He-anomalies in the Roer-to-Rhine area

At some locations in the Roer-to-Rhine area, mostly in the Eifel, He-concentrations or its isotopic composition ($^4He/^3He$) in spring or (shallow) ground-water are elevated. This is typically observed in regions of continental extension and magmatism. An elevated R/RA ratio furthermore indicates a contribution from the mantle to the He-budget (White, 2013).

See also

CO_2-seeps around the Laacher See

Anomalies

In the context of the Geoconnect^{3}d project, the He-signature is defined as anomalous when the gas component of water shows a higher He-content than the atmospheric standard (5.22 ppmv) or when the $^4He/^3He$ ratio (R) is higher compared to the atmospheric value of $1.4*10^{-6}$ (RA), i.e. R/RA > 1 (Davidson and Emerson, 1990). The He-concentrations of He-anomalous natural springs or shallow groundwater in the Roer-to-Rhine show a highly skewed distribution: 0.2 – 22500 ppmv, median of 31 ppmv, mean of 1984 ppmv (n = 23, detailed references in the table). The $^4He/^3He$-signature is less skewed, showing values between 0.10 and 5.61, a median of 3.00 and mean of 2.89 (n = 41; detailed references in the table).

The study of Bräuer et al. (2013) has demonstrated a clear correlation between R/RA-values and distance to the East Eifel degassing center. A low R/RA-ratio of 0.1 is observed in spring water in Bad Kreuznach, located far from the East Eifel. In contrast, the high R/RA-values (1.3 – 5.6) observed around the Laacher See are explained by their close proximity to the East Eifel degassing center, while the intermediate R/RA values (0.7 – 1.7) in the springs around Koblenz relate to their location just south of it (Bräuer et al., 2013). Furthermore, the He-signature of springs in Hetzerath-Salmtal in the southern West Eifel (Heckenmünster) is explained by its origin from the magmatic reservoir, possibly influenced by a small mantle plume (Bräuer et al., 2013). In addition, the He concentrations and R/RA values in gas sampled at mineral springs in the Neuwied Basin demonstrate the influence of preferential conduits with high permeability. Gases from the mantle or crust rise faster where two fault systems crosscut, e.g. at the Flocksmühle, or along more permeable fracture networks, e.g. at the Waldmühle Kärlich. Consequently, both elevated He-concentration and R/RA-ratios are observed in such cases (Berberich et al., 2019).

Most He-anomalies are observed in the Eifel area, in close spatial association to the occurrence of Quaternary volcanism in the West and East Eifel. However, the most western He-anomalies, in Spa (Walloon area) and the coal mines in Limburg (the Netherlands), are less evident to explain in that regard. Taking into account temperature, fluid geochemistry and juvenile gas content, Kimpe (1963) postulates a deep origin of these He-anomalous fluids in the Limburg area after being infiltrated in Paleozoic rock further southwards. Also their occurrence along large-scale NW-SE faults has been pointed out in the same study (Kimpe, 1963).

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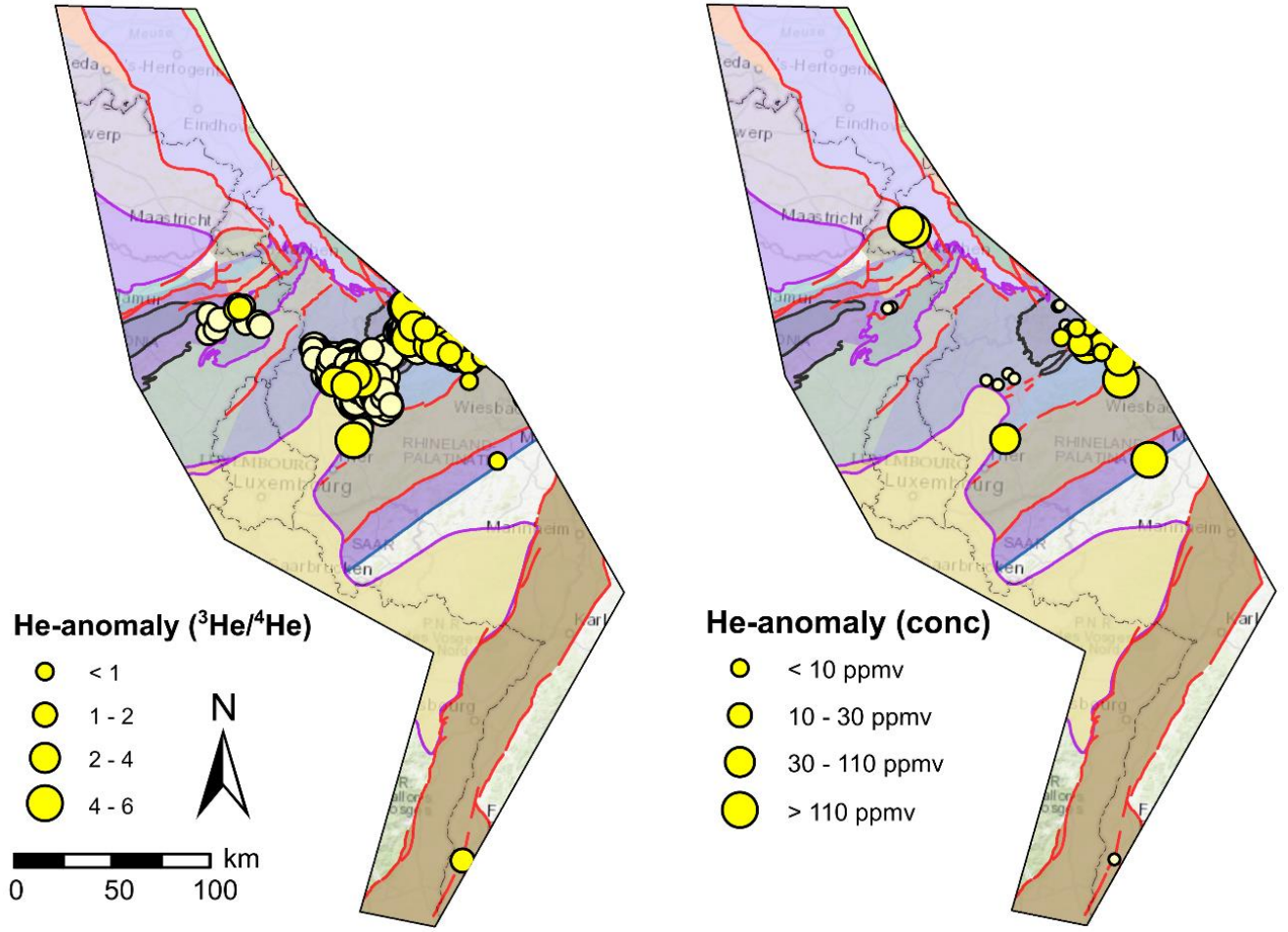

Figure 1: He-anomalies in the Roer-to-Rhine area

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Data

ID	Coordinates	T	Depth	TDS°	Cl	Na	SO_4	Free CO_2	He	$^3He/^4He$	Analysis year	References
		°C	m	g/l	mg/l	mg/l	mg/l	mg/l	ppmv			
Viktoriaquelle, Heckenmünster	49°53'59" North 06°47'16" East	10.9 – 12.3							32 – 37.8	4.19 – 4.46	2005 - 2010	Bräuer et al. (2013)
Schwefelquelle, Heckenmunster	49°53'54" North 06°47'12" East	11.2 – 14.2							30.2 – 37.8	4.21 – 4.49	2005 - 2010	Bräuer et al. (2013)
Wallenborn Sauerbronnen	50°09'19" North 06°42'57" East									3.00	1992	Griesshaber et al. (1992)
Adonisquelle, Birresborn	50°10'29" North 06°37'37" East									3.10	1992	Griesshaber et al. (1992)
Adelheid Mineralquelle, Daun	50°11'20" North 06°50'02" East									4.03	1992	Griesshaber et al. (1992)
Steinborner Drees, Daun	50°12'36" North 06°47'19" East									3.40	1992	Griesshaber et al. (1992)
Waldmühle Sauerbrunnen, Kärlich	50°22'12" North 07°28'39" East									2.83	1992	Griesshaber et al. (1992)
		10 – 15.4							6 – 11		2016	Berberich et al. (2017)
Alte Mineralquelle, Kobern-Gondorf	50°19'43" North 07°28'31" East									1.41	1992	Griesshaber et al. (1992)
		8.5 – 14.4							1 – 7.5		2016	Berberich et al. (2017)
Flocksmühle, Ochtendung	50°20'53" North 07°22'02" East									2.51	1992	Griesshaber et al. (1992)
		12.2 – 17.2							17.4 – 110.4		2016	Berberich et al. (2017)
Burg-Quelle, Plaidt	50°23'08" North 07°22'56" East	13			41	418	91	2340			<1992	Griesshaber et al. (1992)
										3.18	1992	
		13.4							70	3.3	2000	Bräuer et al. (2013)
Laacher See mofettes	50°24'46" North 07°16'14" East									5.4	1992	Griesshaber et al. (1992)
		2.2 – 20.5							15.6 – 28.7	5.08 – 5.61	2001 – 2010	Bräuer et al. (2013)

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Oberzissen Sauerbrunnen	50°27’07” North 07°11’56” East									3.81	1992	Griesshaber et al. (1992)
Römerbrunnen, Wassenach	50°26’27” North 07°17’05” East	9.9							0.2	1.3	2000	Bräuer et al. (2013)
Geyser Andernach (Namedy)	50°26’55” North 07°22’31” East	20			668	1218	188	1878			<1992	Griesshaber et al. (1992)
										3.61	1992	
		18.4							1.6	3.8	2004	Bräuer et al. (2013)
Rieden Sauerbrunnen	50°23’36” North 07°10’10” East	13			7	62	2	2310			<1992	Griesshaber et al. (1992)
										5.17	1992	
		8.1							0.2		1999	Bräuer et al. (2013)
Reginaris-Quelle, Mendig	50°21’57” North 07°18’55” East									0.68	1992	Griesshaber et al. (1992)
		16.6							10.5	3.8	2000	Bräuer et al. (2013)
Walburgisquelle (Ahr Thermen), Bad Neuenahr	50°32’29” North 07°08’27” East	38			37	251	36	1115			<1992	Griesshaber et al. (1992)
										4.4	1992	
Willibrordus Sprudel, Bad Neuenahr	50°32’27” North 07°08’10” East	23			21	68	25	1330			<1992	Griesshaber et al. (1992)
										4.55	1992	
Appolinarisquelle 10, Bad Neuenahr	50°32’45” North 07°09’09” East	42			78	473	63	1013			<1992	Griesshaber et al. (1992)
										4.21	1992	
Grafenwerth Quelle, Bad Honnef	50°38’32” North 07°12’53” East	19			978	142	276	1518			<1992	Griesshaber et al. (1992)
										2.60	1992	
Edelhoff Quelle, Bad Honnef	50°38’48” North 07°13’22” East	21			1280	1520	371	1428			<1992	Griesshaber et al. (1992)
										2.45	1992	
Drachenquelle, Bad Honnef	50°38’32” North 07°13’14” East	14			574	1155	194	2070			<1992	Griesshaber et al. (1992)
										2.32	1992	
Victoria-quellen, Lahnstein	50°17’34” North 07°36’48” East	29.8							41.3	1.7	2003	Bräuer et al. (2013)

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Leonorenquelle, Bad Salzig	50°12’04” North 07°37’32” East	17			1520	2170	1227	981			1988	Griesshaber et al. (1992)
										0.62	1992	
		18.4							1630	0.7	2003	Bräuer et al. (2013)
Bohrung Ia = Robert-Kampe Sprudel, Bad Ems	50°19’50” North 07°43’46” East	52							55.5	1.6	2003	Bräuer et al. (2013)
Bohrung III, Bad Ems	50°19’40” North 07°43’51” East	40			435	835	56	890			<1992	Griesshaber et al. (1992)
										1.55	1992	
Theodorshaller Brünnen, Bad Kreuznach	49°49’28” North 07°51’14” East	28.3							17200	0.1	2003	Bräuer et al. (2013)
Thermalquelle 4 [II], Bad Krozingen	47°55’04” North 07°41’22” East	37			154	348	1706	2230			<1992	Griesshaber et al. (1992)
										1.73	1992	
Schwalbenbrunnen, Bad Schwalbach	50°07’54” North 08°03’49” East									1.90	1992	Griesshaber et al. (1992)
Stahlbrunnen, Bad Schwalbach	50°08’24” North 08°03’55” East	10			15	61	35	2792			<1992	Griesshaber et al. (1992)
										2.10	1992	
Oranje-Nassau I shaft, Heerlen	50°53’36” North 05°58’06” East	19.5									1955	Kimpe (1963)
		50	250	45					1800		1960	
Wilhelmina mine shaft	50°52’18” North 06°01’24” East	38	670						22500		1963	Kimpe (1963)
Marie-Henriette spring, Spa	50°30’01” North 05°53’45” East									1.12	1992	Griesshaber et al. (1992)
Pierre le Grand spring, Spa	50°29’34” North 05°51’57” East	12			23	63	6	2882			<1992	Griesshaber et al. (1992)
										1.16	1992	
Prince de Condé spring, Spa	50°29’37” North 05°51’57” East									1.17	1992	Griesshaber et al. (1992)

° TDS = Total Dissolved Solids

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