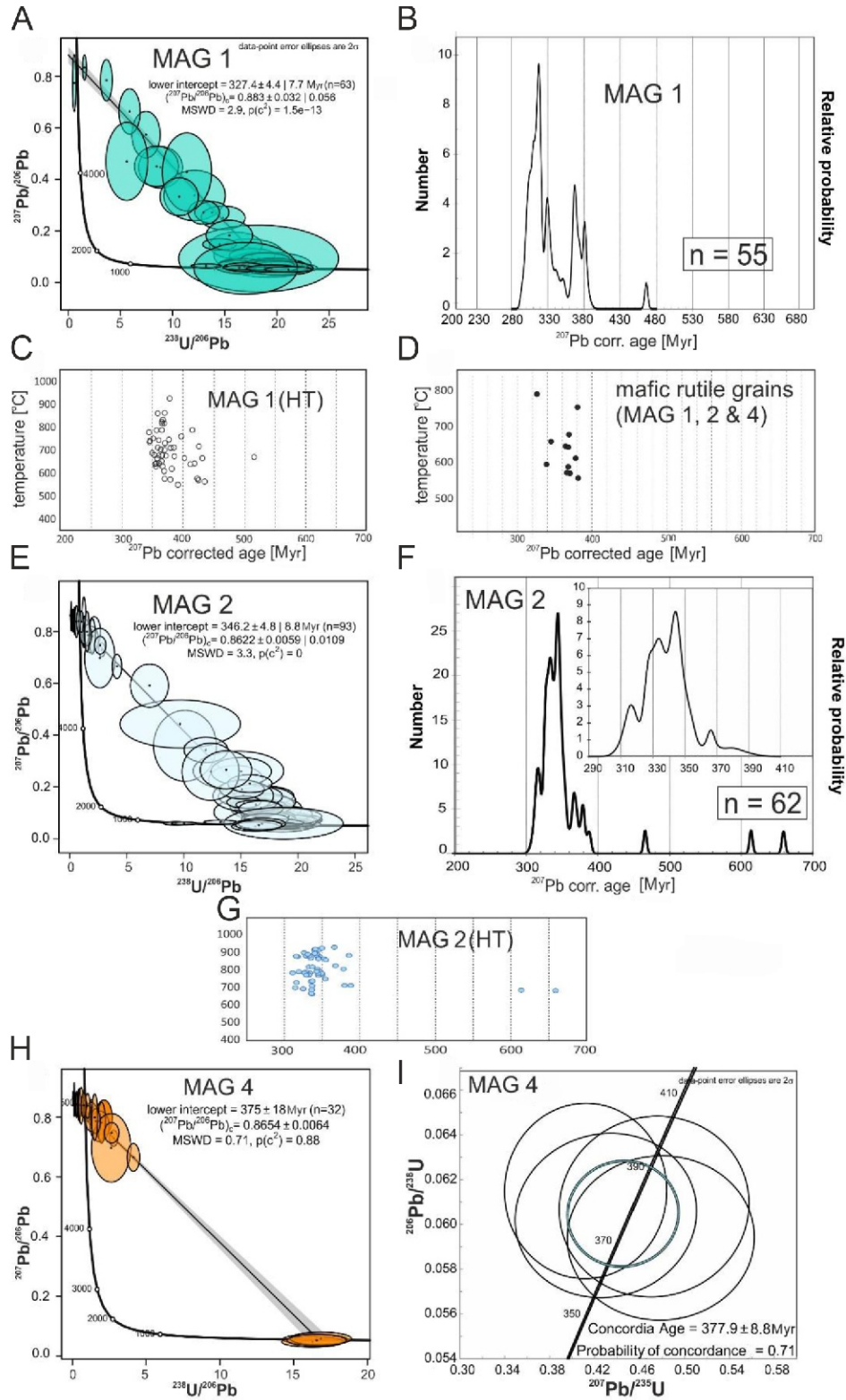


Fig. 5. U-Pb rutile geochronology

A – Tera-Wasserburg diagram of the MAG 1 sample; **B** – probability density plot of concordant data from the same sample; **C**, **D** – biplots of U-Pb rutile age against rutile crystallization temperature using the Zr-in-rutile geothermometer of [Watson et al. \(2006\)](#) for high-temperature (HT) felsic rutile from the MAG 1 sample (**C**) and mafic rutile grains from all three samples; **E** – Tera-Wasserburg diagram of MAG 2 sample with **F** – probability density plot of concordant data from the same sample (inset shows the Variscan age population); **G** – biplot of U-Pb rutile age against rutile crystallization temperature computed using the Zr-in-rutile geothermometer of [Watson et al. \(2006\)](#) for high-temperature felsic rutile from the MAG 2 sample; **H** – Tera-Wasserburg diagram of rutile from the MAG 4 sample; **I** – probability density plot for four concordant data from the same sample with the concordia plot inset

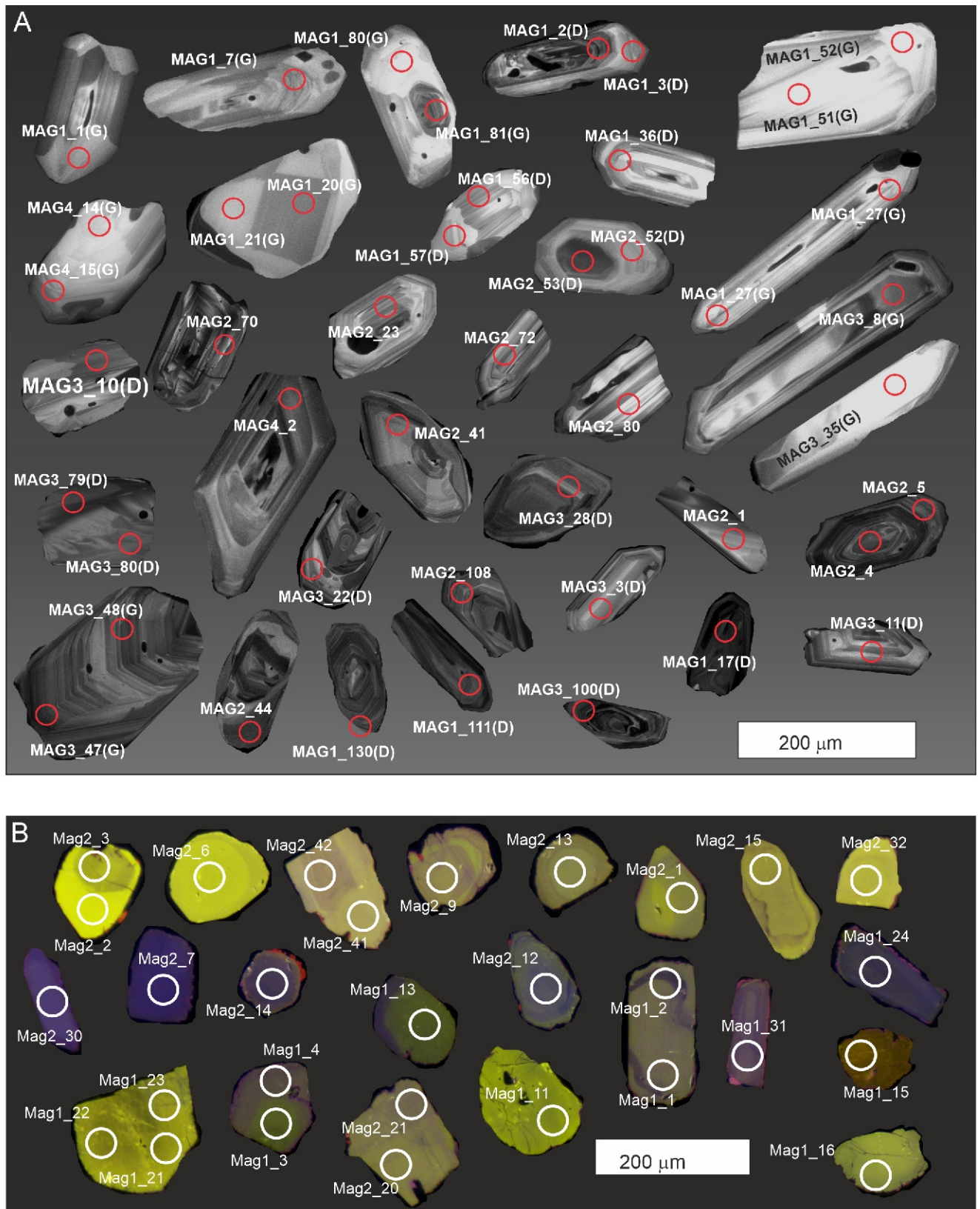


Fig. 6. Examples of zircon (A) and apatite (B) internal structures under cathodoluminescence (CL)

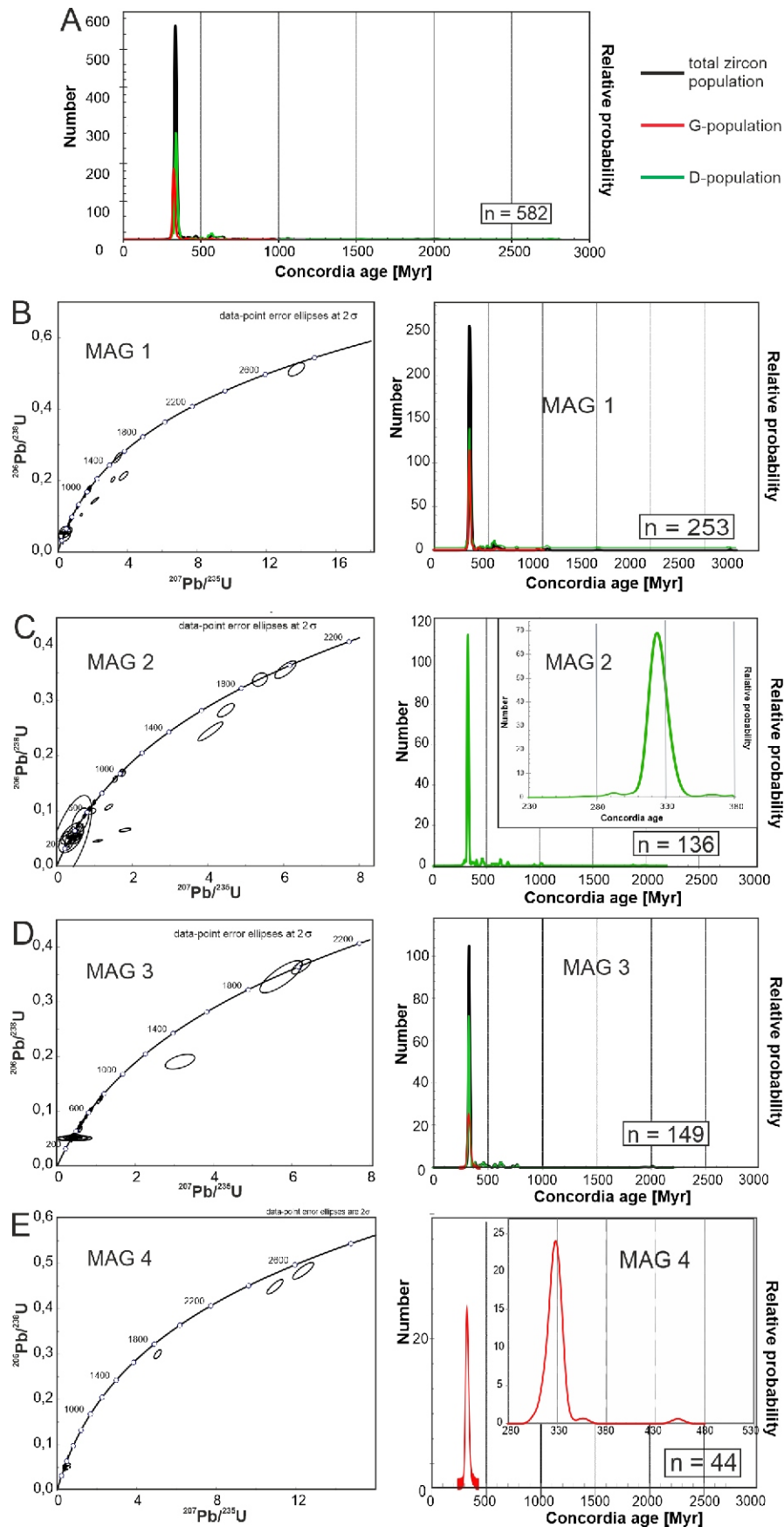


Fig. 7. U-Pb zircon geochronology

A – probability density plots for the entire zircon population from samples MAG 1–4 (black line) with subdivisions into the G-population (red line) and D-population (green line); **B** – concordia diagram and probability density plot of concordant grains from the MAG 1 sample with subdivisions as above; **C** – concordia diagram and probability density plot of concordant grains for the MAG 2 sample (only D population present) with inset showing the Variscan peak; **D** – concordia diagram and probability density plot of concordant grains for the MAG 3 sample, with subdivisions as above; **E** – concordia diagram and probability density plot of concordant grains for sample MAG 4D

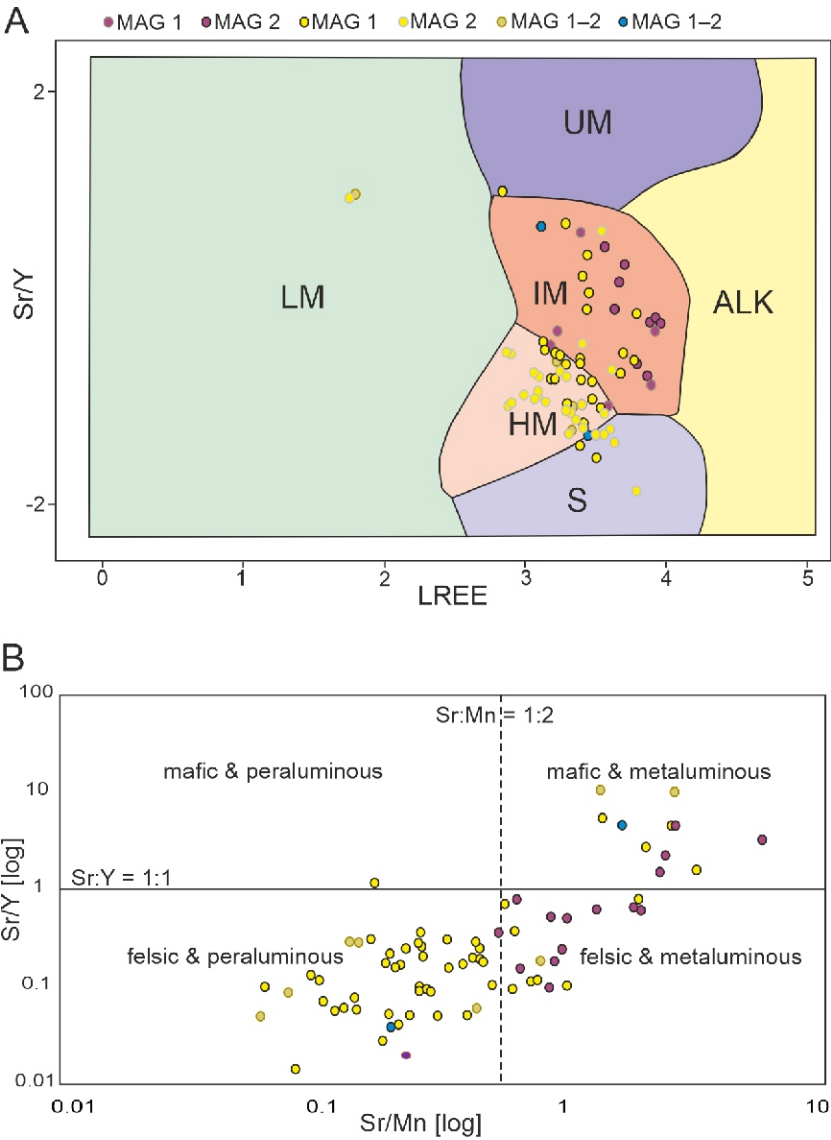


Fig. 8. Trace element geochemistry of apatite from the Biotite Sandstone

A – Support Vector Machine (SVM) classification diagrams (Sr/Y vs. LREE [La, Ce, Pr, Nd]) after [O’Sullivan et al. \(2020\)](#). ALK – alkaline-rich igneous; HM – high-grade metamorphic; IM – I-type granitoids and mafic igneous, LM – low-and medium-grade metamorphic, S – S-type granites, UM – ultramafic igneous; **B** – a plot of log Sr/Mn vs log Sr/Y for the same data (after [O’Sullivan and Chew, 2020](#))

DISCUSSION

POSSIBLE SOURCES OF THE CLASTIC MATERIAL

INTERPRETATION OF THE U-Pb AGE DATA

All three accessory minerals mineral systems yield dominant Variscan age peaks, implying an eroded Variscan crystalline basement source. Not surprisingly zircon, as the most refractory mineral, preserves old (Archean, Proterozoic and Early Paleozoic) recycled populations, represented mainly by inherited zircon cores and rare single crystals. The zircon Variscan peak is dominated by grains in the 320–330 Myr age interval, represented by a pronounced peak on the concordia age probability plots in all samples ([Fig. 7A–E](#)). Two Permian rims, found in the MAG 2 sample suggest a late Variscan event, and sup-

port the earlier findings of [de Doliwa-Zieliński et al. \(2025\)](#). The rutile U-Pb age data show predominantly a 320–330 Myr Variscan interval, but with minor peaks at 360–380 Myr ([Fig. 5B–D, F, J](#)). The U-Pb apatite system has a lower closure temperature and only shows a Variscan age peak.

SOURCE LITHOLOGIES

Evidence for a (meta) granitoid-pelitic source

The predominance of quartz-felspathic clasts, together with the presence of biotite and muscovite ([Fig. 3C–F](#)) imply a predominantly felsic protolith. The presence of detrital metamorphic muscovite grains with both high and low phengite contents ([Table 2](#)), suggests that peak metamorphism in the source region was at ~1 GPa, with subsequent decompression to ~0.5–0.25 GPa. Ti-in-biotite temperatures are in the range of 709–792°C ([Table 1](#)). Zircon is the most abundant detrital ac-

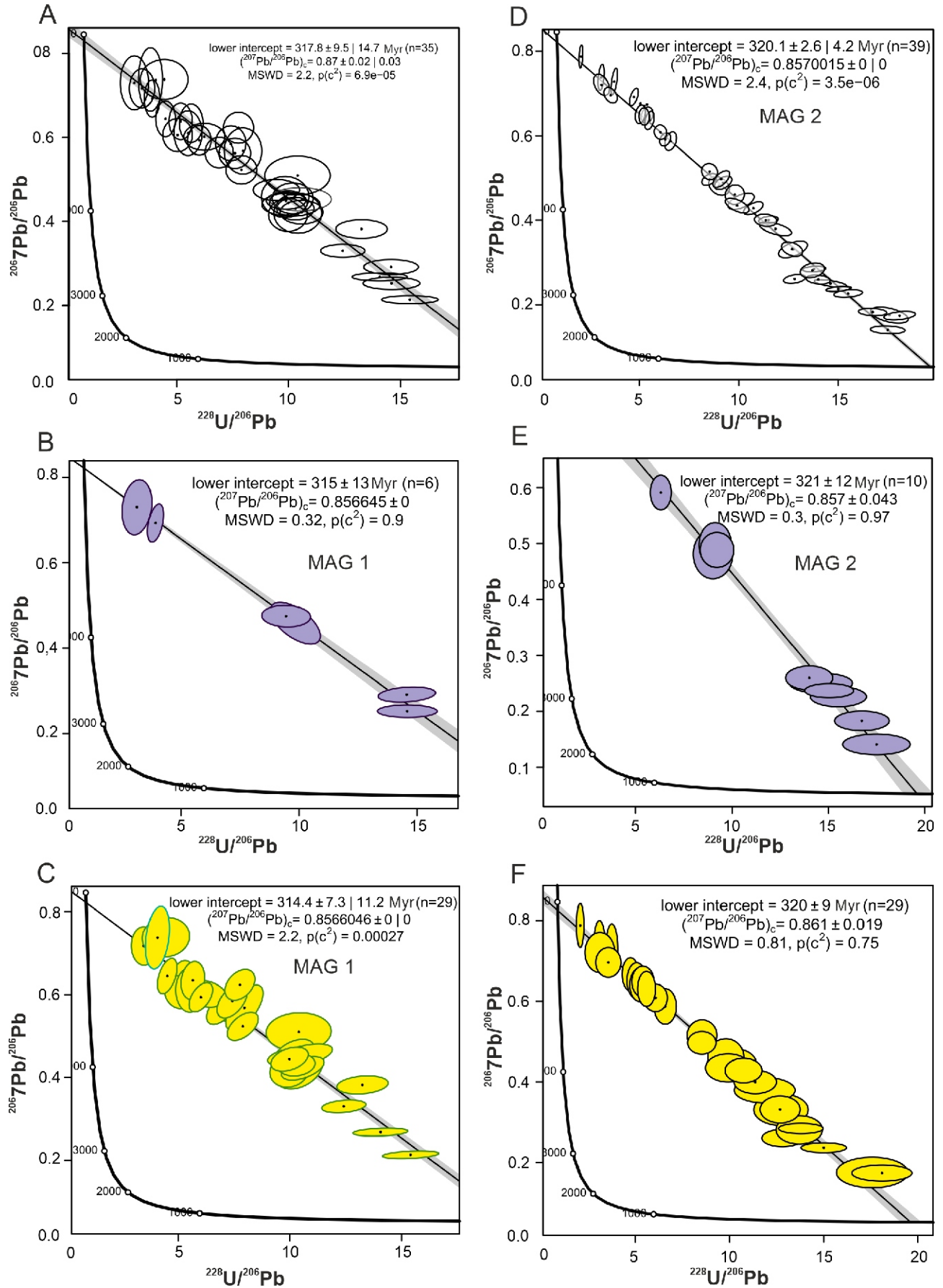


Fig. 9. Tera-Wasserburg U-Pb diagrams for apatite from the MAG 1 (A–C) and MAG 2 (D–F) samples

The CL-violet (c) and CL-yellow (d) apatites do not show any significant difference in age

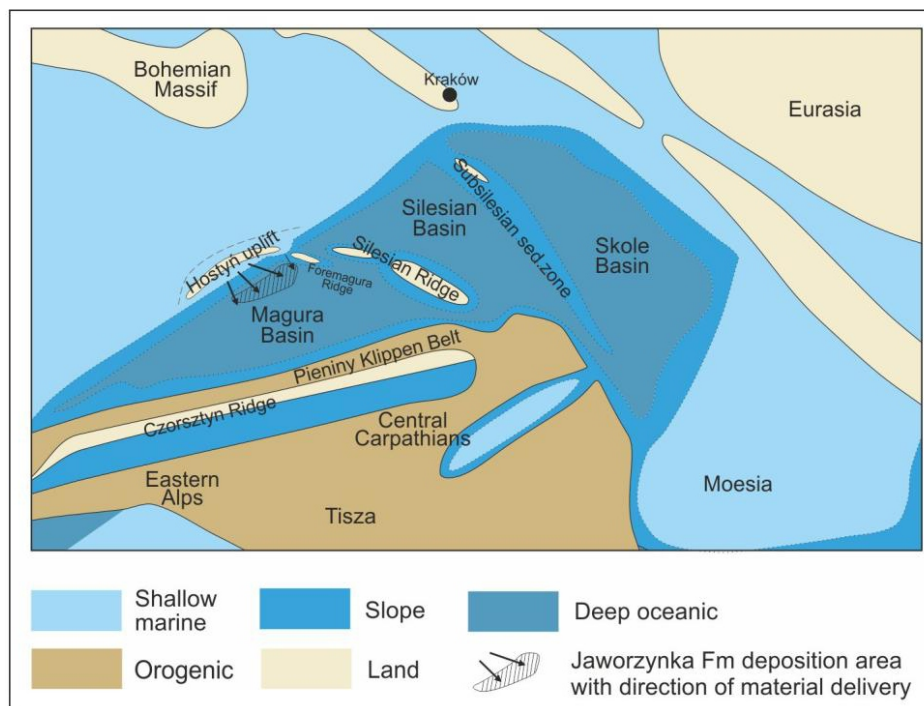


Fig. 10. Late Cretaceous palaeogeography modified after Kowal-Kasprzyk et al. (2021)

cessory phase, and zircon typically crystallizes in intermediate to Si-saturated magmas and high-grade metamorphic rocks. Most of the zircon grains have oscillatory zonation (Fig. 6A), typical of igneous crystallization and Th/U ratios >0.1 , which is often used to imply a magmatic protolith (Rubatto, 2017 and references therein), although this criterion has been questioned by phase equilibria modelling (Yakymchuk et al., 2018). However, some zircons (particularly the G population – Appendix Table 2a, b) show Th/U ratios < 0.1 implying a metamorphic origin, which agrees with the metamorphic origin of the muscovite, as well as the presence of metamorphic micro-clasts. Moreover, the abundance of metamorphic high-Ti biotite and high-pressure muscovite (Tables 1 and 2), suggest high-grade metamorphic rocks were a component of the eroded basement. Therefore the original basement can represent either granitic or high-grade metamorphic rocks or both (e.g. (meta)granites and its metamorphic envelope, which underwent an earlier HP episode).

Evidence from rutile

The application of Triebold et al. (2012) rutile trace element rutile classifier from the three samples (MAG 1, MAG 2 and MAG 4) also supports the metapelitic character of the eroded source rocks (positive x values; Appendix Table 1b). Zr-in-rutile thermometry for the HT population (mean values of 786/764°C; Appendix Table 1a) supports the Ti-in biotite thermometry. The fertility of rutile in the samples suggests high-pressure source rocks, as rutile in felsic lithologies is stable mostly above 1 GPa (Angiboust and Harlov, 2017). The low-temperature rutile population (mean temperature: 505/488°C) also has a felsic source (positive x values in Appendix Table 1b) and low U/Pb ratios. It is likely linked to the rapid temperature drop ($>5^{\circ}\text{C}/\text{Myr}$) on the retrogressive path with possible associated fluid influx, which is typical of late Variscan orogenesis in Central Europe (e.g., Gawęda et al., 2018 and references therein).

Only a small rutile population is derived from mafic/meta-mafic sources (negative x values according to Triebold et al., 2012; Appendix Table 1b). These rutile grains yielded temperatures of 589–839°C (mean value of 686°C; Z04) and 571–815°C (mean value of 665°C; T07). Twelve rutile grains from this population yielded ^{207}Pb -corrected ages in the range of 339–381 Myr (mean value ~ 363 Myr; Appendix Table 1b, Fig. 5G), which can be assumed as the age interval of either HP metamorphism of mafic rocks or mafic magmatism. Considering the assumed pressure of ~ 1 GPa (within the rutile stability field, supported by high phengite content in detrital muscovite a felsic source; Table 2) the first possibility seems more probable.

Evidence from apatite

The predominance of CL-yellow apatites in the analysed population suggests reduced conditions during crystallization, supported by high Mn contents (as Mn^{+2} thus enabling Mn^{+2} - Ca^{+2} substitution) and pronounced negative Eu anomalies (mean value of 0.20; Sha and Chappell, 1999; Appendix Table 3). The CL-yellow apatites plot mostly in the felsic and peraluminous fields on the Sr/Y versus Sr/Mn diagram and in the HM (high-grade metamorphic) and IM (I-type granitoids and mafic igneous) fields on the support vector machine (SVM) classification diagram (O'Sullivan et al., 2020; Fig. 9B).

The small population of apatites with violet CL colours (Fig. 6B) can be interpreted as the result of $(\text{Y} + \text{REE}^{+3}) + \text{Na}^{+}$ - Ca^{+2} substitution, and these apatites have higher REE and Y contents and higher Eu/Eu* values (mean value of 0.30; Appendix Table 3), typical of more oxidizing crystallization conditions (Gaft et al., 1997). The CL violet-red apatites plot exclusively in the IM field and mafic and felsic metaluminous fields (Fig. 9A, B), and probably represent mantle-derived igneous protoliths. All these data agree with the findings of Bónová et al. (2020) from the Strihovce sandstones who showed the subordinate nature of mafic rocks in the eroded protolith.

LATE CRETACEOUS PALAEOGEOGRAPHY AND ITS IMPACT ON MAGURA BASIN SEDIMENTATION

The Tethys basins developed on pre-Mesozoic basement, referred to as the Proto-Carpathians. The elevated fragments of this basement formed several ridges, separating the Outer Carpathian basins. The Proto-Carpathian basement consisted of diverse Neoproterozoic and Variscan rocks, that amalgamated during the Variscan orogeny. Mesozoic rifting affected the Proto-Carpathians and formed the Alpine Tethys Ocean. The Central Carpathian terrane constituted the southern margin of the Alpine Tethys, and the European Platform its northern part. The Magura Basin developed on the northern margin of Alpine Tethys as a prolongation of the Valais-Rheno-Danubian (North Penninic) ocean in the Middle Jurassic, and existed until the Miocene. Both the western part of the Magura Basin and the Eastern Alps share a common development in the Upper Cretaceous to Miocene (Oszczypko et al., 2006 and references therein; Golonka et al., 2019; Herwegh et al., 2023).

Initially, the Magura Basin was bounded by the Czorsztyn Ridge and the North European Platform. Subsequently, the uplifted intrabasinal ridges on its northern side, the Silesian and (later) Foremagura ridges, limited the extent of the basin and supplied detritus the marginal parts of the basin (Rytko, 1992; Cieszkowski et al., 2007). The Jaworzynka Formation is the first thick turbiditic sequence in the northern part of the Magura Basin and its deposition marks the beginning of an pronounced deposition of sand and gravel (e.g., Burtan et al., 1973a, b). The presence of fresh biotite imply the Biotite Sandstone represents an episode of rapid source erosion, transport and sedimentation, as well as rapid burial. As biotite disappears in the overlying sediments and the Biotite Sandstone and shale of Jaworzynka Formation is limited to the western part of the Outer Carpathians, they likely represent the first cycle detrital material. Spatially, they can be correlated with the biotite-rich sandstones of the Soláň Formation (Raztoka Member; e.g., Švábenická et al., 1997; Teták, 2008).

Palaeotransport directions from the north/north-west in the Mutne Sandstone Member, the proximal member of the Jaworzynka Formation (Cieszkowski et al., 2007), imply a northern source of clastic material, an elevated area located in the northern marginal zone of the Magura Basin (Foremagura Ridge; e.g., Książkiewicz, 1965; Rytko, 1992; Fig. 10). Palaeocurrents are from the northwest in other parts of the Jaworzynka Formation and its correlative the Soláň Formation, which indicate the Hostýn Ridge as the source area (e.g., Teták et al., 2019). The Hostýn Ridge, which succeeded the older Pavlov Ridge (Golonka et al., 2019) was an elevated portion of the North European platform and part of Moldanubian zone of the Bohemian Massif and contained Variscan granites with their-country rock envelope (e.g., Hanžl et al., 2000). In the Late Cretaceous, ridge uplift due to the onset of collision along the Alpine-Carpathian orogenic front, occurred along the northern margin of the Magura-Valais-Rheno-Danubian Basin (Oszczypko and Oszczypko-Cloves, 2009; Teták et al., 2019; Herwegh et al., 2023). These basement sources fed Variscan detritus (i.e. 310 Myr and 340 Myr population) into the Late Cretaceous turbiditic subarkosic sediments of the Penninic Alps (Beltrán-Triviño et al., 2013). In the same time, on the northern margin of the Bohemian Massif, the Upper Cretaceous sedimentary rocks of the Saxo-Bohemian Basin yield detrital rutile age spectra that are similar to the Upper Cretaceous sandstones of the Magura Nappe (main population 320–330 Myr, with minor pre-Variscan ages; Rösel et al., 2024).

U-Pb dating of detrital rutile, zircon and apatite of the Late Cretaceous turbiditic sequences of the Magura Nappe yield similar provenance information as the Eocene sedimentary rocks of the same nappe. U-Pb dating of a granite boulder from Eocene sediments yielded an age of 316 ± 3 Myr (zircon) and 311 ± 8 Myr (apatite), with the Saxo-Danubian Granite Belt of the South Bohemian Massif suggested as the source for olistostrome sedimentation (Gawęda et al., 2021). The similarity of these U-Pb spectra imply constant palaeotransport direction from the north-west in the Magura Basin.

CONCLUSIONS

1. The eroded crystalline basement to the Biotite Sandstone from the Jaworzynka Formation represented predominantly high grade (HP) felsic metamorphic and igneous basement while mafic, probably mantle-related meta-igneous rocks, were subordinate.
2. Detrital rutile and apatite ages correspond with the main population of detrital zircon ages and document late Variscan (~330–320 Ma) metamorphism and igneous activity. Rutiles derived from a meta-mafic protolith preserves evidence for early Variscan metamorphism or mafic magmatism (339–381 Ma).
3. As the Campanian Biotite Sandstone represent an episode of rapid basement erosion, transport and sedimentation, the excellent preservation of primary rock-forming minerals (biotite) was likely due to rapid burial. We envisage a source in the Hostýn Ridge, comprised of uplifted blocks of the northern slope of the Magura-Valais-Rheno-Danubian Basin, which contains Variscan (meta)granites and their country-rock envelope.
4. The similarity in both zircon and apatite U-Pb ages and transport directions in the Upper Cretaceous and Eocene turbiditic sedimentary rocks implies a constant sediment source during the development of the Magura Basin.

CRedit authorship contribution statement

Aleksandra Gawęda: Writing – fieldwork, conceptualization, methodology (petrography, zircon, rutile and apatite data presentation and interpretation), writing of the original draft, editing, figures and tables preparation, project administration; Anna Waśkowska – fieldwork, concept discussion, geological setting preparation, drafting of figures 1 & 11, resources; Krzysztof Szopa – fieldwork, analysis (CL and microprobe, apatite age calculation); David Chew – methodology (LA-ICP-MS analyses and data reduction, final text editing and discussion); Jan Golonka – fieldwork, concept and paleogeography discussion; project administration; Krzysztof Kupczak – apatite trace element data modelling and interpretation, concept discussion.

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APPENDIX																									
Table 1a																									
Rutile isotopic data data and calculated U-Pb ages for MAG 1, MAG 2 and MAG 4 samples																									
	Final207_235	Final207_235 Pro p2SE	Final206_238	Final206_238 Pro p2SE	ErrorCorrelation 6_38vs7_35	Final238_206	Final238_206 Pro p2SE	Final207_206	Final207_206 Pro p2SE	ErrorCorrelation 38_5vs7_6	FinalAge206_238	FinalAge206_238 8 Prop2SE	FinalAge207_233	FinalAge207_233 5 Prop2SE	FinalAge207_233 8 Prop2SE	FinalAge207_206_P rop2SE	FinalAge 207Pb corr	FinalAge 207Pb corr Prop2SE	2RSD	Age	6-38/7-35 %	Conc Age	Err		
MAG 1																									
MAG1_Rt_1	0.308	0.041	0.0481	0.0023	0.2305	20.79002	0.9941174	0.0467	0.0058	-0.0938	302.8	14.5	272.6	36.3	33.9	4.2	305.0	14.5	4.8	305.0	-11.1	299.8	13.8		
MAG1_Rt_2	0.349	0.035	0.0481	0.0022	0.1537	20.79002	0.9508949	0.0525	0.0051	0.1535	302.8	13.9	304.0	30.5	307.2	29.8	302.8	13.8	4.5	302.8	0.4	303.0	12.7		
MAG1_Rt_3	7.8	1.3	0.113	0.011	0.9619	8.849558	0.8614614	0.447	0.033	-0.8195	690.1	67.2	2208.2	368.0	4075.3	300.9	362.7	45.0	12.4	362.7	68.7				
MAG1_Rt_4	0.57	0.052	0.0511	0.0024	0.1889	19.56947	0.9191141	0.0805	0.0066	0.0879	321.3	15.1	458.0	41.8	1209.3	99.1	310.4	14.6	4.7	310.4	29.9				
MAG1_Rt_5	0.383	0.025	0.0501	0.002	0.0576	19.96008	0.7968096	0.0557	0.0033	0.2906	315.1	12.6	329.2	21.5	440.4	26.1	314.0	12.4	4.0	314.0	4.3	319.3	10.5		
MAG1_Rt_6	0.454	0.05	0.0599	0.0028	0.2283	16.69449	0.7803769	0.0556	0.0059	0.0787	375.0	17.5	380.1	41.9	436.4	46.3	374.3	17.4	4.6	374.3	1.3	375.6	16.5		
MAG1_Rt_7	0.382	0.032	0.0506	0.0021	0.0870	19.76285	0.8201972	0.0546	0.0042	0.1781	318.2	13.2	328.5	27.5	395.9	30.5	317.5	13.1	4.1	317.5	3.1	320.3	11.7		
MAG1_Rt_8	0.379	0.03	0.0508	0.0022	0.4080	19.88504	0.8525017	0.0547	0.0037	0.0060	319.4	13.8	326.3	25.8	400.0	27.1	318.7	13.7	4.3	318.7	2.1	320.4	13.2		
MAG1_Rt_9	0.83	0.19	0.0578	0.0046	0.0593	17.30104	1.376899	0.106	0.026	-0.0346	362.2	28.8	613.6	140.5	1731.7	424.8	339.1	28.9	8.5	339.1	41.0				
MAG1_Rt_11	0.377	0.062	0.0498	0.0028	0.3085	20.08032	1.129014	0.0591	0.0095	0.1174	313.3	17.6	324.8	53.4	570.8	91.8	310.8	17.6	5.7	310.8	3.6	313.6	17.2		
MAG1_Rt_12	4.34	0.93	0.0826	0.0082	0.9214	12.10654	1.20186	0.338	0.04	-0.7192	511.6	50.8	1701.0	364.5	3653.8	432.4	335.2	41.5	12.4	335.2	69.9				
MAG1_Rt_13	0.416	0.046	0.0498	0.0023	-0.1545	20.08032	0.9274044	0.061	0.0073	0.4588	313.3	14.5	353.2	39.1	639.2	76.5	310.1	14.4	4.6	310.1	11.3	320.6	12.2		
MAG1_Rt_14	2.32	0.22	0.0674	0.0039	0.6597	14.83668	0.8585089	0.251	0.019	-0.0347	420.5	24.3	1218.4	115.5	3191.1	241.6	319.3	20.7	6.5	319.3	65.5				
MAG1_Rt_15	0.432	0.058	0.0506	0.0028	0.3545	19.76285	1.093596	0.0613	0.0079	0.0290	318.2	17.6	364.6	49.0	649.8	83.7	314.9	17.4	5.5	314.9	12.7	319.2	17.2		
MAG1_Rt_16	0.366	0.023	0.0505	0.002	0.3617	19.80198	0.7842368	0.0528	0.0026	-0.0240	317.6	12.6	316.7	19.9	320.2	15.8	317.6	12.4	3.9	317.6	-0.3	317.4	11.5		
MAG1_Rt_17	0.395	0.053	0.0594	0.0032	-0.1886	16.83502	0.9069369	0.0513	0.0077	0.4597	372.0	20.0	338.0	45.4	254.3	38.2	373.2	20.1	5.4	373.2	-10.0	363.6	15.8		
MAG1_Rt_18	0.72	0.18	0.0541	0.0037	0.8981	18.48429	1.264175	0.084	0.014	-0.7373	339.6	23.2	550.7	137.7	1292.6	215.4	326.9	22.8	7.0	326.9	38.3				
MAG1_Rt_19	0.347	0.027	0.04917	0.0019	0.4313	20.3376	0.7858745	0.0514	0.0034	-0.1366	309.4	12.0	302.5	23.5	258.8	17.1	309.9	11.9	3.8	309.9	-2.3	308.7	11.5		
MAG1_Rt_20	1.25	0.19	0.0623	0.004	0.4269	16.05136	1.030585	0.144	0.021	0.0270	389.6	25.0	823.4	125.2	2275.9	331.9	346.9	24.1	6.9	346.9	52.7				
MAG1_Rt_21	10.45	1	0.134	0.01	0.7127	7.462687	0.5569169	0.574	0.037	0.1487	810.6	60.5	2475.5	236.9	4443.5	286.4	295.7	44.4	15.0		67.3				
MAG1_Rt_22	0.54	0.14	0.052	0.0045	0.2564	19.23077	1.664201	0.069	0.02	0.1093	326.8	28.3	438.4	113.7	898.7	260.5	320.4	28.4	8.9	320.4	25.5	327.2	27.6		
MAG1_Rt_23	0.365	0.05	0.0471	0.0024	-0.1172	21.23142	1.081856	0.0568	0.0078	0.3969	296.7	15.1	315.9	43.3	483.8	66.4	295.0	15.1	5.1	295.0	6.1	299.8	13.1		
MAG1_Rt_24	0.389	0.038	0.0489	0.0024	0.2580	20.4499	1.003676	0.0566	0.0052	0.1273	307.8	15.1	333.6	32.6	476.0	43.7	306.2	14.9	4.9	306.2	7.8	311.3	14.2		
MAG1_Rt_25	0.538	0.068	0.0538	0.0028	0.1122	18.58736	0.9673719	0.0733	0.0091	0.1391	337.8	17.6	437.1	55.2	1022.3	126.9	329.5	17.3	5.2	329.5	22.7				
MAG1_Rt_26	0.373	0.063	0.0491	0.0028	0.1576	20.3666	1.161435	0.0531	0.0087	0.1183	309.0	17.6	321.9	54.4	333.1	54.6	308.8	17.7	5.7	308.8	4.0	310.0	16.8		
MAG1_Rt_27	0.809	0.098	0.0568	0.0029	0.4068	17.60563	0.8988792	0.105	0.011	-0.0973	356.1	18.2	601.9	72.9	1714.3	179.6	333.8	17.4	5.2	333.8	40.8				
MAG1_Rt_28	0.72	1.16	0.0548	0.0094	-0.3106	18.24818	3.130161	0.093	0.053	0.4895	343.9	59.0	550.7	887.2	1487.9	847.9	327.2	59.6	18.2		37.5	349.6	53.3		
MAG1_Rt_29	7.5	1.2	0.118	0.012	0.9799	8.474576	0.8618213	0.451	0.032	-0.8095	719.0	73.1	2173.0	347.7	4088.5	290.1	375.3	73.4	12.6	375.3	66.9				
MAG1_Rt_30	0.53	0.049	0.0512	0.0023	0.0369	19.53125	0.8773804	0.0751	0.0069	0.3084	321.9	14.5	431.8	39.9	1071.2	98.4	313.1	14.1	4.5	313.1	25.5				
MAG1_Rt_31	0.354	0.027	0.0481	0.0022	-0.0614	20.79002	0.9508949	0.0532	0.0035	0.3680	302.8	13.9	307.7	23.5	337.3	22.2	302.5	13.7	4.5	302.5	1.6	304.4	10.9		
MAG1_Rt_32	15.6	1.5	0.17	0.012	0.7324	5.882353	0.4152249	0.664	0.036	0.1620	1012.1	71.4	2852.6	274.3	4654.7	252.4	252.6	51.6	20.4		64.5				
MAG1_Rt_33	0.485	0.033	0.0593	0.0026	0.2307	16.86341	0.7393736	0.0591	0.0034	0.2619	371.4	16.3	401.5	27.3	570.8	32.8	369.1	16.0	4.3	369.1	7.5	379.6	14.3		
MAG1_Rt_34	0.639	0.084	0.053	0.0027	0.5742	18.86792	0.9611962	0.09	0.01	-0.1592	332.9	17.0	501.7	65.9	1425.5	158.4	317.9	16.5	5.2	317.9	33.6				
MAG1_Rt_35	0.48	0.043	0.0496	0.0023	0.4046	20.16129	0.9348985	0.0696	0.0054	0.0216	312.1	14.5	398.1	35.7	916.6	71.1	305.6	14.1	4.6	305.6	21.6				
MAG1_Rt_36	0.536	0.05	0.0516	0.0027	0.3705	19.37984	1.014062	0.075	0.006	-0.0179	324.3	17.0	435.8	40.7	1068.5	85.5	315.6	16.4	5.2	315.6	25.6				
MAG1_Rt_37	2.67	0.23	0.0728	0.0035	0.6712	13.7741	0.6640409	0.272	0.017	-0.3094	451.8														

MAG2_Rt_40		1.79	0.22	0.0663	0.0035	0.8303	15.08296	0.7962345	0.191	0.015	-0.5015	413.8	21.8	1041.8	128.0	2750.8	216.0	345.0		19.5	5.6	345.0	60.3			
MAG2_Rt_41		1.92	0.18	0.0634	0.0032	0.7751	15.77287	0.796107	0.213	0.014	-0.4143	396.3	20.0	1088.1	102.0	2928.5	192.5	319.2		17.3	5.4	319.2	63.6			
MAG2_Rt_42		11.9	1.5	0.143	0.014	0.9467	6.993007	0.6846301	0.591	0.034	-0.7333	861.6	84.4	2596.6	327.3	4486.0	258.1	296.5		47.7	16.1		66.8			
MAG2_Rt_43		0.619	0.095	0.0521	0.0032	0.3619	19.13986	1.178893	0.086	0.013	0.0033	327.4	20.1	489.2	75.1	1338.2	202.3	314.1		19.7	6.3	314.1	33.1			
MAG2_Rt_44		0.461	0.064	0.0551	0.003	0.3106	18.14882	0.988139	0.0581	0.0077	-0.0124	345.8	18.8	385.0	53.4	533.5	70.7	343.8		18.7	5.4	343.8	10.2	347.3	18.2	
MAG2_Rt_45		0.375	0.025	0.0519	0.0024	0.4346	19.26782	0.8909976	0.0523	0.0027	0.1313	326.2	15.1	323.4	21.6	298.5	15.4	326.4		14.9	4.6	326.4	-0.9	325.3	13.6	
MAG2_Rt_46		1.118	0.078	0.0613	0.0027	0.4126	16.31321	0.7185265	0.1319	0.0072	0.0202	383.5	16.9	762.0	53.2	2123.4	115.9	347.1		15.4	4.4	347.1	49.7			
MAG2_Rt_47		0.385	0.027	0.052	0.0024	0.5666	19.23077	0.887574	0.0532	0.0028	-0.0137	326.8	15.1	330.7	23.2	337.3	17.8	326.7		14.9	4.6	326.7	1.2	327.5	14.4	
MAG2_Rt_48		0.378	0.023	0.0529	0.0022	0.1547	18.90359	0.7861607	0.0519	0.0029	0.3858	332.3	13.8	325.6	19.8	281.0	15.7	332.8		13.7	4.1	332.8	-2.1	329.8	11.3	
MAG2_Rt_49		0.382	0.024	0.0524	0.0027	0.6419	19.08397	0.9833343	0.0532	0.0021	0.1107	329.2	17.0	328.5	20.6	337.3	13.3	329.2		16.7	5.1	329.2	-0.2	328.9	15.4	
MAG2_Rt_50		0.45	0.036	0.056	0.0026	0.4699	17.85714	0.8290816	0.0571	0.0032	-0.1095	351.3	16.3	377.3	30.2	495.4	27.8	349.7		18.0	4.6	349.7	6.9	354.2	15.7	
MAG2_Rt_51		0.386	0.037	0.0548	0.0027	0.3354	18.24818	0.8990889	0.0506	0.0044	0.1295	343.9	16.9	331.4	31.8	222.6	19.4	345.1		16.8	4.9	345.1	-3.8	341.7	15.8	
MAG2_Rt_52		91.4	5.8	0.804	0.048	0.6034	1.243781	0.07425559	0.835	0.04	0.3469	3803.4	227.1	4595.8	291.6	4982.6	238.7	15.3		267.2	1742.9		17.2			
MAG2_Rt_53		98	5.7	0.854	0.057	0.8500	1.17096	0.07815542	0.801	0.022	0.4417	3979.7	265.6	4665.8	271.4	4923.5	135.2	414.4		153.6	37.1		14.7			
MAG2_Rt_54		4.11	0.42	0.0838	0.0055	0.8285	11.93317	0.7832036	0.343	0.02	-0.3207	518.8	34.0	1656.3	169.3	3676.2	214.4	336.8		25.3	7.5	336.8	68.7			
MAG2_Rt_55		0.95	0.12	0.0597	0.0028	0.6053	16.75042	0.7856143	0.117	0.012	-0.4156	373.8	17.5	678.1	85.7	1917.9	196.0	345.0		16.8	4.9	345.0	44.9			
MAG2_Rt_56		0.604	0.08	0.0581	0.0027	0.5755	17.2117	0.7998554	0.0759	0.0088	-0.3786	364.1	16.9	479.8	63.5	1092.4	126.7	354.3		16.6	4.7	354.3	24.1			
MAG2_Rt_57		0.392	0.021	0.0548	0.0024	0.6077	18.24818	0.7991902	0.0517	0.0019	0.0785	343.9	15.1	335.8	18.0	272.2	10.0	344.6		14.9	4.3	344.6	-2.4	340.3	13.4	
MAG2_Rt_58		0.413	0.021	0.0547	0.0023	0.4665	18.28154	0.7686935	0.0547	0.0017	0.1652	343.3	14.4	351.0	17.8	400.0	12.4	342.7		14.2	4.1	342.7	2.2	346.6	12.5	
MAG2_Rt_59		2.88	0.49	0.081	0.0067	0.3316	12.34568	1.021186	0.259	0.045	0.1876	502.1	41.5	1376.7	234.2	3240.6	563.0	378.3		41.4	11.0	378.3	63.5			
MAG2_Rt_60		0.42	0.2	0.0534	0.0061	0.2119	18.72659	2.13918	0.06	0.025	-0.0345	335.4	38.3	356.1	169.5	603.6	251.5	332.6		36.8	11.7	332.6	5.8	335.6	37.3	
MAG2_Rt_61		2.75	0.36	0.073	0.0049	0.5595	13.69863	0.9194971	0.266	0.03	0.0540	454.2	30.5	1342.1	175.7	3282.6	370.2	337.2		27.9	8.3	337.2	66.2			
MAG2_Rt_62		0.663	0.043	0.0757	0.0034	0.3812	13.21004	0.5933175	0.0648	0.0031	0.1770	470.4	21.1	516.4	33.5	767.8	36.7	465.7		20.5	4.4	465.7	-21.6			
MAG2_Rt_63		525	240000	5.1	2600	0.9360	0.1960784	99.96155	0.863	0.088	-0.1575	11657.0	5942773.3	6361.7	2908196.9	5029.4	512.9	1577.9		784252.7	49701.0		-83.2			
MAG2_Rt_64		51.6	6.7	0.466	0.05	0.7243	2.145923	0.2302492	0.798	0.024	0.5005	2466.0	264.6	4023.7	522.5	4918.2	147.9	184.7		95.0	51.4		38.7			
MAG2_Rt_65		35.6	1.6	0.356	0.015	0.9094	2.808989	0.1183563	0.729	0.011	-0.0419	1963.2	82.7	3655.4	164.3	4789.0	72.3	362.3		38.8	10.7		362.3	46.3		
MAG2_Rt_66		53.9	3.7	0.523	0.033	0.8906	1.912046	0.1206453	0.759	0.014	0.2486	2711.9	171.1	4067.1	279.2	4846.7	89.4	424.7		68.1	16.0		33.3			
MAG2_Rt_67		252	24	2.17	0.19	0.9404	0.4608295	0.04034913	0.841	0.022	-0.0730	7437.4	651.2	5618.5	535.1	4992.8	130.6	609.7		377.2	61.9		-32.4			
MAG2_Rt_68		1780	120	14.84	0.94	0.9826	0.06738544	0.00426835	0.8614	0.0099	-0.1505	17808.5	1128.0	7600.1	512.4	5026.8	57.8	-4048.6		2843.1	-70.2	-4048.6	-134.3			
MAG2_Rt_69		1034	50	8.64	0.43	0.9585	0.1157407	0.005760245	0.871	0.01	0.1985	14607.1	727.0	7048.9	340.9	5042.5	57.9	-3020.1		1431.5	-47.4	-3020.1	-107.2			
MAG2_Rt_70		513	23	4.44	0.21	0.8781	0.2252252	0.01065254	0.841	0.013	0.2940	10918.8	516.4	6338.2	284.2	4992.8	77.2	-674.5		618.4	-91.7	-674.5	-72.3			
MAG2_Rt_71		179.8	10	1.553	0.09	0.9576	0.643915	0.03731639	0.83	0.011	0.2992	6042.0	350.1	5277.3	293.5	4974.1	65.9	450.3		162.5	36.1		-14.5			
MAG2_Rt_72		56.4	9.1	0.54	0.078	0.8462	1.851852	0.2674897	0.769	0.021	0.2582	2783.4	402.1	4112.3	663.5	4865.4	132.9	388.0		107.0	27.6		32.3			
MAG2_Rt_73		356	19	3.12	0.16	0.9126	0.3205128	0.01643655	0.838	0.015	0.1966	9127.2	468.1	5968.2	318.5	4987.7	89.3	-60.8		440.6	-724.2	-60.8	-52.9			
MAG2_Rt_74		54.7	2.8	0.504	0.027	0.6534	1.984127	0.1062925	0.781	0.028	0.4126	2631.0	140.9	4081.8	208.9	4887.5	175.2	293.2		114.3	39.0		35.5			
MAG2_Rt_75		742	45	6.63	0.42	0.9281	0.1508296	0.009554814	0.843	0.017	0.3510	13099.7	829.8	6712.4	407.1	4996.2	100.8	-24906.2		55820.0	-224.1	-24906.2	-95.2			
MAG2_Rt_76		87.7	3.6	0.766	0.03	0.9235	1.305483	0.05112858	0.831	0.011	0.6560	3666.2	143.6	4554.3	186.9	4975.8	65.9	53.7		85.3	158.8		19.5			
MAG2_Rt_77		38.5	8.6	0.379	0.078	0.9516	2.638522	0.5430204	0.697	0.047	-0.2362	2071.6	426.3	3732.9	833.8	4724.5	318.6	499.5		167.7	33.6		44.5			
MAG2_Rt_78		90.8	4.5	0.813	0.038	0.8237	1.230012	0.05749135	0.798	0.01	0.2474	3835.5	179.3	4589.1	227.4	4918.2	61.6	412.2		80.8	19.6		16.4			
MAG2_Rt_79		105.2	6.1	0.94	0.057	0.9512	1.06383	0.06450883	0.811	0.011	0.2940	4272.0	259.0	4737.1	274.7	4941.2	67.0	359.8		100.3	27.9		9.8			
MAG2_Rt_80		40.2	3.3	0.375	0.029	0.9511	2.666667	0.2062222	0.747	0.014	0.0772	2052.9	158.8	3775.6	309.9	4823.9	90.4	322.8		51.9	16.1		45.6			
MAG2_Rt_82		86	12	0.78	0.11	0.9741	1.282051	0.1808021	0.801	0.02	-0.3196	3717.1	524.2	4534.6	632.7	4923.5	122.9	356.5		137.6	38.6		18.0			
MAG2_Rt_83		109	8.1	0.97	0.067	0.9711	1.030928	0.07120842	0.837	0.017	0.4361	4370.9	301.9	4772.8	354.7	4986.0	101.3	0.5		149.8	33005.0		8.4			
MAG2_Rt_84		21.8	1	0.2413	0.01	0.5529	4.144219	0.1717455	0.665	0.019	0.3915	1393.5	57.7	3174.9	145.6	4656.9	133.1	365.9		39.9	10.9		365.9	56.1		
MAG2_Rt_85		384	31	3.3	0.28	0.9553	0.3030303	0.02571166	0.842	0.018	0.1361	9402.8	797.8	6044.8	488.0	4994.5	106.8	-173.5		546.0	-314.6	-173.5	-55.6			
MAG2_Rt_86		194	23	1.67	0.19	0.9641	0.5988024	0.06812722	0.838	0.025	0.0014	6330.9	720.3	5354.1	634.8	4987.7	148.8	204.6		344.9	168.6		-18.2			
MAG2_Rt_87		68.1	6	0.629	0.051	0.9317	1.589825	0.1289047	0.786	0.017	0.0128	3145.6	255.1	4300.7	378.9	4896.6	105.9	361.7		94.4	26.1		26.9			
MAG2_Rt_88		73	4.1	0.659	0.036	0.5646	1.517451	0.08289564	0.799	0.032	0.4729	3263.3	178.3	4370.3	245.5	4920.0	197.0	289.8		168.9	58.3		25.3			
MAG2_Rt_89		149	13	1.29	0.12	0.9802	0.7751938	0.07211105	0.84	0.017	0.0457	5341.2	496.9	5087.7	443.9	4991.1	101.0	-29.6		200.0	-675.8	-29.6	-5.0			
MAG2_Rt_90		0.473	0.069	0.0608	0.0033	-0.0354	16.4473																			

APPENDIX

Table 1b

Rutile selected trace elements, calculated temperatures and petrogenetic indices for MAG 1, MAG 2 and MAG 4 samples

	U_PPM	Th_PPM	Zr_ppm_m90	Nb_ppm_m93	Cr_ppm_m52	Hf_ppm_m178	lnZr		T _{zack2004}	Cr/Nb	x	T _{tomkins2007}	FinalAge 207Pb corr
High temperature felsic rutile grains													
MAG1_Rt_1	6,92	0	391,7	1321	1189	11,27	1,93441577		692	0,9000757	2916	672	305,0
MAG1_Rt_2	7,26	0	384	1366	1250	11,03	1,98237983		690	0,91508053	3080	670	302,8
MAG1_Rt_3	8,44	1084	380,2	1250	1109	10,98	2,13298231		689	0,8872	2641	669	362,7
MAG1_Rt_4	8,48	23,2	397,2	1347	1218	11,26	2,13771045		693	0,90423163	3017	673	310,4
MAG1_Rt_5	18,23	4,1	441	1783	2469	17,75	2,90306859		702	1,38474481	3946	682	314,0
MAG1_Rt_6	5,29	0	161	1607	579	6,15	1,66581825		621	0,36029869	4956	602	374,3
MAG1_Rt_7	12,06	0	2211	1640	984	92,4	2,48989419		868	0,6	4716	844	317,5
MAG1_Rt_8	12,17	0	2236	1752	938	96,9	2,49897391		870	0,53538813	5322	846	318,7
MAG1_Rt_11	3,78	0	584	1981	1637	21,94	1,32972401		728	0,82635033	5768	707	310,8
MAG1_Rt_12	4,22	860	563	1921	1552	20,83	1,43983513		724	0,80791255	5553	703	335,2
MAG1_Rt_13	5,75	0	3136	1038	1281	85,8	1,74919985		912	1,23410405	1409	887	310,1
MAG1_Rt_14	2,93	790	3168	1812	390,2	105,3	1,07500242		913	0,21534216	6169,8	888	319,3
MAG1_Rt_15	3,909	72	574	2361	2163	23,68	1,36328159		726	0,91613723	7142	705	314,9
MAG1_Rt_16	21,7	0	2499	1319	515	105,1	3,07731226		883	0,39044731	3580	859	317,6
MAG1_Rt_17	3,24	0	176,9	1056	1589	6,15	1,17557333		628	1,50473485	1191	609	373,2
MAG1_Rt_18	16	43	1173	3020	1598	56,5	2,77258872		797	0,52913907	11002	774	326,9
MAG1_Rt_19	14,9	0	1151	2966	1537	57,5	2,70136121		795	0,51820634	10793	772	309,9
MAG1_Rt_20	0,999	0	1329	1742	879	51,3	-0,0010005		810	0,50459242	5331	787	346,9
MAG1_Rt_21	0,976	63	1122	1725	879	44,4	-0,0242927		792	0,50956522	5246	770	295,7
MAG1_Rt_22	1,62	0	1010	1493	656	36,3	0,48242615		781	0,43938379	4309	759	320,4
MAG1_Rt_23	5,18	0	1058	1755	689	39	1,64480506		786	0,39259259	5586	764	295,0
MAG1_Rt_24	6,74	0	511	3342	1679	20,88	1,90805992		715	0,50239378	12531	695	306,2
MAG1_Rt_25	3,22	20,5	827	2923	2619	30,59	1,16938136		761	0,89599726	9496	739	329,5
MAG1_Rt_26	2,822	0	837	2822	2570	32,3	1,03744585		762	0,91070163	9040	740	308,8
MAG1_Rt_27	4,27	0	839	2965	2619	31,7	1,45161383		762	0,88330523	9706	741	333,8
MAG1_Rt_28	8,52	0	854	2780	2130	31,3	2,14241634		764	0,76618705	9270	742	
MAG1_Rt_29	6,64	32	878	2722	2081	33,1	1,89311196		767	0,76451139	9029	745	375,3
MAG1_Rt_30	7,37	0	776	2974	1806	29,49	1,99741771		755	0,60726295	10564	733	313,1
MAG1_Rt_31	14,8	0	596	1859	1842	21,94	2,69462718		730	0,9908553	4953	708	302,5
MAG1_Rt_32	1,436	3240	470	473	681	13,06	0,36186147		708	1,4397463	-816	687	
MAG1_Rt_34	8,56	0	266,5	791	905	6,66	2,14710019		660	1,14412137	550	640	317,9
MAG1_Rt_35	10,06	4,5	339	876	749	9,73	2,30856716		680	0,85502283	1131	660	305,6
MAG1_Rt_36	10,51	0	340,7	924	850	9,13	2,35232718		680	0,91991342	1270	660	315,6
MAG1_Rt_37	9,81	199	300,7	714	834	8,23	2,28340227		670	1,16806723	236	650	332,0
MAG1_Rt_38	5,4	149	635	2140	1960	22,5	1,68639895		736	0,91588785	6240	714	
MAG1_Rt_40	16,63	4000	513	1234	1082	21,52	2,81120829		716	0,87682334	2588	695	352,0
MAG1_Rt_41	0,586	33	1572	2386	1312	58,9	-0,5344355		829	0,54987427	8118	805	293,9
MAG1_Rt_42	44,8	165	1238	2660	3690	70,8	3,80220814		802	1,38721805	7110	780	300,7
MAG1_Rt_44	9,01	1,3	858	9600	2940	37,1	2,19833507		765	0,30625	42560	743	
MAG1_Rt_46	1,03	3570	163,5	1815	531	6,33	0,0295588		622	0,29256198	6044	603	
MAG1_Rt_49	1,141	19,7	148	1579	859	6,52	0,13190507		615	0,5440152	4536	596	384,6
MAG1_Rt_50	3,27	189	121,7	1931	759	6,06	1,18478998		601	0,39306059	6396	582	341,2
MAG1_Rt_51	10	17,5	167,1	647	713	4,66	2,30258509		624	1,10200927	22	605	329,5
MAG1_Rt_52	9,92	11	174,6	915	709	4,6	2,29455292		627	0,77486339	1366	608	319,3
MAG1_Rt_53	1,85	0	1711	1768	1109	64,4	0,61518564		838	0,62726244	5231	815	314,6
MAG1_Rt_54	2,43	0	1707	1794	1105	65,6	0,88789126		838	0,61594203	5365	814	306,2
MAG1_Rt_55	15,5	42	1720	3020	19	47	2,74084002		839	0,00629139	12581	815	366,0
MAG1_Rt_56	7,94	5,3	2351	1482	1338	94,5	2,07191328		876	0,90283401	3572	851	316,7
MAG1_Rt_58	5,85	0	750	5010	3691	29,12	1,76644166		751	0,73672655	18859	730	319,1
MAG1_Rt_59	6,08	0	396	307	190	14,4	1,8050047		693	0,61889251	-1155	673	367,8
MAG1_Rt_62	18,2	138	543	5660	613	29,8	2,90142159		721	0,10830389	25187	700	465,7
MAG1_Rt_63	18,09	0	515	6270	628	28,63	2,8953593		716	0,10015949	28222	695	380,2
MAG1_Rt_64	29,7	0	5030	1788	1115	155,4	3,39114705		977	0,62360179	5325	950	328,1
MAG1_Rt_65	8,03	0	576	2866	1893	20,5	2,08318453		726	0,66050244	9937	705	321,8
MAG1_Rt_66	11,8	0	658	1441	2617	21,22	2,46809953		739	1,81609993	2088	717	299,0
MAG2_Rt1	2,95	0	614	5630	2050	23,9	1,08180517		732	0,36412078	23600	711	316,2
MAG2_Rt2	0,452	0	2570	1903	935	102,2	-0,7940731		887	0,49132948	6080	862	385,6
MAG2_Rt3	1,866	0	3300	2076	968	111,9	0,6237971		919	0,46628131	6912	893	345,2
MAG2_Rt4	1,94	0	3310	2260	958	112,4	0,66268797		919	0,42389381	7842	894	339,8
MAG2_Rt5	5,44	6,5	651	1290	1670	24,1	1,69377906		738	1,29457364	2280	716	335,5
MAG2_Rt6	4,72	90	675	1330	1730	24,2	1,5518088		741	1,30075188	2420	720	
MAG2_Rt7	5,02	0	673	1451	1825	24,8	1,61342993		741	1,25775327	2930	720	337,1
MAG2_Rt8	3,43	0	2436	1850	1354	77,9	1,23256026		880	0,73189189	5396	856	317,6
MAG2_Rt9	4,01	0	2480	1843	1452	81,7	1,38879124		882	0,7878459	5263	858	315,8
MAG2_Rt10	3,23	0	2537	1655	1355	81,9	1,17248214		885	0,81873112	4420	861	328,6
MAG2_Rt11	1,669	0	286	6530	3910	13,1	0,51222464		666	0,59877489	26240	646	336,7
MAG2_Rt12	1,541	0	305	7750	3860	14,59	0,43243156		671	0,49806452	32390	651	335,5
MAG2_Rt13	1,255	0	1563	1583	1180	65,9	0,22713557		828	0,74542009	4235	805	367,7
MAG2_Rt14	3,73	0	439	2720	2500	17,1	1,31640823		702	0,91911765	8600	681	314,5
MAG2_Rt15	2,96	0	388	2510	2350	15,48	1,08518927		691	0,93625498	7700	671	336,4
MAG2_Rt16	3,32	0	410	2560	2430	15,71	1,19996478		696	0,94921875	7870	675	324,9
MAG2_Rt17	14,28	0	365	720	356	18,46	2,65885996		686	0,49444444	744	666	659,0
MAG2_Rt18	16,57	0	375	640	352	19,1	2,80759383		688	0,55	348	668	613,6
MAG2_Rt19	2,43	0	1069	2250	558	38,6	0,88789126		787	0,248	8192	765	327,9
MAG2_Rt20	3,07	164	1073	2470	563	40,9	1,12167756		787	0,22793522	9287	765	310,9
MAG2_Rt21	2,74	194	1068	2410	557	38,1	1,00795792		787	0,23112033	8993	765	333,9
MAG2_Rt22	2,872	0	1134	2540	598	40,2	1,05500865		793	0,23543307	9602	771	328,4
MAG2_Rt23	5,18	0	2214	2460	430	86	1,64480506		868	0,17479675	9370	844	352,6
MAG2_Rt24	8,24	0	2264	1678	1008	75,9	2,10900034		871	0,60071514	4882	847	335,1
MAG2_Rt25	8,17	0	2460	1930	1033	86	2,10046891		881	0,53523316	6117	857	346,3
MAG2_Rt26	8,27	13	2300	1750	1009	87,3	2,11263451		873	0,57657143	5241	849	344,8
MAG2_Rt27	3,66	0	2910	4110	728	113,4	1,29746315		902	0,17712895	17322	878	326,2
MAG2_Rt28	1,665	0	2610	804	1160	106,1	0,50982512		889	1,44278607	360	864	342,2
MAG2_Rt29	10,84	0	2510	2370	837	90,7	2,383243		884	0,35316456	8513	859	329,1
MAG2_Rt30	11,05	0	2550	2271	757	97	2,40243043		886	0,33333333	8098	861	333,4
MAG2_Rt31	11,09	453	2710	2320	764	97,9	2,4060438		893	0,32931034	8336	869	330,9
MAG2_Rt32	10,41	11,1	2760	2390	796	98,1	2,34276688		896	0,33305439	8654	871	343,0
MAG2_Rt33	3,03	0	962	2980	352	41,2	1,10856262		776	0,11812081	12048	754	350,0
MAG2_Rt34	1,445	0	2085	1911	805	83,4	0,36810932		861				

MAG2_Rt54	4,03	1,4	501	3010	1552	18,98	1,39376638			714	0,51561462	10998	693	336,8
MAG2_Rt55	11,38	369	2192	1609	846	83,5	2,43185743			867	0,52579242	4699	843	345,0
MAG2_Rt56	6,76	8,9	754	1356	1959	27,5	1,91102289			752	1,44469027	2321	730	354,3
MAG2_Rt57	86,5	0	1041	4460	1910	48	4,46014441			784	0,42825112	17890	762	344,6
MAG2_Rt58	70,3	0	1157	4370	1843	52,6	4,2527718			795	0,42173913	17507	773	342,7
MAG2_Rt59	0,634	96	1318	2320	578	69,3	-0,4557063			809	0,24913793	8522	786	378,3
MAG2_Rt60	0,782	0	1473	2430	587	76,7	-0,2459005			821	0,24156379	9063	798	332,6
MAG2_Rt61	0,891	281	1470	2460	558	75,4	-0,1154109			821	0,22682927	9242	798	337,2
MAG4_Rt28	2,769	46	512	898	637	13,54	1,01848624			716	0,70935412	1353	695	379,7
MAG4_Rt29	3,29	0	465	616	618	11,5	1,19088756			716	0,70935412	1353	695	388,0
								mean T values		793			764	
Low temperature felsic rutile grains														
MAG1_Rt_10	0,98	0	4,33	1667	409	1,01	-0,0202027			415,284015	0,24535093	5426	400,737412	
MAG2_Rt52	0,279	34,2	9,66	2920	73,6	0,764	-1,2765435			452,333457	0,9000757	12026,4	437,003829	
MAG2_Rt53	0,352	12,4	10,78	2037	71,9	0,675	-1,0441241			457,710663	0,9000757	7613,1	442,26739	
MAG4_Rt2	1,11	506	9,08	1637	152,4	0,261	0,10436002			449,333095	0,09309713	5532,6	434,066879	
MAG4_Rt3	13,9	4,60E+03	8,28	943	312	0,249	2,63188884			444,909692	0,33085896	1903	429,736962	
MAG4_Rt4	4,89	6440	20,7	1164	270	0,82	1,5871923			491,415115	0,23195876	3050	475,259512	
MAG4_Rt6	0,541	244	4,2	869	75,2	0,119	-0,614336			413,951038	0,08653625	1769,8	399,432607	
MAG4_Rt8	1,29	670	7,65	1491	43,9	0,433	0,25464222			441,157231	0,02944333	4911,1	426,063808	
MAG4_Rt9	4,18	9240	13,5	1404	74,8	0,475	1,43031125			468,992852	0,05327635	4445,2	453,311134	
MAG4_Rt10	1,42	357	134,5	1619	34,9	5,58	0,35065687			607,971494	0,02155652	5560,1	589,352519	
MAG4_Rt11	0,832	355	44,6	4330	62,8	2,8	-0,1839228			535,277905	0,01450346	19087,2	518,19528	
MAG4_Rt12	0,846	0	9,8	3870	48,6	1,359	-0,1672359			453,034248	0,01255814	16801,4	437,689809	
MAG4_Rt13	0,236	207	44,9	2960	43,3	2,83	-1,4439235			535,683171	0,01462838	12256,7	518,591981	
MAG4_Rt14	24,3	1,91E+04	84,3	1150	102,9	3,3	3,19047635			575,66744	0,08947826	3147,1	557,731198	
MAG4_Rt15	0,94	60	176	1534	621	5,4	-0,0618754			627,706588	0,40482399	4549	608,67052	
MAG4_Rt16	6,51	1060	10,42	1204	353	0,496	1,87333946			456,037244	0,29318937	3167	440,629338	
MAG4_Rt17	6,48	2190	364	1967	170	9,1	1,86872051			685,742057	0,08642603	7165	665,479432	
MAG4_Rt18	11	541	42,7	1341	41,1	1,66	2,39789527			532,655985	0,03064877	4163,9	515,628773	
MAG4_Rt19	0,1962	257	130	970	2,94	6,93	-1,6286207			605,535641	0,00303093	2347,06	586,968147	
MAG4_Rt20	2,12	1470	99	637	64,2	3,4	0,75141609			586,511173	0,10078493	620,8	568,345753	
MAG4_Rt21	4,63	3600	279	904	59,7	11	1,53255687			663,654906	0,06603982	1960,3	643,859085	
MAG4_Rt22	2,15	522	1,61	1384	21,2	0,147	0,76546784			374,506064	0,01531792	4398,8	360,821286	
MAG4_Rt23	0,345	121	11,7	971	103,6	0,694	-1,0642109			461,777311	0,10669413	2251,4	446,248091	
MAG4_Rt24	0,39	166	16,6	1089	185,1	0,74	-0,9416085			479,669703	0,16997245	2759,9	463,762334	
MAG4_Rt25	1,71	132	12,83	1359	14,8	0,65	0,53649337			466,409973	0,01089036	4280,2	450,782844	
MAG4_Rt27	1,72	268	42,7	1473	19,8	1,98	0,54232429			532,655985	0,01344196	4845,2	515,628773	
MAG4_Rt32	0,192	71	3,79	1145	159,8	0,323	-1,6502599			409,497076	0,13956332	3065,2	395,072778	
								mean T values		592,394831			573,101629	
Mafic rutile grains														
MAG1_Rt_9	0,87	10,3	215,1	9,89	927	3,29	-0,1392621			643,01497	93,7310415	-3377,55	623,655365	339,1
MAG1_Rt_33	19,33	394	575	194,7	713	11,64	2,96165829			726,252775	3,66204417	-2239,5	705,133974	369,1
MAG1_Rt_39	8,09	3	400	205,7	2957	10	2,09062873			693,827106	14,3753038	-4428,5	673,393608	365,3
MAG1_Rt_43	2,529	4,6	387	3110	1507	14,66	0,92782397			620,009644	0,08346334	-2184,85	601,136248	367,2
MAG1_Rt_45	0,685	0	160,4	623	1621	5,34	-0,3783364			620,796187	2,60192616	-1006	601,906167	
MAG1_Rt_47	2,31	16,6	130,3	474	223,5	5,72	0,83724752			605,70021	0,47151899	-353,5	587,129238	382,2
MAG1_Rt_59	6,08	0	396	307	190	14,4	1,8050047			690,979199	0,62052117	-1155,5	670,60589	367,8
MAG1_Rt60	4,61	0	387	307	190,5	15,23	1,52822786			636,049908	0,8403452	-572	616,837507	368,2
MAG1_Rt61	0,195	258	196,5	463,5	389,5	7,91	-1,6347557			735,947058	113,355049	-5826,5	714,623371	
MAG2_Rt45	20,41	0	638	30,7	3480	20,1	3,01602498			838,838617	2,27777778	-1177	815,340359	326,4
MAG2_Rt51	9,2	5,9	1720	486	1107	50,6	2,21920348			707,021897	1,00324675	-38	686,309532	345,1
MAG1_Rt48	13,52	666	102,3	85,7	2304	6,27	2,60417007			802,473878	1,38721805	7110	779,744175	381,4
MAG4_Rt30	4,08	9,6	238,2	129,5	144,5	6,76	1,40609699			620,009644	0,08346334	-2184,85	601,136248	370,0
MAG4_Rt31	3,32	8,5	317,6	129,9	145,1	11,71	1,19996478			659,950397	1,14412137	550	640,232869	378,7
								mean T values		685,776535			665,513182	363,3834575

APPENDIX																										
Table 2a																										
Zircon isotopic data data and calculated U-Pb ages for MAG 1_G, MAG 3_G and MAG 4_G samples																										
sample No	²⁰⁷ Pb/ ²³⁵ U	2s	²⁰⁶ Pb/ ²³⁸ U	2s	Rho	²⁰⁶ U/ ²³⁸ Pb	2s	²⁰⁷ Pb/ ²³⁵ Pb	2s	Rho	Age ²⁰⁷ Pb/ ²³⁵ U	2s	Age ²⁰⁶ Pb/ ²³⁸ U	2s	Age ²⁰⁷ Pb corr	2s	Conc Age	Err	6-38/7-35%	U (ppm)	Th (ppm)	Pb (ppm)	Th/U			
MAG 1 -G																										
MAG1_G_1	0.386	0.016	0.0505	0.0018	0.6699	19.80198	0.7058132	0.0555	0.0014	-0.0457	317.6	11.3	331.4	13.7	432.4	10.9	316.5	11.1	323.1	10.4	4.2	432	356	59	0.82	
MAG1_G_2	0.383	0.025	0.0517	0.0018	0.0876	19.34236	0.6734284	0.0534	0.0032	0.2822	325.0	11.3	329.2	21.5	345.8	20.7	324.8	11.2	326.0	9.8	1.3	72.3	58.8	9.02	0.81	
MAG1_G_3	0.372	0.019	0.0502	0.0017	0.0308	19.92032	0.6745925	0.0548	0.0025	0.4450	315.7	10.7	321.1	16.4	404.1	18.4	314.9	10.5	317.6	8.5	1.7	153	145.3	21.7	0.95	
MAG1_G_4	0.387	0.019	0.05228	0.0016	0.0010	19.12777	0.5853948	0.0541	0.0025	0.4503	328.5	10.1	332.2	16.3	375.2	17.3	328.1	9.9	329.7	8.0	1.1	125.7	76.4	11.61	0.61	
MAG1_G_5	0.369	0.014	0.0512	0.0019	0.3621	19.53125	0.7247925	0.0534	0.0016	0.4514	321.9	11.9	318.9	12.1	345.8	10.4	321.7	11.8	320.1	9.0	-0.9	309	85.2	13.5	0.28	
MAG1_G_6	0.396	0.017	0.0534	0.0017	0.2970	18.72659	0.5961649	0.0538	0.0019	0.2867	335.4	10.7	338.7	14.5	362.7	12.8	335.1	10.5	336.6	9.0	1.0	242	186.8	30.5	0.77	
MAG1_G_7	0.381	0.015	0.0522	0.0017	0.1974	19.15709	0.6238898	0.0543	0.0018	0.4345	328.0	10.7	327.8	12.9	383.5	12.7	327.5	10.5	327.9	8.3	-0.1	226.5	192.9	30.7	0.85	
MAG1_G_8	0.3821	0.014	0.05241	0.0015	0.5316	19.08033	0.5460884	0.0533	0.0011	-0.0222	329.3	9.4	328.6	12.0	341.6	7.0	329.2	9.3	329.0	8.4	-0.2	466	114.9	18.13	0.25	
MAG1_G_9	0.4	0.015	0.0548	0.0017	0.3073	18.24818	0.566093	0.0534	0.0013	0.5180	343.9	10.7	341.6	12.8	345.8	8.4	343.9	10.5	342.9	8.6	-0.7	961	1077	161.3	1.12	
MAG1_G_10	0.394	0.028	0.05294	0.0017	0.5229	18.88931	0.6065702	0.0549	0.0021	0.4014	332.5	10.7	337.3	24.0	408.2	15.6	331.8	10.5	332.5	10.4	1.4	1172	593	81.1	0.51	
MAG1_G_11	0.388	0.015	0.05341	0.0016	0.4670	18.72309	0.5608963	0.0538	0.0015	0.4470	335.4	10.0	332.9	12.9	362.7	10.1	335.2	9.9	334.4	8.8	-0.8	463	184	27.8	0.40	
MAG1_G_12	0.402	0.018	0.0528	0.0017	0.0185	18.93939	0.6097911	0.0549	0.0023	0.6206	331.7	10.7	343.1	15.4	408.2	17.1	330.9	10.5	336.1	8.2	3.3	198.2	266.3	38.3	1.34	
MAG1_G_13	0.376	0.017	0.052	0.0016	0.4733	19.23077	0.591716	0.0532	0.0017	0.2436	326.8	10.1	324.1	14.7	337.3	10.8	326.7	9.9	326.0	9.2	-0.8	632	1210	175	1.91	
MAG1_G_14	0.391	0.014	0.0524	0.0016	0.4511	19.08397	0.5827166	0.054	0.0014	0.4454	329.2	10.1	335.1	12.0	371.0	9.6	328.8	9.9	331.9	8.5	1.7	537	329.6	48.3	0.61	
MAG1_G_15	0.383	0.016	0.05319	0.0016	0.4198	18.80053	0.5655357	0.0523	0.0016	0.1498	334.1	10.0	329.2	13.8	298.5	9.1	334.4	9.9	332.4	8.9	-1.5	289	167.4	25.6	0.58	
MAG1_G_16	0.381	0.016	0.0535	0.0017	0.2050	18.69159	0.5939383	0.0525	0.0017	0.3737	336.0	10.7	327.8	13.8	307.2	9.9	336.2	10.5	332.5	8.5	-2.5	415	280	43.1	0.67	
MAG1_G_17	0.399	0.13	0.0538	0.0022	0.4287	18.58736	0.7600779	0.0553	0.013	0.1399	337.8	13.8	340.9	111.1	328.8	80.6	337.9	14.6	337.7	12.8	0.9	367	349	57.7	0.95	
MAG1_G_18	0.377	0.014	0.0505	0.0014	0.0010	19.80198	0.5489568	0.0522	0.0018	0.5409	317.6	8.8	324.8	12.1	294.2	10.1	317.8	8.7	320.5	6.6	2.2	437	390	63.4	0.89	
MAG1_G_19	0.391	0.014	0.05194	0.0016	0.0241	19.25298	0.5930838	0.0559	0.0017	0.4734	326.4	10.1	335.1	12.0	448.4	13.6	325.2	9.9	330.6	7.2	2.6	507	479	77.8	0.94	
MAG1_G_20	0.3899	0.014	0.05276	0.0016	0.0709	18.95375	0.5747916	0.0539	0.0016	0.5604	331.4	10.1	334.3	12.0	366.9	10.9	331.1	9.9	332.8	7.3	0.9	468	720	126	1.54	
MAG1_G_21	0.389	0.016	0.05217	0.0016	0.3805	19.1681	0.587866	0.0541	0.0017	0.1688	327.8	10.1	333.6	13.7	375.2	11.8	327.4	9.9	329.9	8.8	1.7	393.1	185	32.8	0.47	
MAG1_G_22	0.366	0.017	0.0519	0.0016	0.1922	19.26782	0.5939984	0.0513	0.0021	0.3065	326.2	10.1	316.7	14.7	254.3	10.4	326.8	10.0	322.9	8.4	-3.0	211	561	96.4	2.66	
MAG1_G_23	0.382	0.018	0.05096	0.0016	0.4125	19.62323	0.6161141	0.053	0.002	0.0783	320.4	10.1	328.5	15.5	328.8	12.4	320.3	9.9	322.5	9.2	2.5	232.7	641	108	1.75	
MAG1_G_24	0.396	0.021	0.0553	0.0019	0.3775	18.08318	0.6213028	0.0523	0.0024	0.1971	347.0	11.9	338.7	18.0	298.5	13.7	347.5	11.8	344.6	10.7	-2.4	202	398	73.2	1.97	
MAG1_G_25	0.389	0.017	0.0545	0.0018	0.1852	18.34862	0.6060096	0.0518	0.0019	0.4091	342.1	11.3	333.6	14.6	276.6	10.1	342.7	11.2	338.5	8.9	-2.5	227.7	552	96.7	2.42	
MAG1_G_26	0.385	0.015	0.0536	0.0017	0.1709	18.65672	0.5917242	0.0532	0.0016	0.4310	336.6	10.7	330.7	12.9	337.3	10.1	336.6	10.5	333.8	8.2	-1.8	451	747	133	1.66	
MAG1_G_27	0.386	0.16	0.0528	0.0024	0.1893	18.93939	0.8608815	0.0531	0.015	0.1806	331.7	15.1	331.4	137.4	333.1	94.1	331.7	16.0	331.7	14.7	-0.1	119.4	229	39.1	1.92	
MAG1_G_28	0.3899	0.013	0.0535	0.0016	0.4064	18.69159	0.5590008	0.0531	0.0013	0.5137	336.0	10.0	334.3	11.1	333.1	8.2	336.0	9.9	335.1	8.1	-0.5	656	434	88	0.66	
MAG1_G_29	0.3728	0.014	0.0524	0.0018	0.4191	19.08397	0.6555562	0.0526	0.0012	0.4176	329.2	11.3	321.7	12.1	311.6	7.1	329.4	11.1	325.1	9.0	-2.3	625	197.1	31.7	0.32	
MAG1_G_30	0.366	0.016	0.0506	0.0017	0.2561	19.76285	0.6639691	0.052	0.0019	0.3152	318.2	10.7	316.7	13.8	285.4	10.4	318.5	10.6	317.6	8.8	-0.5	138.4	259.5	40.7	1.88	
MAG1_G_31	0.378	0.015	0.0518	0.0016	0.1824	19.30502	0.5																			

MAG3_G_18	0.362	0.015	0.05082	0.0016	0.1819	19.67729	0.6195133	0.052	0.0018	0.3667	319.6	10.1	313.7	13.0	285.4	9.9	319.9	9.9	317.1	8.0	-1.9	185	83.6	14.93	0.45
MAG3_G_19	0.399	0.017	0.05314	0.0015	0.2724	18.81822	0.5311879	0.0541	0.0019	0.2244	333.8	9.4	340.9	14.5	375.2	13.2	333.4	9.3	335.9	8.3	2.1	507	-233	-59.7	-0.46
MAG3_G_20	0.367	0.014	0.0507	0.0016	0.4630	19.72387	0.6224494	0.0517	0.0015	0.1048	318.8	10.1	317.4	12.1	272.2	7.9	319.2	9.9	318.2	8.6	-0.4	584	-156	-41.6	-0.27
MAG3_G_21	0.396	0.018	0.0523	0.0015	0.0101	19.12046	0.5483879	0.0563	0.0023	0.4185	328.6	9.4	338.7	15.4	464.2	19.0	327.3	9.3	331.9	7.6	3.0	336	-93.6	-23.8	-0.28
MAG3_G_22	0.372	0.016	0.05153	0.0015	0.4522	19.40617	0.5648992	0.0536	0.0015	0.1470	323.9	9.4	321.1	13.8	354.3	9.9	323.6	9.3	323.1	8.6	-0.9	812	-711	-175.1	-0.88
MAG3_G_23	0.373	0.02	0.0509	0.0017	0.0504	19.64637	0.6561654	0.0538	0.0027	0.3927	320.0	10.7	321.9	17.3	362.7	18.2	319.7	10.6	320.6	8.7	0.6	310	-141.8	-33.9	-0.46
MAG3_G_24	0.37	0.023	0.0507	0.0017	0.1650	19.72387	0.6613525	0.0521	0.0028	0.2371	318.8	10.7	319.7	19.9	289.8	15.6	319.1	10.6	319.0	9.5	0.3	239	-68.5	-16.9	-0.29
MAG3_G_25	0.3821	0.014	0.05199	0.0014	0.4387	19.23447	0.5179507	0.0533	0.0012	0.0790	326.7	8.8	328.6	12.0	341.6	7.7	326.6	8.7	327.4	7.9	0.6	1450	-222	-55.8	-0.15
MAG3_G_26	0.378	0.015	0.0525	0.0017	0.5000	19.04762	0.61678	0.0514	0.0013	0.1632	329.9	10.7	325.6	12.9	258.8	6.5	330.5	10.5	328.0	9.3	-1.3	896	-164.3	-40.9	-0.19
MAG3_G_27	0.374	0.016	0.05147	0.0016	0.1564	19.42879	0.6039648	0.0533	0.002	0.3047	323.5	10.1	322.6	13.8	341.6	12.8	323.4	9.9	323.2	8.1	-0.3	554	-201	-47.6	-0.36
MAG3_G_28	0.384	0.017	0.05139	0.0015	0.0757	19.45904	0.5679813	0.0554	0.002	0.3716	323.0	9.4	330.0	14.6	428.4	15.5	322.0	9.3	325.4	7.7	2.1	691	-213	-51.2	-0.31
MAG3_G_29	0.374	0.016	0.05196	0.0016	0.1091	19.24557	0.5926274	0.0521	0.0018	0.4054	326.5	10.1	322.6	13.8	289.8	10.0	326.9	9.9	325.0	7.9	-1.2	723	-97.3	-26.2	-0.13
MAG3_G_30	0.381	0.022	0.05078	0.0015	0.1088	19.69279	0.5817091	0.0553	0.0029	0.2323	319.3	9.4	327.8	18.9	424.4	22.3	318.3	9.3	321.1	8.4	2.6	249	-91.6	-23.1	-0.37
MAG3_G_31	0.375	0.017	0.05081	0.0015	0.3677	19.68117	0.5810224	0.0538	0.002	0.1005	319.5	9.4	323.4	14.7	362.7	13.5	319.1	9.3	320.5	8.6	1.2	877	-116.6	-31	-0.13
MAG3_G_32	0.357	0.35	0.0508	0.0032	0.2442	19.68504	1.240002	0.0508	0.028	0.1106	319.4	20.1	310.0	303.9	231.8	127.7	320.2	22.7	319.6	19.3	-3.1	197	-99.6	-25.9	-0.51
MAG3_G_33	0.3862	0.013	0.05194	0.0016	0.2157	19.25298	0.5930838	0.0543	0.0015	0.5301	326.4	10.1	331.6	11.2	383.5	10.6	325.9	9.9	329.1	7.5	1.6	1057	-317	-99.5	-0.30
MAG3_G_34	0.382	0.015	0.05279	0.0016	0.1882	18.94298	0.5741385	0.0528	0.0017	0.4640	331.6	10.1	328.5	12.9	320.2	10.3	331.7	9.9	330.3	7.9	-0.9	799	-225	-75.8	-0.28
MAG3_G_35	0.385	0.014	0.0515	0.0015	0.6119	19.41748	0.5655575	0.0539	0.0013	0.2859	323.7	9.4	330.7	12.0	366.9	8.8	323.3	9.3	326.2	8.7	2.1	1093	-389.8	-149.6	-0.36
MAG3_G_36	0.395	0.025	0.05336	0.0017	0.0559	18.74063	0.597059	0.0544	0.003	0.4440	335.1	10.7	338.0	21.4	387.6	21.4	334.6	10.6	335.8	9.2	0.9	739	-694	-378	-0.94
MAG3_G_37	0.369	0.013	0.05153	0.0015	0.2593	19.40617	0.5648992	0.0518	0.0014	0.1922	323.9	9.4	318.9	11.2	276.6	7.5	324.3	9.3	321.6	7.5	-1.6	493	-528	-1240	-1.07
MAG3_G_38	0.388	0.015	0.0531	0.0015	0.0612	18.83239	0.5319885	0.0529	0.0016	0.5617	333.5	9.4	332.9	12.9	324.5	9.8	333.6	9.3	333.3	7.2	-0.2	965	-2916	1640	-3.02
MAG3_G_39	0.379	0.017	0.05154	0.0016	0.0257	19.40241	0.6023254	0.0538	0.0023	0.4220	324.0	10.1	326.3	14.6	362.7	15.5	323.6	9.9	324.8	7.8	0.7	215	-2360	147	-10.98
MAG3_G_40	0.3889	0.013	0.05132	0.0016	0.3064	19.48558	0.6075006	0.0527	0.0013	0.4520	322.6	10.1	318.8	11.2	315.9	7.8	322.7	9.9	320.7	7.9	-1.2	943	1560	49.5	1.65
MAG3_G_41	0.594	0.034	0.0531	0.0018	0.1829	18.83239	0.6383862	0.0802	0.0042	0.1684	333.5	11.3	473.4	27.1	1201.9	62.9	322.5	10.9			29.5	189	1010	81.6	5.98
MAG3_G_42	0.483	0.089	0.0559	0.002	0.0010	17.88909	0.6400389	0.0623	0.01	0.4346	350.6	12.5	400.1	73.7	684.4	109.9	346.9	12.9	352.4	12.0	12.4	166	710	91	4.28
MAG3_G_43	0.461	0.35	0.0511	0.004	0.0010	19.56947	1.531857	0.0655	0.032	0.4495	321.3	25.1	385.0	292.3	790.4	386.2	316.3	27.4	321.9	24.4	16.5	229	362	48.1	1.58
MAG3_G_44	0.377	0.018	0.0524	0.0018	0.4146	19.08397	0.6555562	0.0528	0.0019	0.1462	329.2	11.3	324.8	15.5	320.2	11.5	329.3	11.2	327.7	10.0	-1.4	231	204.9	36.9	0.89
MAG3_G_45	0.384	0.017	0.05262	0.0016	0.2880	19.00418	0.5778542	0.0542	0.0019	0.2590	330.6	10.1	330.0	14.6	379.4	13.3	330.1	9.9	330.4	8.7	-0.2	170.8	88.1	15.5	0.52
MAG3_G_46	0.38	0.017	0.05143	0.0015	0.1604	19.4439	0.5670981	0.0535	0.0019	0.2415	323.3	9.4	327.0	14.6	350.1	12.4	323.0	9.3	324.5	8.0	1.1	247	169	26.3	0.68
MAG3_G_47	0.381	0.018	0.0525	0.0016	0.2585	19.04762	0.5804989	0.0521	0.0021	0.2099	329.9	10.1	327.8	15.5	289.8	11.7	330.2	9.9	329.2	8.8	-0.6	190	307	50	1.62
MAG3_G_48	0.376	0.019	0.05043	0.0015	0.0542	19.82947	0.5989116	0.0544	0.0025	0.3526	317.2	9.4	324.1	16.4	387.6	17.8	316.5	9.3	319.2	7.9	2.1	128.6	204.7	33.7	1.59
MAG3_G_49	0.42	0.02	0.053	0.0019	0.0010	18.86792	0.6763973	0.0562	0.0025	0.5535	332.9	11.9	356.1	17.0	460.3	20.5	331.7	11.7	342.0	9.1	6.5	100.3	50.2	84.2	0.50
MAG3_G_50	0.387	0.018	0.0527	0.0017	0.2880	18.97533	0.6121075	0.0543	0.0019	0.2679	331.1	10.7	332.2	15.5	383.5	13.4	330.6	10.5	331.4	9.2	0.3	157	67.9	11.89	0.43
MAG3_G_51	0.376	0.019	0.0505	0.0016	0.2396	19.80198	0.6273895	0.0543	0.0021	0.2476	317.6	10.1	324.1	16.4	383.5	14.8	317.0	9.9	319.4	8.9	2.0	206.3	165.1	25.9	0.80
MAG3_G_52	0.394	0.017	0.0517	0.0017	0.2933	19.34236	0.6360157	0.0543	0.002	0.2572	325.0	10.7	337.3	14.6	383.5	14.1	324.4	10.5	329.6	9.1	3.7	94.4	68.3	11.19	0.72

MAG 4 - G																									
MAG4_G_1	0.3898	0.013	0.05295	0.0015	0.3403	18.88574	0.5350068	0.0544	0.001	0.3437	332.6	9.4	334.2	11.1	387.6	7.1	332.1	9.3	333.4	7.6	0.5	1586	-5101	-1208	-3.22
MAG4_G_2	0.529	0.12	0.05885	0.0019	0.1246	17.59015	0.5878854	0.0692	0.013	0.0151	356.4	11.9	431.1	97.8	904.7	170.0	349.7	12.8	356.6	11.6	17.3	534	-2170	-486	-4.06
MAG4_G_3	0.386	0.013	0.05274	0.0014	0.2770	18.96094	0.5033242	0.05399	0.0011	0.1933	331.3	8.8	331.4	11.2	370.6	7.6	330.9	8.7	331.4	7.2	0.0	1530	-6940	-680	-4.54
MAG4_G_4	0.379	0.017	0.05198	0.0015	0.1404	19.23817	0.5551607	0.0548	0.0019	0.2642	326.7	9.4	326.3	14.6	404.1	14.0	325.9	9.3	326.5	7.9	-0.1	353	3,00E+04	-341	84.99
MAG4_G_5	0.384	0.03	0.05264	0.0016	0.2962	18.99896	0.5774152	0.0533	0.0035	0.2357	330.7	10.1	330.0	25.8	341.6	22.4	330.6	10.0	330.7	9.7	-0.2	536	4100	-1343	7.65
MAG4_G_6	0.38	0.017	0.05139	0.0015	0.2629	19.45904	0.5679813	0.0542	0.0016	0.2259	323.0	9.4	327.0	14.6	379.4	11.2	322.5	9.3	324.2	8.3	1.2	934	2880	6,00E+03	3.08
MAG4_G_7	0.38	0.015	0.05176	0.0016	0.2220	19.31994	0.597216	0.054	0.0016	0.2907	325.3	10.1	327.0	12.9	371.0	11.0	324.9	9.9	326.0	8.1	0.5	433	952	609	2.20
MAG4_G_8	0.37	0.016	0.05156	0.0015	0.1763	19.39488	0.564242	0.0528	0.0019	0.2486	324.1	9.4	319.7	13.8	320.2	11.5	324.1	9.3	322.5	7.8	-1.4	322	571	259	1.77
MAG4_G_9	0.392	0.02	0.05225	0.0016	0.3097	19.13876	0.5860672	0.055	0.0021	0.1318	328.3	10.1	335.8	17.1	412.2	15.7	327.5	9.9	330.1	9.2	2.2	211	298	111.3	1.41
MAG4_G_10	0.367	0.016	0.05114	0.0015	0.2203	19.55417	0.5735481	0.052	0.0018	0.2513	321.5	9.4	317.4	13.8	285.4	9.9	321.8	9.3	320.1	8.0	-1.3	323	419	144.1	1.30
MAG4_G_11	0.378	0.072	0.0511	0.0015	0.2673	19.56947	0.5744463	0.0573	0.0083	0.2744	321.3	9.4	325.6	62.0	503.1	72.9	319.5	9.8	321.2	9.2	1.3	284.4	194.8	66.3	0.68
MAG4_G_12	0.37	0.017	0.0519	0.0017	0.0941	19.26782	0.6311233	0.0529	0.0023	0.2994	326.2	10.7	319.7	14.7	324.5	14.1	326.2	10.6	323.6	8.4	-2.0	211.1	183.2	52.3	0.87
MAG4_G_13	0.377	0.015	0.05249	0.0017	0.2100	19.05125	0.6170151	0.0528	0.0017	0.3402	328.10	10.7	324.8	12.9	320.5	10.3	329.9	10.5	327.5	8.3	-1.5	589	237	64.1	0.40
MAG4_G_14	0.368	0.019	0.05232	0.0016	0.0450	19.11315	0.5845	0.0518	0.0026	0.2891	328.7	10.1	318.2	16.4	276.5	13.9	329.2	10.0	325.4	8.2	-3.3	150.5	93.4	25.3	0.62
MAG4_G_15	0.3786	0.012	0.05181	0.0015	0.4755	19.30129	0.5588099	0.05325	0.00096	0.3362	325.6	9.4	326.0	10.3	339.6	6.3	325.5	9.3	325.8	7.7	0.1	1910	1183	322	0.62
MAG4_G_16	0.3827	0.013	0.05375	0.0015	0.0531	18.60465	0.5191996	0.0514	0.0014	0.4857	337.5	9.4	329.0	11.2	258.8	7.0	338.2	9.3	333.4	6.8	-2.6	351	109	31.3	0.31
MAG4_G_17	0.4452	0.015	0.05189	0.0015	0.2631	19.27154	0.5570881	0.0629	0.0014	0.4102	326.1	9.4	373.9	12.6	704.9	15.7	322.1	9.2			12.8	571	202.1	55.7	0.35
MAG4_G_18	0.394	0.017	0.05329	0.0015	0.2898	18.76525	0.5282017	0.0547	0.0019	0.1866	334.7	9.4	337.3	14.6	400.0	13.9	334.0	9.3	335.5	8.3	0.8	270	85.9	21	0.32
MAG4_G_19	0.377	0.015	0.05167	0.0015	0.3769	19.35359	0.5618422	0.0533	0.0012	0.0912	324.8	9.4	324.8	12.9	341.6	7.7	324.6	9.3	324.8	8.3	0.0	454	219	53.3	0.48
MAG4_G_20	0.376	0.016	0.05197	0.0015	0.1238	19.24187	0.5653744	0.0529	0.0017	0.2614	325.6	9.4	324.1	13.8	324.5	10.4	326.6	9.3	325.7	7.7	-0.8	198.1	146.3	34.1	0.73
MAG4_G_21	0.374	0.015	0.05214	0.0015	0.4430	19.17913	0.5517587	0.0521	0.0016	-0.0638	327.6	9.4	322.6	12.9	289.8	8.9	328.0	9.3	325.9	8.4	-1.6	218	158	37.6	0.72
MAG4_G_22	0.376	0.015	0.05205	0.0014	0.2995	19.2123	0.5167572	0.0529	0.0015	0.0988	327.1	8.8	324.1	12.9	324.5	9.2	327.1	8.7	326.1	7.7	-0.9	273	198	45.4	0.73
MAG4_G_23	0.438	0.084	0.0526	0.0016	0.2837	19.01141	0.5782937	0.061	0.01	0.0696	330.5	10.1	368.8	70.7	639.2	104.8	327.2	10.6	329.6	9.7	10.4	102.7	66.5	16	0.65
MAG4_G_24	0.377	0.019	0.05295	0.0015	0.0010	18.92148	0.5370334	0.0517	0.0025	0.4214	332.0	9.4	324.8	16.4	272.2	13.2	302.6	9.3	329.8	7.7	-2.2	135.1	78.6	17.3	0.58
MAG4_G_25	12.36	0.43	0.484	0.015	0.8337	2.066116	0.06403251	0.1878	0.0021	0.3079	2544.7	78.9	2632.1	91.6	2723.0	30.4	2485.5	82.6			3.3	683	-777	1005	-1.14
MAG4_G_26	10.95	0.33	0.4488	0.013	0.8365	2.228164	0.06454129	0.1776	0.002	0.4057	2389.9	69.2	2518.9	75.9	2630.6	29.6	2323.0	70.0			5.1	548	-544	768	-0.99
MAG4_G_27	10.67	0.15	0.2999	0.008	0.6772	3.334445	0.08894818	0.1232	0.0015	0.2861	1690.8	45.1	1828.9	54.2	2003.1	24.6	1653.6	43.0			7.6	653	-519	454	-0.64
MAG4_G_28	0.3493	0.052	0.0488	0.0015	0.3799	20.4918	0.629871	0.0524	0.0058	0.0677	307.2	9.4	304.2	45.3	302.9	33.5	307.2	9.6	307.3	9.1	-1.0	1231	-1736	360	-1.41
MAG4_G_29	0.379	0.015	0.05278	0.0015	0.1929	18.94657	0.5384588	0.0531	0.0016	0.3247	331.6	9.4	326.3	12.9	333.1	10.0	331.6	9.3	329.5	7.7	-1.6	314	-809	195	-2.58
MAG4_G_30	0.383	0.017	0.05327	0.0016	0.4154	18.77229	0.5638383	0.0527	0.0016	0.1188	334.6	10.0	329.2	14.6	315.9	9.6	334.7	9.9	333.0	9.1	-1.6	221.6	-255	61.3	-1.15
MAG4_G_31	0.647	0.024	0.05063	0.0014	0.6338	19.75114	0.5461503	0.0939	0.0022	0.1119	318.4	8.8	506.6	18.8	1506.1	35.3	302.3	8.3			37.2	1561	-518	362.3	-0.33
MAG4_G_32	0.3867	0.015	0.0524	0.0015	0.2045	19.08397	0.5462968	0.0537	0.0015	0.2459	329.2	9.4	332.0	12.9	358.5	10.0	329.0	9.3	330.3	7.7	0.8	347	-488	90.4	-1.41
MAG4_G_33	0.389	0.014	0.0537	0.0015	0.0010	18.62187	0.5201669	0.0534	0.001	0.0929	337.2	9.4	333.6	12.0	345.8	6.5	337.1	9.3	333.6	6.8	-1.1	1358	-966	153	-0.71
MAG4_G_34	0.3847	0.014	0.0527	0.0015	0.3789	18.97533	0.5400948	0.0537	0.0013	0.3365	331.1	9.4	330.5	12.0	358.5	8.7	330.8	9.3	330.8	8.0	-0.2	269	-855	99.3	-0.78
MAG4_G_35	0.377	0.014	0.0522	0.0018	0.4432	19.15709	0.6605892	0.0533	0.0012	0.3875	328.0	11.3	324.8	12.1	341.6	7.7	327.9	11.1	326.2	9.0	-1.0	968	-258	22.7	-0.27
MAG4_G_36	0.3652	0.013	0.051	0.0014	0.5448	19.60784	0.5382545	0.0522	0.0013	0.2932	320.7	8.8	316.1	11.3	294.2	7.3	320.9	8.7	318.9	7.9	-1.4	455	-889	52.9	-1.95
MAG4_G_37	0.387	0.015	0.05216	0.0014	0.3518	19.17178	0.515458	0.0541	0.0015	0.0496	327.8	8.8	332.2	12.9	375.2	10.4	337.3	8.7	329.2	7.8	1.3	226	-2121	67.4	-0.98
MAG4_G_38	0.389	0.017	0.05365	0.0016	0.2216	18.6933	0.5558793	0.0524	0.0018	0.2389	336.9	10.0	333.6	14.6	302.9	10.9	337.2	9.9	335.7	8.5	-1.0	194	-1,10E+04	49.6	-56.70
MAG4_G_39	0.377	0.013	0.0528	0.0015	0.5688	18.93939	0.539051	0.051	0.001	0.1570	331.7	9.4	324.8	11.2	240.8	4.7	332.5	9.3	328.6	8.3	-2.1	393.8	8370	174.7	21.25
MAG4_G_40	0.404	0.017	0.04751	0.0014	0.1735	21.0482	0.6022374	0.0628	0.002	0.2961	299.2	8.8	344.5	14.5	701.5	22.3	295.4	8.6			13.2	310	1944	71.4	6.27
MAG4_G_41	0.384	0.015	0.053	0.0017	0.6238	18.86792	0.6051976	0.0527	0.0014	0.2311	332.9	10.7	330.0	12.9	315.9	8.4	333.1	10.5	332.7	9.6	-0.9	394	2200	124.5	5.58
MAG4_G_42	0.4013	0.014	0.04973	0.0015	0.5770	20.10859	0.6065329	0.0591	0.0013	0.2951	312.9	9.4	342.6	12.0	570.8	12.6	310.4	9.2			8.7	322	998	68	3.10
MAG4_G_43	0.498	0.024	0.04577	0.0013	0.0210	21.84837	0.6205568	0.0796	0.0031	0.3210	288.5	8.2	410.3	19.8	1187.1	46.2	278.7	7.9			29.7	344.1	917	81.8	2.66
MAG4_G_44	0.387	0.016	0.0536	0.0016	0.1433	18.65672	0.5569189	0.0524	0.0017	0.4840	336.6	10.0	332.2	13.7	302.9	9.8	336.9	9.9	334.8	8.0	-1.3	239	163.2	14.94	0.68
MAG4_G_45	0.3736	0.012	0.04966	0.0015	0.5828	20.13693	0.608244	0.05472	0.00099	0.4176	321.4	9.4	322.3	10.4	400.8	7.3	311.6	9.3	317.8	8.1	3.1	889	738	70.4	0.83
MAG4_G_46	0.428	0.031	0.0487	0.0047	0.9226	20.53388	1.981709	0.0854	0.008	0.8720	306.5	29.6	361.8	26.2	787.2	96.3	301.7	28.8			15.3	2032	2520	269	1.24
MAG4_G_47	0.3718	0.025	0.0502	0.0026	0.3868	19.92032	1.03173	0.0555	0.0063	0.5065	315.7	16.4	321.0	21.6	432.4	49.1	314.7	16.2	317.7	14.2	1.6	1278	1284	136.7	1.00
MAG4_G_48	0.3924	0.014	0.05107																						

APPENDIX																										
Table 2b																										
Zircon isotopic data data and calculated U-Pb ages for MAG 1_D, MAG 2_D & MAG 3_D samples																										
sample No	²⁰⁷ Pb/ ²³⁵ U	2s	²⁰⁶ Pb/ ²³⁸ U	2s	Rho	²³⁸ U/ ²⁰⁶ Pb	2s	²⁰⁷ Pb/ ²³⁵ Pb	2s	Rho	Age ²⁰⁷ Pb/ ²³⁵ U	2s	Age ²⁰⁶ Pb/ ²³⁸ U	2s	Age ²⁰⁶ Pb/ ²³⁵ U	2s	Age ²⁰⁷ Pb cor	2s	Conc Age	Err	6-38/7-35%	U (ppm)	Th (ppm)	Pb (ppm)	Th/U	
MAG 1_D																										
MAG1_D_1	0.3788	0.015	0.0513	0.0015	0.3510	19.49318	0.5699759	0.054	0.0016	0.4674	322.5	9.4	326.2	12.9	371.0	11.0	322.0	9.3	323.8	8.2	1.12	621	375	38.5	0.60	
MAG1_D_2	0.392	0.013	0.0517	0.0016	0.1797	19.34236	0.598603	0.0548	0.0014	0.4376	325.0	10.1	335.8	11.1	404.1	10.3	324.2	9.9	330.6	7.4	3.24	423	228	28.6	0.54	
MAG1_D_3	0.37	0.014	0.05011	0.0015	0.2114	19.9561	0.5973687	0.0536	0.0017	0.2903	315.2	9.4	319.7	12.1	354.3	11.2	314.8	9.3	317.1	7.6	1.39	436	177	20.5	0.41	
MAG1_D_4	0.38	0.018	0.0505	0.0016	0.2945	19.80198	0.6273895	0.0541	0.0021	0.2396	317.6	10.1	327.0	15.5	375.2	14.6	317.1	9.9	320.4	8.9	2.89	151.7	171.1	19.9	1.13	
MAG1_D_5	0.381	0.015	0.0496	0.0016	0.4876	20.16129	0.6503642	0.0561	0.0018	0.0889	312.1	10.1	327.8	12.9	456.3	14.6	310.7	9.9	318.0	8.9	4.79	168	304	36.8	1.81	
MAG1_D_6	0.452	0.021	0.053	0.0016	0.3274	18.86792	0.5695977	0.0611	0.0024	0.3089	332.9	10.1	378.7	17.6	642.8	25.2	329.7	9.8			12.09	236	400	56.2	1.69	
MAG1_D_7	0.376	0.014	0.0505	0.0015	0.5819	19.80198	0.5881776	0.0544	0.0015	0.0132	317.6	9.4	324.1	12.1	387.6	10.7	316.9	9.3	319.9	8.6	2.01	474.7	190.7	23.2	0.40	
MAG1_D_8	0.695	0.022	0.0859	0.0025	0.3786	11.64144	0.338808	0.0588	0.0013	0.2664	531.2	15.5	535.8	17.0	559.7	12.4	530.8	15.1	533.9	11.6	0.85	310	26	5.9	0.08	
MAG1_D_9	0.389	0.018	0.0522	0.0016	0.0010	19.15709	0.5871904	0.0542	0.0025	0.5491	328.0	10.1	333.6	15.4	379.4	17.5	327.5	9.9	330.0	7.9	1.69	95.8	64.9	9.19	0.68	
MAG1_D_10	0.432	0.044	0.0506	0.0016	0.1944	19.76285	0.6249121	0.0613	0.0051	0.3679	318.2	10.1	364.6	37.1	648.8	54.1	314.9	10.0	319.8	9.8	12.72	212	110.2	19.6	0.52	
MAG1_D_11	0.398	0.28	0.0506	0.017	0.1961	19.76285	6.639691	0.0578	0.0065	0.4876	318.2	106.9	340.2	239.3	522.2	58.7	316.2	104.6	321.5	99.5	6.46	637	141	25.3	0.22	
MAG1_D_12	0.386	0.014	0.05226	0.0016	0.3904	19.13509	0.5858428	0.0539	0.0016	0.2878	328.4	10.1	331.4	12.0	366.9	10.9	328.0	9.9	329.8	8.1	0.92	349	67.2	10.5	0.19	
MAG1_D_13	0.357	0.017	0.04708	0.0014	0.4891	21.24044	0.6316189	0.0551	0.0021	-0.2096	296.6	8.8	310.0	14.8	416.3	15.9	295.5	8.7	298.6	8.4	4.32	182.7	60.6	9.98	0.33	
MAG1_D_14	0.368	0.025	0.04942	0.0014	0.5364	20.23472	0.5732216	0.0536	0.0032	0.0234	311.0	8.8	318.2	21.6	354.3	21.2	310.6	8.8	310.6	8.6	2.27	293	103	18.6	0.35	
MAG1_D_15	0.389	0.021	0.0529	0.0017	0.1975	18.90359	0.6074878	0.053	0.0025	0.2613	332.3	10.7	333.6	18.0	328.8	15.5	332.3	10.6	332.7	9.3	0.40	88.8	30	5.03	0.34	
MAG1_D_16	0.3182	0.013	0.0315	0.0011	0.5691	31.74603	1.108592	0.073	0.002	0.4070	199.9	7.0	280.5	11.5	1014.0	27.8	194.3	6.7			28.73	579	129.4	12.94	0.22	
MAG1_D_17	0.417	0.015	0.05411	0.0016	0.2663	18.48087	0.5464682	0.0557	0.0017	0.2854	339.7	10.0	353.9	12.7	440.4	13.4	338.7	9.9	345.8	8.2	4.01	403	171	30.8	0.42	
MAG1_D_18	0.429	0.028	0.05252	0.0016	0.0010	19.04037	0.5800568	0.0592	0.0035	0.4479	330.0	10.1	362.5	23.7	574.5	34.0	327.5	9.9	336.1	8.8	8.96	114.3	46.6	9.18	0.41	
MAG1_D_19	0.3655	0.013	0.0504	0.0015	0.1401	19.84127	0.590514	0.0527	0.0017	0.4394	317.0	9.4	316.3	11.3	315.9	10.2	317.0	9.3	316.7	7.1	-0.21	314	57.1	10.1	0.18	
MAG1_D_20	0.388	0.014	0.052	0.0016	0.3472	19.23077	0.591716	0.0539	0.0014	0.4226	326.8	10.1	332.9	12.0	366.9	9.5	326.4	9.9	329.6	8.2	1.84	405	157.9	30.7	0.39	
MAG1_D_21	0.4226	0.014	0.05242	0.0015	0.2971	19.07669	0.5458801	0.0581	0.0014	0.2701	329.4	9.4	357.9	11.9	533.5	12.9	327.3	9.2			7.98	543	161	30.9	0.30	
MAG1_D_22	0.371	0.016	0.0509	0.0015	0.2179	19.64637	0.5789695	0.0531	0.0017	0.2296	320.0	9.4	320.4	13.8	333.1	10.7	319.9	9.3	320.2	8.0	0.11	486	28.1	5.72	0.06	
MAG1_D_23	0.37	0.016	0.04997	0.0016	0.3130	20.01201	0.6407687	0.0538	0.0015	0.2628	314.3	10.1	319.7	13.8	362.7	10.1	313.9	9.9	316.3	8.6	1.66	599	86.3	16.65	0.14	
MAG1_D_24	13.72	0.39	0.5114	0.015	0.5768	1.955417	0.05735481	0.1947	0.0032	0.4419	2662.6	78.1	2730.6	77.6	2782.3	45.7	2617.1	85.4	2737.0	26.3	2.49	214	58.8	107.1	0.27	
MAG1_D_25	0.402	0.017	0.0527	0.0018	0.2844	18.97533	0.6481138	0.0553	0.0019	0.3906	331.1	11.3	343.1	14.5	424.4	14.6	330.2	11.1	336.1	9.3	3.50	99	51.1	10	0.52	
MAG1_D_26	0.384	0.015	0.05266	0.0016	0.4776	18.98975	0.5769767	0.053	0.0016	0.0483	330.8	10.1	330.0	12.9	328.8	9.9	339.9	9.9	330.5	8.9	-0.26	434.4	363.8	86.9	0.84	
MAG1_D_27	0.371	0.014	0.0518	0.0016	0.4219	19.30502	0.596294	0.0519	0.0015	0.1479	325.6	10.1	320.4	12.1	281.0	8.1	326.0	9.9	323.2	8.5	-1.61	335.9	214.9	42.3	0.64	
MAG1_D_28	0.385	0.013	0.0512	0.0015	0.4463	19.53125	0.5722046	0.055	0.0014	0.1967	321.9	9.4	330.7	11.2	412.2	10.5	321.0	9.3	326.0	8.0	2.67	447	55.3	10.5	0.12	
MAG1_D_29	0.374	0.024	0.0509	0.0018	0.0138	19.64637	0.6947634	0.0538	0.0034	0.4085	320.0	11.3	322.6	2												

MAG2_D_11	0.381	0.017	0.0516	0.002	0.4737	19.37984	0.7511568	0.0537	0.0013	0.2329	324.3	12.6	327.8	14.6	358.5	8.7	324.0	12.4	326.0	10.6	1.0	722	707	90.6	0.98
MAG2_D_12	0.387	0.018	0.0522	0.0022	0.5464	19.15709	0.8073989	0.0541	0.0015	0.3589	328.0	13.8	332.2	15.5	375.2	10.4	327.6	13.6	330.2	11.7	1.3	621	554	72.3	0.89
MAG2_D_13	0.383	0.086	0.0511	0.0017	0.2377	19.56947	0.6510392	0.0538	0.0096	0.3827	321.3	10.7	329.2	73.9	362.7	64.7	320.9	11.2	321.2	10.4	2.4	440	29.8	1.87	0.07
MAG2_D_14	0.435	0.016	0.0574	0.002	0.4559	17.4216	0.6070245	0.0549	0.0012	0.3008	359.8	12.5	366.7	13.5	408.2	8.9	359.3	12.3	363.7	10.0	1.9	342.8	72.1	16.6	0.21
MAG2_D_15	0.385	0.27	0.0511	0.022	0.5588	19.56947	8.425213	0.055	0.0041	0.2473	321.3	138.3	330.7	231.9	412.2	30.7	324.0	135.8	322.3	133.6	2.9	347	241	38.3	0.69
MAG2_D_16	0.386	0.019	0.05141	0.0016	0.2301	19.45147	0.6053754	0.0551	0.0026	0.1554	323.2	10.1	331.4	16.3	416.3	19.6	322.3	9.9	325.5	8.8	2.5	100.2	51.7	8.86	0.52
MAG2_D_17	0.373	0.014	0.05202	0.0016	0.3503	0.5912611	0.052	0.0016	0.2646	326.9	10.1	321.9	12.1	285.4	8.8	327.3	9.9	324.6	8.3	-1.6	276	73.8	12.53	0.27	
MAG2_D_18	0.319	0.016	0.0532	0.0014	0.6465	28.40909	1.129907	0.0661	0.0018	0.2218	223.0	8.9	281.1	14.1	809.5	22.0	218.7	8.6			20.7	1001	764	45.6	0.78
MAG2_D_19	0.755	0.028	0.0927	0.0028	0.3962	10.78749	0.3258356	0.059	0.0017	0.2127	571.5	17.3	571.1	21.2	567.1	16.3	571.6	16.9	571.3	13.7	-0.1	189.3	77.5	21	0.41
MAG2_D_20	0.393	0.015	0.0527	0.0018	0.3800	18.97533	0.6481138	0.0542	0.0015	0.2556	331.1	11.3	336.6	12.8	379.4	10.5	330.6	11.1	333.8	9.1	1.6	172	127.8	19.1	0.74
MAG2_D_21	0.409	0.019	0.05142	0.0016	0.0010	19.44769	0.60514	0.0578	0.0026	0.4243	323.2	10.1	348.2	16.2	522.2	23.5	321.3	9.9	331.5	8.0	7.2	109.1	131.9	20.4	1.21
MAG2_D_22	0.373	0.015	0.0519	0.0017	0.2926	19.26782	0.6311233	0.0526	0.002	0.3939	326.2	10.7	321.9	12.9	311.6	11.8	326.3	10.5	324.2	8.6	-1.3	162	123	17.8	0.76
MAG2_D_23	0.37	0.023	0.05145	0.0018	0.2199	19.43635	0.6799888	0.0527	0.0023	0.3559	323.4	11.3	319.7	19.9	315.9	13.8	323.5	11.2	322.5	10.1	-1.2	255	187.1	27.7	0.73
MAG2_D_24	0.377	0.013	0.05134	0.0015	0.3431	19.47799	0.5690881	0.0532	0.0014	0.2196	322.7	9.4	324.8	11.2	337.3	8.9	322.6	9.3	323.7	7.7	0.6	472	334	50.5	0.71
MAG2_D_25	0.372	0.017	0.05037	0.0016	0.1813	19.85309	0.6306321	0.0536	0.002	0.4267	316.8	10.1	321.1	14.7	354.3	13.2	316.5	9.9	318.3	8.4	1.4	169.7	151	21.5	0.89
MAG2_D_26	0.479	0.019	0.05381	0.0016	0.4807	18.58391	0.5525785	0.0642	0.0018	0.0530	337.9	10.0	397.4	15.8	748.2	21.0	333.3	9.8			15.0	218.1	230	41.2	1.05
MAG2_D_27	0.3733	0.028	0.0509	0.0016	0.3072	19.64637	0.6175675	0.0534	0.0029	0.3525	320.0	10.1	322.1	22.4	345.8	18.8	319.8	10.0	320.3	9.6	0.6	951	185.9	26.3	0.22
MAG2_D_28	0.866	0.031	0.1038	0.0031	0.4654	9.633911	0.297718	0.0604	0.0016	0.1593	636.6	19.0	633.4	22.7	617.9	16.4	637.0	18.5	634.8	14.9	-0.5	201	401	112.6	2.00
MAG2_D_29	0.378	0.014	0.05055	0.0015	0.1010	19.78239	0.5870146	0.0541	0.0017	0.4786	317.9	9.4	325.6	12.1	375.2	11.8	317.4	9.3	321.2	7.2	2.4	315	199.8	28.4	0.63
MAG2_D_30	0.376	0.017	0.05116	0.0016	0.2187	19.54652	0.6113064	0.0533	0.0022	0.2316	321.6	10.1	324.1	14.7	341.6	14.1	321.5	9.9	322.5	8.5	0.8	153	197	27.1	1.29
MAG2_D_31	0.365	0.017	0.0505	0.0017	0.4943	19.80198	0.6666013	0.0524	0.002	-0.0001	317.6	10.7	315.9	14.7	302.9	11.6	317.7	10.6	317.1	9.7	-0.5	153	181	26.2	1.18
MAG2_D_32	0.374	0.014	0.05138	0.0015	0.0790	19.46283	0.5862024	0.0529	0.0017	0.3821	323.0	9.4	322.6	12.1	324.5	10.4	323.0	9.3	322.8	7.1	-0.1	323	217	31.1	0.67
MAG2_D_33	0.3686	0.011	0.05077	0.0015	0.5989	19.69667	0.5819383	0.05279	0.001	0.1749	319.2	9.4	318.6	9.5	319.8	6.1	319.2	9.3	318.8	7.7	-0.2	991	445	57.8	0.46
MAG2_D_34	0.3624	0.46	0.0501	0.064	0.6581	19.96008	25.49791	0.053	0.0027	0.3998	315.1	402.6	314.0	398.6	328.8	16.8	315.0	396.2	314.3	329.7	-0.4	1230	364	47.2	0.30
MAG2_D_35	0.378	0.022	0.0528	0.0022	0.2959	18.93939	0.7891414	0.0519	0.0018	0.2464	331.7	13.8	325.6	18.9	281.0	9.7	332.2	13.6	329.4	11.7	-1.9	218	174	23.5	0.80
MAG2_D_36	0.373	0.014	0.051	0.0016	0.4854	19.60784	0.615148	0.0529	0.0016	0.2592	320.7	10.1	321.9	12.1	324.5	9.8	320.6	9.9	321.2	8.7	0.4	382	480	64.8	1.26
MAG2_D_37	0.384	0.061	0.0526	0.0017	0.5139	19.01141	0.6144371	0.0533	0.0085	-0.0851	320.5	10.7	330.0	52.4	341.6	54.5	330.4	11.1	330.5	9.9	-0.1	185	209	27.5	1.13
MAG2_D_38	0.863	0.029	0.1022	0.0029	0.2593	9.784736	0.2776491	0.0611	0.002	0.6498	637.3	17.8	631.8	21.2	642.8	21.0	627.0	17.4	629.7	13.0	0.7	274	133.4	41.4	0.49
MAG2_D_39	0.383	0.018	0.0522	0.0017	0.2997	19.15709	0.6238988	0.0532	0.0022	0.1937	328.0	10.7	329.2	15.5	337.3	13.9	327.9	10.5	328.4	9.3	0.4	130.2	170.8	24.2	1.31
MAG2_D_40	0.3681	0.012	0.05073	0.0015	0.2958	19.7122	0.5828564	0.0526	0.0014	0.3467	319.0	9.4	318.2	10.4	311.6	8.3	319.1	9.3	318.6	7.3	-0.2	544.7	196.7	27.6	0.36
MAG2_D_41	0.378	0.017	0.0453	0.0016	0.3904	22.07506	0.7796929	0.0605	0.0023	0.1489	285.6	10.1	325.6	14.6	621.5	23.6	282.6	9.9			12.3	133	142	20.8	1.07
MAG2_D_42	0.378	0.015	0.05238	0.0015	0.2347	19.09126	0.5467141	0.0524	0.0018	0.1901	329.1	9.4	325.6	12.9	302.9	10.4	329.4	9.3	327.8	7.8	-1.1	240	209	29.4	0.87
MAG2_D_43	0.38	0.017	0.0506	0.0015	0.0180	19.76285	0.5858551	0.0551	0.0021	0.3844	318.2	9.4	327.0	14.6	416.3	15.9	317.3	9.3	321.3	7.5	2.7	201.3	106.6	17.2	0.53
MAG2_D_44	0.387	0.013	0.05248	0.0016	0.4266	19.05488	0.5809414	0.0529	0.0012	0.2269	329.7	10.1	332.2	11.2	324.5	7.4	329.8	9.9	331.0	8.2	0.7	355	124	21.1	0.35
MAG2_D_45	0.39	0.19	0.0517	0.01	0.0143	19.34236	3.741269	0.055	0.013	0.6963	325.0	62.9	334.4	162.9	412.2	97.4	324.1	61.9	326.4	56.4	2.8	119	71	11.6	0.60
MAG2_D_46	1.095	0.1	0.0456	0.0018	0.7089	21.92982	0.865651	0.172	0.012	-0.4311	287.5	11.3	750.9	68.6	257.2	179.8	244.9	10.5			61.7	1420	780	274	0.55
MAG2_D_47	0.3775	0.013	0.0513	0.0016	0.3966	19.49318	0.6079743	0.0537	0.0015	0.3272	322.5	10.1	325.2	11.2	358.5	10.0	322.2	9.9	323.9	8.1	0.8	352	178.7	29.5	0.51
MAG2_D_48	0.395	0.1	0.0513	0.0021	0.1017	19.49318	0.7979663	0.0554	0.0096	0.5460	322.5	13.2	338.0	85.6	428.4	74.2	321.5	13.5	322.7	12.8	4.6	469	343	57.4	0.73
MAG2_D_49	0.569	0.02	0.0749	0.0022	0.3520	19.33113	0.3921562	0.0551	0.0015	0.1311	465.6	13.7	457.4	16.1	416.3	11.3	466.3	13.4	461.3	10.7	-1.8	259	40.3	9.5	0.16
MAG2_D_50	0.3793	0.013	0.05176	0.0015	0.2453	19.31994	0.559989	0.0531	0.0015	0.3350	325.3	9.4	326.5	11.2	333.1	9.4	325.2	9.3	325.9	7.4	0.4	389	298	43.6	0.77
MAG2_D_51	1.382	0.084	0.1071	0.0044	0.7722	9.337068	0.3835957	0.0934	0.0038	0.0655	655.9	26.9	881.3	53.6	1496.0	60.9	631.0	25.4			25.6	281	45.2	25.1	0.16
MAG2_D_52	0.399	0.016	0.0524	0.0017	0.0231	19.08397	0.6191364	0.0557	0.002	0.4583	329.2	10.7	340.9	13.7	440.4	15.8	328.5	10.5	334.4	7.9	3.4	162	163	24.2	1.01
MAG2_D_53	6.05	0.23	0.3559	0.013	0.7535	2.809778	1.0126331	0.1237	0.0024	0.2422	1962.7	71.7	1983.1	75.4	2010.3	39.0	1955.5	70.9	1988.0	31.3	1.0	180.7	163.1	142.1	0.90
MAG2_D_54	0.383	0.014	0.052	0.0015	0.0829	19.23077	0.5547337	0.0534	0.0017	0.3327	326.8	9.4	329.2	12.0	345.8	11.0	326.6	9.3	327.9	7.1	0.7	262	172.6	23.3	0.66
MAG2_D_55	0.638	0.03	0.0564	0.0019	0.0395	17.7305	0.597304	0.0829	0.0038	0.7427	353.7	11.9	501.1	23.6	1266.9	58.1	341.0	11.4			29.4	319	288	58.8	0.90
MAG2_D_56	0.378	0.016	0.05102	0.0015	0.5790	19.60016	0.5762492	0.0535	0.002	0.0581	320.8	9.4	325.6	13.8	350.1	13.1	320.5	9.3	321.8	8.9	1.5	469	383	52	0.82
MAG2_D_57	0.375	0.013	0.05207	0.0016	0.1747	19.20492	0.5901261	0.0525	0.0015	0.3419	327.2	10.1	323.4	11.2	307.2	8.8	327.4	9.9	325.2	7.4	-1.2	427	382	51.4	0.89
MAG2_D_																									

MAG3_D_16	0.401	0.12	0.0495	0.0026	0.5943	20.20202	1.061116	0.0592	0.0082	-0.2714	311.5	16.4	342.4	102.5	574.5	79.6	308.9	16.3	308.6	14.2	9.0	507	602	96	1.19
MAG3_D_17	0.3721	0.012	0.05152	0.0016	0.1448	19.40994	0.6027931	0.0525	0.0016	0.5480	323.8	10.1	321.2	10.4	307.2	9.4	324.0	9.9	322.37334	7.03705414	-0.8	415.3	63.3	11	0.15
MAG3_D_18	0.827	0.04	0.0502	0.002	0.3589	19.92032	0.7936382	0.1189	0.0037	0.6974	315.7	12.6	611.9	29.6	1959.8	60.4	290.1	11.5			48.4	582	409	93	0.70
MAG3_D_19	0.3812	0.052	0.0528	0.0055	0.6167	18.93939	1.972854	0.0527	0.0016	0.4398	331.7	34.6	327.9	44.7	315.9	9.6	331.8	34.0	330.4	31.9	-1.1	848	855	135.8	1.01
MAG3_D_20	0.383	0.015	0.05289	0.0016	0.2851	18.90717	0.5719695	0.053	0.0018	0.3286	332.2	10.1	329.2	12.9	328.8	11.2	332.3	9.9	331.0	8.3	-0.9	359	135	21.6	0.38
MAG3_D_21	0.423	0.021	0.0533	0.0016	0.0544	18.76173	0.5632038	0.0571	0.0025	0.5411	334.7	10.0	358.2	17.8	495.4	21.7	333.1	9.9	341.4	8.4	6.5	382	172	31.3	0.45
MAG3_D_22	0.377	0.027	0.051	0.0016	0.4456	19.60784	0.615148	0.054	0.003	0.3328	320.7	10.1	324.8	23.3	371.0	20.6	320.2	10.0	320.8	9.8	1.3	175.2	241.1	36.4	1.38
MAG3_D_23	0.374	0.019	0.0508	0.0017	0.1035	19.68504	0.6587513	0.0532	0.0026	0.3075	319.4	10.7	322.6	16.4	337.3	16.5	319.3	10.6	320.5	8.8	1.0	110.6	107.8	16.6	0.97
MAG3_D_24	0.423	0.022	0.0523	0.0017	0.4539	19.12046	0.6215063	0.0599	0.0025	0.0213	328.6	10.7	358.2	18.6	600.0	25.0	325.9	10.5			8.3	336	255	42.7	0.78
MAG3_D_25	0.46	0.016	0.0531	0.0017	0.3266	18.83239	0.6029203	0.063	0.0019	0.5230	333.5	10.7	384.3	13.4	708.2	21.4	329.5	10.4			13.2	322	279	43.1	0.87
MAG3_D_26	0.368	0.012	0.0524	0.0016	0.3831	19.08397	0.5827166	0.0515	0.0017	0.1889	329.2	10.1	318.2	10.4	263.3	8.7	329.8	9.9	322.810241	7.72387672	-3.5	163.9	71.4	11.24	0.44
MAG3_D_27	1.061	0.034	0.1186	0.0035	0.4420	8.431703	0.2488277	0.0649	0.0015	0.3856	722.5	21.3	734.3	23.5	771.1	17.8	721.2	20.7	730.282957	15.4051508	1.6	364	209	65.1	0.57
MAG3_D_28	0.378	0.016	0.0524	0.0018	0.3929	19.08397	0.6555562	0.0528	0.0019	0.3927	329.2	11.3	325.6	13.8	320.2	11.5	329.3	11.2	327.6	9.5	-1.1	257	183.8	25.2	0.72
MAG3_D_29	0.389	0.016	0.0526	0.0017	0.4223	19.01141	0.6144371	0.0536	0.0017	0.1923	330.5	10.7	333.6	13.7	354.3	11.2	330.2	10.5	331.7	9.3	1.0	263	183	25.9	0.70
MAG3_D_30	0.379	0.14	0.0513	0.0027	0.2982	19.49318	1.0295957	0.0537	0.013	0.1897	322.5	17.0	326.3	120.5	358.5	96.8	322.2	17.5	322.4	16.4	1.2	109.6	111.6	16.3	1.02
MAG3_D_31	0.382	0.021	0.0539	0.0021	0.4192	18.55288	0.7228393	0.0508	0.0016	0.1687	338.4	13.2	328.5	18.1	231.8	7.3	339.4	13.0	334.946241	11.6688843	-3.0	411	24.9	5.1	0.06
MAG3_D_32	0.609	0.028	0.078	0.0025	0.0841	12.82051	0.4109139	0.0567	0.0022	0.6209	484.2	15.5	482.9	22.2	479.9	18.6	484.2	15.2	483.7	11.9	-0.3	308.8	207.3	41.1	0.67
MAG3_D_33	0.372	0.013	0.0519	0.0016	0.3752	19.26782	0.5939984	0.0517	0.0015	0.2835	326.2	10.1	321.1	11.2	272.2	7.9	326.7	9.9	323.6	8.0	-1.6	384	545	73.6	1.42
MAG3_D_34	0.473	0.032	0.0496	0.0018	0.5179	20.16129	0.7316597	0.0699	0.0027	0.2762	312.1	11.3	393.3	26.6	925.4	35.7	305.4	11.0			20.6	1134	273	42.8	0.24
MAG3_D_35	0.399	0.014	0.0536	0.0016	0.2311	18.65672	0.5569169	0.0535	0.0012	0.3749	336.6	10.0	340.9	12.0	350.1	7.9	336.5	9.9	338.6	7.8	1.3	393	199	28.2	0.51
MAG3_D_36	6.24	0.2	0.3646	0.011	0.7291	2.742732	0.08274835	0.1238	0.0021	0.2511	2003.9	60.5	2010.1	64.4	2011.7	34.1	2002.7	60.3	2011.3	27.0	0.3	78.2	70.1	59.9	0.90
MAG3_D_37	5.73	0.44	0.346	0.024	0.7912	2.890173	0.2004745	0.1212	0.0032	0.2365	1915.5	132.9	1935.9	148.7	1974.0	52.1	1907.0	130.7	1941.9	62.3	1.1	98.1	118.5	96.3	1.21
MAG3_D_38	0.392	0.019	0.0535	0.0017	0.0449	18.69159	0.5939383	0.0535	0.0025	0.5498	336.0	10.7	335.8	16.3	350.1	16.4	335.8	10.0	335.9	8.5	0.0	338	460	60	1.38
MAG3_D_39	1.139	0.033	0.1269	0.0039	0.6806	7.880221	0.2421817	0.0653	0.0012	0.4573	770.2	23.7	772.0	22.4	784.0	14.4	769.8	22.9	772.0	15.7	0.2	389	296	94.6	0.78
MAG3_D_40	0.751	0.022	0.0915	0.0027	0.3369	10.92896	0.322494	0.0597	0.0014	0.4730	564.4	16.7	568.8	16.7	592.7	13.9	563.9	16.3	567.318019	11.4568214	0.8	222.9	150.4	34.0	0.67
MAG3_D_41	0.371	0.025	0.0492	0.0018	0.1945	20.3252	0.743605	0.0545	0.0034	0.1331	309.6	11.3	320.4	21.6	391.8	24.4	308.9	11.2	311.9	10.2	3.4	46.6	77.5	9.91	1.66
MAG3_D_42	0.372	0.024	0.0512	0.0018	0.3442	19.53125	0.6866455	0.0526	0.0031	0.0905	321.9	11.3	321.1	20.7	311.6	18.4	322.0	11.2	321.749673	10.5854131	-0.2	52.5	68.9	10.61	1.31
MAG3_D_43	0.377	0.18	0.0525	0.0023	0.1888	19.04762	0.8344671	0.0525	0.0089	0.2665	329.9	14.5	324.8	155.1	307.2	52.1	330.1	14.7	329.897159	14.0380967	-1.5	107.7	72	11.9	0.67
MAG3_D_44	0.456	0.018	0.05323	0.0016	0.0459	18.7864	0.564686	0.0619	0.0022	0.4651	334.3	10.0	381.5	15.1	670.7	23.8	330.7	9.8			12.4	244	182	30.5	0.75
MAG3_D_45	0.371	0.019	0.0517	0.0017	0.3174	19.34236	0.6360157	0.052	0.0022	0.0966	325.0	10.7	320.4	16.4	285.4	12.1	325.3	10.6	323.6	9.5	-1.4	161.3	173.1	26.1	1.07
MAG3_D_46	0.395	0.021	0.0523	0.0017	0.1998	19.12046	0.6215063	0.055	0.0026	0.2397	328.6	10.7	338.0	18.0	412.2	19.5	327.8	10.5	331.183515	9.36093756	2.8	83.6	89.2	12.5	1.07
MAG3_D_47	0.393	0.018	0.0531	0.0018	0.5258	18.83239	0.6383662	0.0531	0.0017	0.0357	333.5	11.3	336.6	15.4	333.1	10.7	333.5	11.1	334.5	10.3	0.9	165	209	29.5	1.27
MAG3_D_48	0.375	0.015	0.05249	0.0016	0.2876	19.05125	0.5807201	0.0517	0.0017	0.1555	329.8	10.1	323.4	12.9	272.2	8.9	330.3	9.9	327.105783	8.3052893	-2.0	233.9	137	19.9	0.59
MAG3_D_49	0.423	0.061	0.0508	0.0019	0.0010	19.68504	0.7362515	0.0611	0.0062	0.6710	319.4	11.9	358.2	51.7	642.8	65.2	316.2	11.9	321.9	11.3	10.8	238.6	334	48.8	1.40
MAG3_D_50	0.3857	0.014	0.05292	0.0016	0.2082	18.89645	0.5713212	0.0531	0.0016	0.5046	332.4	10.1	331.2	12.0	333.1	10.0	332.4	9.9	331.9	7.8	-0.4	363	160.6	23.3	0.44
MAG3_D_51	0.39	0.093	0.0545	0.0018	0.2321	18.34862	0.6060096	0.0522	0.011	0.5307	342.1	11.3	334.4	79.7	294.2	62.0	342.6	12.0	342.2	11.0	-2.3	357	473	66.8	1.32
MAG3_D_52	0.3972	0.014	0.05412	0.0017	0.2292	18.47746	0.5804079	0.0532	0.0015	0.4886	339.8	10.7	339.6	12.0	337.3	9.5	339.8	10.5	339.688885	8.06133532	0.0	477	127.3	18.85	0.27
MAG3_D_53	0.377	0.018	0.051	0.0017	0.4371	19.60784	0.6535948	0.0534	0.002	0.1183	320.7	10.7	324.8	15.5	345.8	13.0	320.4	10.5	321.9	9.7	1.3	155.3	203	27.7	1.31
MAG3_D_54	1.123	0.038	0.1243	0.0041	0.5552	8.045052	0.2653638	0.0659	0.0017	0.3174	755.3	24.9	764.4	25.9	803.2	20.7	753.9	24.2	762.3	17.6	1.2	165.3	66.7	21.5	0.40
MAG3_D_55	0.515	0.017	0.0666	0.0022	0.6178	15.01502	0.4959915	0.0562	0.0013	0.3636	415.6	13.7	421.8	13.9	460.3	10.6	415.1	13.5	419.9	10.9	1.5	564	273	50.7	0.48
MAG3_D_56	0.573	0.034	0.0728	0.0022	0.54891	13.73626	0.4151069	0.0575	0.0026	0.25304	453.002759	13.69	459.95	27.29	510.76	23.10	452.19	13.45	453.30	13.20	1.5	851	153.6	21.8	0.18
MAG3_D_57	0.737	0.024	0.0899	0.0028	0.39977	11.12347	0.3464485	0.0591	0.0015	0.37882	554.945682	17.28	560.65	18.26	570.78	14.49	554.66	16.88	558.56	12.62	10	361	258	60.4	0.71
MAG3_D_58	0.3813	0.013	0.05241	0.0016	0.19697	19.08033	0.5824943	0.0527	0.0015	0.43213	329.300707	10.05	327.99	11.18	315.90	8.99	329.43	9.91	328.63	7.48	-0.4	453	271	38	0.60
MAG3_D_59	0.367	0.014	0.0468	0.0021	0.34494	21.36752	0.958799	0.0578	0.0021	0.63633	328.845394	13.23	317.43	12.11	522.19	18.97	292.82	12.97			7.1	313	321	31.2	1.03
MAG3_D_60	0.3787	0.012	0.05145	0.0015	0.47146	19.43635	0.5665793	0.05302	0.0011	0.257125	323.417656	9.43	326.08	10.33	329.65	6.84	323.36	9.29	324.85	7.73	0.8	852	800	99	0.94
MAG3_D_61	0.381	0.013	0.0528	0.0016	0.46666	18.93939	0.5739291	0.0524	0.0012	0.25114	331.689164	10.05	327.77	11.18	302.90	6.94	331.96	9.91	329.63	8.28	-1.2	631	309.5	38.4	0.49
MAG3_D_62																									

APPENDIX
Table 3
Selected trace elements [in ppm] and LA-ICP-MS U-Pb isotopic data of apatites from the

	Final U238/Pb206_mean	Final U238/Pb206_2SE(prop)	Final Pb207/Pb206_mean	Final Pb207/Pb206_2SE(prop)	rho 207Pb/206Pb v 238U/206Pb	Final Pb206/U238 age_mean	2s	Final Pb207/U235 age_mean	2s	6-38/7-35 %	Approx_U_PPM mean	Approx_U_PPM 2SE(int)	Approx_Th_PPM mean	Approx_Th_PPM 2 SE(int)	Approx Pb_PP M_mean	Approx Pb_PPM 2 SE(int)	Mn55 (ppm)	Sr88 (ppm)	Y89 (ppm)	La139 ppm mean	Ce140 ppm mean	Pr141 ppm mean	Nd146 ppm mean	Sm147 pp m_mean	Eu153 ppm mean	Gd157 ppm mean	Tb159 ppm mean	Dy163 ppm mean	Ho165 ppm mean	Er166 ppm mean	Tm169 ppm mean	Yb172 ppm mean	Lu175 ppm mean	Total REE	CeN/YbN	Eu/Eu*
MAG 1																																				
yellow to yellowish luminescing grains																																				
MAG1-1	7.59794525	0.288053454	0.562573979	0.014637423	0.080293025	799.2506118	19.2495679	2454.239361	29.52819526	67.43	16.7	0.8	26.5	1.2	12.4	0.6	655.2	120.7	4383.7	393.6	1355.8	217.1	1209.9	451.5	7.3	623.7	109.9	686.0	139.8	373.0	46.1	269.2	33.6	5916.6	1.3	0.0
MAG1-2	5.180894454	0.213577826	0.638608512	0.017839005	0.234511877	1140.522893	33.2255171	2907.61062	39.17120357	60.77	9.2	0.3	14.1	0.6	10.7	0.6	611.6	121.3	3177.8	305.4	1025.8	166.4	938.4	345.9	5.8	481.7	81.3	526.1	106.4	280.3	34.8	205.4	25.2	4528.8	1.3	0.0
MAG1-3	3.45632936	0.22844123	0.71705419	0.018886298	0.01509954	1639.689477	86.6225591	3420.89833	62.94575325	52.07	5.3	0.2	3.1	0.3	10.1	0.5	358.2	217.0	583.0	146.3	528.7	97.8	558.7	158.8	5.9	160.1	21.7	118.0	22.0	53.7	6.4	35.5	4.6	1918.2	3.9	0.1
MAG1-5	13.25218751	0.469337815	0.382152766	0.008940721	0.208011098	470.5773866	7.50301775	1630.797946	23.86858641	71.14	43.5	1.5	1280.7	98.6	15.7	1.0	871.9	372.1	1299.3	576.8	2250.6	359.7	1763.4	470.7	70.8	452.0	64.2	297.5	46.7	98.4	10.2	54.0	6.3	6521.3	56.8	6.7
MAG1-6	6.89886655	0.257162034	0.564267601	0.014856805	0.506739284	873.93943	19.6536655	2556.593964	25.53856031	65.82	12.5	0.5	64.2	14.6	10.1	0.6	588.5	259.8	1053.1	313.8	1074.4	168.1	917.8	316.7	31.1	320.5	41.0	201.4	35.3	82.3	9.1	47.3	6.0	3564.8	27.9	9.0
MAG1-7	6.237427929	0.372203322	0.601777904	0.013109696	-0.223879842	975.6712153	38.392363	2699.734581	59.06552906	63.86	11.9	1.0	30.2	2.7	11.6	0.7	476.0	159.0	1030.7	403.6	1363.6	206.5	1079.1	277.1	12.4	256.8	34.4	188.7	36.1	91.6	11.2	68.6	9.4	4039.1	22.0	12.4
MAG1-8	10.39643746	0.595429892	0.509744771	0.018979301	0.040643812	592.8171796	23.6208698	2106.388332	57.9799356	71.86	17.3	1.1	1168.1	65.7	13.3	0.7	293.6	286.2	2787.6	336.7	1219.4	209.7	1157.2	369.0	59.3	456.5	74.7	444.6	88.0	237.1	29.4	176.3	25.1	4882.9	8.4	6.9
MAG1-10	10.18156336	0.372703715	0.455193634	0.015022386	0.426037051	606.4728062	11.6060205	2001.217154	22.95462198	69.69	24.9	1.0	24.7	8.7	9.4	0.7	1158.7	227.9	1051.8	192.5	799.2	149.6	836.7	271.9	7.2	285.8	42.1	220.8	36.5	81.9	9.2	52.5	6.4	2992.3	4.0	0.1
MAG1-11	5.042807829	0.270193697	0.605881462	0.0161604	-0.09123166	1176.458612	48.7040266	2937.071626	58.39356725	59.94	7.7	0.3	230.4	9.6	8.7	0.5	1026.5	222.2	1331.6	174.6	634.8	109.6	620.6	209.7	25.7	247.6	42.3	252.5	49.9	144.9	19.9	135.6	19.7	2687.1	1.2	0.3
MAG1-12	5.511470578	0.256534854	0.610635275	0.021793107	-0.011405461	1086.570737	36.4797763	2829.098335	37.32457998	61.59	6.8	0.3	18.0	0.9	8.4	0.7	610.9	802.4	76.7	143.8	325.2	41.2	175.7	31.1	5.9	25.5	2.8	13.9	2.7	7.0	0.9	5.9	1.0	782.5	14.5	0.6
MAG1-13	10.40729132	0.436522022	0.419936969	0.019464411	0.341758799	595.9741743	16.1410262	1913.398093	36.95324134	68.85	9.1	0.4	37.8	8.0	3.4	0.3	316.4	988.8	627.0	332.5	1103.2	169.5	883.8	207.6	9.4	203.8	25.5	131.3	22.1	52.8	5.9	32.0	3.7	3183.1	9.1	0.1
MAG1-14	7.959585319	0.343622381	0.568065657	0.022457979	0.64080223	766.117888	23.3136581	2431.61439	27.0586564	68.49	15.3	0.8	684.0	54.2	12.8	0.9	497.9	381.0	2050.7	517.9	2051.4	334.1	1760.5	503.0	48.2	511.6	74.5	397.5	71.3	172.1	18.5	99.0	12.3	6572.1	5.4	0.3
MAG1-15	10.60842264	0.531257825	0.452831138	0.011433483	0.519076243	581.0291835	19.4160357	1972.294491	33.73309043	70.54	19.7	0.7	107.7	9.3	7.4	0.5	421.6	181.7	3041.2	274.8	1028.5	182.1	1076.5	420.8	23.7	535.1	88.5	543.6	104.3	276.0	35.7	206.4	25.8	4821.7	1.3	0.2
MAG1-16	7.889427872	0.284746092	0.523307591	0.01390705	0.533288722	772.5470834	15.1817911	2346.834739	21.81672503	67.08	19.4	0.7	5.4	2.1	11.6	0.6	1423.5	293.7	1873.7	269.0	1028.5	181.6	987.2	345.2	11.8	359.9	54.8	329.2	64.8	178.0	24.1	157.3	21.2	4012.6	1.7	0.1
MAG1-17	9.881053831	0.355867711	0.449402489	0.008342534	0.409056123	621.0920301	8.52896072	2010.329237	18.40277676	69.10	38.6	1.2	2.8	0.2	15.3	0.8	1291.2	294.7	1239.7	235.6	1046.3	179.3	1001.1	343.2	7.9	364.0	55.2	276.4	42.5	78.9	6.7	28.1	2.6	3667.7	9.8	0.1
MAG1-18	4.504142376	0.18019252	0.644604927	0.017471438	0.475978388	1287.157968	28.5287441	3079.290574	25.02634133	58.20	6.4	0.2	3.9	0.2	8.5	0.6	584.8	160.2	1705.1	262.5	803.0	132.9	762.1	261.8	6.3	324.2	50.6	303.8	59.3	152.2	17.2	93.7	11.8	3242.2	2.3	0.1
MAG1-19	5.652894177	0.215843088	0.63412706	0.018724279	0.160391352	1050.218386	19.7846989	2834.626126	28.20156307	62.95	8.9	0.3	76.2	4.7	9.4	0.4	670.7	174.5	1898.6	330.7	1076.6	168.8	934.1	290.2	10.3	377.8	57.4	339.5	66.3	165.7	19.4	104.0	13.2	3954.0	2.7	0.1
MAG1-21	12.41230107	0.40383842	0.33034773	0.006303842	0.284986457	499.927928	5.51215964	1563.273997	13.73388594	68.02	85.5	1.9	0.8	0.1	18.8	0.9	2490.5	412.3	1350.8	100.3	502.5	103.8	665.6	244.9	15.6	249.5	38.9	231.3	43.1	119.3	17.7	118.8	15.2	2466.5	1.1	0.2
MAG1-22	14.06059568	0.502132725	0.26823778	0.003907628	0.282170897	442.4323015	6.09245907	1305.225349	13.2687166	66.10	144.5	4.4	1.5	0.1	21.7	1.0	3008.9	419.0	1454.1	130.4	613.2	123.3	742.3	269.5	16.5	275.2	41.2	249.0	46.2	129.7	18.9	127.7	16.5	2799.5	1.3	0.2
MAG1-23	15.40557457	0.514434994	0.213577216	0.003863452	0.346040858	406.0077715	5.5653226	1086.449917	10.68630851	62.63	20.2	6.7	3.0	0.2	20.0	1.1	2904.7	432.7	1530.2	136.9	6464															