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华北、扬子板块碰撞后热演化史的初步研究*

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摘 要 对采自苏北-胶南-大别高压变质构造混杂岩带的片麻岩、糜棱岩和郯庐断裂带上的片麻岩中 9 个钾长石进行了 ^{40}Ar-^{39}Ar 年龄测定和多重扩散域(MDD)模式处理,9 个样品的热演化史表明上述地区存在 5 个不同的快速冷却时段,并就其可能的构造含义,提出了华北与扬子板块碰撞后的折返历史过程。

主题词: **变质带** **热历史** **地质年代测定** MDD 模式

1 前 言

近年来,苏北-胶南构造混杂岩带被认为是华北与扬子板块碰撞带的一部分,并且是秦岭-大别山造山带的向东延伸。有关苏北-胶南和大别山南、北麓获得的一批高压变质带榴辉岩的 Rb-Sr 和 Sm-Nd 年龄,以及围岩单矿物的 K-Ar 年龄大都在 210～250Ma 之间[1],从而认为 220Ma 左右可能是华北与扬子陆陆碰撞最后对接的时间;刘若新等[2]最新获得了 4 组大别山地区碧溪岭榴辉岩块中锆石的 U-Pb 年龄,其中最年轻的一组年龄是 254±67Ma,它与杨巍然等[3]对碧溪岭榴辉岩的全岩-矿物 243±0.3Ma 的 Sm-Nd 等时年龄一致,可能代表了超高压变质榴辉岩最终脱离榴辉岩相 P-T 条件折返上升的年龄,而榴辉岩作为外来岩块进入地壳肯定是在 210～250Ma 之后发生的;本文旨在从年代学角度研究碰撞后,也就是研究自 210～250Ma 以来,当高压变质岩体(或地质体)处于中-上地壳后的抬升历史。

2 采样位置(图 1)

大别山南麓的碧溪岭岩块是已知苏北-胶南-大别高压变质构造混杂岩带中最大的榴辉岩岩块。它产于片麻岩与糜棱岩中。野外观察表明,该岩块上覆和下伏岩石均为糜棱岩,其外侧为含榴辉岩的片麻岩岩片。本工作选择了上覆岩层中含榴辉岩的片麻岩(DX54)和下伏构造岩带的长英质糜棱岩(DX334),以及采自江苏东海双湖村郯庐断裂带上的片麻岩(MH89-14)进

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** 参加野外工作的还有樊祺诚和张旗。

行了^{40}Ar-^{39}Ar 分析和 MDD (multiple diffusion domain)模式处理;并对已发表的苏北-胶南构造混杂岩带上的 6 个钾长石再次进行了更好的 MDD 模式处理。

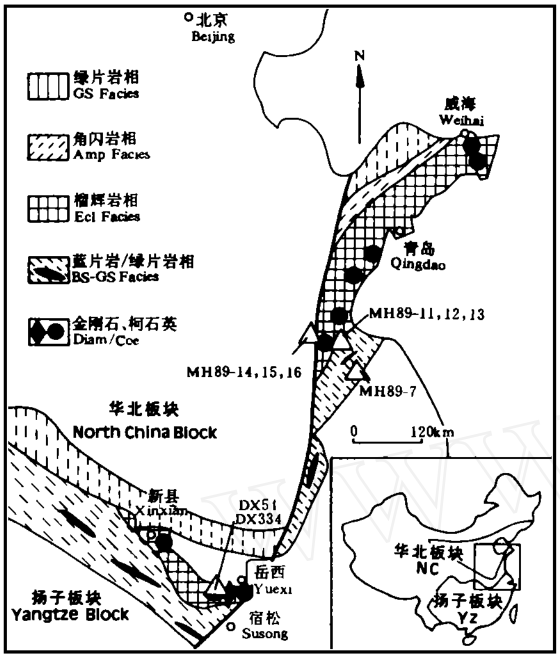

图 1 苏北-胶南-大别构造混杂岩带采样位置示意图

Fig. 1 Sketch map of North Jiangsu-Jiaonan-Dabie tectonic melange belt showing sampling localities.

3 实验方法及 MDD 模式处理

用常规磁选和重液选取单矿物,选矿及^{40}Ar-^{39}Ar分析均在美国加州大学洛杉矶分校地球和空间科学系 T. M. Harrison 实验室进行[4,5],为了进行 MDD 模式处理,对钾长石的分析实验采取了特殊的程序:(1) 为了校正样品低温区段可能存在的过剩^{40}Ar,在 400～800℃温度区间采用了同一温度两次加热法;(2) 为了尽可能多地获得最大扩散域的扩散信息,在 1100℃时采用了多次重复加热法,所得钾长石年龄结果分别见图 2 和表 1。

值得指出的是,当利用 Lovera 等[6]提出的 MDD 模式及相应的程序进行模式计算时,如果假设的冷却历史过程温度相差 10℃时(图 2b, d, f 中的模式 1 和模式 2),就不可能得到模式年龄谱与实测年龄谱的一致(图 2a, c, e 中模式 2 均未能与实测年龄谱很好地拟合),而模式 1 与实测年龄谱的一致,增加了我们对模拟冷却历史的可信度。MDD 模式处理及冷却历史综合对比结果见表 2 和图 3。

4 冷却历史及可能的构造含义

4.1 冷却历史

4.1.1 大别山南麓构造混杂岩带的冷却历史

花岗片麻岩样品(DX54)中钾长石的^{40}Ar-^{39}Ar 年龄范围为 111～274Ma(图 2c),低温阶段经过校正后的最低年龄为 82Ma,考虑到在^{39}Ar 释放的最后 25%时已失去扩散信息,因此相应的冷却历史模拟的最高年龄为 252Ma(图 2d)。假设样品在 252Ma 之前处于快速冷却过程(～10℃/Ma),本样品最重要的结果是揭示了一个从 252Ma→102Ma 之间的“等温”阶段,在长达 150Ma 的时间范围内,温度的变化仅为 1.5℃,在 102Ma 时,则又开始了一次新的快速冷却过程(～15℃/Ma)。采自该岩体北部糜棱岩样品(DX334)中钾长石的^{40}Ar-^{39}Ar 年龄范围为 96～167Ma(图 2a),低温阶段校正后的最低年龄为 59Ma。167Ma 之前冷却曲线为假设的(图 2b),考虑到共生白云母的年龄为 206.9±0.8Ma,因此在 210Ma→165.5Ma 之间可能存在一个缓慢冷却的过程,冷却曲线穿过白云母位置点(图 2b);当样品冷却至 324℃(165.5Ma)时,开始快速冷却过程(冷却速度为 40℃/Ma),并使温度降至 225℃(163Ma),从图 3 可见,此时的样品 DX334 与 DX54 处于等温水平;在 163Ma→102Ma 期间,样品 DX334 与 DX54 处于相

表 1　DX334 钾长石阶段加热实验数据($J=0.007121$, $W=0.022$g)

Table 1　Stepped heating data of DX334 K-feldspar ($J=0.007121$, $W=0.022$g)

温度 Temp. (℃)	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (10^{-3})	^{39}Ar ($\times 10^{-15}$mol)	^{39}Ar (%)	$^{40}Ar^*$ (%)	$^{40}Ar^*/^{39}Ar_K$	Age±1σ (Ma)
400	318.3	0.0013	519.3	1.34	0.056	51.7	164.8	1401±18.4
450	261.1	0.0047	142.3	2.08	0.143	83.8	219.0	1696±5.0
450	49.39	0.0051	97.49	1.52	0.207	41.4	20.56	246.5±3.2
500	126.7	0.0032	55.06	4.27	0.386	87.1	110.4	1046±1.3
500	21.44	0.0034	31.85	4.58	0.577	55.7	12.00	147.9±2.4
550	42.37	0.0026	11.27	9.44	0.972	92.0	39.02	422.3±1.0
550	8.960	0.0017	2.262	14.5	1.58	91.9	8.266	103.2±0.1
600	23.13	0.0019	5.061	16.7	2.28	93.3	21.61	258.2±0.6
600	8.175	0.0020	1.149	18.0	3.03	95.2	7.810	97.6±0.1
650	15.61	0.0022	3.084	35.0	4.50	93.9	14.68	179.4±0.3
650	7.847	0.0023	0.6356	29.7	5.74	97.1	7.634	95.5±0.1
700	10.62	0.0021	1.371	37.3	7.30	95.8	10.19	126.4±0.2
700	8.075	0.0018	0.4241	31.9	8.64	97.9	7.924	99.0±0.1
700	8.164	0.0018	0.7822	11.6	9.12	96.3	7.908	98.8±0.2
750	9.593	0.0017	0.8335	35.0	10.6	97.0	9.321	115.9±0.1
750	8.407	0.0016	0.5117	18.7	11.4	97.6	8.230	102.7±0.3
800	9.059	0.0012	0.6132	42.4	13.1	97.6	8.852	110.3±0.2
800	8.493	0.0006	0.4751	27.3	14.3	97.8	8.327	103.9±0.2
850	9.011	0.0009	0.5529	32.6	15.7	97.7	8.822	109.9±0.1
850	8.535	0.0007	0.5460	21.0	16.5	97.5	8.348	104.2±0.2
900	8.595	0.0007	0.4713	29.0	17.7	97.9	8.430	105.2±0.2
900	8.641	0.0012	0.7750	22.6	18.7	96.8	8.387	104.6±0.2
950	8.646	0.0008	0.5636	29.4	19.9	97.6	8.454	105.5±0.2
950	8.701	0.0014	0.6921	16.0	20.6	97.0	8.471	105.7±0.2
1000	8.905	0.0014	0.5424	39.6	22.2	97.8	8.719	108.7±0.2
1000	9.103	0.0012	0.7607	23.1	23.2	97.0	8.853	110.3±0.2
1050	9.509	0.0016	0.6343	39.2	24.9	97.6	9.296	115.6±0.1
1050	9.793	0.0010	0.7548	24.3	25.9	97.3	9.544	118.6±0.2
1100	10.36	0.0017	0.7559	43.9	27.7	97.5	10.11	125.4±0.1
1100	10.92	0.0024	0.9930	58.4	30.2	97.0	10.60	131.3±0.2
1100	11.71	0.0022	1.456	72.0	33.2	96.1	11.25	139.0±0.4
1100	12.50	0.0024	1.606	84.8	36.7	96.0	12.00	147.9±0.4
1100	13.03	0.0025	1.866	60.1	39.2	95.5	12.45	153.2±0.4
1100	13.43	0.0020	2.077	78.8	42.5	95.2	12.79	157.2±0.2
1100	13.67	0.0018	2.124	91.3	46.3	95.2	13.01	159.9±0.3
1100	14.07	0.0011	2.712	164	53.2	94.1	13.24	162.5±0.2
1100	14.36	0.0008	3.269	102	57.5	93.1	13.37	164.1±0.6
1100	14.49	0.0005	3.584	83.9	61.0	92.5	13.41	164.5±0.3
1100	14.66	0.0005	4.087	60.3	63.5	91.5	13.43	164.7±0.4
1100	14.86	0.0005	4.655	49.2	65.5	90.5	13.46	165.1±0.3
1200	13.83	0.0012	2.116	19.8	66.4	95.1	13.18	161.8±0.3
1250	13.65	0.0007	2.047	69.1	69.3	95.3	13.02	159.9±0.3
1300	13.80	0.0007	1.809	194	77.4	95.9	13.24	162.6±0.2
1400	14.16	0.0007	1.768	383	93.4	96.1	13.61	166.9±0.2
1500	14.04	0.0006	2.183	157	100	95.2	13.37	164.1±0.3

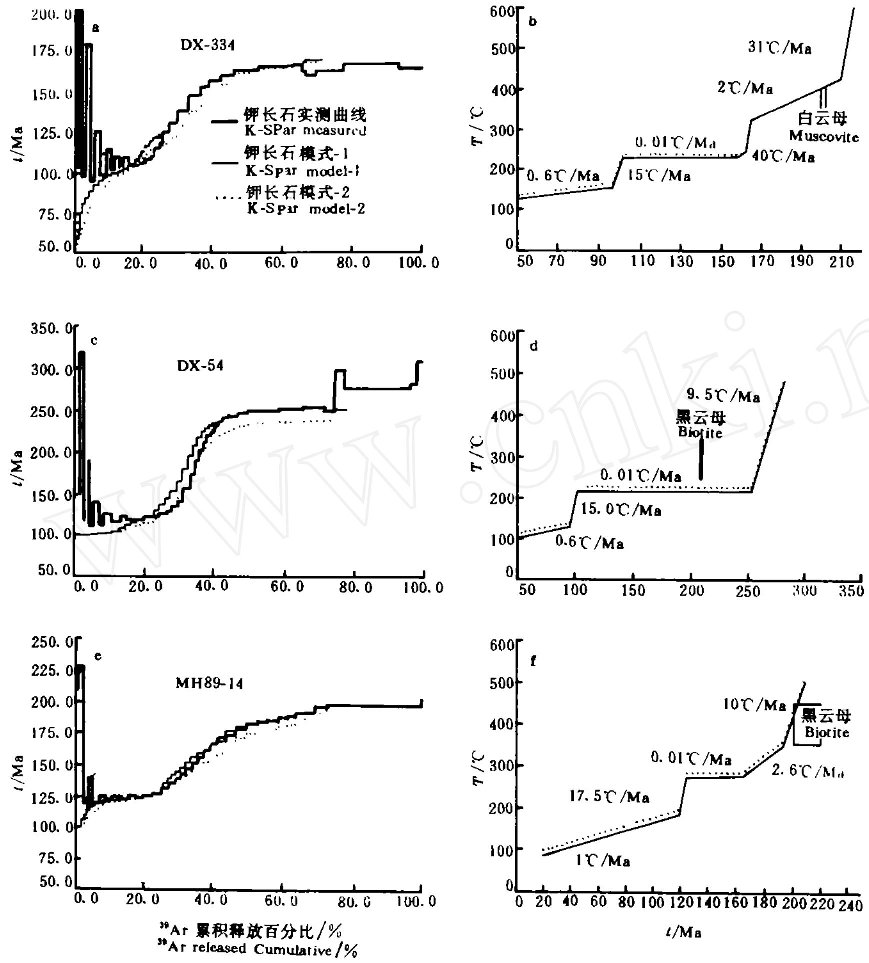

图 2 3个钾长石样品年龄谱及冷却曲线

Fig. 2 Age spectra and cooling history of three K-feldspar samples.

a,c,e 实测及模拟年龄谱;b,d,f 冷却历史曲线

a,c,e. age spectra; b,d,f. Cooling history curves

同的"等温"阶段,并在102Ma时,与DX54同时开始了最后一次快速冷却过程(15℃/Ma)。显然,碧溪岭岩体不同产状的两个样品均记录了102Ma→97Ma之间的快速冷却事件。

4.1.2 苏北构造混杂岩带的冷却历史

采自苏北灌云的绿泥片岩样品(MH89-7)位于华北与扬子板块的缝合线上,早期假设的快速冷却事件时间的下限为245Ma,与DX54假设的结果相似;有趣的是在245Ma→187Ma之间也存在一个"等温"阶段(持续时间为58Ma,温度变化为40℃);第二次快速冷却时间为187Ma→180Ma(冷却速度为15℃/Ma),与苏北东海至连云港一带3个样品(MH89-11,12,13)的快速冷却时间(194Ma→189Ma)大致相当(图3)。

表 2　钾长石样品 MDD 模式所得快速冷却时段有关数据

Table 2　Results of modelling the cooling history on the MDD model for K-feldspar samples

采样地点 Sampling localities	样品号 Samples	第一快速冷却时段 The first cooling stage			第二快速冷却时段 The second cooling stage		
		起始时间 Starting time (Ma)	速　度 cooling rate (℃/Ma)	终止时间 ending rate (Ma)	起始时间 Starting time (Ma)	速　度 cooling rate (℃/Ma)	终止时间 ending rate (Ma)
大别山地区 Dabie mountains area	DX334	165	40	163	102	15	97
	DX54	280	9.5	252	102	15	97
郯庐断裂 Tancheng-Lujiang fault zone	MH89-14	～210	10	195	125	17.5	121
	MH89-15	145	10	132	125	18.5	117
	MH89-16	～200	9.5	169	125	18.5	119
	MH89-7	～264	9.5	245	187	15	180
苏北-胶南 North Jiangsu-Jiaonan tectonic melange segment	MH89-11	～210	9.3	195	195	40	193
	MH89-12				193	40	190
	MH89-13				193	40	190

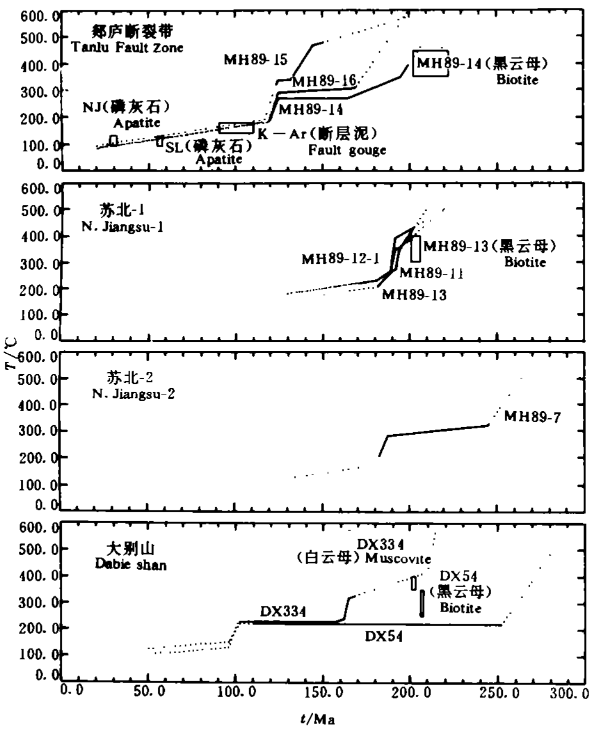

图 3　苏北-胶南-大别构造混杂岩带冷却历史综合对比图

Fig. 3　A comparison between the modelled cooling history data of the North Jiangsu-Jiaonan-Dabie tectonic melange belt.

4.1.3　郯庐断裂带的冷却历史

采自苏北东海双湖村郯庐断裂带上的片麻岩样品(MH89-14)中钾长石的^{40}Ar-^{39}Ar年龄谱范围为 120～199Ma(图 2e)，低温阶段校正后最低年龄为 78Ma，考虑到共生黑云母的年龄为 217.9±1.3Ma，因此在 210～195Ma 期间可能存在一次快速冷却(至少从 199Ma 是有年龄谱证据的)。这次快速冷却事件与 MH89-7 的第 2 次快速冷却，以及苏北至东海地区的钾长石的冷却事件在时间上是一致的；在 165～125Ma 之间，样品处于一个十分缓慢的冷却阶段，125～120Ma 为第 2 次快速冷却事件发生时间(18℃/Ma)，这次快速冷却事件，得到了采自同一地区，但属郯庐断裂分支的两个钾长石^{40}Ar-^{39}Ar结果(MH89-15，16)的证实。MH89-14 第 2 次快速冷却事件后，样品处于平缓阶段，但当把以往所得沂沭断裂上的断层泥 K-Ar 年龄和磷灰石裂变径迹年龄一并绘于图 3 中时，这种缓慢的冷却和抬升历史可一直延至约 30Ma。

4.2　**可能的构造含义**

根据 9 个钾长石的冷却历史，并结合野

外地质观察表明，研究区存在不同的快速冷却事件和“等温”平稳期，它们可能反映了不同的构造含义：

(1)210Ma 以前，各地区均不同程度的显示出可能存在一次快速冷却事件，这可能是华北与扬子板块碰撞至大面积闭合抬升的最小估算时间；

(2)195～190Ma 在苏北-胶南地区和 187～180Ma 在灌云缝合带上的快速冷却事件(冷却速度为 40℃/Ma 和 15℃/Ma)，大别地区无反映，可能说明了在此之前，由于郯庐断裂带发生的左旋走滑运动已使二者分开，原来位于大别地区的地质体移至现今苏北地区；

(3)165～163Ma 之间的快速冷却(DX334)，使该岩体与长期处于“等温”状态的 DX54 岩体对接，继而又共同保持“等温”平稳状态至 103Ma；

(4)125～120Ma 在郯庐断裂带上发生的快速冷却事件(MH89-14,15,16)，与以往获得的早白垩纪晚期形成的断层泥时间也大致相等，反映了郯庐断裂带白垩纪中期的一次强烈抬升活动；

(5)102～97Ma 之间大别地区的快速冷却事件(冷却速度为 15℃/Ma)，可能是现今大别山最后抬升及定位的时间。

5 结 语

利用 MDD 模式可以研究温度范围在 150～400℃之间的地质体的连续冷却(隆升)过程；从本工作中的 9 个钾长石样品冷却曲线，结合野外观察所反演的构造演化史，得到了苏北-胶南-大别构造混杂岩带在华北与扬子板块碰撞后的垂直(抬升与剥蚀)及水平运动的演化过程，从年代学角度支持了 Arall Okey[7]所建立的大别-苏鲁超高压变质带形成和折返模式。显然，这一工作仅仅是一种初步尝试，有许多问题还有待进一步解决。

美国加州大学洛杉矶分校 T. M. Harrison 实验室为本项研究提供了良好的实验条件，刘若新先生对本文给予了指导，在此一并致谢。

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THERMAL EVOLUTION HISTORY AFTER COLLISION OF NORTH CHINA PLATE WITH YANGTZE PLATE

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Abstract

^{40}Ar-^{39}Ar analyses and MDD (multiple diffusion domain) model treatements were performed for 9 K-feldspar samples. They were collected from gneiss and mylonite of North Jiangsu-Jiaonan-Dabie tectonic melange belt and Tancheng-Lujiang fault zone. The thermal evolution history exhibits five fast cooling stages found in these samples. In relation with their possible tectonic implications a recovery process after the collision of the North China plate with the Yangtze plate is suggested here.

Key words: **Metamorphic belt, Thermal history, Geological age determination,** MDD model

1 Introduction

In recent years the North Jiangsu-Jiaonan tectonic melange belt was considered to be a part of the collsion zone between North China plate and Yangtze plate and also the eastward extension of the Qinling-Dabie orogenic belt. The age of the final collision of the North China plate with the Yangtze plate is about 220 Ma because Rb-Sr and Sm-Nd ages of eclogites in several high-pressure metamorphic belts distributed in North Jiangsu-Jiaonan and the southern and northern piedmonts of the Dabie Mountains as well as K-Ar ages of single minerals from the country rocks of eclogites are mostly in a range of 210 Ma to 250 Ma[1]. However, Liu Ruoxin et al[2]. recently obtained four U-Pb ages of zircon from Bixiling eclogite in the Dabie Mountains. Of the four ages, the youngest is 254±67 Ma, which is consistent with a whole rock-mineral Sm-Nd age of 243±0.3 Ma obtained by Yang Weiran et al[3]. for the same eclogite. This age may represent the time during which the ultra-high pressure metamorphic eclogites recvered and uprised from their largest depth (about 140～150 km). It is certain after 210～250 Ma that the eclogites as exotic blocks entered the crust. This paper is aimed to study cooling (uplifting) history of this region since 210～250 Ma after collision between the two plates from chronological aspect, or rather the uplifting history after the high-pressure metamorphic rocks (or geological bodies) deviated from P-T conditions of eclogite facies having reached the middle-upper crust.

* Fan Qichengg and Zhang Qi took also part in the field work.

2 Samples (Fig. 1)

K-feldspar samples in this study were collected from the Bixiling eclogite body at the southern piedmont of the Dabie Mountains and from the Tancheng-Lujiang fault zone at Shuanghu Village, Donghai County, Jiangsu Province. The Bixiling eclogite body is the largest one of known eclogite bodies in the North Jiangsu-Jiaonan-Dabie metamorphic-tectonic melange belt. Sample DX54 was collected from its overlying eclogite-bearing gneiss and sample DX334 from its underlying felsic mylonite. Samples MH89-14 were collected from gneiss at Shuanghu Village. ^{40}Ar-^{39}Ar analyses and MDD (multiple diffusion domain) model treatments of all these samples were performed. In addition, MDD model treatments were again performed in a more accurate way for the published data of six K-feldspar samples from the North Jiangsu-Jiaonan segment of the melange belt.

3 Experimental Methods and MDD Model Treatments

K-feldspar single minerals were separated by using magnetic and heavy liquid separations for analyzing their ^{40}Ar and ^{39}Ar in T. M. Harrison Laboratory[4,5], Department of Earth and Space Sciences, University of California, Los Angeles, U. S. A. In order to make MDD treatments, two special procedures were taken in the analysis and experiment of K-feldspar: (1) heating of samples was carried out two times at one temperature between 400℃ and 800℃ so as to correct excessive ^{40}Ar possibly existing in the lower temperature interval, and (2) heating of samples were carried out repeatedly at 1100℃ in order to obtain the diffusion information of the maximum diffusion domain as much as possible. The obtained age results of K-feldspar samples are plotted in Fig. 2 and listed in Table 1.

It should be pointed out that when the age data are calculated by the MDD model and related procedures proposed by Lovera et al. [6], if the difference of the assumed temperature in the cooling process was 10℃, (in Fig. 2b, d, f, model-1, model-2) the obtained model age spectrum would not be coincident with the measured age spectrum (in Fig. 2a, c, e, the model-2 can not give a good fit to the measured age spectra). But the coincidence of model-1 with measured age spectrum increases the confidence of modelling the cooling history. Results of the cooling history on the MDD model for K-feldspar are listed in Table 2 and a comprehensive comparison is shown in Fig. 3.

4 Cooling History and Possible Tectonic Implications

4.1 Cooling History

4.1.1 Melange belt on southern piedmont of Dabie Mountains

K-feldspar sample DX54 from granite-gneiss adjacent to the eclogite yields a ^{40}Ar-^{39}Ar age of 111～274 Ma (Fig. 2c), and its minimum age obtained by correction at a lower temperature stage is 82 Ma. In considering that the diffusion information lost when the final 25% of ^{39}Ar was released, the maximum age of the sample modelled on the corresponding cooling historic MDD model should be 252 Ma (Fig. 2d). Assuming that the sample has undergone a fast cooling event before 252 Ma (10℃/Ma), its most important result shows an "isothermal" stage from 252 Ma to 102 Ma. In this long period of 150 Ma the temperature change was only 1.5℃. Then, a newly fast cooling process (15℃/Ma) started from 102 Ma.

K-feldspar sample DX334 from mylonite at the northern side of the eclogite body yields a ^{40}Ar-^{39}Ar age of 96～167 Ma(Fig. 2a), and its minimum age by correction at a lower temperature stage is 59 Ma. In Fig. 2b, the cooling curve before 167 Ma is assumed. As the age of paragenetic muscovite is 206.9±0.8 Ma, a slow cooling process could exist between 210 Ma and 165.5 Ma (the cooling curve passes through the muscovite age point Fig. 2b). When the sample was cooled to 324℃ (at 165.5 Ma), a fast cooling process started (40℃/Ma) and developed until temperature dropped down to 225℃ (at 163 Ma). It can be seen in Fig. 3 that the samples DX334 and DX54 are at an isothermal level and at the same "isothermal" state during 163～102 Ma. Again like sample DX54, the sample exhbits a fast cooling beginning from 102 Ma (15℃/Ma). Finally, it can be seen that these two differently occurring samples each recorded a fast cooling event from 102 Ma to 97 Ma.

4.1.2 North Jiangsu tectonic melange belt

K-feldspar sample MH89-7 was collected from chlorite schist in Guanyun of northern Jiangsu, which is located in the suture between the North China and Yangtze plates. An assumed low limit age of an early fast cooling event was 245 Ma, it is similar to that of sample DX 54, but an "isothermal" stage also exists between 245 Ma and 187 Ma, (lasting 58 Ma with a temperature change of 40℃). The second fast cooling event took place between 187 Ma and 189 Ma with a cooling rate of 15℃/Ma, approximately corresponding to the fast cooling event given by samples MH89-11, 12 and 13 (Fig. 3), which were collected from the Donghai-Lianyungang zone, North Jiangsu.

4.1.3 Tancheng-Lujiang fault zone

K-feldspar sample MH89-14 from gneiss in the Tancheng-Lujiang fault zone at Shuanghu, Donghai County, North Jiangsu, yields a ^{40}Ar-^{39}Ar age of 120～199 Ma (Fig. 2e), and its minimum age by correcton at a lower temperature stage is 78 Ma. As the age of paragenetic biotite is 217.9±1.3 Ma, a fast cooling event might exist between 210 Ma and 195 Ma, and a cooling event at least after 199 Ma is supported by evidence of age spectra. This cooling event is conincident with the second cooling event found in sample MH89-7 and that found in samples MH89-11, 12 and 13. A very slow cooling took place between 165 Ma and 125 Ma. Then the second fast cooling event occurred between 125 Ma and 120 Ma, with a cooling rate of 18℃/Ma. This fast cooling event is also confirmed by samples MH89-15 and 16, which were collected from a branch fault of the Tancheng-Lujiang fault zone in the same area. After this event a slow cooling else occurred. If previously obtained K-Ar age of gouge and fission-track age of apatite from the Yishu fault are taken into account, this slow cooling together with uplifting history can last about 30 Ma.

4.2 Possible Tectonic Implications

In combination with field observations, the fast cooling events and "isothermal" stages given by the above nine samples may have the following tectonic implications:

(1) A fast cooling event is assumed to occur before 210 Ma according to various geologic indications in the studied areas, it corresponds to minimum time interval from the collision between North China and Yangtze plates to the closing and uplifting of the extensive area.

(2) The fast cooling event with a cooling rate of 40℃/Ma between 195 Ma and 190 Ma in the North Jiangsu-Jiaonan region and the fast cooling event with a cooling rate of 15℃/Ma between 187 Ma and 180 Ma in the suture between North China and Yangtze plates did not be found in the Dabie Mountains area, indicating that sinistral strike-slip movement along the Tancheng-Lujiang fault zone before the fast cooling made them separate, causing the geologic bodies which were originally located in the Dabie Mountains area to migrate to the North Jiangsu area.

(3) The fast cooling event between 165 Ma and 163 Ma (represented by sample DX334) led the eclogite body to connect with that at a long isothermal state (represented by sample DX54) and then together with it retained a steady isothermal state till to 102 Ma.

(4) The fast cooling event between 125 Ma and 120 Ma in the Tancheng-Lujiang fault zone (represented by samples MH89-14, 15 and 16) is approximately contemporaneos with the formation of fault gouge, which was previously dated to be the late stage of early Cretaceous, suggesting that this fault zone has undergone a strong uplifting in the middle Cretaceous.

(5) The fast cooling event with a cooling rate of 15℃/Ma in the Dabie Mountains area between 102 Ma and 97 Ma might correspond to the last uplifting and locating of this region.

5 Conclusions

The MDD model can be used to study the continuous cooling (uplifting) of geological bodies in a temperature range of 150～400℃. In this paper, using the cooling curves of nine K-feldspar samples and tectonic evolution history obtained by inversion in combination with field observations, an evolutional process of vertical and horizontal movements of the North Jiangsu-Jiaonan-Dabie tectonic melange belt is established. From chronological aspect, this process supports the formation and recovery model of the Dabie-Jiangsu-Shandong ultrahigh-pressure metamophic belt suggested by Arall Okey[7]. This work is only a preliminary attempt. Undoubtedly, there many problems remain to be solved.

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