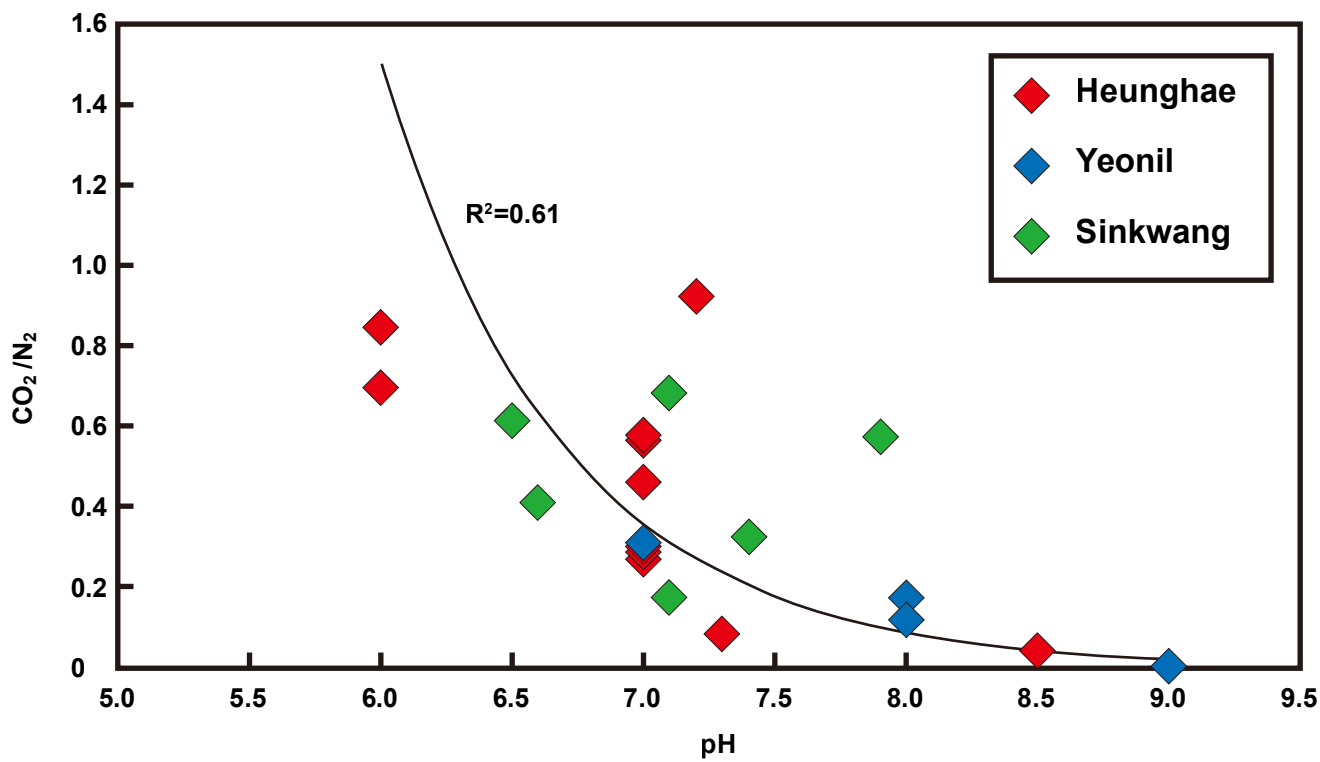
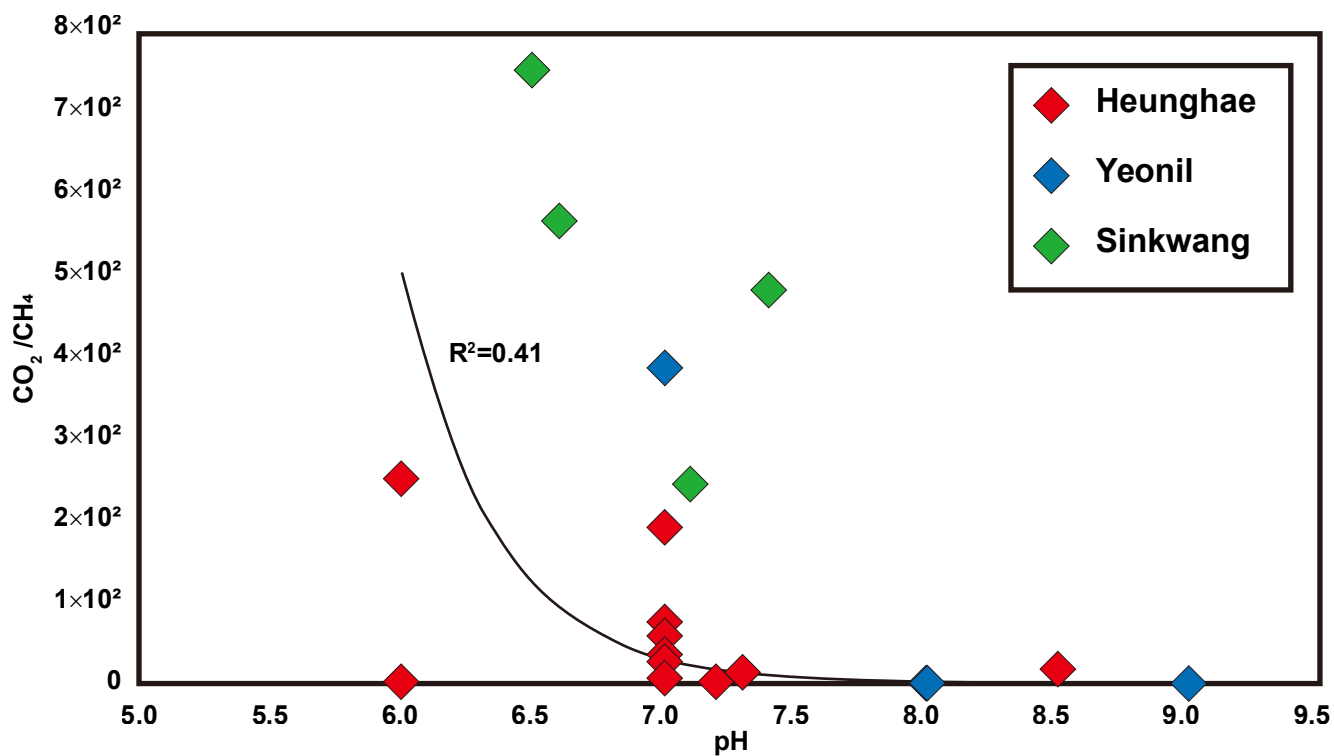


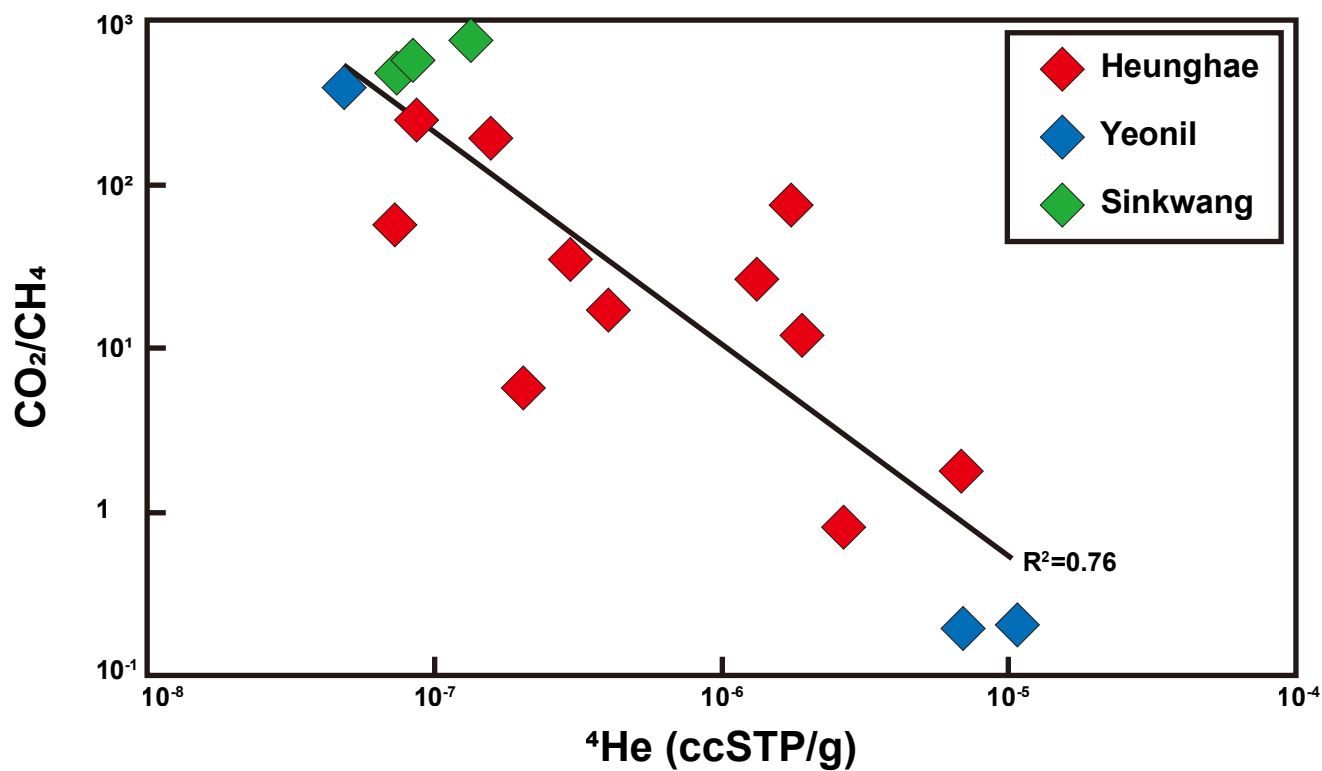
Figure S1: (a) Relative concentration of CO₂ and pH plot.



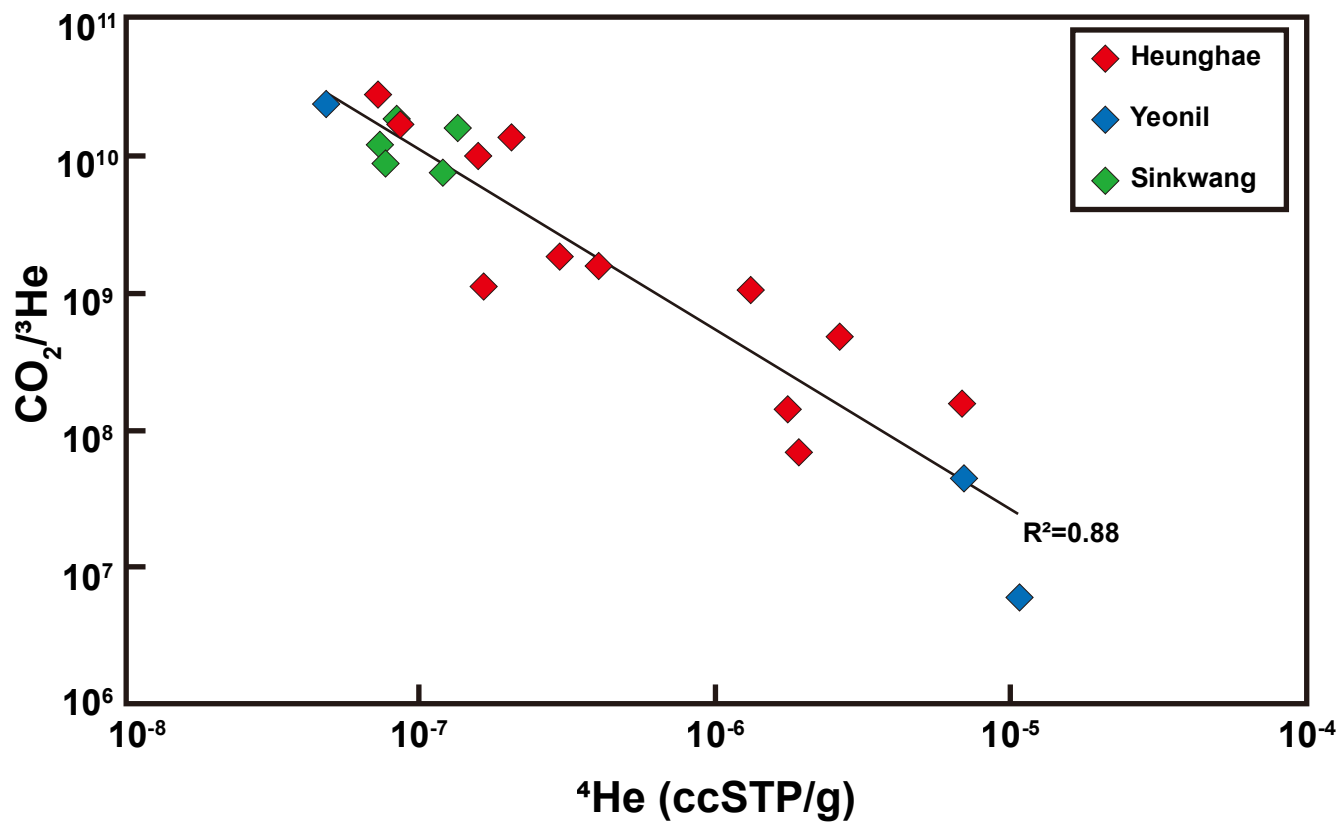
(b) CO₂/N₂ and pH plot.



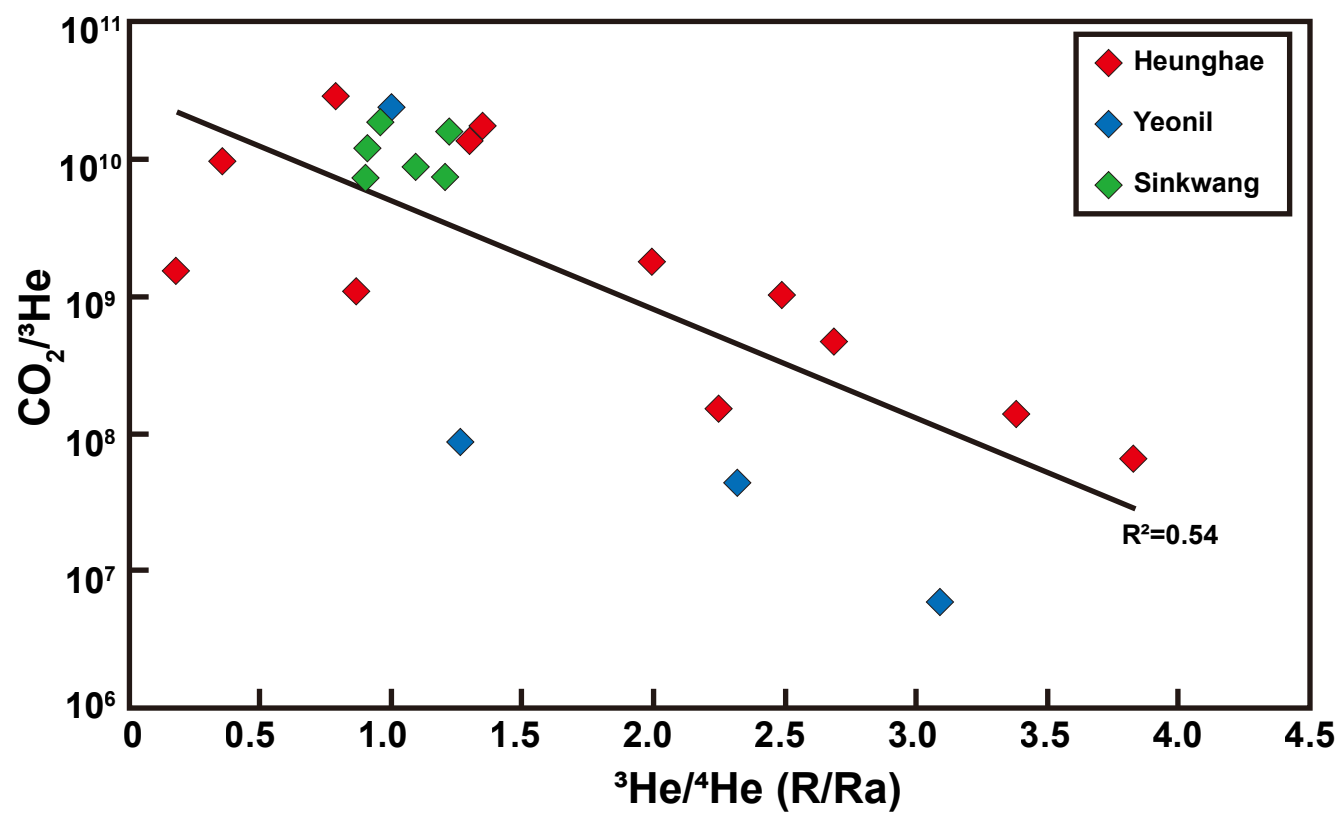
(c) CO_2/CH_4 and pH plot.



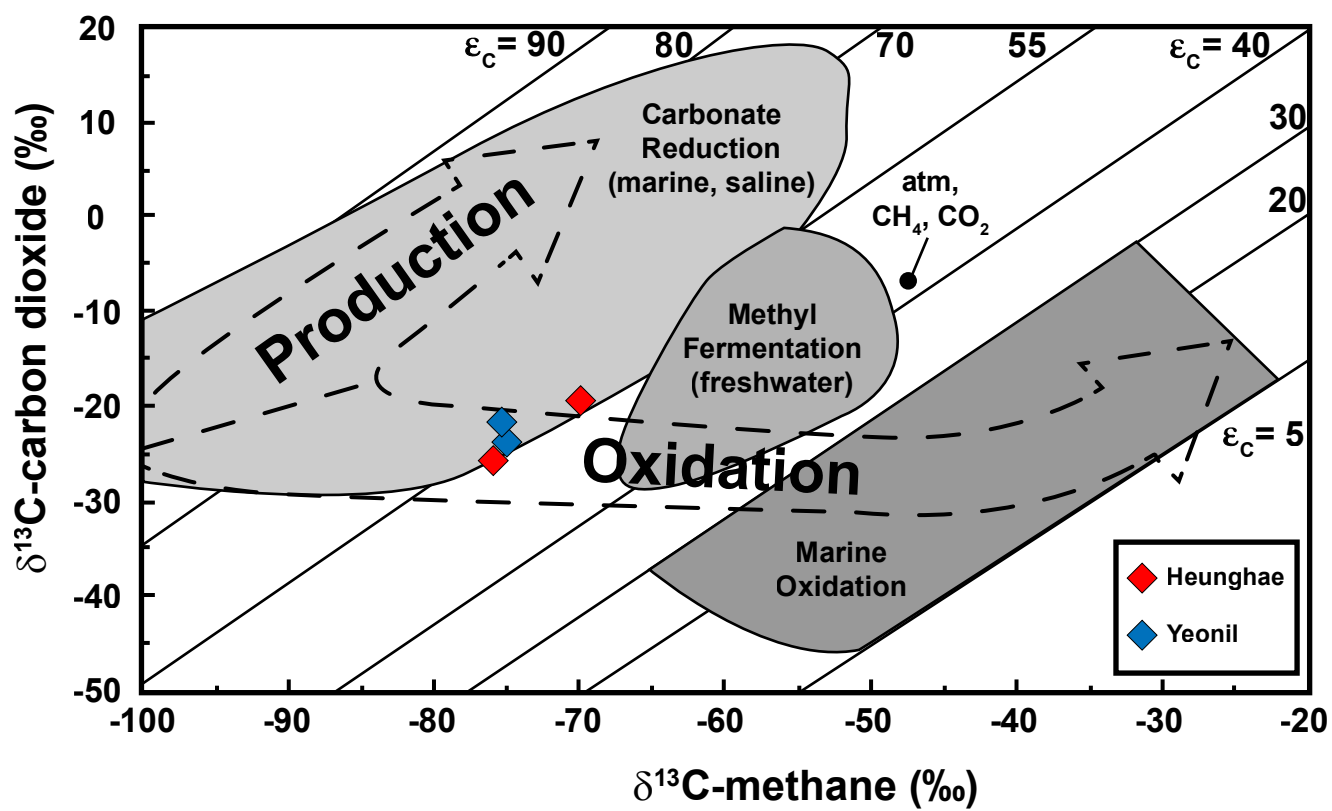
(d) CO_2/CH_4 and concentration of ^4He plot.



(e) $\text{CO}_2/^3\text{He}$ and concentration of ^4He plot.



(f) $\text{CO}_2/^3\text{He}$ and $^3\text{He}/^4\text{He}$ ratio plot.



(b) $\delta^{13}\text{C}$ of CO_2 and $\delta^{13}\text{C}$ of CH_4 plot (modified from Whiticar [34]).

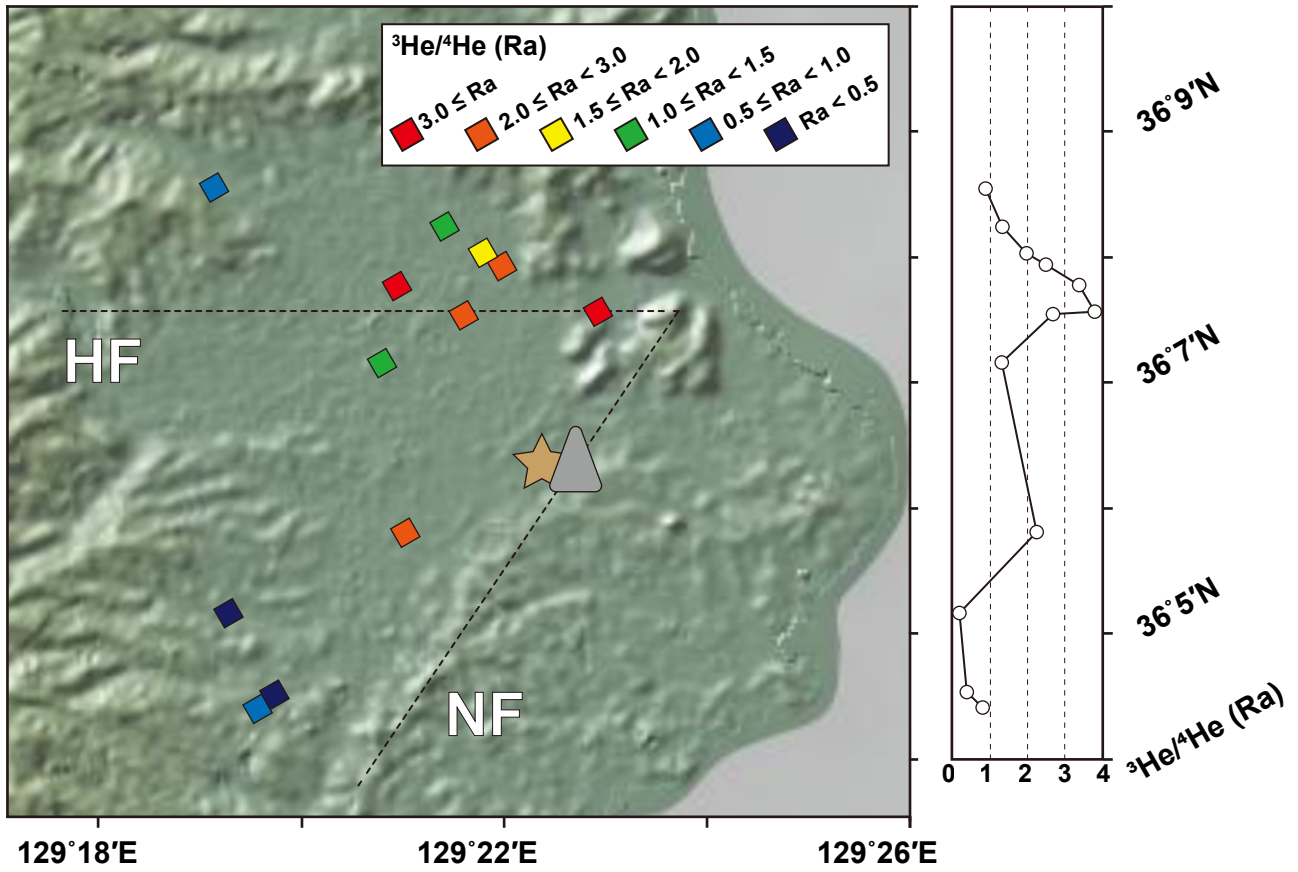


Figure S3: Helium samples from the Heunghae area (diamond symbol) and the helium isotope and latitude plot. Each symbol is colored by its helium isotope ratio ($^3\text{He}/^4\text{He}$). The locations of Heunghae (HF) and Namsong (NF) fault lines (dashed line) are described in Section 4.4. The gray triangle indicates the location of the EGS site, and the brown star indicates the location of the M_w 5.5 earthquake.

ID	Region	$\delta^{15}\text{N}$	$\text{N}_2/{}^3\text{He}$	fm	fs	fa
		N_2		MORB	Sediment	Air
P-11	Heunghae	2.15	6.7 E+10	0.0%	30.7%	69.3%
P-12		3.15	1.5 E+09	0.1%	45.0%	54.9%
P-14		3.16	9.6 E+08	0.1%	45.2%	54.7%
DS-1		2.43	3.6 E+09	0.0%	34.7%	65.2%
PH19-01		3.12	8.5 E+10	0.0%	44.6%	55.4%
PH19-03		2.62	3.9 E+10	0.0%	37.4%	62.6%
PH19-04		2.42	1.2 E+10	0.0%	34.6%	65.4%
PH19-05		0.96	3.3 E+09	0.0%	13.7%	86.2%
PH19-06		1.8	5.7 E+08	0.2%	25.8%	74.0%
PH19-10		1.78	9.2 E+10	0.0%	25.4%	74.6%
PH19-11		1.25	6.8 E+10	0.0%	17.9%	82.1%
PH19-12		1.57	4.1 E+08	0.2%	22.6%	77.2%
PH19-07	Yeonil	1.26	9.3 E+07	1.0%	18.7%	80.4%
PH19-08		0.19	4.7 E+08	0.2%	2.8%	97.0%
PH19-09		2.06	1.5 E+11	0.0%	29.4%	70.6%
PH-3		0.33	8.2 E+10	0.0%	4.7%	95.3%
P-2	Sinkwang	1.44	8.0 E+10	0.0%	20.6%	79.4%
P-3		3.56	7.0 E+10	0.0%	50.9%	49.1%
P-4		1.21	8.9 E+10	0.0%	17.3%	82.7%
P-5		3.07	2.4 E+10	0.0%	43.9%	56.1%
P-7		1.91	4.9 E+10	0.0%	27.3%	72.7%
Mantle	Endmembers	-5	8.9 E+05	100%	0%	0%
Sediment		7	1.4 E+12	0%	100%	0%
Air		0	1.1 E+11	0%	0%	100%

Table S1: $\delta^{15}\text{N}$, $\text{N}_2/{}^3\text{He}$, and the contribution of three nitrogen endmembers on the Pohang samples: the mantle, sediment, and the air. The $\delta^{15}\text{N}$ and $\text{N}_2/{}^3\text{He}$ of each endmember and the mixing model are described in Section 4.2.

Sample name	Rc/Ra	[He] _{F.m} (ccSTP g ⁻¹)	Helium flow rate (mm a ⁻¹)				³ He flux (atoms cm ⁻² sec ⁻¹)			
			Φ=0.01	Φ=0.05	Φ=0.1	Φ=0.2	Φ=0.01	Φ=0.05	Φ=0.1	Φ=0.2
P-12	3.92	9.34E-07	1279.9	1279.9	606.3	269.5	3.02 E+03	5.80 E+02	2.75 E+02	1.22 E+02
PH19-12	2.26	1.92E-06	253.7	253.7	120.2	53.4	1.28 E+03	2.44 E+02	1.16 E+02	5.15 E+01
PH19-07	3.09	4.11E-06	190.2	190.2	90.1	40	2.05 E+03	3.93 E+02	1.87 E+02	8.21 E+01

Table S2: The corrected Helium isotope ratio, the concentration of helium in original mantle fluid, the helium flow rate, and the ³He flux of each fault system.

Fault name	Sampling site	Distance	⁴ He	Corrected ³ He/ ⁴ He	³ He flux
		km	ccSTP/g	Ra	(atoms cm ⁻² sec ⁻¹)
Futagawa	Ajisai	-5.0	1.37 E-07	1.604	1.3E+03
	Mifune	-2.7	8.36 E-06	1.790	1.5E+03
	Otsu	2.2	1.60 E-05	4.184	5.6 E+03
	Kikuchi	23.0	1.10 E-05	1.215	9.1 E+02
	Ueki	25.1	1.08 E-05	1.627	1.3 E+03
	Tamana	30.8	1.88 E-06	0.584	4.0 E+02
	Hirayama	40.0	1.53 E-05	0.626	4.3 E+02
Heunghae	DS-1	-1.9	1.65 E-07	0.791	3.9 E+02
	PH19-03	-1.3	8.59 E-08	2.552	8.0 E+02
	PH19-04	-0.9	2.99 E-07	2.121	1.1 E+03
	PH19-05	-0.7	1.32 E-06	2.540	1.5 E+03
	PH19-06	-0.4	1.75 E-06	3.452	2.4 E+03
	P-12	0.0	1.91 E-06	3.922	3.0 E+03
	P-14	0.0	2.66 E-06	2.709	1.7 E+03
	PH19-01	0.8	2.04 E-07	1.384	6.4 E+02

Table S3: The ⁴He concentration, corrected ³He/⁴He ratio, and ³He flux of each sample and their distance from related faults, respectively. The data of the Futagawa fault is from Sano et al. [6].