GSA Data Repository Item 2020181

Junlai Liu, Mo Ji, Jinlong Ni, Liang Shen, Yuanyuan Zheng, Xiaoyu Chen, and John P. Craddock, 2020, Inhomogeneous thinning of a cratonic lithospheric keel by tectonic extension: The Early Cretaceous Jiaodong Peninsula–Liaodong Peninsula extensional provinces, eastern North China craton: GSA Bulletin, https://doi.org/10.1130/B35470.1.

Data Repository

DR1. Sampling strategy and analytical techniques.

DR2. LA-ICPMS U-Pb zircon data for samples SL0827 and SL0768x from the LEP.

DR3. Samples, sampling locations and age dating results of volcanic and plutonic rocks with precise dating information from the literature and the present study from LEP and JEP.

DR4. Whole rock geochemistry of samples from DR3.

DR5. Sr-Nd isotopes of the samples from DR3.

DR6. Major early Cretaceous extensional structural associations in the JEP.

DR1. Sampling strategy and analytical techniques

1. Geology Analysis and Sampling Strategy

Structural analysis of the early Cretaceous extensional structures in LEP (e.g., the Liaonan mcc, the Wanfu mcc, the Dayingzi detachment fault zone, etc.) were conducted in much details with respect the geological and structural geology characteristics. Stratigraphic columns of each basin were built on the basis of detailed field investigations. Geochronological dating were done for volcanic rocks in the basins and plutonic intrusions in the lower plates of extensional fault zones (Liu et al., 2005, Liu et al., 2013, Shen et al., 2011). On such a basis, samples of volcanic rocks from the basins were taken for whole-rock and isotope analysis at the Institute of Geology and Geophysics, Chinese Academy of Sciences.

2. Whole Rock Chemistry

After petrographic examinations, fresh samples were selected for geochemical analysis. The samples were crushed in a hardened jaw crusher and then powdered in an agate mill to <200 mesh (75μm). Major element oxides were analyzed on fused glass disks employing a Pillips PW 1500 X-ray fluorescence spectrometer. The precision accuracy of the major-element data as determined on the Chinese whole-rock basalt standard GSR-3 (Xie et al., 1989) is ≤3% and ca. 5% (2σ), respectively. The FeO concentration was determined using a conventional titration procedure.

3. Zircon U-Pb Dating

Zircon grains were separated from two whole-rock samples using conventional techniques. After crushing and sieving of the samples, heavy minerals were concentrated by panning and then by magnetic separation. Zircon grains were handpicked and then the grains were mounted in an epoxy disc with chips of standard zircons of 91500 zircon age standards (91500–1063 ± 6 Ma; Wiedenbeck et al., 1995) for LA-ICP-MS analyses. These are then carefully polished until their cores were exposed. Cathodoluminescence (CL) images of zircons combined with reflected and transmitted light images were used to morphologically target distinct areas on the zircons for LA-ICP-MS analyses. CL images were obtained using a Mini CL attached to a scanning electron microscope (LEO1450VP) at the Electron Microprobe Laboratory at the Institute of Geology and Geophysics (IGG), Chinese Academy of Sciences, Beijing. The LA-ICP-MS analyses were finished at the same Institution. The analyses were conducted using the Agilent ICP-MS equipped with a 193 nm laser ablation. The zircon standard 91500 was used as the external calibration standard. The collected data were then processed using GLITTER, a data reduction software package for LA-ICP-MS. The zircon U-Pb concordia plots diagram and weighted ages were calculated by Isoplot program. The detailed analytical procedure refers to Yuan et al. (2008) or Xie et al. (2008).

4. Sr-Nd Isotopes

Samples for isotope analysis were dissolved in Teflon bombs after being spiked with ^{84}Sr, ^{87}Sr, ^{150}Nd and ^{147}Sm tracers before $HF+HNO_3$ (with a ratio of 2:1) dissolution. Rb, Sr, Sm and Nd were separated using conventional ion exchange procedures as described by Yang et al. (2004). Sr-Nd isotopic data were measured on a MAT 262 mass spectrometer. The Sr and Nd isotope ratios were respectively normalized to $^{86}Sr/^{88}Sr = 0.1194$ and $^{146}Nd/^{144}Nd = 0.7219$. Typical within-run precision (2σ) for Sr and Nd was estimated to be ± 0.000015. The BCR-2 Nd standards and NBS-987 Sr standard were $^{143}Nd/^{144}Nd = 0.512630 \pm 12$ (2σ, n = 2) and $^{87}Sr/^{86}Sr = 0.710252 \pm 11$ (2σ, n = 1). The initial $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios were calculated using their Zircon U-Pb LA-ICP-MS ages.

REFERENCES CITED

Liu, J.L., Davis, G.A., Lin, Z.Y., and Wu, F.Y., 2005, The Liaonan metamorphic core complex, southeastern Liaoning Province, North China: A likely contributor to Cretaceous rotation of eastern Liaoning, Korea and contiguous areas: Tectonophysics, v. 407, p. 65–80, https://doi.org/10.1016/j.tecto.2005.07.001.

Liu, J.L., Shen, L., Ji, M., Guan, H.M., Zhang, Z.C., and Zhao, Z.D., 2013, The Liaonan/Wanfu paired metamorphic core complexes in the Liaodong Peninsula: Progressive exhumation and constraints on destruction of the North China Craton: Tectonics, v. 32, p. 1121–1141, https://doi.org/10.1002/tect.20064.

Shen, L., Liu, J.L., Hu, L., Ji, M., Guan, H.M., and Davis, G.A., 2011, The Dayingzi detachment fault in Liaodong Peninsula: Characteristics and regional tectonic implications: Science China Earth Sciences, v. 54, p. 1469–1483, https://doi.org/10.1007/s11430-011-4202-5.

Wiedenbeck, M., Alle, P., Corfu, F., Griffin, W.L., Meier, M., Oberli, F., Vonquadt, A., Roddick, J.C., Spiegel, W., 1995, Three natural zircon standards for U–Th–Pb, Lu–Hf, trace-element and REE analyses: Geostandards Newsletter, v. 19, p. 1–23, https://doi.org/10.1111/j.1751-908x.1995.tb00147.x.

Xie, L.W., Zhang, Y.B., Zhang, H.H., Sun, J.F., Wu, F.Y., 2008, In situ simultaneous determination of trace elements, U–Pb and Lu–Hf isotopes in zircon and baddeleyite: Chinese Science Bulletin, v. 53, p. 1565–1573, https://doi.org/10.1007/s11434-008-0086-y.

Yang, J.H., Wu, F.Y., Chung, S.L., Wilde, S.A., and Chu, M.F., 2004, Multiple sources for the origin of granites: Geochemical and Nd/Sr isotopic evidence from the Gudaoling granite and its mafic enclaves, northeast China: Geochimica et Cosmochimica Acta, v. 68, p. 4469–4483, https://doi.org/10.1016/j.gca.2004.04.015.

Yuan, H.L., Gao, S., Dai, M.N., Zong, C.L., Günther, D., Fontaine, G.H., Liu, X.M., Diwu, C.R., 2008, Simultaneous determinations of U–Pb age, Hf isotopes and trace element compositions of zircon by excimer laser-ablation quadrupole and multiplecollector ICP-MS: Chemical Geology, v. 247, p. 100–118, https://doi.org/10.1016/j.chemgeo.2007.10.003.

DR2. LA-ICPMS U–Pb zircon data for samples SL0827 and SL0768x from the LEP

Spot number	Content		Th/U	Isotopic ration						Age (Ma)			
	Th	U		$^{207}Pb/^{206}Pb$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ	$^{207}Pb/^{235}U$	1σ	$^{206}Pb/^{238}U$	1σ
SL0768X													
SL0768X 08	16.56	474.37	0.03	0.0521	0.0036	0.1472	0.0093	0.0205	0.0007	139	8	131	5
SL0768X 09	9.69	350.58	0.03	0.0461	0.0040	0.1317	0.0099	0.0207	0.0009	126	9	132	5
SL0768X 10	5.49	249.62	0.02	0.0554	0.0079	0.1447	0.0189	0.0189	0.0012	137	17	121	8
SL0768X 11	7.88	223.14	0.04	0.0536	0.0044	0.1499	0.0113	0.0203	0.0008	142	10	129	5
SL0768X 12	4.02	171.95	0.02	0.0576	0.0069	0.1514	0.0170	0.0191	0.0008	143	15	122	5
SL0768X 16	30.43	699.41	0.04	0.0476	0.0026	0.1189	0.0057	0.0181	0.0005	114	5	116	3
SL0768X 18	4.69	178.15	0.03	0.0461	0.0031	0.1321	0.0072	0.0208	0.0008	126	6	133	5
SL0768X 19	3.30	169.41	0.02	0.0461	0.0045	0.1287	0.0117	0.0203	0.0007	123	11	129	5
SL0768X 21	9.50	311.10	0.03	0.0461	0.0030	0.1148	0.0063	0.0181	0.0006	110	6	116	4
SL0768X 22	8.63	306.91	0.03	0.0466	0.0030	0.1203	0.0070	0.0187	0.0006	115	6	120	4
SL0768X 23	11.94	356.33	0.03	0.0513	0.0034	0.1450	0.0088	0.0205	0.0007	138	8	131	4
SL0827													
SL0827 08	69.68	64.53	1.08	0.0674	0.0100	0.2029	0.0276	0.0218	0.0014	188	23	139	9
SL0827 09	58.56	58.05	1.01	0.0593	0.0096	0.1870	0.0276	0.0229	0.0016	174	24	146	10
SL0827 10	68.78	138.63	0.50	0.0509	0.0046	0.1527	0.0129	0.0217	0.0008	144	11	139	5
SL0827 12	93.76	82.69	1.13	0.0735	0.0076	0.2330	0.0213	0.0230	0.0012	213	17	146	8
SL0827 13	24.43	35.15	0.70	0.0526	0.0135	0.1495	0.0367	0.0206	0.0016	141	32	132	10
SL0827 15	86.91	77.71	1.12	0.0536	0.0086	0.1479	0.0222	0.0200	0.0012	140	20	128	8
SL0827 17	61.04	66.03	0.92	0.0461	0.0063	0.1231	0.0157	0.0194	0.0010	118	14	124	7
SL0827 18	85.20	88.93	0.96	0.0565	0.0081	0.1422	0.0188	0.0183	0.0011	135	17	117	7
SL0827 19	98.00	116.01	0.84	0.0583	0.0056	0.1577	0.0142	0.0196	0.0008	149	12	125	5
SL0827 21	41.15	48.47	0.85	0.0496	0.0110	0.1518	0.0326	0.0222	0.0013	143	29	142	8

DR3. Samples, sampling locations and age dating results of volcanic and plutonic rocks with precise dating information from the literature and the present study from LEP and JEP.

	Sample No.	Location	Rock type	Age (Ma)
1) **Early Cretaceous volcanic rocks (LEP) from this study**				
			Stage 1	
01.	SL0826	Dayingzi	Trachyte	132 (Shen et al., 2011)
02.	SL0827	Dayingzi	Andesite	132 (This study)
03.	SL0678	Huanghuadian	Rhyolite	135 (Shen et al., 2011)
04.	SL0731	Tongyuanpu	Pyroxene andesite	132-129 (Kong et al., 2019)
05.	SL0734	Tongyuanpu	Andesite	
06.	SL0735	Tongyuanpu	Andesite	
07.	SL0748	Tongyuanpu	Andesite	
08.	SL0761	Tongyuanpu	Basalt	
09.	QC34-1	Tongyuanpu	Andesite	
10	SL0719	Benxi	Rhyolite	126 (Liu et al., 2011)
11	SL0768x	Dandong	Trachyte	124 (This study)
12	SL0577	Wafangdian	Trachytes	126 (Liu et al., 2011)
12	SL0581	Wafangdian	Trachytes	
13	SL0583	Wafangdian	Trachytes	
14	SL0585	Wafangdian	Trachytes	
15	SL06129	Guiyunhua	Andesite	122 (Ma et al., 2014)
16	SL05128	Guiyunhua	Basaltic andesite	
17	SL05104	Guiyunhua	Basaltic andesite	
18	SHY16	Guiyunhua	Dacite	
			Stage 2	
20	SL0768	Dandong	Trachyte	106 (Liu et al., 2011)
21	SL0771	Dandong	Trachyte	106 (Liu et al., 2011)

2) Early Cretaceous pultonic rocks (LEP) from the literature				
01.	SL06205	Zhaotun	Monzogranite	130 (Wu et al., 2005; Ji et al., 2015)
02.	SL0694	Qixingtai	Monzogranite	116 (Liu et al., 2013)
03.	SL0615	Wazidian	Monzogranite	120 (Ji et al., 2015)
04.	SL0536	Zhaofang	Granitic porphyry	113 (Ji et al., 2009)
05.	JH-37	Gudaoling	Monzogranite	118 (122, Yang et al., 2004b)
06.	JH-38	Gudaoling	Monzogranite	118 (122, Yang et al., 2004b)
07.	JH-39	Gudaoling	Monzogranite	118 (122, Yang et al., 2004b)
08.	JH-43-2	Gudaoling	Monzogranite	118 (122, Yang et al., 2004b)
09.	FW01-22	Gudaoling	Monzogranite	118 (122, Yang et al., 2004b)
10.	FW01-26	Gudaoling	Monzogranite	118 (122, Yang et al., 2004b)
11.	FW01-353	Gudaoling	Granodiorite	124 (Yang et al., 2004b)
12.	FW01-353c	Gudaoling	Granodiorite	124 (Yang et al., 2004b)
13.	FW01-21	Gudaoling	Granodiorite	124 (Yang et al., 2004b)
14.	FW01-18	Gudaoling	Qz diorite	127 (Yang et al., 2004b)
15.	FW01-350	Gudaoling	Qz diorite	127 (Yang et al., 2004b)
16.	FW01-38	Gudaoling	Qz diorite	127 (Yang et al., 2004b)
17.	JH-34	Gudaoling	Dioritic enclave	118 (Yang et al., 2004b)
18.	JH-35	Gudaoling	Dioritic enclave	118 (Yang et al., 2004b)
19.	JH-43-1	Gudaoling	Dioritic enclave	118 (Yang et al., 2004b)
20.	FW01-14	Gudaoling	Dioritic enclave	118 (Yang et al., 2004b)

21.	JH-48	Gudaoling	Dioritic enclave	118 (Yang et al., 2004b)
22.	JH-46	Gudaoling	Monzonitic enclave	118 (Yang et al., 2004b)
23.	JH-47	Gudaoling	Monzonitic enclave	118 (Yang et al., 2004b)
24.	FW04-337	Guanshui	Monzogranite	130 (Yang et al., 2008)
25.	SK11-1	Yinmawanshan	Gneissic granite	122 Guo et al., 2004)
26.	SK11-4	Yinmawanshan	Monzogranitic dyke	124 (Guo et al., 2004)
27.	FW02-41	Yinmawanshan	Porphyritic granite	129 (Guo et al., 2004)
28.	FW02-39	Yinmawanshan	Porphyritic granite	122 (Guo et al., 2004)

3) Early Cretaceous volcanic rocks (JEP) with precise age dating from the literature				
01.	LY-6	Laiyang	Basaltic andesite	126 (Whole rock Ar-Ar, Pang, 2015)
02.	LY-9	Laiyang	Andesite	119 (Whole rock Ar-Ar, Pang, 2015)
03.	LY14	Laiyang	Basaltic andesite	125 (Whole rock Ar-Ar, Pang, 2015)
04.	QD-3	Qingdao	Basalt	114 (Whole rock Ar-Ar, Kuang et al., 2012)
05.	HY-2	Haiyang	Andesite	113 (Whole rock Ar-Ar, Kuang et al., 2012)
06.	JZ-6	Jiaozhou	Basaltic andesite	119 (Whole rock Ar-Ar, Kuang et al., 2012)
07.	JM-7	Jimo	Basaltic andesite	122 (Whole rock Ar-Ar, Kuang et al., 2012)
08.	JM-15	Jimo	Basaltic andesite	122 (Whole rock Ar-Ar, Kuang et al., 2012)
09.	JJLT-01	Jiaojia	lamprophyre	121 (LA-ICP-MS, Ma et al., 2014)
10.	JJHT-02	Jiaojia	lamprophyre	122 (LA-ICP-MS, Ma et al., 2014)
11.	JJHT-05	Jiaojia	lamprophyre	121 (LA-ICP-MS, Ma et al., 2014)
12.	JJLT-01	Jiaojia	lamprophyre	121 (LA-ICP-MS, Ma et al., 2014)

4) Early Cretaceous granitic plutons (JEP) with precise age dating from the literature				
01.	SJS-8	Shijiusuo	Monzogranite	127 (SHRIMP+Ar-Ar, Yang et al., 2005)
02.	SJS-12	Shijiusuo	mafic microgranular enclave	124 (SHRIMP+Ar-Ar, Yang et al., 2005)
03.	SJS-1	Shijiusuo	mafic dike	111 (Whole rock Ar-Ar, Yang et al., 2005)
04.	FZ-1	Shichang	monzodiorite	122 (SHRIMP, Yang et al., 2005)
05.	SC-1	Shichang	monzonite	122 (SHRIMP, Yang et al., 2005)
06.	03SD47	Qibaoshan	Granite	125 (SHRIMPP,121, LA-ICPMS, Huang et al., 2006)
07.	03SD73	Dadian	Granite	118 (LA-ICPMS, Huang et al., 2006)
08.	06SD01	Sanfoshan	Granite	114 (LA-ICPMS, Zhang et al., 2010)
09.	06SD17	Sanfoshan	Granite	116 (SHRIMP, Zhang et al., 2010)
10.	08G32	Guojialing	Granite	129 (LA-ICPMS, Yang et al., 2012)
11.	08G37	Guojialing	Granite	129 (LA-ICPMS, Yang et al., 2012)
12.	XC11D007B4	Guojialing	Granite	128 (LA-ICPMS, Wang et al., 2014)
13.	XC11D016B9	Guojialing	Granite	129 (LA-ICPMS, Wang et al., 2014)

5) Early Cretaceous mafic dykes (JEP) with precise age dating from the literature				
01.	XC-M02	Xincheng	Qz dolerite	128 (Yang et al., 2004a)
02.	DK-M04	Linglong	Dolerite	133 (Yang et al., 2004a)
03.	JQ-M02	Linglong	Dolerite	123 (Yang et al., 2004a)
04.	LL-M06	Linglong	Dolerite	124 (Yang et al., 2004a)
05.	MP-M06	Mouping	Lamprophre	120 (Yang et al., 2004a)
06.	30-6	Lingshan	Andesite porphyrite	123 (Wang et al., 2015)
07.	15-3	Lingshan	Andesite porphyrite	123 (Wang et al., 2015)
08.	27-3	Lingshan	Andesite porphyrite	120 (Wang et al., 2015)
09.	CY01	Changyi	Dolerite	130 (Liu et al., 2015)
10.	WF02	Weifang	Dolerite	127 (Liu et al., 2015)
11.	YS01	Yishui	Dolerite	126 (Liu et al., 2015)

12.	JX01	Juxian	Dolerite	125 (Liu et al., 2015)
13.	JN01	Junan	Dolerite	126 (Liu et al., 2015)
14.	LY02	Linyi	Dolerite	125 (Liu et al., 2015)
15.	09M09	Zhaoyuan	Diorite	116 (Cai et al., 2013)
16.	09QX01	Qixia	Pyroxene-diorite	117 (Cai et al., 2013)

REFERENCES CITED

Cai, Y.C., Fan, H.R., Santosh, M., Liu, X., Hu, F.F., Yang, K.F., Lan, T.G., Yang, Y.H., and Liu, Y.S., 2013, Evolution of the lithospheric mantle beneath the southeastern North China Craton: Constraints from mafic dikes in the Jiaobei terrain: Gondwana Research, v. 24, p. 601–621, https://doi.org/10.1016/j.gr.2012.11.013.

Guo, C.L., Wu, F.Y., Yang, J.H., Lin, J.Q., and Sun, D.Y., 2004, The extensional setting of the Early Cretaceous magmatism in eastern China: Example from the Yinmawanshan pluton in southern Liaodong Peninsula: Acta Petrologica Sinica, v. 20, p. 1193–1204 (in Chinese with English abstract).

Huang, J., Zheng, Y.F., Zhao, Z.F., Wu, Y.B., Zhou, J.B., and Liu, X.M., 2006, Melting of subducted continent: Element and isotopic evidence for a genetic relationship between Neoproterozoic and Mesozoic granitoids in the Sulu orogen: Chemical Geology, v. 229, p. 227–256, https://doi.org/10.1016/j.chemgeo.2005.11.007.

Ji, M., Liu, J.L., Hu, L., Guan, H.M., Davis, G.A., Zhang, W., 2009, Zircon SHRIMP U-Pb age of Yinmawanshan and Zhaofang pluton in South Liaoning metamorphic core complex and its geological implications: Acta Petrologica Sinica, v. 25, p. 173-181.

Ji, M., Liu, J.L., Hu, L., Shen, L., and Guan, H.M., 2015, Evolving magma sources during continental lithospheric extension: Insights from the Liaonan metamorphic core complex, eastern North China craton: Tectonophysics, v. 647–648, p. 48–62, https://doi.org/10.1016/j.tecto.2015.01.023.

Kong, R.Y., Yan, D.P., Qiu, L., Well, M.L., Wang, A.P., Dong, X.Y., Mu, H.X., and Gong, L.X., 2019, Early Cretaceous tectonic transition and SW-ward basin migration in northern Liaodong Peninsula, NE China: Sedimentary, structural, and geochronological constraints: Geological Journal, https://doi.org/10.1002/gj.3620.

Kuang, Y.S., Pang, C.J., Luo, Z.Y., Hong, L.B., Zhong, Y.T., Qiu, H.N., and Xu, Y.G., 2012, ^{40}Ar-^{39}Ar geochronology and geochemistry of mafic rocks from Qingshan Group, Jiaodong area: Implications for the destruction of the North China Craton: Acta Petrologica Sinica, v. 28, p. 1073–1091 (in Chinese with English abstract).

Liu, J.L., Ji, M., Shen, L., Guan, H.M., and Davis, G.A., 2011, Early Cretaceous extensional structures in the Liaodong Peninsula: Structural associations, geochronological constraints and regional tectonic implications: Science in China, Series D: Earth Sciences, v. 54, p. 823–842, https://doi.org/10.1007/s11430-011-4189-y.

Liu, J.L., Shen, L., Ji, M., Guan, H.M., Zhang, Z.C., and Zhao, Z.D., 2013, The Liaonan/Wanfu paired metamorphic core complexes in the Liaodong Peninsula: Progressive exhumation and constraints on destruction of the North China Craton: Tectonics, v. 32, p. 1121–1141, https://doi.org/10.1002/tect.20064.

Liu, S., Feng, C.X., Hu, R.Z., Zhai, M.G., Gao, S., Lai, S.C., Yan, J., Coulson, I.M., and Zou, H.B., 2015, Zircon U-Pb geochronological, geochemical, and Sr-Nd isotope data for Early Cretaceous mafic dykes in the Tancheng-Lujiang Fault area of the Shandong Province, China: Constraints on the timing of magmatism and magma genesis: Journal of Asian Earth Sciences, v. 98, p. 247–260, https://doi.org/10.1016/j.jseaes.2014.11.001.

Ma, L., Jiang, S.Y., Hofmann, A.W., Dai, B.Z., Hou, M.L., Zhao, K.D., Chen, L.H., Li, J.W., and Jiang, Y.H., 2014, Lithospheric and asthenospheric sources of lamprophyres in the Jiaodong Peninsula: A consequence of rapid lithospheric thinning beneath the North China Craton?: Geochimica et Cosmochimica Acta, v. 124, p. 250–271, https://doi.org/10.1016/j.gca.2013.09.035.

Pang, C.J., 2015, Geochronology and geochemistry of the Cretaceous mafic to intermediate volcanic rocks in the eastern North China Craton [Ph.D. thesis]: Guangzhou, Graduate University of Chinese Academy of Sciences, 184 p.

Shen, L., Liu, J.L., Hu, L., Ji, M., Guan, H.M., and Davis, G.A., 2011, The Dayingzi detachment fault in Liaodong Peninsula: Characteristics and regional tectonic implications: Science China Earth Sciences, v. 54, p. 1469–1483, https://doi.org/10.1007/s11430-011-4202-5.

Wang, J., Chang, S.C., Wang, K.L., Lu, H.B., Zhang, H.C., 2015, Geochronology and geochemistry of Early Cretaceous igneous units from the central Sulu orogenic belt: Evidence for crustal delamination during a shift in the regional tectonic regime: Journal of Asian Earth Sciences, v. 112, p. 49-59, http://dx.doi.org/10.1016/j.jseaes.2015.09.009.

Wang, Z.L., Zhao, R.X., Zhang, Q., Lu, H.W., Li, J.L., and Cheng, W., 2014, Magma mixing for the high Ba-Sr Guojialing-type granitoids in Northwest Jiaodong Peninsula: Constraints from petrogeochemistry and Sr-Nd isotopes: Acta Petrologica Sinica, v. 30, p. 2595–2608.

Wu, F.Y., Lin, J.Q., Wilde, S.A., Zhang, X.O., and Yang, J.H., 2005a, Nature and significance of the Early Cretaceous giant igneous event in eastern China: Earth and Planetary Science Letters, v. 233, p. 103–119, https://doi.org/10.1016/j.epsl.2005.02.019.

Yang, J.H., Chung, S.L., Zhai, M.G., and Zhou, X.H., 2004a, Geochemical and Sr-Nd-Pb isotopic compositions of mafic dikes from the Jiaodong Peninsula, China: Evidence for vein-plus-peridotite melting in the lithospheric mantle: Lithos, v. 73, p. 145–160, https://doi.org/10.1016/j.lithos.2003.12.003.

Yang, J.H., Wu, F.Y., Chung, S.L., Wilde, S.A., and Chu, M.F., 2004b, Multiple sources for the origin of granites: Geochemical and Nd/Sr isotopic evidence from the Gudaoling granite and its mafic enclaves, northeast China: Geochimica et Cosmochimica Acta, v. 68, p. 4469–4483, https://doi.org/10.1016/j.gca.2004.04.015.

Yang, J.H., Wu, F.Y., Chung, S.L., Wilde, S.A., Chu, M.F., Lo, C.H., and Song, B., 2005, Petrogenesis of Early Cretaceous intrusions in the Sulu ultrahigh-pressure orogenic belt, east China and their relationship to lithospheric thinning: Chemical Geology, v. 222, p. 200–231, https://doi.org/10.1016/j.chemgeo.2005.07.006.

Yang, J.H., Wu, F.Y., Wilde, S.A., Belousova, E., and Griffin, W.L., 2008, Mesozoic decratonization of the North China block: Geology, v. 36, p. 467–470, https://doi.org/10.1130/G24518A.1.

Yang, K.F., Fan, H.R., Santosh, M., Hu, F.F., Wilde, S.A., Lan, T.G., Lua, L.N., and Liu, Y.S., 2012, Reactivation of the Archean lower crust: Implications for zircon geochronology, elemental and Sr-Nd-Hf isotopic geochemistry of late Mesozoic granitoids from northwestern Jiaodong Terrane, the North China Craton: Lithos, v. 146–147, p. 112–127, https://doi.org/10.1016/j.lithos.2012.04.035.

Zhang, J., Zhao, Z.F., Zheng, Y.F., and Dai, M.N., 2010, Postcollisional magmatism: Geochemical constraints on the petrogenesis of Mesozoic granitoids in the Sulu orogen, China: Lithos, v. 119, p. 512–536, https://doi.org/10.1016/j.lithos.2010.08.005.

DR4. Whole rock geochemistry of samples from DR3

Sample No.		Major elements (wt.%)												
		SiO_2	TiO_2	Al_2O_3	TFeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O-	LOI	Total
1) Early Cretaceous volcanic rocks (LEP) from this study														
						Stage 1								
01.	SL0826	59.56	0.67	16.38	5.02	0.08	1.35	3.86	4.64	3.34	0.23	0.20	4.70	100.03
02.	SL0827	49.56	0.62	18.33	5.32	0.08	5.41	9.88	2.46	0.14	0.17	0.44	7.90	100.31
03.	SL0678	73.88	0.15	13.38	1.08	0.02	0.24	0.54	2.76	5.98	0.04	0.18	1.76	100.00
01.	SL0731	57.84	0.63	15.99	5.87	0.07	4.58	6.04	2.61	1.91	0.13	0.28	4.14	100.09
02.	SL0734	57.27	0.52	14.38	6.46	0.10	6.00	6.41	3.00	1.81	0.11	0.16	3.76	99.98
03.	SL0735	67.10	0.44	14.67	2.96	0.05	1.22	2.17	2.98	2.97	0.13	0.20	5.18	100.07
04.	SL0748	53.29	0.72	13.72	7.43	0.08	8.61	5.22	2.50	1.25	0.14	0.26	7.00	100.22
05.	SL0761	50.64	0.56	14.17	5.80	0.12	5.41	5.93	2.93	1.52	0.12	0.48	12.48	100.16
04.	SL0719	74.28	0.19	12.77	2.45	0.02	0.16	0.08	2.81	6.10	0.03	0.10	1.08	100.07
05.	SL0768x							N/A						
06.	SL0577	66.90	0.50	15.44	2.95	0.03	1.02	2.03	4.08	3.62	0.20	n/a	3.18	99.94
07.	SL0581	67.40	0.52	15.43	2.97	0.02	1.06	1.52	5.05	3.73	0.20	n/a	1.62	99.52
08.	SL0583	67.24	0.49	15.04	3.08	0.04	1.21	1.95	4.75	3.62	0.19	n/a	2.05	99.66
09.	SL0585	67.66	0.51	15.36	2.97	0.03	0.98	1.28	5.17	3.71	0.19	n/a	1.90	99.76
06.	SL06129	61.18	0.53	13.91	4.82	0.08	3.04	4.99	3.36	2.84	0.15	0.28	5.12	100.30
07.	SL05128	55.17	0.76	16.08	7.68	0.11	2.32	5.90	3.11	1.83	0.18	n/a	6.80	99.95
08.	SL05104	55.56	1.01	15.37	8.31	0.07	4.91	3.74	3.05	0.63	0.37	n/a	6.91	99.94
						Stage 2								
09.	SL0768	60.57	0.70	16.53	5.21	0.04	1.60	2.77	5.40	3.94	0.76	0.16	2.32	100.00
10.	SL0771	62.30	0.70	17.23	4.78	0.05	0.63	1.56	5.58	4.57	0.47	0.26	1.90	100.03
2) Early Cretaceous volcanic rocks (LEP) from the literature														
01.	SL0577	66.90	0.49	15.44	2.95	0.03	1.02	2.03	4.08	3.62	0.20	N/A	3.18	99.94
02.	SL0581	67.40	0.52	15.43	2.97	0.02	1.06	1.52	5.05	3.73	0.20	N/A	1.62	99.52
03.	SL0583	67.24	0.49	15.04	3.08	0.04	1.21	1.95	4.75	3.62	0.19	N/A	2.05	99.66
04.	SL0585	67.66	0.51	15.36	2.97	0.03	0.98	1.28	5.17	3.71	0.19	N/A	1.90	99.76
3) Early Cretaceous pultonic rocks (LEP) from the literature														
01.	SL06205	73.09	0.08	15.19	0.53	0.02	0.21	1.38	5.21	3.66	0.02	N/A	0.28	99.67
02.	SL0694	71.54	0.37	14.35	2.23	0.03	0.44	1.74	3.63	4.57	0.08	N/A	0.60	99.58
03.	SL0615	69.88	0.40	15.17	2.29	0.03	0.65	2.05	3.80	4.55	0.12	N/A	0.60	99.54
04.	SL0536	66.85	0.46	15.06	3.38	0.04	0.12	2.07	3.77	4.64	0.21	N/A	3.13	99.73
05.	JH-37	71.56	0.19	15.06	1.44	0.03	0.34	1.42	3.96	4.45	0.07	N/A	N/A	98.52

06.	JH-38	71.54	0.18	15.21	1.38	0.03	0.30	1.37	3.94	4.57	0.06	N/A	N/A	98.58
07.	JH-39	71.44	0.17	14.89	1.40	0.02	0.27	1.35	3.95	4.60	0.06	N/A	N/A	98.15
08.	JH-43-2	72.56	0.15	14.45	0.73	0.02	0.31	1.47	3.92	4.27	0.05	N/A	N/A	97.93
09.	FW01-22	72.42	0.14	14.49	1.49	0.02	0.36	1.48	3.93	4.89	0.07	N/A	N/A	99.29
10.	FW01-26	72.00	0.18	14.35	1.77	0.03	0.42	1.37	3.95	4.86	0.07	N/A	N/A	99.00
11.	FW01-353	72.86	0.21	14.87	1.38	0.02	0.55	1.76	4.12	4.25	0.09	N/A	N/A	100.11
12.	FW01-353c							N/A						
13.	FW01-21	69.20	0.38	15.25	2.77	0.04	0.87	2.34	4.14	4.03	0.14	N/A	N/A	99.16
14.	FW01-18	61.86	0.70	16.39	5.43	0.07	2.91	4.85	3.86	2.69	0.21	N/A	N/A	98.97
15.	FW01-350	54.16	0.98	17.81	7.77	0.10	4.88	7.18	4.14	1.91	0.27	N/A	N/A	99.20
16.	FW01-38	60.14	0.75	15.79	5.78	0.08	4.49	5.28	3.74	2.87	0.21	N/A	N/A	99.13
17.	JH-34	52.71	0.89	15.76	6.68	0.11	6.70	7.56	3.65	2.74	0.57	N/A	N/A	97.37
18.	JH-35	53.66	0.86	15.92	6.27	0.10	6.21	7.63	3.82	2.80	0.56	N/A	N/A	97.83
19.	JH-43-1	56.74	0.73	14.96	5.78	0.11	5.67	6.43	3.78	2.67	0.40	N/A	N/A	97.27
20.	FW01-14	51.25	0.86	13.45	8.21	0.13	10.72	8.97	2.84	1.69	0.39	N/A	N/A	98.51
21.	JH-48	55.36	0.87	16.26	6.76	0.10	2.75	4.38	3.96	3.54	0.66	N/A	N/A	94.64
22.	JH-46	60.23	0.64	19.22	4.70	0.07	1.14	5.13	4.23	1.73	0.22	N/A	N/A	97.31
23.	JH-47	59.46	0.68	19.66	5.41	0.08	1.01	4.83	4.59	1.79	0.22	N/A	N/A	97.73
24.	FW04-337	60.27	0.93	15.56	6.07	0.08	3.72	4.75	3.99	3.30	0.20	N/A	0.99	99.86
25.	SK11-1	62.9	0.79	16.39	4.79	0.05	2.08	4.19	4.27	2.83	0.28	N/A	0.4	98.96
26.	SK11-4	72.6	0.21	14.20	1.72	0.03	0.31	1.4	3.63	5.37	0.06	N/A	0.33	99.81
27.	FW02-41	71.4	0.24	14.69	2.07	0.02	0.64	1.84	3.79	4.68	0.1	N/A	0.03	99.51
28.	FW02-39	72.0	0.21	14.78	1.79	0.03	0.46	1.57	4.10	4.57	0.08	N/A	0.36	99.95

4) Early Cretaceous volcanic rocks (JEP) with precise age dating from the literature

01.	LY-6	60.8	0.71	16.04	5.30	0.05	3.44	5.06	3.64	3.43	0.23	N/A	1.01	99.73
02.	LY-9	53.3	1.01	16.47	6.37	0.08	3.87	8.59	3.37	2.64	0.39	N/A	3.73	99.81
03.	LY14	54.4	0.95	16.39	6.70	0.10	4.06	7.41	3.30	2.79	0.35	N/A	3.34	99.81
04.	QD-3	48.6	1.40	13.73	9.15	0.13	9.75	7.70	2.96	3.48	1.15	N/A	2.11	100.16
05.	HY-2	51.2	0.96	14.88	9.54	0.07	8.36	5.18	2.59	2.72	0.30	N/A	4.18	99.97
06.	JZ-6	54.4	1.40	17.21	7.55	0.12	3.72	6.47	4.28	2.99	0.64	N/A	0.92	99.69
07.	JM-7	47.6	1.17	16.26	7.01	0.08	4.60	11.29	2.68	1.03	0.24	N/A	8.32	100.20
08.	JM-15	52.5	1.11	16.34	6.89	0.06	6.67	8.14	2.96	1.40	0.20	N/A	3.91	100.18
09.	JJLT-01	51.2	0.79	12.40	8.47	0.14	11.59	7.35	1.57	3.23	0.41	N/A	3.13	99.78
10.	JJHT-02	46.4	2.16	14.29	11.81	0.20	6.65	7.11	3.79	2.84	0.84	N/A	4.58	99.89
11.	JJHT-05	46.4	2.26	15.96	11.25	0.20	6.65	8.33	3.74	2.84	0.89	N/A	2.19	100.03

5) Early Cretaceous granitic pultons (JEP) with precise age dating from the literature

01.	SJS-8	69.16	0.5	14.42	3.52	0.07	1.38	2.6	3.52	3.86	0.28	N/A	N/A	99.29
02.	SJS-12	53.72	1.14	15.51	8.67	0.19	4.8	5.59	3.51	4.47	0.84	N/A	N/A	98.42
03.	SJS-1	49.68	1.24	12.07	8.46	0.15	8.92	6.57	1.6	4.68	1.01	N/A	N/A	94.36
04.	FZ-1	56.35	0.77	14.7	7.26	0.25	5.02	5.24	3.42	4.69	0.34	N/A	N/A	98.05
05.	SC-1	59.61	0.81	16.02	5.84	0.1	2.4	4.25	3.59	4.73	0.36	N/A	N/A	97.71
06.	03SD47	68.72	0.38	13.5	3.02	0.08	0.41	3.31	2.61	2.9	0.13	N/A	4.56	99.62
07.	03SD73	66.49	0.47	16	2.63	0.05	0.75	1.12	4.61	6	0.17	N/A	1.31	99.6
08.	06SD01	60.8	0.56	17.33	4.98	0.06	2.91	4.84	4.33	2.93	0.35	N/A	0.87	99.91
09.	06SD17	77.3	0.08	12.81	0.72	0.03	0.08	0.67	4.4	3.76	0.01	N/A	0.49	100.28
10.	08G32	70.70	0.27	14.90	1.56	0.01	0.46	1.99	4.58	3.49	0.07	N/A	1.38	99.45
11.	08G37	71.20	0.19	15.40	1.14	0.01	0.38	2.12	4.73	3.66	0.05	N/A	0.44	99.37
12.	XC11D007B4	71.5	0.18	15.72	0.956	0.01	0.39	1.56	4.4	4.32	0.05	N/A	1.31	99.9
13.	XC11D016B9	70.9	0.30	15.15	1.57	0.022	0.62	1.93	4.2	4	0.08	N/A	1.19	99.99

6) Early Cretaceous mafic dykes (JEP) with precise age dating from the literature														
01.	XC-M02	57.85	0.65	12.58	6.92	0.2	8.19	5.32	2.73	2.4	0.18	N/A	2.96	99.98
02.	DK-M04	44.08	0.76	13.28	8.1	0.24	9.35	8.86	1.72	1.2	0.35	N/A	12.03	99.97
03.	JQ-M02	48.15	0.86	14.14	9.32	0.17	10.23	8.84	1.71	1.36	0.15	N/A	5.31	100.24
04.	LL-M06	46.26	0.8	13.52	8.19	0.18	8.85	8.26	1.95	2.53	0.37	N/A	9.24	100.15
05.	MP-M06	47.84	0.59	14.51	5.53	0.14	5.01	6.69	0.41	4.13	0.28	N/A	14.81	99.94
06.	30-6	58.45	1.23	15.36	6.27	0.07	2.53	3.54	5.33	4.05	0.58	N/A	2.49	99.9
07.	15-3	62.96	0.61	16.68	3.62	0.16	0.97	1.24	4.78	6.07	0.26	N/A	2.56	99.9
08.	27-3	64.02	0.39	16.21	3.47	0.02	1.42	2.56	2.63	5.45	0.23	N/A	3.70	100.1
09.	CY01	51.5	0.86	14.72	9.27	0.15	9.82	7.36	2.66	2.53	0.48	N/A	0.25	99.61
10.	WF02	51.5	0.78	14.65	9.27	0.15	9.76	7.35	2.66	2.51	0.52	N/A	0.43	99.57
11.	YS01	51.5	0.77	14.68	9.29	0.14	9.75	7.35	2.69	2.48	0.53	N/A	0.42	99.59
12.	JX01	51.5	0.74	14.64	9.25	0.15	9.76	7.35	2.7	2.45	0.47	N/A	0.49	99.55
13.	JN01	51.5	0.73	14.66	9.27	0.13	9.75	7.34	2.7	2.43	0.46	N/A	0.53	99.57
14.	LY02	52.2	0.75	14.52	9.26	0.14	9.77	7.31	2.7	2.35	0.49	N/A	0.32	99.73
15.	09M09	56.46	0.64	12.59	5.58	0.15	6.86	5.92	2.32	4.6	0.61	N/A	3.82	99.55
16.	09QX01	55.44	0.73	14.99	6.68	0.11	6.88	7.23	2.81	2.96	0.36	N/A	1.26	99.45

DR5. Sr-Nd isotopes of the samples from DR3

	Sample No.	Sr-Nd Isotopes								Ref
		$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd$	$(^{87}Sr/^{86}Sr)_i$	$\varepsilon_{Nd}(t)$	TDM	fSm/Nd	
1) Early Cretaceous volcanic rocks (LEP) from this study										
					Stage 1-1					
01.	SL0826	0.5162	0.715793	0.0991	0.51161	0.7148	-18.49	2046	-0.50	
02.	SL0827	0.0253	0.711155	0.1097	0.51214	0.7111	-8.27	1480	-0.44	
03.	SL0678	3.8222	0.718693	0.0895	0.51172	0.7114	-16.05	1749	-0.54	
04.	SL0731	0.2335	0.712967	0.1142	0.51185	0.7126	-14.09	1982	-0.42	
05.	SL0734	9.7978	0.729348	0.0809	0.51172	0.7126	-16.24	1644	-0.59	This paper
06.	SL0735	1.7547	0.716216	0.0909	0.51173	0.7132	-16.02	1754	-0.54	
07.	SL0748	0.4107	0.712207	0.1279	0.51228	0.7115	-5.85	1536	-0.35	
08.	SL0761	0.2330	0.710672	0.1234	0.51217	0.7103	-7.99	1649	-0.37	
09.	SL0719	8.8853	0.724224	0.1066	0.51223	0.7083	-6.61	1315	-0.46	
10	SL0768x				N/A					
11	SL0577	0.4163	0.709367	0.0863	0.51161	0.7086	-18.36	1843	-0.56	This paper
12	SL0581	0.3903	0.709358	0.0858	0.51159	0.7087	-18.60	1849	-0.56	
13	SL0583	0.3818	0.709705	0.0885	0.51160	0.7090	-18.48	1880	-0.55	
14	SL0585	0.4436	0.709481	0.0878	0.51160	0.7087	-18.49	1870	-0.55	
01.	SL06129	0.4044	0.711903	0.1071	0.51205	0.7112	-10.19	1576	-0.46	
02.	SL05128	0.3650	0.712359	0.1106	0.51173	0.7117	-16.41	2092	-0.44	This paper
03.	SL05104	0.1358	0.710493	0.1032	0.51196	0.7103	-11.77	1635	-0.48	
					Stage 2					
04.	SL0768	0.4316	0.706475	0.0878	0.51159	0.7058	-18.97	1882	-0.55	
05.	SL0771	0.5878	0.707296	0.0886	0.51158	0.7064	-19.21	1908	-0.55	

$$^{87}Sr/^{86}Sr_{(i)} = \left(^{87}Sr/^{86}Sr\right)_s - \left(^{87}Rb/^{86}Sr\right)\times\left(e^{\lambda T}-1\right)$$

$$^{87}Rb/^{86}Sr = \left(Rb/Sr\right)\times 2.8956$$

$$\varepsilon_{Nd(t)} = \left(\left(^{143}Nd/^{144}Nd\right)_s(t)/\left(^{143}Nd/^{144}Nd\right)_{CHUR}(t)-1\right)\times 10000$$

$$\left(^{143}Nd/^{144}Nd\right)_s(t) = \left(^{143}Nd/^{144}Nd\right)_s - \left(^{147}Sm/^{144}Nd\right)_s\times\left(e^{\lambda t}-1\right)$$

$$^{147}Sm/^{144}Nd = \left(Sm/Nd\right)\times 0.60456$$

$$\left(^{143}Nd/^{144}Nd\right)_{CHUR}(t) = 0.512638 - 0.1967\times\left(e^{\lambda t}-1\right)$$

$$T_{DM}-Nd = 1/\lambda\times\ln\left(1+\left(\left(\left(^{143}Nd/^{144}Nd\right)_s-0.51315\right)/\left(\left(^{147}Sm/^{144}Nd\right)_s-0.2137\right)\right)\right)$$

2) Early Cretaceous volcanic rocks (LEP) from the literature

01.	SL0577	0.4163	0.7094	0.0863	0.5116	0.7086	-18.41	1845	-0.56	
02.	SL0581	0.3903	0.7094	0.0858	0.5116	0.7087	-18.64	1852	-0.56	Ji et al., 2015
03.	SL0583	0.3818	0.7097	0.0885	0.5116	0.7090	-18.52	1882	-0.55	

04.	SL0585	0.4436	0.7095	0.0878	0.5116	0.7087	-18.53	1872	-0.55	
05.	SHY-01	0.216	0.706676	0.1240	0.512191	0.706290	–5.56	1.45	N/A	Ma et al., 2014
06.	SHY-02	0.216	0.706639	0.1199	0.512190	0.706253	–5.57	1.40	N/A	
07.	SHY-03	0.211	0.706645	0.1252	0.512210	0.706267	–5.19	1.44	N/A	
08.	SHY-04	0.242	0.706595	0.1233	0.512228	0.706161	–4.83	1.38	N/A	
09.	SHY-05	0.221	0.706655	0.1281	0.512179	0.706260	–5.78	1.54	N/A	
10.	SHY-14	0.242	0.707995	0.1050	0.512018	0.707561	–8.94	1.46	N/A	
11.	SHY-15	0.361	0.708655	0.1088	0.512012	0.708008	–9.04	1.52	N/A	
12.	SHY-16	0.353	0.712125	0.0930	0.511513	0.711493	–18.78	1.96	N/A	
3) Early Cretaceous pultonic rocks (LEP) from the literature										
01.	SL06205	0.5902	0.7083	0.1153	0.5126	0.7072	-0.25	922	-0.41	Ji et al., 2015
02.	SL0694	0.6504	0.7134	0.0886	0.5115	0.7122	-19.52	1946	-0.55	
03.	SL0615	0.4708	0.712	0.0962	0.5116	0.7112	-19.02	2027	-0.51	
04.	SL0536	1.0889	0.708	0.0886	0.5116	0.7062	-19.38	1928	-0.55	
05.	JH-37	0.8323	0.707130	0.0827	0.51150	0.7057	-20.4	1912	-0.58	Yang et al., 2004b
06.	JH-38	0.8532	0.706979	0.0880	0.51149	0.7055	-20.6	2001	-0.55	
07.	JH-39	0.8527	0.707106	0.0848	0.51148	0.7057	-20.9	1974	-0.57	
08.	JH-43-2	0.6796	0.706783	0.0840	0.51151	0.7056	-20.2	1917	-0.57	
09.	FW01-22	0.6716	0.709786	0.0396	0.51156	0.7086	-18.5	1387	-0.80	
10.	FW01-26	1.223	0.708998	0.0761	0.51152	0.7069	-19.9	1798	-0.61	
11.	FW01-353	0.5419	0.709305	0.0775	0.51165	0.7084	-17.4	1678	-0.61	
12.	FW01-353c	0.5419	0.709323	0.0750	0.51160	0.7083	-17.8	1661	-0.63	
13.	FW01-21	0.5699	0.710414	0.0992	0.51193	0.7094	-12.2	1619	-0.50	
14.	FW01-18	0.3363	0.712969	0.1082	0.51164	0.7124	-18.1	2176	-0.45	
15.	FW01-350	0.1773	0.712335	0.1059	0.51164	0.7120	-18.1	2133	-0.46	
16.	FW01-38	0.4101	0.712552	0.0760	0.51187	0.7119	-13.2	1420	-0.61	
17.	JH-34	0.2266	0.706682	0.0987	0.51218	0.7063	-7.3	1280	-0.50	
18.	JH-35	0.1865	0.706579	0.0968	0.51219	0.7063	-7.2	1251	-0.51	
19.	JH-43-1	0.3863	0.706451	0.1010	0.51215	0.7058	-8	1352	-0.49	
20.	FW01-14	0.1714	0.707597	0.1051	0.51217	0.7073	-7.6	1371	-0.47	
21.	JH-48	0.4132	0.705925	0.0906	0.51165	0.7052	-17.6	1853	-0.54	
22.	JH-46	0.3235	0.708958	0.0975	0.51167	0.7084	-17.2	1931	-0.50	
23.	JH-47	0.3119	0.708944	0.0864	0.51171	0.7084	-16.4	1724	-0.56	
24.	FW04-337	0.6778	0.709209	0.1169	0.51255	0.7080	-0.5	952	-0.41	
25.	SK11-1	0.2295	0.711495	0.0984	0.51159	0.7111	-18.98	2058	-0.5	Guo et al., 2004
26.	SK11-4	1.0717	0.713501	0.0911	0.51157	0.7117	-19.32	1964	-0.54	
27.	FW02-41	0.4529	0.710003	0.0587	0.51737	0.7092	-15.47	1388	-0.56	

28.	FW02-39	0.7747	0.708772	0.0865	0.51156	0.7075	-19.31	1898	-0.7	
4) Early Cretaceous volcanic rocks (JEP) with precise age dating from the literature										
01.	LY-6	0.2345	0.710878	0.0879	0.51170	0.7105	-16.61	1767		Pang, 2015
02.	LY-9	0.1481	0.708993	0.0923	0.51170	0.7087	-16.76	1830		
03.	LY14	0.1774	0.709286	0.0907	0.51167	0.7090	-17.20	1840		
04.	QD-3	0.1883	0.707555	0.1060	0.51182	0.7073	-14.62	1875	-0.46	Kuang et al., 2012
05.	HY-2	0.6567	0.709895	0.1004	0.51173	0.7089	-16.30	1903	-0.49	
06.	JZ-6	0.2481	0.707597	0.1022	0.51171	0.7072	-16.61	1958	-0.48	
07.	JM-7	0.0651	0.707614	0.1144	0.51192	0.7075	-12.66	1877	-0.42	
08.	JM-15	0.0800	0.708023	0.1076	0.51191	0.7079	-12.75	1772	-0.45	
09.	JJLT-01	0.294	0.709539	0.095	0.51179	0.7090	−14.93	1739		Ma et al., 2014
10.	JJHT-02	0.195	0.706062	0.103	0.51265	0.7057	1.76	684		
11.	JJHT-05	0.132	0.70594	0.114	0.51259	0.7057	0.24	868		
5) Early Cretaceous granitic pultons (JEP) with precise age dating from the literature										
01.	SJS-8	0.7826	0.71023	0.0992	0.511519	0.7088	−20.2	2162	− 0.50	Yang et al., 2005
02.	SJS-12	1.332	0.710897	0.105	0.511534	0.7085	−20.0	2256	− 0.47	
03.	SJS-1	0.5006	0.708505	0.1108	0.511661	0.7076	−17.7	2196	− 0.44	
04.	FZ-1	2.389	0.712807	0.0968	0.511658	0.7085	−17.5	1939	− 0.51	
05.	SC-1	0.4961	0.709294	0.0882	0.511685	0.7084	−16.8	1775	− 0.55	
06.	03SD47	1.6034	0.711586	0.0913	0.511637	0.7089	−17.9	1880		Huang et al., 2006
07.	03SD73	1.8618	0.710588	0.08904	0.511659	0.7075	−17.4	1819		
08.	06SD01	0.1623	0.709551	0.0904	0.511703	0.7093	−16.6	1785	−0.54	Zhang et al., 2010
09.	06SD17	4.6722	0.716243	0.0791	0.511855	0.7083	−13.0	1465	−0.60	
10.	08G32	0.2724	0.712066	0.0989	0.511692	0.7116	−16.8			Yang et al., 2012
11.	08G37	0.2148	0.711985	0.0969	0.511727	0.7116	−16.1			
12.	XC11D007B4	0.3458	0.712353	0.1189	0.511671	0.7117	-17.6			Wang et al., 2014
13.	XC11D016B9	0.3036	0.711873	0.0958	0.511677	0.7113	-17.1			
6) Early Cretaceous mafic dykes (JEP) with precise age dating from the literature										
01.	XC-M02	0.4563	0.710885	0.1055	0.512006	0.7101	−10.9	1710	-0.47	Yang et al., 2004a
02.	DK-M04	0.2128	0.710397	0.0993	0.511806	0.7100	−14.7	1800	-0.54	
03.	JQ-M02	0.1453	0.710165	0.11	0.51179	0.7099	−15.2	1840	-0.52	
04.	LL-M06	0.159	0.709572	0.1029	0.511788	0.7093	−15.1	1830	-0.53	
05.	MP-M06	0.2382	0.709727	0.092	0.511711	0.7093	-16.4	1800	0.53	
06.	30-6	0.3766	0.708525	0.1014	0.51172	0.7079	-16.39	1934	-0.48	Wang et al., 2015
07.	15-3	1.3283	0.7116	0.0951	0.51175	0.7093	-15.69	1792	-0.52	

08.	27-3	0.3032	0.710176	0.0901	0.51143	0.7097	-22.00	2121	-0.54	
09.	CY01	0.1420	0.710205	0.0946	0.51182	0.7099	−14.4	1703	-0.52	Liu et at., 2015
10.	WF02	0.1450	0.710288	0.0904	0.51184	0.7099	−13.8	1612	-0.54	
11.	YS01	0.1280	0.710263	0.0976	0.51184	0.7100	−13.9	1710	-0.50	
12.	JX01	0.4200	0.710776	0.1013	0.51185	0.7100	−13.9	1762	-0.49	
13.	JN01	0.3170	0.710613	0.1081	0.51183	0.7100	−14.3	1896	-0.45	
14.	LY02	0.3570	0.710674	0.1038	0.51185	0.7100	−13.9	1801	-0.47	
15.	09M09	0.5285	0.711018	0.1017	0.51164	0.7101	− 18.08			Cai et al., 2013
16.	09QX01	0.2485	0.709167	0.1184	0.51188	0.7087	− 13.60			

REFERENCES CITED

Cai, Y.C., Fan, H.R., Santosh, M., Liu, X., Hu, F.F., Yang, K.F., Lan, T.G., Yang, Y.H., and Liu, Y.S., 2013, Evolution of the lithospheric mantle beneath the southeastern North China Craton: Constraints from mafic dikes in the Jiaobei terrain: Gondwana Research, v. 24, p. 601–621, https://doi.org/10.1016/j.gr.2012.11.013.

Guo, C.L., Wu, F.Y., Yang, J.H., Lin, J.Q., and Sun, D.Y., 2004, The extensional setting of the Early Cretaceous magmatism in eastern China: Example from the Yinmawanshan pluton in southern Liaodong Peninsula: Acta Petrologica Sinica, v. 20, p. 1193–1204 (in Chinese with English abstract).

Huang, J., Zheng, Y.F., Zhao, Z.F., Wu, Y.B., Zhou, J.B., and Liu, X.M., 2006, Melting of subducted continent: Element and isotopic evidence for a genetic relationship between Neoproterozoic and Mesozoic granitoids in the Sulu orogen: Chemical Geology, v. 229, p. 227–256, https://doi.org/10.1016/j.chemgeo.2005.11.007.

Ji, M., Liu, J.L., Hu, L., Shen, L., and Guan, H.M., 2015, Evolving magma sources during continental lithospheric extension: Insights from the Liaonan metamorphic core complex, eastern North China craton: Tectonophysics, v. 647–648, p. 48–62, https://doi.org/10.1016/j.tecto.2015.01.023.

Kuang, Y.S., Pang, C.J., Luo, Z.Y., Hong, L.B., Zhong, Y.T., Qiu, H.N., and Xu, Y.G., 2012, ^{40}Ar-^{39}Ar geochronology and geochemistry of mafic rocks from Qingshan Group, Jiaodong area: Implications for the destruction of the North China Craton: Acta Petrologica Sinica, v. 28, p. 1073–1091 (in Chinese with English abstract).

Liu, S., Feng, C.X., Hu, R.Z., Zhai, M.G., Gao, S., Lai, S.C., Yan, J., Coulson, I.M., and Zou, H.B., 2015, Zircon U-Pb geochronological, geochemical, and Sr-Nd isotope data for Early Cretaceous mafic dykes in the Tancheng-Lujiang Fault area of the Shandong Province, China: Constraints on the timing of magmatism and magma genesis: Journal of Asian Earth Sciences, v. 98, p. 247–260, https://doi.org/10.1016/j.jseaes.2014.11.001.

Ma, L., Jiang, S.Y., Hofmann, A.W., Dai, B.Z., Hou, M.L., Zhao, K.D., Chen, L.H., Li, J.W., and Jiang, Y.H., 2014, Lithospheric and asthenospheric sources of lamprophyres in the Jiaodong Peninsula: A consequence of rapid lithospheric thinning beneath the North China Craton?: Geochimica et Cosmochimica Acta, v. 124, p. 250–271, https://doi.org/10.1016/j.gca.2013.09.035.

Pang, C.J., 2015, Geochronology and geochemistry of the Cretaceous mafic to intermediate volcanic rocks in the eastern North China Craton [Ph.D. thesis]: Guangzhou, Graduate University of Chinese Academy of Sciences, 184 p.

Wang, J., Chang, S.C., Wang, K.L., Lu, H.B., and Zhang, H.C., 2015, Geochronology and geochemistry of Early Cretaceous igneous units from the central Sulu orogenic belt: Evidence for crustal delamination during a shift in the regional tectonic regime: Journal of Asian Earth Sciences, v. 112, p. 49-59, https://doi.org/10.1016/j.jseaes.2015.09.009.

Wang, Z.L., Yang, L.Q., Deng, J., Santosh, M., Zhang, H.F., Liu, Y., Li, R.H., Huang, T., Zheng, X.L., and Zhao, H., 2014, Gold-hosting high Ba-Sr granitoids in the Xincheng gold deposit, Jiaodong Peninsula, East China: Petrogenesis and tectonic setting: Journal of Asian Earth Sciences, v. 95, p. 274–299, https://doi.org/10.1016/j.jseaes.2014.03.001.

Yang, J.H., Chung, S.L., Zhai, M.G., and Zhou, X.H., 2004a, Geochemical and Sr-Nd-Pb isotopic compositions of mafic dikes from the Jiaodong Peninsula, China: Evidence for vein-plus-peridotite melting in the lithospheric mantle: Lithos, v. 73, p. 145–160, https://doi.org/10.1016/j.lithos.2003.12.003.

Yang, J.H., Wu, F.Y., Chung, S.L., Wilde, S.A., and Chu, M.F., 2004b, Multiple sources for the origin of granites: Geochemical and Nd/Sr isotopic evidence from the Gudaoling granite and its mafic enclaves, northeast China: Geochimica et Cosmochimica Acta, v. 68, p. 4469–4483, https://doi.org/10.1016/j.gca.2004.04.015.

Yang, J.H., Wu, F.Y., Chung, S.L., Wilde, S.A., Chu, M.F., Lo, C.H., and Song, B., 2005, Petrogenesis of Early Cretaceous intrusions in the Sulu ultrahigh-pressure orogenic belt, east China and their relationship to lithospheric thinning: Chemical Geology, v. 222, p. 200–231, https://doi.org/10.1016/j.chemgeo.2005.07.006.

Yang, K.F., Fan, H.R., Santosh, M., Hu, F.F., Wilde, S.A., Lan, T.G., Lua, L.N., and Liu, Y.S., 2012, Reactivation of the Archean lower crust: Implications for zircon geochronology, elemental and Sr-Nd-Hf isotopic geochemistry of late Mesozoic granitoids from northwestern Jiaodong Terrane, the North China Craton: Lithos, v. 146–147, p. 112–127, https://doi.org/10.1016/j.lithos.2012.04.035.

Zhang, J., Zhao, Z.F., Zheng, Y.F., and Dai, M.N., 2010, Postcollisional magmatism: Geochemical constraints on the petrogenesis of Mesozoic granitoids in the Sulu orogen, China: Lithos, v. 119, p. 512–536, https://doi.org/10.1016/j.lithos.2010.08.005.

DR6. Major early Cretaceous extensional structural associations in the JEP

Five major extensional structures are recognized in an area of ca. 30,000 km^2 in JEP. They are, the Wulian, Linglong and Queshan mcc's, the Guojialing LANF, and the Lidao basin. The three mcc's share the Jiaolai basin in their upper plates (Fig. 1).

1. The Wulian mcc

The Wulian mcc encompasses a major LANF (i.e., the Wulian-Qingdao fault) that separates the Sulu HP-UHP orogenic belt in its lower plate to the Jiaolai basin in the upper plate. The LANF extends for more than 250 km in ENE orientation. The master fault and mylonitic foliations beneath the fault dip generally NW and have dip angles of less than 30°. A sequence of mylonitic to cataclastic rocks of several kilometers in thickness comprises the fault zone. Due to the low dip angles and wavy-shaped foliation surfaces, the fault zone may crop-out for more than 50 km in the direction across the strike of the fault zone.

The lower plate, including the mylonitic rocks of the Wulian-Qingdao fault zone, are dominantly granitic rocks with UH-UHP enclaves of the Sulu orogenic belt, most of which were originated from the subducted north margin of the Yangtze plate. Neoproterozoic and late Triassic magmatic and metamorphic ages are often reported from the lower plate rocks. In the upper plate of the Wulian-Qingdao LANF is the Jiaolai Mesozoic volcanic-sedimentary basin (for details see the following context).

Post-extension granitic plutons are often observed across the LANF. The plutons intrude both the lower and upper plates, and cut-across the LANF. U-Pb dating of magmatic zircons from the intrusions suggests that the magmatism occurred at ca. 122 Ma. This age constrains the cessation of shearing along the LANF.

2. The Queshan mcc

Restored geological map shows that the Queshan mcc, located in the northern part of the JEP, consists of a LANF, an upper plate of a Cretaceous half-graben basin on a basement of weakly deformed Paleoproterozoic, a lower plate of Neoarchean high-grade metamorphic complexes intruded by late Mesozoic granitic plutons (e.g., the Queshan pluton and Yuangezhuang pluton).

The LANF of the Queshan mcc is a corrugated fault surface, that the strikes and dips of the fault vary from place to place. There is a sequence of fault rocks from mylonitic gneisses, mylonites, cataclasitic mylonites, chloritized microbreccias to fault gauges toward the LANF. The fault rocks possess consistent stretching lineations plunging NWW285°-SEE105° with plunge angles between 5 and 25°. A variety of high to low temperature deformation microstructures are preserved in the mylonitic rocks. Microscopic and microscopic shear indicators are consistent with a top-to-the west shearing due to WNE-ESE oriented tectonic extension.

The lower plate of the Queshan mcc is composed of Neoarchean high-grade metamorphic complexes intruded by Late Mesozoic granitic plutons. Tonalite-trondhjemite-granodiorite (TTG) gneisses contain xenoliths of mafic granulites and amphibolite. The protoliths of the rocks have zircon U-Pb ages at ca. 2.6–2.9 Ga (Xia et al., 2016). They were metamorphosed to granulite facies at Neoarchean and retrograded to amphibolite facies in early Cretaceous. Late Jurassic (162–155 Ma) gneissic biotite granite and medium-grained monzogranite were sheared into mylonitic fabrics. An early Cretaceous (ca. 113 Ma) coarse-grained porphyritic monzogranite show intrusive relationships with the other rocks. The monzogranite have huge k-feldspar crystals and mafic xenoliths that show obvious parallel alignment to form a magmtic foliation. Weak shear fabrics are also observed in places where the monzogranite was involved in detachment faulting.

The upper plate consists of a supradetachment basin and its basement of weakly deformed Paleoproterozoic. The supradetachment basin is a half-graben basin, as the northeast corner of the Jiaolai basin. Lower Cretaceous fluvial-lacustrine sediments and volcanic rocks and upper Cretaceous sandstones and siltstones unconformably overlie on the Paleoproterozoic.

3. Structural elements of the Linglong mcc and the Guojialing LANF

Two extensional structures (i.e., the Linglong mcc and the Guojialing LANF) at the northwestern part of the JEP have been recently described and studied by Charles et al., (2011, 2013). They show different structural characteristics, and were formed successively in early Cretaceous.

The Linglong mcc, a NNE–SSW trending asymmetric domal shaped structure with low angle LANF separating Neoarchean and Paleoproterozoic units in the upper plate, from migmatites and anatectic granites in its lower plate. Neoarchean rocks dated as 2665 ± 9 Ma include Trondhjemite-Tonalite-Granodorite (TTG) sequences and supracrustal xenoliths metamorphosed up to granulite facies. The Paeloproterozoic is composed mainly of marbles and schists. A major part of the upper plate is the early Cretaceous Jiaolai basin that is shared with the Wulian mcc. The lower plate is dominated by migmatites of Archean and a granite pluton (the Linglong granite) of late Jurassic age. Rocks become more and more foliated eastward. When approaching the master detachment fault, the rocks become mylonitized. Various fault rocks (e.g., mylonites, cataclasites and fault gouges) are present in the fault zone. They possess foliations dipping east and stretching lineations plunging in SE. Mesoscopic and microscopic structures and quartz c-axis fabrics indicate an overall and systematic top-to-the SE sense of shear.

The Guojialing LANF, a NNW-dipping, 25 km-long extensional ductile shear zone, lies to the north of the Linglong complex. It consists of a thick shear zone of up to 6 km in some areas.Mylonitic fabrics within the shear zone exhibit consistent top-to-the-NW senses of shear (Charles et al., 2011). To the south of the shear zone, the lower plate of the Linglong mcc is intruded by the syn-kinematic Guojialing granodiorite pluton. The pluton was dated as 130–126 Ma (Guan et al., 1998; Yang et al., 2012). Its central part remains massive, but its northern part was partly sheared by the Guojialing shear zone to form various mylonitic rocks. Stretching lineations from the mylonites plunge in NW direction (N20–30°W).

4. The Jiaolai basin

As the upper plate supradetachment basin shared by the three mcc's (i.e., the Wulian mcc to the south, the Queshan mcc to the northeast and the Linglong mcc to the northwest), the Jiaolai basin is a large Cretaceous basin filled with terrestrial volcanic and sedimentary rocks. The basin has sedimentations of an area of over 11200km^2 sitting on Archean to Neoproterozoic basement. The southwestern and western part of the basin is cut by the Tanlu fault. To the northwest and northeast, the basin is bounded by the LANFs of the Linglong and Queshan mcc's, respectively. To the southeast, the lower part of the basin is confined by the LANF of the Wulian mcc. The middle and upper part of the basin are possibly bounded by a different fault zone (i.e., the Yantai-Qingdao-Wulian fault zone or YQW fault, Zhang et al., 2008) that postdating the exhumation of the Wulian mcc. Early Cretaceous volcano-sedimentary rocks in the basin are grouped into two units, i.e., the Laiyang and Qingshan groups.

The Laiyang group is characterized by a sequence of lacustrine to delta sedimentation. In most areas the Laiyang group is over 1100m in thickness, up to 8000m at some localities (Tong, 2007). The sedimentation basin of the Laiyang group is oriented in northeast direction, which is subparalleling to orientation of the Wulian LANF. The sediments start, from the bottom, with a thick sequence of conglomerates to coarse-grained sandstones, through mudstones, siltstones, fine-grained sandstones and marls in the middle part, to conglomerates, pebble-bearing sandstones and lithic sandstones at the top. The basin sedimentation has been dated back to ca. 135–130 Ma (Zhang et al., 2008; Ni et al., 2016) by geochronological dating of magmatic zircons from volcanic interlayers.

The Qingshan group volcanic rocks of over 2000m in thickness are unconformably overlying, with a low angle, on the Laiyang sedimentary rocks. The volcanic rocks cover an area larger than that covered by the Laiyang group. It is shown from the isopach map of the volcanic rocks that the center of the volcanic basin is next to the YQWF and is oriented in the north-east-north direction (Lu and Dai, 1994). Major rock types are basaltic-trachytic andesites, andesite, andesitic trachytes and rhyolites, and tuffs, volcanic breccias and agglomerates. Zircon U-Pb dating and whole rock Ar-Ar dating revealed that the magmatism occurred between 120 and 105Ma (Zhang et al., 2008).

5. The Lidao basin

The Lidao basin of ca. 120 km^2 is a NW-SE elongated, fault-bounded half-graben basin at the northeast corner of the Jiaodong peninsula. Tectonically the early Cretaceous basin lies on the Sulu HP-UHP orogenic belt. High grade granitic gneisses have xenoliths of Hp-UHP rocks. They are mostly mylonitized and have foliations striking in NS to NNE direction, which is obviously different from that of the boundary fault of the basin. Stretching lineations are observed in most outcrops, but may vary their plunging directions. A large granitic pluton, i.e., the Weideshan pluton (108 ± 2Ma, zircon U-Pb age, Guo et al., 2005) intruded the HP-UHP rocks, but not the volcanic-sedimentary rocks in the basin.

The southwestern boundary fault of the basin is a narrow normal fault zone that extends of more than 27 km along strike. The fault strikes 300°~320° and dips northeast. Dip angles are variable and general high up to 75°~85°. Cataclastic fault rocks of up to 100 m thick cut across the major foliation in the footwall high grade rocks. Fault gauges, tectonic breccias, cataclasites are the mjor rock types.

At the bottom is a thin layer (ca. 70m in thickness) of sandstone, siltstone and marl. The upper part of the basin fill is dominated by a thick sequence of volcanic rocks of mafic to felsic in composition. Rock types include tuffaceous sandstones, tuffs, breccias, agglomerates, and basaltic trachytes, andesites and rhyolites etc.

REFERENCES CITED

Charles, N., Gumiaux, C., Augier, R., Chen, Y., Zhu, R.X., and Lin, W., 2011, Metamorphic core complexes vs. synkinematic plutons in continental extension setting: Insights from key structures (Shandong Province, eastern China): Journal of Asian Earth Sciences, v. 40, p. 261–278, https://doi.org/10.1016/j.jseaes.2010.07.006.

Charles, N., Augier, R., Gumiaux, C., Monié, P., Chen, Y., Faure, M., and Zhu, R.X., 2013, Timing, duration and role of magmatism in wide rift systems: Insights from the Jiaodong Peninsula (China, East Asia): Gondwana Research, v. 24, p. 412–428, https://doi.org/10.1016/j.gr.2012.10.011.

Guan, K., Luo, Z.K., Miao, L.C., and Huang, J.Z., 1998, SHRIMP zircon chronology for Guojialing suite granite in Jiaodong Zhaoye district: Scientia Geologia Sinica, v. 33, p. 318–328.

Guo, J.H., Chen, F.K., Siebel, W., and Zhai, M.G., 2005, Evolution of syn- to post-collisional magmatism from north Sulu UHP belt, eastern China: Zircon U-Pb geochronology: Acta Petrologica Sinica, v. 21, p. 1281–1301 (in Chinese with English abstract).

Lu, K.Z., and Dai, J.S., 1994, Formation and Evolution of the Jiaolai Basin, China: Dongying, China University of Petroleum Press, 147 p.

Ni, J.L., Liu, J.L., Tang, X.L., Yang, H.B., Xia, Z.M., and Zhang, T.T., 2016, Early Cretaceous exhumation of the Sulu orogenic belt as a consequence of the eastern Eurasian tectonic extension: Insights from the newly discovered Wulian metamorphic core complex, eastern China: Journal of the Geological Society, v. 173, p. 531–549, https://doi.org/10.1144/jgs2014-122.

Tong, Y.M., 2007. Tectonic evolution of Jiaolai basin [Ph.D. thesis]: Wuhan, China University of Geosciences, 90 p.

Xia, Z.M., Liu, J.L., Ni, J.L., Zhang, T.T., Shi, X.M., and Wu, Y., 2016, Structure, evolution and regional tectonic implications of the Queshan metamorphic core complex in eastern

Peninsula of China: Science China Earth Sciences, v. 59, p. 997–1013, https://doi.org/10.1007/s11430-015-5259-3.
Yang, K.F., Fan, H.R., Santosh, M., Hu, F.F., Wilde, S.A., Lan, T.G., Lua, L.N., and Liu, Y.S., 2012, Reactivation of the Archean lower crust: Implications for zircon geochronology, elemental and Sr-Nd-Hf isotopic geochemistry of late Mesozoic granitoids from northwestern Jiaodong Terrane, the North China Craton: Lithos, v. 146–147, p. 112–127, https://doi.org/10.1016/j.lithos.2012.04.035.
Zhang, Y.Q., Li, J.L., Zhang, T., Dong, S.W., and Yuan, J.Y., 2008, Cretaceous to Paleocene tectono-sedimentary evolution of the Jiaolai basin and the contiguous areas of the Shandong peninsula (North China) and its geodynamic implications: Acta Geologica Sinica, v. 82, p. 1082–1229.