Supporting materials

SAMPLE PREPARATION AND ANALYSES

Over 100 sites around the volcano on the Chinese side of the border areas have been described over decades of study. We recognized that the deposits of the Bingchang (BC) episode are exposed in Heishigou Valley (HSV) and Erdaobai Valley (EBV). We collected samples of BC-T at HSV and BC-P at EBV. All loose BC-T samples were thoroughly rinsed with deionized water in an ultrasonic bath for 30 min to remove surface contaminants, while the exposed surfaces of BC-P samples were cut off entirely. All samples were then dried in an oven for 24 hours. Each sample was divided to be prepared for thin sectioning, epoxy mounts for probe microanalysis, and age determination.

Geochemistry

15 polished thin-sections from BC-T and BC-P were prepared by Wagner Petrographic, USA. Major compositions of glass in both BC-T and BC-P were analyzed by Electron Probe Micro-analyzer (EPMA) using a Cameca SX-100 electron microprobe at Oregon State University (OSU), USA, with an accelerating voltage of 15 KV and an electron beam of 30 nA. A beam size of 5 μm was used for glass analysis.

Geochronology

Sanidine phenocrysts were separated at Rock Preparation Lab of OSU. Raw samples were gently and coarsely crushed with hammer to avoid damage to single large crystals, and then phenocrysts like feldspar and quartz were separated from crushed granules using 1.5 Amps magnetism with Frantz Isodynamic Separator. The non-magnetic phenocrysts were etched for 8 minutes in 15% hydrofluoric acid in an ultrasonic bath to remove melt inclusion and adhering glass. Magnetic separation and hydrofluoric acid etching were repeated progressively until the crystals became purity and free of visible impurities and melt inclusion. Next, the alkali feldspar was extracted from non-magnetic clean crystals using Heavy Liquid Separator in 2.582 g/cm^3. Then, the large sanidine crystals (>850 μm) were sieved for the single-crystal step-heating fuse. Finally, each piece of alkali feldspar was handpicked to remove the crystal remaining any impurities under a binocular microscope.

Prepared crystals were split into ~100 mg aliquots, wrapped in aluminum foil, and loaded into quartz tubes of 5 mm in diameter and ~10 cm in length. International standard Fish Canyon Tuff sanidine (FCT) with an age of 28.201 ± 0.023 Ma (Kuiper et al., 2008) was loaded within wells adjacent to the samples and throughout the entire stack to permit detailed characterization of the irradiation flux to the samples. They were then irradiated for 1 h at OSU TRIGA reactor in the Cadmium-Lined In-Core Irradiation Tube. Argon extraction for heating was performed using a 25 W Synrad CO_2 laser with industrial scan head at OSU Argon Geochronology Lab. The purified gas was analyzed on an ARGUS VI multi-collector mass spectrometer with five fixed Faraday detectors and one ion-counting CuBe electron multiplier mounted detector.

All resulting ages are calculated using the ArArCALC v2.7.2 software package (Koppers, 2002). Uncertainties reflect ± 2σ analytical contributions. In addition, the J values used in the age calculation were configured according to the position of sample aliquots in the quartz tube and TRIGA reactor. For each sample, we report $^{40}Ar/^{39}Ar$ dating results that show a relatively younger weighted plateau age with more released ^{39}Ar gas (>90%) and smaller MSWD value (than those presented in Table S2). To justify such criteria for the selection of the reported younger ages, we applied the same analytical protocol to date both the Millennium eruption (~1.1 ka or 946-947 CE; Xu et al., 2013) and Qixiangzhan eruption (~8.1 cal ^{14}C ka; Sun et al., 2018) of the CBS-TC volcano. The relatively younger plateau ages obtained for these two recent eruptions are 1.1 ± 0.8 ka and 8.2 ± 1.3 ka, respectively, in good agreement with their corresponding radiocarbon-dated eruption ages (Pan et al., 2020). This finding indicates that the younger end of the plateau ages derived for each sample most likely approximates the actual eruption age, and other relatively older ages might have been influenced by excess argon in the samples. The sources of excess argon will be discussed in a separate paper.

SUPPLEMENTARY FIGURES

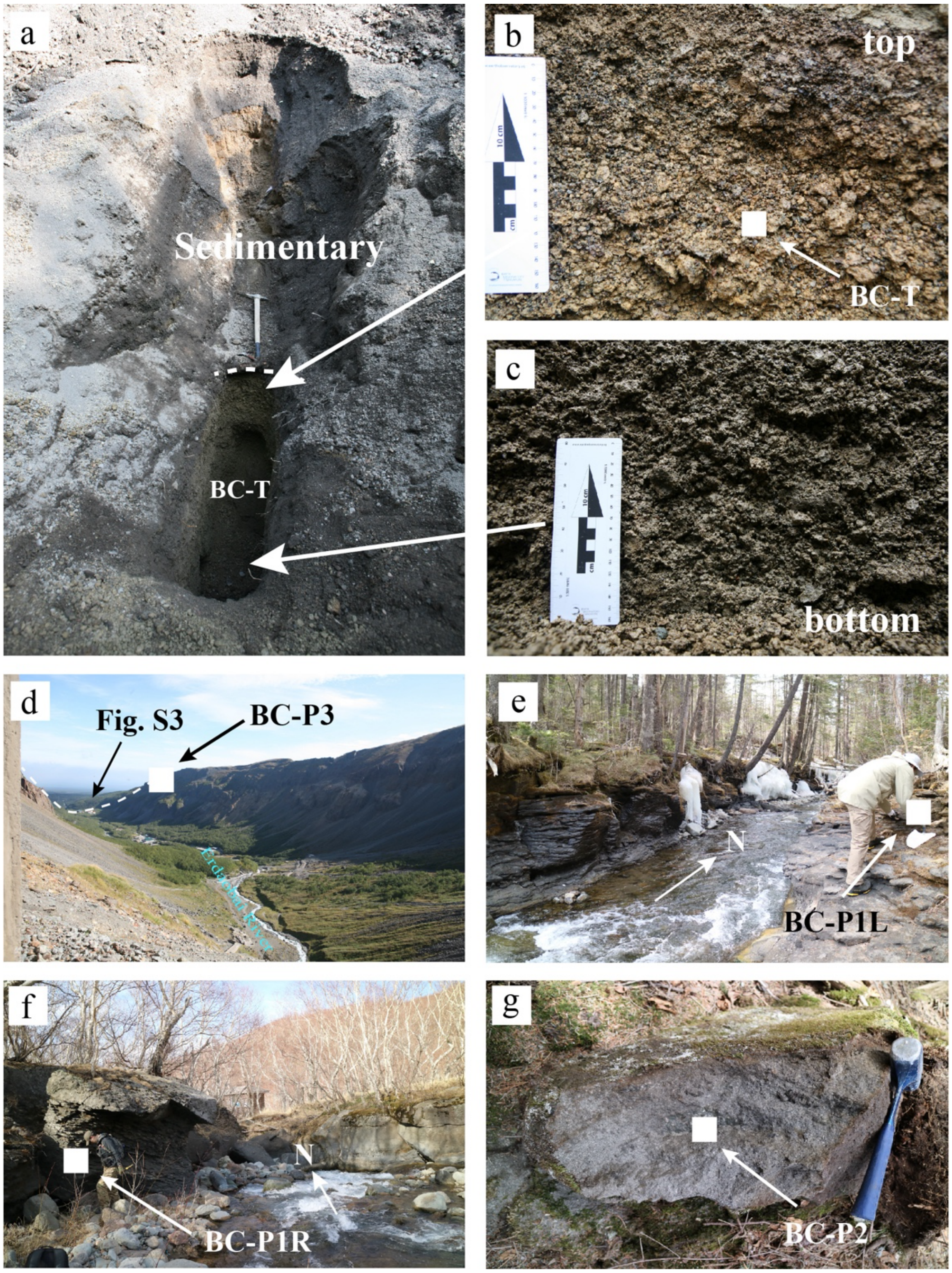

Figure S1. Field photos showing the BC tephra deposit (BC-T) in Heishi Valley (HSV) and BC pyroclastic deposit (BC-P) in the Erdaobai Valley (EBV). (a) A trench in HSV fully exposing the BC-T deposit. (b) Light-yellow tephra at the top section of the BC-T deposit. (c) Grey tephra at the bottom section of the BC-T depoist. (d) BC-P deposits in EBV viewed northward from the Tianchi water fall. (e) BC-P deposit along EBV at the coach transfer station. (f) BC-P deposit along EBV at the Xiaotianchi pond. (g) Close-up view of a rock sample (BC-P2).

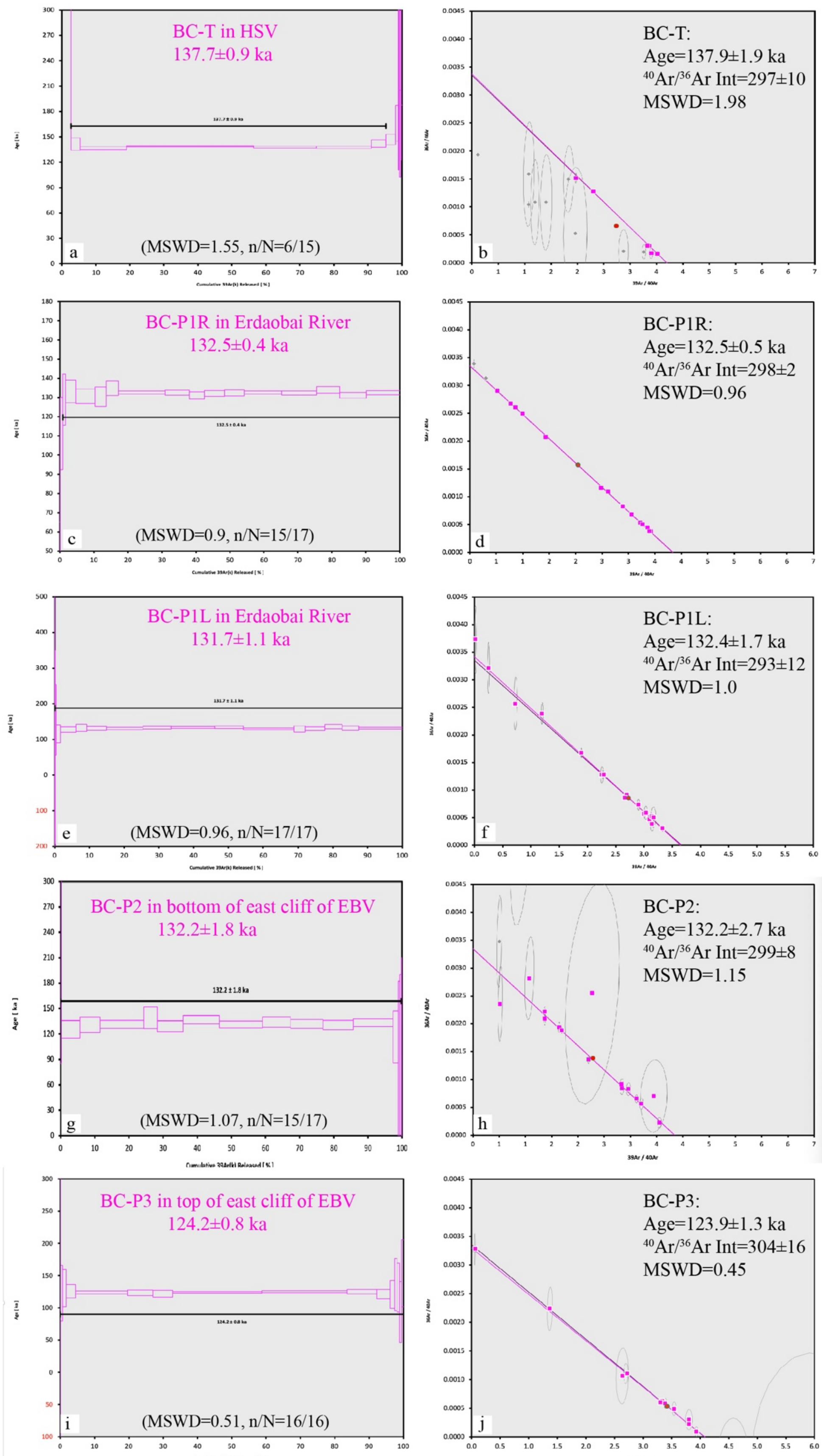
BC-T in HSV
137.7±0.9 ka
(MSWD=1.55, n/N=6/15)
a
BC-T:
Age=137.9±1.9 ka
40Ar/36Ar Int=297±10
MSWD=1.98
b
BC-P1R in Erdaobai River
132.5±0.4 ka
(MSWD=0.9, n/N=15/17)
c
BC-P1R:
Age=132.5±0.5 ka
40Ar/36Ar Int=298±2
MSWD=0.96
d
BC-P1L in Erdaobai River
131.7±1.1 ka
(MSWD=0.96, n/N=17/17)
e
BC-P1L:
Age=132.4±1.7 ka
40Ar/36Ar Int=293±12
MSWD=1.0
f
BC-P2 in bottom of east cliff of EBV
132.2±1.8 ka
(MSWD=1.07, n/N=15/17)
g
BC-P2:
Age=132.2±2.7 ka
40Ar/36Ar Int=299±8
MSWD=1.15
h
BC-P3 in top of east cliff of EBV
124.2±0.8 ka
(MSWD=0.51, n/N=16/16)
i
BC-P3:
Age=123.9±1.3 ka
40Ar/36Ar Int=304±16
MSWD=0.45
j

Figure S2. $^{40}Ar/^{39}Ar$ plateau age spectra and inverse isochron plots of the single-crystal incremental heating with 15-17 steps for 5 samples of the BC eruptions. Sample locations are given in Table 1 and Figures 1 and 3. All age data are reported with 2-sigma uncertainties. Purple steps are used in plateau age calculation while grey steps are not. Red dots denote total fusion ages for each sample. MSWD is mean square of weighted deviates, n is the number of heating steps used in plateau age calculation, and N is the total number of heating steps used in $^{40}Ar/^{39}Ar$ age measurements. (a, b) BC tephra in HSV, first deposited in the BC eruption episode and yielded the oldest plateau age (137.7 ± 0.9 ka) among 5 samples. (c, d) BC tuff, sampled on the right bank of EBV and produced during the middle session of the BC eruption episode. (e, f) BC tuff, sampled on the left bank of EBV and produced during the middle session of the BC eruption episode. (g, h) BC tuff, sampled at the bottom of east cliff along EBV. (i, j) BC tuff, sampled on the top of east cliff along EBV.

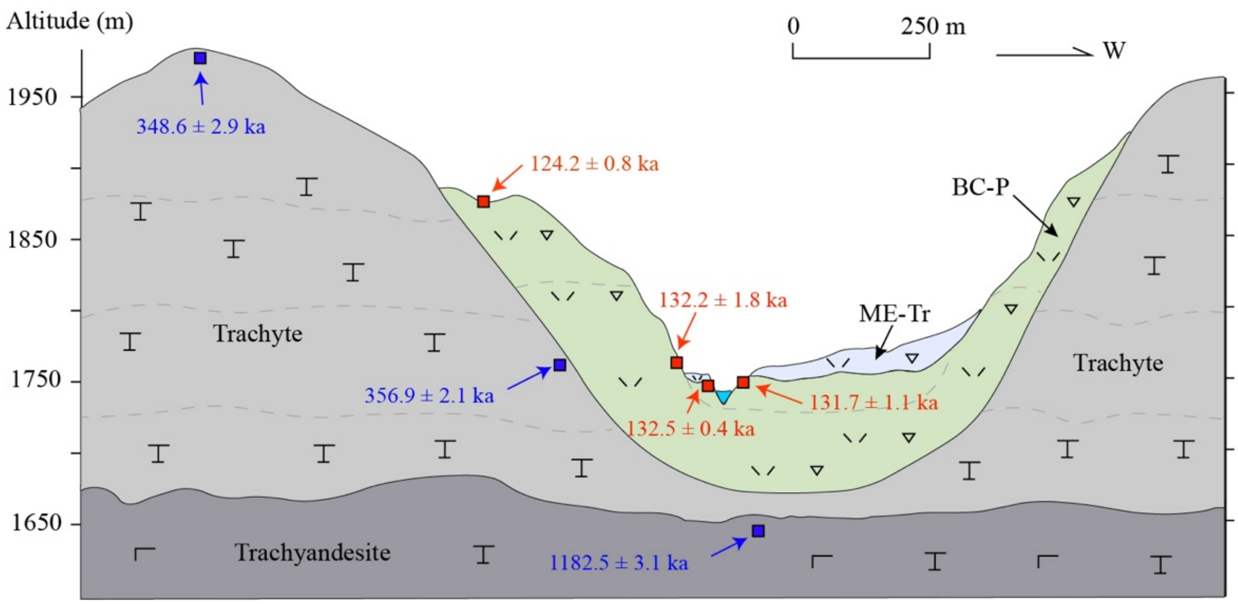

Figure S3. Cross-sectional distribution of volcanic deposits at EBV, showing BC pyroclastic flow sequences and relevant $^{40}Ar/^{39}Ar$ ages, along with ME-Tr deposits produced in 946-947 CE (Pan et al., 2020). The surrounding rock is trachyte emplaced during the cone-forming stage around 1.18-0.35 Ma.

References

Koppers, A. A. P. (2002). ArArCALC-software for $^{40}Ar/^{39}Ar$ age calculations. *Computers & Geosciences, 28*, 605-619.

Kuiper, K. F., Deino, A., Hilgen, F. J., Krijgsman, W., Renne, P. R., & Wijbrans, J. R. (2008). Synchronizing Rock Clocks of Earth History. *Science, 320,* 500-504.

Pan, B., de Silva, S. L., Xu, J. D., Liu, S. J., & Xu, D. (2020). Late Pleistocene to present day eruptive history of the Changbaishan-Tianchi Volcano, China/DPRK: New field, geochronological and chemical constraints. *Journal of Volcanology and Geothermal Research, 399,* L106870.

Sun, C. Q., Wang, L., Plunkett, G., You, H. T., Zhu, Z. Y., Zhang, L., et al. (2018). Ash from the Changbaishan Qixiangzhan Eruption: A new early Holocene marker horizon across East Asia. *Journal of Geophysical Research - Solid Earth, 123*, 6442-6450.

Xu, J. D., Pan, B., Liu, T. Z., Hajdas, I., Zhao, B., Yu, H. M., et al. (2013). Climatic impact of the Millennium eruption of Changbaishan volcano in China: new insights from high-precision radiocarbon wiggle-match dating. *Geophysical Research Letters, 40,* 54–59.

Table S1. GEOCHEMISTRY RESULTS (major elements by EPMA)

Deposit Unit	Sample	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
ME-Tr	LA-20	65.719	0.735	15.717	6.136	0.173	0.208	1.305	3.899	5.897
ME-Tr	LA-20	65.771	0.538	16.767	5.103	0.073	0.261	1.42	4.003	5.846
ME-Tr	LA-20	66.238	0.526	16.75	5.047	0.17	0.247	1.419	3.28	6.077
ME-Tr	LA-20	66.574	0.504	16.467	5.102	0.128	0.215	1.388	3.916	5.469
ME-Tr	LA-20	66.059	0.562	16.373	5.021	0.141	0.281	1.499	4.236	5.577
ME-Tr	17 thin_1	65.476	0.479	16.425	5.274	0.178	0.188	1.469	4.791	5.507
ME-Tr	17 thin_1	65.243	0.49	16.452	5.252	0.125	0.196	1.52	4.801	5.687
ME-Tr	17 thin_1	65.498	0.476	16.251	5.174	0.153	0.197	1.538	4.844	5.629
ME-Tr	17 thin_1	65.382	0.46	16.452	5.133	0.142	0.188	1.35	4.691	5.99
ME-Tr	17 thin_1	65.386	0.452	16.25	5.044	0.127	0.189	1.715	4.904	5.699
ME-Tr	17 thin_2	66.091	0.477	16.509	5.155	0.185	0.188	1.083	3.866	6.254
ME-Tr	17 thin_2	65.53	0.481	16.593	4.873	0.138	0.193	1.242	4.657	6.106
ME-Tr	17 thin_2	65.761	0.463	16.331	5.007	0.129	0.189	1.711	4.665	5.535
ME-Tr	17 thin_2	65.28	0.47	16.461	5.151	0.191	0.185	1.352	4.915	5.796
ME-Tr	17 thin_2	65.751	0.487	16.582	4.89	0.121	0.181	1.118	4.828	5.845
ME-Tr	LA-04_01	65.303	0.464	16.425	5.158	0.124	0.213	1.332	4.92	5.86
ME-Tr	LA-04_01	65.008	0.517	16.587	5.216	0.13	0.245	1.463	4.861	5.759
ME-Tr	LA-04_01	65.136	0.521	16.893	5.203	0.11	0.247	1.487	4.308	5.89
ME-Tr	LA-04_01	65.204	0.503	16.746	5.173	0.148	0.238	1.462	4.596	5.681
ME-Tr	LA-04_01	65.408	0.503	16.619	4.997	0.157	0.202	1.315	5.05	5.545
ME-Tr	LA-04_02	66.42	0.458	16.415	5.072	0.145	0.179	1.331	4.046	5.707
ME-Tr	LA-04_02	65.407	0.53	16.225	5.185	0.159	0.271	1.478	4.941	5.579
ME-Tr	LA-04_02	65.648	0.543	16.787	5.192	0.153	0.256	1.41	3.919	5.885
ME-Tr	LA-03	65.949	0.479	15.847	5.04	0.138	0.211	1.15	4.762	6.198
ME-Tr	LA-03	65.748	0.477	15.868	5.133	0.14	0.182	1.346	6.532	4.364
ME-Tr	LA-03	66.132	0.511	15.799	5.049	0.129	0.269	1.095	5.164	5.628
ME-Tr	LA-03	65.66	0.512	16.216	5.212	0.124	0.283	1.569	4.371	5.825
ME-Tr	LA-05	65.581	0.462	15.998	5.162	0.168	0.192	1.279	5.112	5.847
ME-Tr	LA-05	66.13	0.462	15.764	5.108	0.14	0.191	1.286	5.095	5.619
ME-Tr	LA-05	65.562	0.462	16.11	5.113	0.111	0.183	1.321	5.382	5.549
ME-Tr	LA-05	66.028	0.474	15.891	5.05	0.121	0.195	1.278	4.86	5.906
ME-Tr	LA-05	65.474	0.465	16.014	5.177	0.179	0.198	1.269	5.209	5.811
ME-Tr	LA-05	64.995	0.517	16.78	5.021	0.097	0.244	1.425	5.099	5.603
ME-com	LA-10	74.9	0.238	10.976	4.184	0.059	0.012	0.207	4.561	4.381
ME-com	LA-10	75.055	0.209	10.869	4.251	0.079	0.016	0.241	4.528	4.261
ME-com	LA-10	74.924	0.234	10.992	4.239	0.09	0.019	0.216	4.3	4.515

ME-com	**LA-10**	**75.182**	**0.227**	**10.81**	**4.286**	**0.097**	**0.025**	**0.231**	**4.223**	**4.44**
ME-com	**LA-10**	**74.593**	**0.221**	**11.009**	**4.307**	**0.036**	**0.018**	**0.228**	**4.759**	**4.344**
ME-com	**LA-10**	**75.133**	**0.245**	**10.959**	**4.251**	**0.112**	**0.012**	**0.216**	**4.232**	**4.366**
ME-com	**LA-10**	**75.011**	**0.235**	**10.868**	**4.178**	**0.09**	**0.017**	**0.207**	**4.596**	**4.314**
ME-com	**LA-10**	**74.902**	**0.215**	**11.078**	**4.248**	**0.055**	**0.012**	**0.223**	**4.355**	**4.416**
ME-com	**LA_19_sample**	**74.952**	**0.253**	**11.566**	**4.371**	**0.088**	**0.026**	**0.308**	**3.436**	**4.536**
ME-com	**LA_19_sample**	**74.898**	**0.263**	**11.539**	**4.38**	**0.072**	**0.027**	**0.313**	**3.304**	**4.663**
ME-com	**LA_19_sample**	**74.866**	**0.263**	**11.747**	**4.455**	**0.109**	**0.02**	**0.344**	**3.029**	**4.716**
ME-com	**LA_19_sample**	**75.616**	**0.222**	**11.347**	**4.275**	**0.064**	**0.016**	**0.261**	**3.311**	**4.405**
ME-com	**LA_19_sample**	**75.457**	**0.27**	**11.825**	**4.517**	**0.042**	**0.033**	**0.324**	**2.269**	**4.783**
ME-com	**LA_19_sample**	**75.953**	**0.257**	**11.607**	**4.312**	**0.097**	**0.016**	**0.303**	**2.279**	**4.712**
BKY-1	**BKY1**	**75.14**	**0.23**	**9.17**	**5.91**	**0.12**	**0**	**0.22**	**5.02**	**4.18**
BKY-1	**BKY2**	**75.08**	**0.15**	**9.39**	**6**	**0.11**	**0**	**0.21**	**4.83**	**4.24**
BKY-1	**BKY3**	**73.88**	**0.1**	**10.51**	**5.79**	**0.15**	**0**	**0.35**	**4.71**	**4.5**
BKY-1	**BKY4**	**72.41**	**0.03**	**11.86**	**5.48**	**0.13**	**0**	**0.48**	**5.21**	**4.4**
BKY-1	**BKY5**	**73.69**	**0.16**	**11.53**	**5.61**	**0.15**	**0**	**0.44**	**3.9**	**4.5**
BKY-1	**BKY6**	**70.6**	**0.15**	**13.28**	**5.2**	**0.15**	**0.02**	**0.62**	**5.38**	**4.6**
BKY-1	**BKY7**	**73.26**	**0.07**	**11.26**	**6.05**	**0.14**	**0**	**0.63**	**4.23**	**4.36**
BKY-1	**BKY8**	**74.96**	**0.22**	**9.24**	**5.81**	**0.13**	**0.04**	**0.24**	**5.06**	**4.29**
BKY-1	**BKY9**	**75.36**	**0.12**	**9.2**	**5.75**	**0.13**	**0**	**0.22**	**4.9**	**4.32**
BKY-1	**BKY10**	**67.53**	**0.22**	**15.15**	**5.3**	**0.16**	**0.09**	**1**	**5.34**	**5.21**
BKY-1	**BKY11**	**68.63**	**0.2**	**15.5**	**5.44**	**0.14**	**0.09**	**0.97**	**3.67**	**5.35**
BKY-1	**BKY12**	**68.47**	**0.27**	**15.06**	**5.37**	**0.19**	**0.05**	**0.89**	**4.37**	**5.32**
BKY-1	**BKY13**	**66.59**	**0.16**	**15.74**	**5.54**	**0.15**	**0.08**	**1.09**	**5.47**	**5.17**
BKY-1	**BKY14**	**67.68**	**0.22**	**15.76**	**5.45**	**0.13**	**0.12**	**1.06**	**4.3**	**5.29**
BKY-1	**BKYT**	**68.45**	**0.17**	**14.7**	**5.2**	**0.17**	**0.05**	**0.9**	**5.33**	**5.05**
BC-P2	**LYT1-01**	**67.38**	**0.02**	**15.92**	**3.47**	**0.01**	**0.00**	**0.00**	**5.89**	**7.32**
BC-P2	**LYT1-4**	**73.12**	**0.08**	**12.52**	**3.43**	**0.05**	**0.00**	**0.05**	**4.74**	**6.01**
BC-P2	**LYT1-5**	**75.57**	**0.03**	**12.14**	**2.55**	**0.00**	**0.00**	**0.00**	**4.23**	**5.48**
BC-P2	**LYT1-6**	**76.30**	**0.03**	**11.39**	**2.73**	**0.01**	**0.00**	**0.00**	**4.46**	**5.09**
BC-P2	**LYT1-7**	**78.20**	**0.07**	**10.59**	**2.35**	**0.03**	**0.00**	**0.02**	**3.82**	**4.93**
BC-P2	**LYT1-10**	**69.08**	**0.05**	**16.13**	**2.37**	**0.03**	**0.01**	**0.05**	**5.84**	**6.43**
BC-P2	**LYT1-12**	**73.53**	**0.03**	**12.96**	**2.60**	**0.00**	**0.00**	**0.02**	**4.96**	**5.90**
BC-P2	**LYT1-13**	**67.68**	**0.04**	**16.18**	**2.93**	**0.00**	**0.00**	**0.01**	**6.08**	**7.08**
BC-P2	**LYT1-16**	**68.73**	**0.03**	**15.54**	**2.93**	**0.02**	**0.00**	**0.00**	**5.70**	**7.05**
BC-P2	**LYT1-17**	**75.50**	**0.06**	**11.79**	**2.88**	**0.03**	**0.01**	**0.02**	**4.57**	**5.15**
BC-P2	**LYT1-18**	**74.91**	**0.02**	**12.00**	**2.64**	**0.04**	**0.00**	**0.00**	**5.13**	**5.27**
BC-P2	**LYT1-19**	**70.36**	**0.01**	**15.16**	**2.33**	**0.02**	**0.00**	**0.00**	**5.78**	**6.35**
BC-P2	**LYT1-21**	**74.48**	**0.03**	**12.41**	**2.70**	**0.01**	**0.00**	**0.00**	**4.86**	**5.51**

BC-P2	LYT1-23	75.92	0.04	11.38	2.81	0.04	0.00	0.02	4.42	5.38
BC-P2	LYT1-24	70.20	0.02	14.62	3.08	0.01	0.00	0.17	5.99	5.91
BC-P2	LYT1-25	68.52	0.35	14.31	4.72	0.12	0.11	0.89	6.74	4.25
BC-P2	LYT1-26	67.75	0.40	14.73	4.83	0.12	0.11	0.95	6.74	4.37
BC-P2	LYT1-27	72.98	0.20	12.02	4.00	0.18	0.02	0.12	5.09	5.40
BC-P2	LYT1-29	67.46	0.01	15.74	3.70	0.02	0.00	0.05	5.91	7.11
BC-P2	LYT1-30	72.27	0.08	13.95	2.52	0.01	0.00	0.03	5.55	5.59
BC-P2	LYT1-31	69.75	0.08	14.06	4.00	0.04	0.05	0.68	5.34	6.00
BC-P2	LYT1-32	67.40	0.28	15.82	3.76	0.02	0.00	0.01	5.71	7.01
BC-P2	LYT1-33	70.93	0.06	14.23	2.96	0.04	0.00	0.01	5.30	6.47
BC-P2	LYT1-35	73.49	0.04	12.93	2.59	0.01	0.00	0.02	4.92	6.01
BC-P2	LYT3-1	67.95	0.34	14.65	4.32	0.10	0.05	0.80	5.77	6.01
BC-P2	LYT3-3	67.22	0.33	14.79	4.80	0.14	0.10	1.00	5.63	5.98
BC-P2	LYT3-4	66.91	0.24	16.86	2.98	0.01	0.00	0.35	6.67	5.99
BC-P2	LYT3-5	71.80	0.11	13.12	3.78	0.10	0.10	0.85	4.81	5.32
BC-P2	LYT3-7	71.55	0.16	14.42	2.59	0.01	0.00	0.07	5.10	6.09
BC-P2	LYT3-8	67.87	0.38	14.92	4.68	0.03	0.00	0.08	5.71	6.33
BC-P2	LYT3-10	68.21	0.06	16.50	2.29	0.00	0.00	0.04	6.33	6.57
BC-P2	LYT3-11	74.72	0.15	12.29	2.58	0.02	0.01	0.20	4.46	5.57
BC-P2	LYT3-12	68.03	0.03	16.58	2.47	0.00	0.00	0.02	6.40	6.48
BC-P2	LYT3-13	67.29	0.08	16.13	3.03	0.05	0.01	0.31	6.76	6.34
BC-P2	LYT3-14	73.00	0.12	13.16	3.00	0.00	0.00	0.01	5.13	5.58
BC-P2	LYT3-4	75.30	0.07	12.52	2.12	0.00	0.00	0.11	4.53	5.36
BC-P2	LYT32-1	68.53	0.37	14.26	4.62	0.11	0.11	0.91	6.64	4.45
BC-P2	LYT32-3	68.67	0.42	13.95	5.04	0.07	0.07	0.70	5.32	5.75
BC-P2	LYT32-4	68.38	0.01	16.35	2.35	0.01	0.00	0.04	5.74	7.12
BC-P2	LYT32-5	67.20	0.32	15.19	4.84	0.16	0.06	1.17	5.82	5.24
BC-P2	LYT32-6	67.99	0.33	14.50	4.65	0.09	0.14	0.88	6.21	5.22
BC-P2	LYT12-2	67.85	0.02	16.34	2.73	0.00	0.00	0.01	6.22	6.83
BC-P2	LYT12-3	74.89	0.07	11.90	3.05	0.01	0.01	0.02	4.43	5.62
BC-P2	LYT12-4	68.46	0.33	14.23	4.90	0.13	0.06	0.91	6.86	4.11
BC-P2	LYT12-5	75.41	0.01	11.92	2.62	0.01	0.00	0.00	4.67	5.36
BC-P2	LYT12-6	68.24	0.00	16.26	2.49	0.02	0.00	0.00	5.74	7.25
BC-P2	LYT12-7	76.28	0.07	11.62	2.54	0.01	0.01	0.02	4.42	5.04
BC-P2	LYT12-8	69.02	0.06	14.85	3.50	0.04	0.00	0.00	5.87	6.66
BC-P2	LYT12-9	67.00	0.45	16.61	3.15	0.05	0.06	0.39	6.26	6.04
BC-P2	LYT12-10	68.31	0.04	15.05	3.66	0.00	0.00	0.00	5.84	7.10
BC-P1	DXTF glass	67.27	0.14	15.36	3.82	0.16	0.06	0.93	6.51	5.75
BC-P1	DXTF glass	65.15	0.54	15.78	4.59	0.17	0.25	1.28	5.91	6.34

BC-P1	**CTL1 glass**	**65.43**	**0.46**	**16.85**	**3.54**	**0.10**	**0.21**	**0.83**	**6.34**	**6.23**
BC-P1	**BCC1 glass**	**66.26**	**0.50**	**15.17**	**5.17**	**0.16**	**0.22**	**1.24**	**6.29**	**4.98**
BC-P1	**BCC1 glass**	**65.90**	**0.55**	**15.04**	**5.47**	**0.08**	**0.23**	**1.41**	**6.42**	**4.90**
BC-P1	**BCC1 glass**	**71.03**	**0.40**	**13.07**	**4.41**	**0.10**	**0.11**	**0.93**	**4.70**	**5.25**
BC-P1	**BCL1 Glass**	**69.03**	**0.14**	**15.89**	**2.56**	**0.06**	**0.01**	**0.20**	**6.45**	**5.65**
BC-P1	**BCL1 Glass**	**68.65**	**0.25**	**16.00**	**2.52**	**0.05**	**0.02**	**0.19**	**6.23**	**6.10**
BC-P1	**BCL1 Glass**	**67.54**	**0.27**	**16.10**	**3.54**	**0.08**	**0.07**	**0.64**	**6.14**	**5.62**
BC-P1	**BCL1 Glass**	**66.44**	**0.33**	**15.50**	**4.21**	**0.19**	**0.09**	**1.16**	**5.89**	**6.21**
BC-P1	**BCL1 Glass**	**66.41**	**0.47**	**15.17**	**4.71**	**0.10**	**0.16**	**1.15**	**5.71**	**6.12**
BC-P1	**BCL1 Glass**	**66.66**	**0.35**	**15.21**	**5.01**	**0.09**	**0.10**	**0.91**	**6.03**	**5.65**
BC-P1	**BCR1 Glass**	**69.53**	**0.03**	**14.16**	**3.74**	**0.01**	**0.01**	**0.01**	**5.48**	**7.02**
BC-P1	**BCR1 Glass**	**64.52**	**0.22**	**14.96**	**5.60**	**0.17**	**0.28**	**2.58**	**5.86**	**5.80**
BC-T	**TY03 glass**	**73.85**	**0.24**	**8.61**	**6.81**	**0.11**	**0.01**	**0.22**	**5.96**	**4.18**
BC-T	**TY03 glass**	**72.96**	**0.23**	**8.94**	**6.74**	**0.17**	**0.00**	**0.24**	**6.34**	**4.37**
BC-T	**TY03 glass**	**73.64**	**0.26**	**8.84**	**6.52**	**0.21**	**0.01**	**0.22**	**6.16**	**4.14**
BC-T	**TY03 glass**	**73.56**	**0.26**	**8.68**	**6.74**	**0.14**	**0.01**	**0.28**	**6.17**	**4.17**
BC-T	**TY03 glass**	**73.33**	**0.25**	**8.63**	**6.72**	**0.16**	**0.00**	**0.25**	**6.34**	**4.33**
BC-T	**TY03 glass**	**73.74**	**0.23**	**8.73**	**6.55**	**0.11**	**0.03**	**0.23**	**6.12**	**4.25**
BC-T	**TY03 glass**	**72.89**	**0.25**	**9.04**	**7.07**	**0.16**	**0.02**	**0.24**	**6.09**	**4.24**
BC-T	**TY03 glass**	**73.01**	**0.26**	**8.94**	**6.92**	**0.15**	**0.01**	**0.27**	**6.27**	**4.18**
BC-T	**TY03 glass**	**72.98**	**0.25**	**8.87**	**6.87**	**0.18**	**0.01**	**0.24**	**6.20**	**4.39**
BC-T	**TY03 glass**	**72.74**	**0.22**	**9.01**	**7.00**	**0.18**	**0.03**	**0.28**	**6.30**	**4.26**
B-Tm	**C01**	**74.9**	**0.24**	**10.58**	**3.92**	**0.1**	**0**	**0.23**	**5.27**	**4.26**
B-Tm	**C02**	**74.97**	**0.2**	**10.36**	**4.13**	**0.08**	**0**	**0.23**	**5.25**	**4.3**
B-Tm	**C03**	**66.15**	**0.48**	**15.49**	**4.81**	**0.17**	**0.23**	**1.25**	**5.45**	**5.76**
B-Tm	**C04**	**66.12**	**0.48**	**15.66**	**4.64**	**0.16**	**0.18**	**1.26**	**5.67**	**5.62**
B-Tm	**C05**	**66.2**	**0.42**	**15.86**	**4.35**	**0.12**	**0.17**	**1.26**	**5.81**	**5.63**
B-Tm	**SG06-0226**	**74.8447**	**0.2084**	**10.2208**	**3.9181**	**0.0605**	**0**	**0.1779**	**5.7088**	**4.4047**
B-Tm	**SG06-0226**	**75.1729**	**0.2384**	**10.1762**	**3.9513**	**0.0629**	**0.0688**	**0.2289**	**5.1934**	**4.4311**
B-Tm	**SG06-0226**	**74.8253**	**0.2569**	**10.2984**	**4.1985**	**0**	**0.0007**	**0.2328**	**5.2891**	**4.4141**
B-Tm	**SG06-0226**	**75.4878**	**0.2036**	**10.2049**	**3.7242**	**0.0842**	**0.0511**	**0.2226**	**5.0946**	**4.4401**
B-Tm	**SG06-0226**	**74.9608**	**0.178**	**10.2273**	**3.9938**	**0.1171**	**0**	**0.2168**	**5.337**	**4.4579**
B-Tm	**SG06-0226**	**74.9464**	**0.2636**	**10.1375**	**3.9703**	**0.0924**	**0.0022**	**0.2363**	**5.4312**	**4.4047**
B-Tm	**SG06-0226**	**74.8675**	**0.2946**	**10.389**	**3.9801**	**0.1251**	**0**	**0.2859**	**5.1949**	**4.3492**
B-Tm	**SG06-0226**	**75.1391**	**0.1903**	**10.1676**	**4.0212**	**0.0554**	**0.0226**	**0.231**	**5.3398**	**4.3516**
B-Tm	**SG06-0226**	**74.7322**	**0.1965**	**10.1621**	**4.1708**	**0.0907**	**0.0536**	**0.2307**	**5.3395**	**4.4787**
B-Tm	**SG06-0226**	**75.198**	**0.2274**	**10.194**	**4.1893**	**0.1125**	**0.0038**	**0.2358**	**5.1227**	**4.2228**
B-Tm	**SG06-0226**	**75.0376**	**0.169**	**10.1935**	**4.1984**	**0.092**	**0.0264**	**0.2107**	**5.2039**	**4.4115**
B-Tm	**SG06-0226**	**74.6145**	**0.2324**	**10.4898**	**4.055**	**0.1085**	**0.0207**	**0.2347**	**5.1579**	**4.5461**

B-Tm	**SG06-0226**	**74.9363**	**0.252**	**10.2458**	**4.2782**	**0.0864**	**0.0079**	**0.2096**	**5.2589**	**4.2057**
B-Tm	**SG06-0226**	**74.6685**	**0.2322**	**10.3079**	**4.1014**	**0.0377**	**0**	**0.2432**	**5.4945**	**4.43**
B-Tm	**SG06-0226**	**74.8885**	**0.2337**	**10.3178**	**3.9749**	**0.1356**	**0**	**0.2277**	**5.5121**	**4.2145**
B-Tm	**SG06-0226**	**74.5663**	**0.1867**	**10.2835**	**4.2682**	**0.0415**	**0**	**0.1793**	**5.5104**	**4.4444**
B-Tm	**SG06-0226**	**74.8024**	**0.2431**	**10.3032**	**4.2688**	**0.0412**	**0**	**0.2318**	**5.3341**	**4.2723**
B-Tm	**SG06-0226**	**75.075**	**0.1963**	**10.2353**	**4.053**	**0.0896**	**0**	**0.1881**	**5.2714**	**4.4534**
B-Tm	**SG06-0226**	**74.6534**	**0.284**	**10.2779**	**4.1859**	**0.1718**	**0.0145**	**0.1974**	**5.4154**	**4.2683**
B-Tm	**SG06-0226**	**74.8449**	**0.1917**	**10.2245**	**4.0533**	**0.0942**	**0.0337**	**0.2112**	**5.5314**	**4.3113**
B-Tm	**SG06-0226**	**74.8509**	**0.1863**	**10.5342**	**3.8961**	**0.1231**	**0**	**0.2077**	**5.3298**	**4.3796**
B-Tm	**SG06-0226**	**65.1432**	**0.574**	**16.1021**	**4.5485**	**0.1452**	**0.2845**	**1.4781**	**5.406**	**6.1452**
B-Tm	**SG06-0226**	**74.9648**	**0.1912**	**10.2236**	**3.9918**	**0.1305**	**0.0759**	**0.1851**	**5.4806**	**4.2542**
B-Tm	**SG06-0226**	**74.8855**	**0.2349**	**10.2837**	**4.0565**	**0.0593**	**0.0636**	**0.219**	**5.419**	**4.3002**
B-Tm	**SG06-0226**	**75.058**	**0.1777**	**10.1824**	**4.0244**	**0.0355**	**0**	**0.2219**	**5.4527**	**4.3269**
B-Tm	**SG06-0226**	**74.5484**	**0.2631**	**10.301**	**4.1251**	**0.17**	**0.0025**	**0.2187**	**5.3568**	**4.5044**
B-Tm	**SG06-0226**	**74.6065**	**0.2694**	**10.4335**	**3.7342**	**0.0855**	**0**	**0.2293**	**5.6241**	**4.4389**
B-Tm	**SG06-0226**	**74.7952**	**0.2346**	**10.394**	**3.9125**	**0.1077**	**0.0623**	**0.2409**	**5.4645**	**4.2699**
B-Tm	**SG06-0226**	**74.8791**	**0.1776**	**10.2324**	**4.0153**	**0**	**0.0279**	**0.228**	**5.4472**	**4.4777**
B-Tm	**SG06-0226**	**75.0575**	**0.1962**	**10.251**	**4.2014**	**0.0062**	**0.0133**	**0.207**	**5.1704**	**4.4233**

Table S2: Summary of the $^{40}Ar/^{39}Ar$ dating results for BC eruptions at Changbaishan-Tianchi volcano

No	Sample Name	Experiment Number	Material	Method	Plateau age (ka)						Inverse isochron age (ka)		
					Age ± 2σ	^{39}Ar released	K/Ca ± 2σ	MSWD	n	N	Age ± 2σ	$^{40}Ar/^{36}Ar$ Intercept ± 2σ	MSWD
1	BC-T	21G10988	Sanidine	SCIH	137.7±0.9	92.59%	435±285	1.55	6	15	137.9±1.9	296.47±10.50	1.98
2	BC-T	21G11048	Sanidine	SCIH	139.5±1.0	53.34%	12±121	1.19	11	16	138.8±2.2	332.54±100.60	1.26
3	BC-T	21G11098	Sanidine	SCIH	141.6 ±1.0	94.67%	18.6±4.3	1.04	15	16	141.8±1.1	296.34±6.51	1.08
4	BC-T	21G11128	Sanidine	SCIH	140.1±1.7	36.96%	124±153	1.19	11	16	140.1±2.8	298.97±89.18	1.34
5	BC-T	21G11158	Sanidine	SCIH	139±0.8	77.43%	39±173	0.92	10	16	138.8±1.7	318.83±110.02	1
6	BC-T	21G11238	Sanidine	SCIH	139±1.8	74.82%	62±101	1.75	12	16	123.9±13.2	296.47±1222.29	1.12
7	BC-P1R	21G10409	Sanidine	SCIH	132.5±0.4	99.19%	8.1±0.3	0.9	15	17	132.5±0.5	298.13±1.66	0.96
8	BC-P1R	21G10441	Sanidine	SCIH	136.4±1.0	80.98%	8.3±0.4	2.91	9	17	136.3±2.5	299.1±15.22	3.33
9	BC-P1R	21G10473	Sanidine	SCIH	132±1.4	82.76%	8±1.2	0.6	13	17	132.1±2.8	309.89±10.75	0.97
10	BC-P1R	21G10525	Sanidine	SCIH	130.4±1.4	58.00%	8.4±0.2	0.82	9	17	132±1.8	293.65±3.28	0.41
11	BC-P1R	21G10557	Sanidine	SCIH	136.6±1.6	71.57%	7.2±0.2	4.75	7	17	135.3±6.3	306.17±37.96	5.52
12	BC-P1R	21G10589	Sanidine	SCIH	134±0.8	67.74%	4.1±12.3	1.55	12	17	134.1±1.9	296.78±18.90	1.72
13	BC-P1R	21G10621	Sanidine	SCIH	132.3±1.0	78.94%	7.4±3.5	1.36	9	17	132.3±1.3	304.53±4.77	1.91
14	BC-P1R	21G10673	Sanidine	SCIH	133.8±1.0	99.71%	2.92±5.02	1.11	16	17	134.3±1.0	294.89±3.30	1.07
15	BC-P1L	20F18622	Sanidine	SCIH	134.4±1.0	78.51%	8.9±0.3	1.9	12	17	135±1.7	295.65±6.85	1.96
16	BC-P1L	20F18655	Sanidine	SCIH	131.4±1.6	98.65%	8.8±0.3	1.16	14	17	128.5±2.9	331.38±26.57	0.65
17	BC-P1L	20F18688	Sanidine	SCIH	131.7±1.1	100.00%	5.9±1.7	0.96	17	17	132.4±1.7	292.55±11.74	1
18	BC-P1L	20F18721	Sanidine	SCIH	136.8±2.2	97.14%	8.8±0.4	1.8	13	17	135.6±4.4	302.58±13.45	1.9
19	BC-P2	21G10108	Sanidine	SCIH	133.1±0.9	58.10%	7.6±0.2	0.68	7	17	133±8.1	299.38±66.25	0.81
20	BC-P2	21G10140	Sanidine	SCIH	134.6±0.7	80.81%	5.4±9.0	0.44	13	17	134.6±1.2	298.37±6.25	0.48
21	BC-P2	21G10172	Sanidine	SCIH	133.3±1.4	88.11%	9.1±0.8	0.91	16	17	133.4±3.6	298.5±4.71	0.99
22	BC-P2	21G10224	Sanidine	SCIH	135.8±1.2	84.69%	6.6±9.5	1.08	13	17	134.6±2.7	302.7±7.93	1.08
23	BC-P2	21G10256	Sanidine	SCIH	133.9±0.7	88.07%	8.4±4.3	0.86	15	17	134.7±1.0	292.86±5.32	0.59
24	BC-P2	21G10288	Sanidine	SCIH	134.4±1.7	58.99%	11.7±18.3	0.68	13	17	132.6±9.7	302.15±18.48	0.73
25	BC-P2	21G10320	Sanidine	SCIH	132.2±1.8	99.69%	6.1±3.0	1.07	15	17	132.2±2.7	298.59±8.37	1.15
26	BC-P2	21G10377	Sanidine	SCIH	133.5±1.7	89.38%	9.3±0.4	0.39	10	17	133.4±2.1	299.67±12.45	0.44
27	BC-P3	20F17571	Sanidine	SCIH	126.3±1.0	99.38%	37.9±2.4	2.11	13	15	126.2±1.3	276.61±11.15	2.65
28	BC-P3	20F17603	Sanidine	SCIH	125.8±1.1	82.67%	43.6±3.3	1.81	8	15	125.9±1.1	285±77.12	2.09
29	BC-P3	20F17635	Sanidine	SCIH	126±1.4	77.68%	4.6±7.5	1.12	15	16	125.9±1.6	305.16±46.67	1.05
30	BC-P3	20F17667	Sanidine	SCIH	124.2±0.8	100.00%	10.4±8.7	0.51	16	16	123.9±1.3	303.51±16.21	0.45
31	BC-P3	20F17699	Sanidine	SCIH	125.8±2.1	95.18%	33.2±5.0	1.84	11	16	124.5±2.3	305.75±7.39	1.42

SCIH: Single Crystal Incremental Heating; MSWD: Mean Square Weighted Deviation; n: the step number of age calculation; N: the total step number of determination. Note that relatively younger weighted plateau ages (marked in red) with more released ^{39}Ar gas (>90%) and smaller MSWD values are reported for each sample.