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阿尔泰递增变质带中夹层石英岩的LA-ICP-MS 碎屑锆石U-Pb年龄:对沉积时限及物源的限定

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提要:阿尔泰造山带广泛分布各种变质沉积岩并发育典型递增变质带,变质沉积岩变质之前的沉积时代与物源特征 对于限定成岩历史以及造山带演化具有重要意义。文章对采自阿勒泰组变质带中石英岩夹层样品进行了岩相学分 析并采用LA-ICP-MS 方法对其碎屑锆石进行了U-Pb 年代学分析。共获得100个谐和或近于谐和的碎屑锆石年 龄,表面年龄分布范围为(443±5) Ma 至(2682±19) Ma。碎屑锆石年龄主要集中在寒武纪(486~540 Ma)并具有527~ 535 Ma 的年龄峰值,可能源于区域内同时代的岩浆活动。新元古代年龄约占1/4,少量锆石具有古中元古代甚至太 古宙年龄。结合年轻碎屑锆石年龄以及直接侵入该变质带中的英云闪长岩年龄可确定石英岩原岩的沉积时限为早 志留世—早泥盆世,其后发生变质作用。古老碎屑锆石在该地区缺乏对应的岩石,可能源于区内隐伏的古老基底岩 石或邻区古老陆块。

关 键 词: 阿尔泰造山带;石英岩;碎屑锆石;LA-ICP-MS;U-Pb定年 中图分类号:P597 文献标志码:A 文章编号:1000-3657(2016)02-0500-11

LA-ICP-MS detrital zircon U-Pb ages of interbedded quartzite from the metamorphic belt of the Chinese Altay: Constraint on depositional time and provenance

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Abstract: Progressive metamorphic belts occur extensively in Chinese Altay. The depositional time and provenance of the

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metasediments in the metamorphic belts are critical for understanding the rock-forming process and the evolution of the orogen. Based on petrological analysis, the authors conducted LA-ICP-MS U-Pb analysis of detrital zircons from the quartzite narrowly interbedded in the metamorphic belt and yielded 100 concordant or nearly concordant ages with a range from (443±5) Ma to (2682± 19) Ma. Most of the detrital zircons have Cambrian ages of 486~540 Ma with the peaks between 527 and 535 Ma. One fourth of the zircon grains show Neoproterozoic ages. A few detrital zircon grains formed in the Meso-Paleoproterozoic period and even in the Archean period. Combining the youngest detrital zircon age with the emplacement time of the tonalite which directly intruded in the metamorphic belt, it could be inferred that the protolith of the quartzite deposited between the Early Silurian and the Early Devonian and later experienced metamorphism. The Cambrian and even younger detrital zircons were possibly derived from the contemporaneous igneous rocks in the region. Since the lack of Precambrian rocks in the Chinese Altay, the Precambrian detrital zircons may imply a hidden ancient basement in the region or could be ascribed to a faraway source from the neighboring block.

Key words: Altay orogen; quartzite; detrital zircon; LA-ICP-MS; U-Pb ages

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中国阿尔泰造山带是中亚造山带的重要组成 部分,一般认为由弧体系拼贴于西伯利亚板块而形 成[1-4]。阿尔泰地区广泛发育花岗质侵入岩[5-10]和 变质沉积岩。变质沉积岩主要包括片岩、片麻岩等 岩石类型[11-13],并发育十分完善的递增变质带[14-17]。 变质沉积岩中保留并记录了丰富的物质信息和演 化历史[18-21],分析变质沉积岩的物质来源以及形成 过程对理解地质演化具有重要意义。关于阿尔泰 地区的变质沉积岩已有相关研究并取得了一些重 要认识[9,19,22-23],但由于其分布广泛,成分上具有明显 不同,变质沉积岩的形成时代以及物源在空间上可 能存在一定差异,同时缺乏对典型递增变质带中变 质沉积岩的直接研究。本文选取阿勒泰市附近阿 勒泰组递增变质带中石英岩夹层样品进行LA-ICP -MS 碎屑锆石 U-Pb 年龄分析, 直接限定了递增变 质带中变质沉积岩原岩的沉积时限并讨论了变质 沉积岩原岩的物质来源。

1 区域地质

中国阿尔泰造山带是中亚造山带的一部分,呈 NW向展布,向西北延至哈萨克斯坦的矿区阿尔泰 和俄罗斯的山区阿尔泰,向东南连至蒙古的戈壁阿 尔泰(图1-a),北邻西萨彦岭古岛弧带,南侧以额尔 齐斯断裂与准噶尔地块相接^[1-2,14,16,24-27]。阿尔泰造山 带于晚前寒武纪处于稳定大陆边缘阶段^[16,24-25,28],自 寒武纪以来转变为活动陆缘环境^[9,22],并长期处于俯

冲环境[1-2]。根据已有的地质调查该区域一般被分 成5个主要的NW-SE向延伸的构造单元[14,17,25](图 1-b):(1)阿尔泰山区块体,中晚泥盆世的火山岩(安 山岩和英安岩)以及晚泥盆世到早石炭世的变质沉 积岩(页岩、粉砂岩、杂砂岩、砂岩、灰岩)构成了该块 体的主体,多数沉积岩已经变质到绿片岩相印。(2) 西北阿尔泰山块体,主要包括哈巴河群的浊积岩及 其上覆的白哈巴群的晚奥陶世火山岩。前人认为 哈巴河群形成于震旦—寒武纪^[11]或南华—震旦纪^[29] 或新元古代(震旦纪)到中奥陶世[25];而最近的锆石 年代学表明哈巴河群形成的时代下限是470 Ma,上 限是384 Ma,即中奥陶世到早泥盆世,目形成于活 动大陆边缘构造环境[30]。哈巴河群的岩石已经发生 等倾褶皱,具有很陡的轴面,并变质到低绿片岩 相。(3)中阿尔泰山块体,该块体构成了中国西北阿 尔泰造山带的中心部分,主要由中奥陶世到早泥盆 世的哈巴河群^[30](主要是大陆碎屑组成的浊积岩)以 及中一晚志留世的库鲁木提群组成。在该块体中 的沉积岩已经发生了各种级别的变质,从绿片岩相 到高角闪岩相,一般达到较高的变质相。该块体的 北部边界为红山嘴断裂。(4)阿巴宫块体,康布铁堡 组以及阿勒泰组构成了阿巴宫块体的主体,康布铁 堡组主要由晚志留世到早泥盆世的弧火山岩和火 山碎屑岩构成,也包括少量基性火山岩和细碧 岩[2,8.25]。康布铁堡组可能形成于弧背景而非大陆裂 谷背景[2.25]。阿勒泰组由中泥盆世的变质岩构成,



图 1 阿尔泰地区地质简图(据文献[17]修改) I —阿尔泰山区块体; II—西北阿尔泰山块体; II—中阿尔泰山块体; IV—阿巴宫块体; V—额尔齐斯块体 Fig. 1 Geological map of the Altay region (modified after reference [17]) I –Altay Mountains; II –Northwest Altay; III—Central Altai; IV–Abagong Terrane; V–Erqis Terrane

从绿片岩相到高角闪岩相的变质带在该地块出露,局部地区达到了麻粒岩相^[31]。(5)额尔齐斯块体,北 部边界为科沙哈拉尔断裂,在南部,额尔齐斯断裂 将额尔齐斯地块与准噶尔板块分开。该块体自西 往东变窄,在其东部宽度只有 10 km 左右,其西部 被第四纪沉积物覆盖,主要由早古生代到泥盆纪的 沉积岩及石炭纪火山碎屑岩组成,它们已经变质到 绿片岩到角闪岩相。高级片麻岩在局部地区出露, 之前被认为是前寒武纪的基底^[32],而新的锆石年代 学研究表明其可能形成于石炭纪^[33]。阿尔泰造山 带发育有蓝晶石型和红柱石型两种不同压力类型 的变质带。蓝晶石型变质带从低向高出现黑云母

2 样品特征

阿勒泰市西部发育有典型递增变质带,传统上 归于阿勒泰组。其中变质程度较低的黑云母带中 有较窄的石英岩夹层,样品A7110采自该夹层中(图 1-c)。岩相学显示其主要矿物为石英(约为92%), 并含角闪石约为5%)(图2-a~c)及非常少量的黑云 母(图2-d)、绿帘石和斜长石等。石英常呈变余粒



图2 石英岩岩相显微图片 Qtz—石英; Bt—黑云母; Amp—角闪石; Ep—绿帘石; a、b、d—单偏光; c—正交光 Fig. 2 Petrographic microphotos of the quartzite Qtz-Quartz; Bt-Biotite; Amp-Amphibole; Ep-Epidote; a,b,d-Under plainlight; c-Under crossed nicols

状结构,大小为0.2~1 mm,可见石英颗粒间构成 120°三边平衡结构(图2-c)。角闪石长径多在0.4~ 2 mm,单偏光下呈淡绿色,正交光下呈稻黄色及黄 绿色,呈定向一半定向排列(图2-a)。斜长石已发生 微弱蚀变。

3 分析方法

样品经磨碎淘洗和重液分选后在显微镜下完成锆石颗粒挑选。将锆石置于双面胶带上固定,注入环氧树脂制靶。在光学显微镜下拍摄反射和透射光图像,并在扫描电子显微镜上照射阴极发光(CL)图像以帮助确定合适的分析点。LA-ICP-MS 锆石 U-Pb定年在天津地质矿产研究所完成,激光 束斑直径35 μm,用GJ-1作为外部锆石年龄标准来 进行U、Pb同位素分馏校正,利用NIST610 玻璃标 样作为外标计算锆石样品的U、Pb、Th含量。原始 数据处理方法采用中国地质大学的ICPMSDataCal 程序,年龄计算及谐和图绘制使用Isoplot3.0^[36]程序 完成,采用²⁰⁴Pb法进行普通铅校正。按照碎屑锆石 的年龄范围,对于²⁰⁶Pb/²³⁸U年龄小于1200 Ma的,采 用²⁰⁶Pb/²³⁸U的表面年龄,对于²⁰⁶Pb/²³⁸U年龄大于 1200 Ma的,采用²⁰⁷Pb/²⁰⁶Pb的表面年龄^[37-38]。

4 碎屑锆石特征与测年结果

石英岩样品碎屑锆石颗粒多呈棱柱状,阴极发 光(CL)图像显示其常发育清晰的震荡环带(图 3中

a~t),具有岩浆锆石形貌特征,其Th/U比值也通常 大于0.1,与岩浆成因锆石特征相符;少部分锆石颗 粒呈浑圆状,不发育清晰的韵律生长环带(图3u~y),浑圆状的特征可能由长时间的搬运磨蚀造 成。同时碎屑锆石边部均发育很窄的增生边,呈灰 白色,可能形成于沉积成岩之后的变质过程。对锆石 核部进行LA-ICP-MS碎屑锆石U-Pb年龄分析,得 到100个谐和或接近谐和的数据点(表1和图4)。

样品A7110的碎屑锆石表面年龄分布范围为 (443±5) Ma至(2682±19) Ma(图5),主要集中于寒武 纪(486~540 Ma),多达56%,其中年龄峰值出现在 527~535 Ma;该组锆石绝大多数发育清晰的震荡环 带,且Th/U比值大于0.1,具有明显的岩浆成因特征, 少部分锆石呈浑圆状,无清晰的震荡环带,但Th/U比 值仍较高(>0.1)(表1,图3-x~y)。样品中具有新元 古代年龄(542~971 Ma)的锆石较多,达28%,并在 544~553 Ma和620~629 Ma年龄段上较集中。该样 品最年轻碎屑锆石形成于晚奥陶世((443±5) Ma与 (451±5) Ma);还有较少锆石具有中元古代年龄 (1020~1094 Ma)和古元古代年龄(1731~2460 Ma)。 两颗碎屑锆石显示谐和的太古宙年龄(²⁰⁶Pb/²⁰⁷Pb年龄 (2675±19) Ma,Th/U=0.768,Disc=-4;²⁰⁶Pb/²⁰⁷Pb年龄 (2682±19) Ma,Th/U=0.651,Disc=1)。

5 讨 论

质

5.1 递增变质带中变质沉积岩的沉积时限

阿勒泰市西部典型递增变质带属于阿勒泰组, 该组分布于哈巴河—阿勒泰—富蕴—带,其主要为



图 3 石英岩碎屑锆石 CL 图像 Fig. 3 CL images for the detrital zircons of the quartzite

http://geochina.cgs.gov.cn 中国地质, 2016, 43(2)

表1 石英岩碎屑锆石 U-Pb 年龄测试结果

Table 1 U–Pb dating results for the detrital zircons of the quartzite														
御母子	Th/II		同位素比值/10-6						表面年龄/Ma					
	Th/O	²⁰⁶ Pb/ ²³⁸ U	1σ	²⁰⁷ Pb/ ²³⁵ U	1σ	²⁰⁷ Pb/ ²⁰⁶ Pb	1 σ	²⁰⁶ Pb/ ²³⁸ U	1σ	²⁰⁷ Pb/ ²³⁵ U	1σ	²⁰⁷ Pb/ ²⁰⁶ Pb	1σ	
A7110														
01	0.514	0.0829	0.0009	0.6590	0.0301	0.0576	0.0027	514	6	514	24	516	103	0
02	0.586	0.0933	0.0011	0.7963	0.0593	0.0619	0.0045	575	7	595	44	670	157	4
03	0.341	0.0910	0.0010	0.7511	0.0181	0.0599	0.0014	561	6	569	14	599	49	2
04	0.104	0.1572	0.0016	1.5268	0.0204	0.0705	0.0008	941	10	941	13	942	24	0
05	0.374	0.0836	0.0009	0.6653	0.0089	0.0577	0.0007	518	5	518	7	519	25	0
06	0.756	0.0862	0.0009	0.7214	0.0096	0.0607	0.0007	533	5	551	7	628	25	4
07	0.708	0.1115	0.0012	0.9588	0.0137	0.0623	0.0008	682	7	683	10	686	27	0
08	0.446	0.0825	0.0009	0.6634	0.0259	0.0583	0.0022	511	6	517	20	541	83	1
09	1.273	0.0859	0.0009	0.6900	0.0153	0.0583	0.0012	531	5	533	12	540	47	1
10	0.675	0.0819	0.0009	0.6665	0.0161	0.0590	0.0014	508	5	519	13	567	50	2
11	0.375	0.0769	0.0008	0.6047	0.0108	0.0570	0.0009	478	5	480	9	491	36	1
12	0.161	0.0874	0.0009	0.7049	0.0093	0.0585	0.0007	540	6	542	7	548	26	0
13	0.464	0.0834	0.0009	0.6656	0.0280	0.0579	0.0024	516	6	518	22	526	89	1
14	0.228	0.0865	0.0009	0.6984	0.0093	0.0585	0.0007	535	6	538	7	549	26	1
15	0.253	0.0874	0.0009	0.7083	0.0093	0.0588	0.0007	540	6	544	7	559	25	1
16	0.861	0.0868	0.0009	0.6989	0.0093	0.0584	0.0007	536	6	538	7	545	26	0
1 7	0.440	0.0880	0.0009	0.7092	0.0095	0.0584	0.0007	544	6	544	7	547	26	0
18	0.488	0.0896	0.0010	0.7305	0.0264	0.0591	0.0021	553	6	557	20	571	76	1
19	0.441	0.0878	0.0009	0.7117	0.0111	0.0588	0.0008	542	6	546	9	560	31	1
20	0.359	0.0711	0.0008	0.5588	0.0365	0.0570	0.0037	443	5	451	29	492	144	2
21	0.597	0.0773	0.0008	0.6260	0.0099	0.0587	0.0009	480	5	494	8	557	32	3
22	0.705	0.1412	0.0017	1.3311	0.0803	0.0684	0.0041	851	10	859	52	880	124	1
23	0.477	0.0908	0.0009	0.7391	0.0170	0.0591	0.0013	560	6	562	13	569	48	0
24	0.768	0.5559	0.0057	13.9797	0.1818	0.1824	0.0021	2850	29	2748	36	2675	19	-4
25	0.382	0.0883	0.0009	0.7175	0.0099	0.0589	0.0007	546	6	549	8	564	27	1
26	0.714	0 1714	0.0018	1 6669	0.0223	0.0705	0.0008	1020	10	996	13	944	24	-2
27	0.743	0.4596	0.0048	10 1651	0.1838	0.1604	0.0028	2438	26	2450	44	2460	29	1
28	0.229	0.3505	0.0037	6.6135	0.1004	0.1369	0.0017	1937	21	2061	31	2188	22	6
20	0.580	0.0896	0.0009	0.7386	0.0103	0.0598	0.0007	553	6	562	8	595	27	2
30	0.573	0.0828	0.0009	0.6623	0.0177	0.0580	0.0015	513	5	516	14	531	56	1
31	0.539	0.0853	0.0009	0.6858	0.0117	0.0583	0.0009	528	5	530	9	541	35	1
32	0.588	0.0970	0.0010	0.8499	0.0254	0.0635	0.0019	597	6	625	19	726	62	5
33	0.101	0.0906	0.0000	0.7410	0.0100	0.0593	0.0007	559	6	563	8	578	26	1
34	0.312	0.1065	0.0003	0.0410	0.0134	0.0618	0.0008	652	8	655	10	666	27	0
35	0.012	0.1485	0.0015	1 / 2/9	0.0104	0.0018	0.0008	802	9	800	13	017	27	1
36	0.684	0.1405	0.0012	1.5249	0.0591	0.0738	0.0026	971	10	991	35	1036	71	2
37	0.004	0.1747	0.0017	1.0040	0.0259	0.0750	0.0020	1038	11	1098	15	1210	23	6
38	0.315	0.1010	0.0011	0.8460	0.0257	0.0608	0.0010	620	7	622	11	630	34	1
39	0.618	0.1025	0.0017	0.8640	0.0199	0.0611	0.0013	629	, 7	632	15	644	46	1
40	0.335	0.1025	0.0012	0.7217	0.0133	0.0589	0.0015	549	6	552	25	563	95	0
41	0.308	0.0859	0.0010	0.7217	0.0140	0.0502	0.0011	531	6	540	11	576	41	2
42	0.300	0.0856	0.0011	0.6050	0.0140	0.0592	0.0032	530	7	536	30	562	110	1
42	0.376	0.1553	0.0011	1 5358	0.0384	0.0717	0.0032	031	10	945	24	078	51	2
43	0.113	0.1555	0.0017	0.7060	0.0221	0.0580	0.0018	538	6	542	17	562	67	1
44	0.500	0.0070	0.0010	0.8876	0.0221	0.0589	0.0018	643	8	645	24	653	86	0
45	0.300	0.2207	0.0013	4 9201	0.0520	0.1050	0.0023	1842	10	1700	24	1721	21	2
40	0.373	0.0952	0.0034	0 6020	0.0052	0.1039	0.0012	104Z	19	524	23 0	565	∠ I 20	-5
47	0.411	0.0017	0.0009	0.0928	0.0100	0.0579	0.0008	521	2 -	500	07	500	20	∠ 1
48	0.185	0.0770	0.0008	0.6061	0.0085	0.0578	0.0007	300	2	209 401	7	323	23	1
49	0.334	0.0770	0.0008	0.0001	0.0094	0.0571	0.0008	4/8	5	481	/	490	22	1
50	0.757	0.5012	0.0009	12 6667	0.0107	0.1922	0.0008	327	27	329	8	338	32 10	1
51	0.051	0.3013	0.0052	0.6505	0.1629	0.1832	0.0021	2620	27	2000	54	2082	19	1
52	1.064	0.0798	0.0012	0.6505	0.1036	0.0592	0.0097	495	7	509	81	573	356	5
53	0.417	0.0845	0.0009	0.6756	0.0089	0.0580	0.0007	523	5	524	1	530	26	1
54	0.750	0.0854	0.0009	0.6920	0.0151	0.0588	0.0012	528	5	534	12	560	45	1

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A7110 55 1.643 0.1292 0.0014 1.2479 0.0370 0.019 783 8 822 24 930 55 5 55 0.508 0.0384 0.009 0.6790 0.0142 0.558 0.0008 51 5 52.5 8 6612 11 541 52 11 541 52 11 541 52 11 541 52 11 541 52 11 541 51 525 8 612 11 51 50 328 0.0544 0.0009 0.6331 0.0008 7.63 50 50 7 513 26 1 60 0.576 0.013 0.0040 0.6037 0.0007 504 5 507 7 513 26 13 3 3 6 6 6 6 113 13 23 3 3 6 6 6 113 1147 0.003 13	测试点		²⁰⁶ Pb/ ²³⁸ U	1σ	²⁰⁷ Pb/ ²³⁵ U	1σ	²⁰⁷ Pb/ ²⁰⁶ Pb	1σ	²⁰⁶ Pb/ ²³⁸ U	1σ	²⁰⁷ Pb/ ²³⁵ U	1σ	²⁰⁷ Pb/ ²⁰⁶ Pb	1σ	Disc
55 1.643 0.129 0.0044 0.0390 0.0710 0.0011 753 8 822 24 9.30 55 5 56 0.779 0.0845 0.0009 0.6790 0.0100 0.590 0.0008 515 5 526 11 541 54 5 528 5 6 12 31 5 59 0.828 0.0099 0.633 0.0007 523 5 529 7 555 26 1 60 0.576 0.0470 0.572 0.0007 506 5 507 7 522 26 1 61 0.013 0.0049 0.6474 0.0037 0.551 0.517 10 535 24 13 3 64 0.951 0.013 1.1479 0.114 0.0064 0.0009 131 110 53 11 131 33 65 0.575 0.1740 0.013 1.479	A7110														
56 0.779 0.0831 0.0099 0.6764 0.0100 0.0583 0.0011 523 5 526 11 541 43 1 57 0.508 0.0031 0.0099 0.6764 0.0090 0.6828 0.0099 4.711 5 4.96 8 6.12 3 58 0.828 0.0444 0.0090 0.6831 0.0097 5006 5 507 7 513 2.6 1 61 0.0111 0.0088 0.6477 0.0087 0.0075 504 5 507 7 513 2.6 1 63 0.961 0.0808 0.6497 0.0087 0.018 501 5 517 7 513 2.6 1 63 0.961 0.0488 0.009 0.639 0.018 5011 5 5 5 10 8.33 2.4 3 64 0.298 0.124 0.0154 0.0050 0.0018	55	1.643	0.1292	0.0014	1.2479	0.0370	0.0701	0.0019	783	8	822	24	930	55	5
57 0.508 0.008 0.0078 0.0008 0.613 0.00758 0.0008 0.629 0.0009 0.629 0.0009 0.471 5 496 8 612 31 5 0 0.576 0.0075 0.0007 0.573 0.0008 4471 5 496 8 612 26 1 60 0.576 0.0075 0.0007 0.573 0.0008 451 5 460 7 513 26 0 61 1.111 0.0813 0.0008 0.6477 0.0087 0.0007 504 5 507 7 513 26 0 64 0.980 0.124 0.0113 1.1479 0.0124 0.0008 764 8 71 10 8.35 24 3 65 0.123 0.013 1.498 0.0140 0.0000 1013 11 1080 15 13 543 13 16 537 11 1	56	0.779	0.0845	0.0009	0.6790	0.0142	0.0583	0.0011	523	5	526	11	541	43	1
58 0.613 0.0758 0.0009 0.602 0.0009 471 5 496 8 612 31 5 59 0.828 0.0844 0.0009 0.6831 0.0080 0.0573 0.0007 523 5 529 7 555 26 1 60 0.575 0.0071 0.0081 0.0575 0.0007 566 5 507 7 513 26 0 61 0.0181 0.0080 0.6477 0.0087 0.0576 0.0007 566 5 507 7 513 22 6 1 63 0.0128 0.0121 0.0154 0.0056 0.0018 756 8 776 10 835 24 3 64 0.288 0.0101 0.0142 0.0668 0.0008 753 10 752 24 3 6 0.475 0.1748 0.0393 0.0012 0.0123 0.011 0.0013	57	0.508	0.0831	0.0009	0.6764	0.0100	0.0590	0.0008	515	5	525	8	568	29	2
59 0.828 0.0841 0.0099 0.0571 0.0077 523 5 529 7 555 26 1 60 0.0756 0.0072 0.0723 0.0088 0.0573 0.0008 451 5 507 7 513 26 0 61 1.111 0.0808 0.0070 0.0576 0.0077 504 5 507 7 513 26 1 63 0.961 0.0808 0.0009 0.653 0.0299 0.0576 0.0007 504 5 507 7 512 26 1 64 0.298 0.124 0.013 1.147 0.0099 0.0108 513 5 545 11 0.832 2 3 65 0.163 0.123 0.013 1.046 0.0000 0.0137 111 1068 15 113 23 3 66 0.163 0.0290 0.0146 0.0000 0.021 <t< td=""><td>58</td><td>0.613</td><td>0.0758</td><td>0.0008</td><td>0.6298</td><td>0.0099</td><td>0.0602</td><td>0.0009</td><td>471</td><td>5</td><td>496</td><td>8</td><td>612</td><td>31</td><td>5</td></t<>	58	0.613	0.0758	0.0008	0.6298	0.0099	0.0602	0.0009	471	5	496	8	612	31	5
60 0.576 0.0752 0.0007 5.723 0.0088 0.0573 0.0008 451 5 460 7 502 29 2 61 1.111 0.0813 0.0008 0.477 0.0087 0.5576 0.0007 506 5 507 7 513 26 1 63 0.561 0.8813 0.0009 0.6579 0.0254 0.0774 0.0008 766 8 776 10 835 24 3 64 0.250 0.1746 0.0012 0.0254 0.0774 0.0009 756 8 767 10.68 15 113 23 3 66 0.163 0.1233 0.012 0.0546 0.0001 231 5 545 11 6.34 0.487 0.009 0.6970 0.123 0.0012 513 5 537 8 566 29 1 70 0.474 0.0887 0.0008 0.523 0.0007 <td>59</td> <td>0.828</td> <td>0.0844</td> <td>0.0009</td> <td>0.6831</td> <td>0.0090</td> <td>0.0587</td> <td>0.0007</td> <td>523</td> <td>5</td> <td>529</td> <td>7</td> <td>555</td> <td>26</td> <td>1</td>	59	0.828	0.0844	0.0009	0.6831	0.0090	0.0587	0.0007	523	5	529	7	555	26	1
61 1.111 0.0818 0.0008 0.6477 0.0087 0.0007 506 5 507 7 513 2.6 1 62 0.651 0.0818 0.0009 0.653 0.0209 0.0558 0.0017 504 5 507 7 522 2.6 1 64 0.288 0.0009 0.663 0.0209 0.0568 0.0008 756 8 776 10 835 2.4 3 65 0.250 0.1744 0.0012 0.9146 0.0668 0.0008 628 8 674 12 8.002 2.0 1 66 0.654 0.0858 0.0009 0.670 0.012 0.916 5.0 5.37 8 5.66 29 1 70 0.475 0.3450 0.003 5.865 0.0766 0.1233 0.0014 1910 20 1956 26 2005 2.0 2 1 71 0.3450 0.009 0.6794 0.0084 0.0533 0.0007 533 6 534	60	0.576	0.0725	0.0007	0.5723	0.0083	0.0573	0.0008	451	5	460	7	502	29	2
62 0.681 0.0813 0.0008 0.6477 0.0087 0.018 501 5 517 6 500 67 3 63 0.204 0.01013 1.147 0.0003 1.141 0.0013 5 517 10 852 24 3 64 0.228 0.1744 0.0013 1.147 0.003 1.11 1068 15 111 0.33 24 3 65 0.250 0.1744 0.0012 0.0162 0.0668 0.0008 6.28 8 674 12 830 26 7 66 0.123 0.0013 1.0984 0.0142 0.0660 0.0012 531 5 537 8 566 29 1 70 0.4475 0.3450 0.0003 5.865 0.0761 0.1014 1910 20 1955 517 7 512 7 512 7 512 7 512 7 512 513<	61	1.111	0.0816	0.0008	0.6477	0.0085	0.0576	0.0007	506	5	507	7	513	26	0
63 0.961 0.888 0.0009 0.6639 0.0296 0.018 501 5 517 16 590 67 3 64 0.298 0.1244 0.0019 1.8428 0.0244 0.074 0.0008 756 8 776 10 835 2.4 3 66 0.163 0.102 0.0191 1.8428 0.0244 0.0744 0.0088 6.74 12 830 26 7 67 0.543 0.0019 1.628 0.0140 0.0646 0.0007 749 8 545 11 603 42 3 68 0.0757 0.133 0.014 0.013 10.94 0.013 1.94 3 5 537 8 566 20 2	62	0.651	0.0813	0.0008	0.6477	0.0087	0.0578	0.0007	504	5	507	7	522	26	1
64 0.298 0.1244 0.0013 1.1479 0.0154 0.0669 0.0008 756 8 776 10 835 24 3 65 0.250 0.1746 0.0012 0.4164 0.0162 0.0668 0.0008 6288 8 674 12 830 26 7 67 0.654 0.0858 0.0009 0.7100 0.0146 0.0600 0.0012 531 5 545 11 603 42 3 68 0.977 0.1233 0.0014 0.0007 749 8 753 10 762 24 1 69 0.748 0.0877 0.0036 5.8665 0.0766 0.1233 0.0014 1910 21 1956 26 2052 2065 20 2 2 1 73 0.393 0.0883 0.009 6533 0.007 533 6 535 7 541 26 0 27	63	0.961	0.0808	0.0009	0.6639	0.0209	0.0596	0.0018	501	5	517	16	590	67	3
65 0.250 0.1746 0.0019 1.8628 0.0254 0.0774 0.0009 1037 11 1068 15 1131 23 3 66 0.163 0.1023 0.0012 0.9416 0.0162 0.0088 628 8 674 12 830 26 7 67 0.654 0.0088 0.0009 0.7100 0.0146 0.0001 531 5 545 11 603 422 1 69 0.748 0.0857 0.0036 5.8665 0.0766 0.1233 0.0141 1910 20 1955 26 2005 20 2 71 0.434 0.0794 0.0088 6.0270 0.0084 0.0573 0.0007 493 5 494 7 502 26 1 73 0.393 0.0833 0.0090 6.652 0.0124 0.0010 510 5 30 7 541 26 0 74	64	0.298	0.1244	0.0013	1.1479	0.0154	0.0669	0.0008	756	8	776	10	835	24	3
66 0.163 0.1023 0.0012 0.9416 0.0162 0.0068 0.0012 531 5 545 11 603 42 3 68 0.957 0.1233 0.0013 1.0984 0.0143 0.0646 0.0007 749 8 743 10 762 24 1 69 0.748 0.0857 0.0003 5.8665 0.0766 0.1233 0.0014 1910 20 1956 26 2005 20 2 71 0.348 0.0798 0.0008 6.6270 0.0084 0.0571 0.0007 493 5 494 7 502 26 1 73 0.393 0.0852 0.0009 6.6520 0.0573 0.0007 533 6 535 7 541 26 1 74 0.439 0.8852 0.0024 0.0573 0.0007 486 5400 6 506 25 1 74 0.435	65	0.250	0.1746	0.0019	1.8628	0.0254	0.0774	0.0009	1037	11	1068	15	1131	23	3
67 0.654 0.0858 0.0009 0.7100 0.0140 0.0600 0.0017 749 8 753 10 762 24 1 69 0.748 0.0857 0.003 1.0984 0.0143 0.0690 0.0007 749 8 753 10 762 24 1 69 0.748 0.0357 0.0365 5.666 200 20 22 202 2 70 0.475 0.3450 0.0008 0.622 0.0084 0.0573 0.0017 493 5 495 7 497 26 0 71 0.348 0.0794 0.0090 0.6830 0.0007 533 6 533 7 541 26 0 7 433 0.0833 0.0007 533 6 534 6 566 25 1 7 0.782 0.0823 0.0090 0.6734 0.0090 0.6749 0.0013 517 5 <td< td=""><td>66</td><td>0.163</td><td>0.1023</td><td>0.0012</td><td>0.9416</td><td>0.0162</td><td>0.0668</td><td>0.0008</td><td>628</td><td>8</td><td>674</td><td>12</td><td>830</td><td>26</td><td>7</td></td<>	66	0.163	0.1023	0.0012	0.9416	0.0162	0.0668	0.0008	628	8	674	12	830	26	7
68 0.957 0.1233 0.0013 1.0984 0.0143 0.0646 0.0007 749 8 753 10 762 24 1 69 0.748 0.857 0.009 0.6970 0.0120 0.0590 0.008 530 5 537 8 566 29 1 70 0.475 0.0345 0.008 0.6220 0.0084 0.0571 0.007 493 5 494 7 502 26 1 73 0.333 0.0863 0.009 0.6822 0.0164 0.007 493 5 494 7 502 26 1 74 0.439 0.0852 0.009 0.6852 0.0164 0.001 510 530 10 618 37 4 6 0.465 0.0784 0.008 0.619 0.0013 517 5 546 12 670 45 6 76 0.745 0.0862 0.00	67	0.654	0.0858	0.0009	0.7100	0.0146	0.0600	0.0012	531	5	545	11	603	42	3
690.7480.08570.00090.69700.01020.05900.000853055378566291700.4750.34500.00365.86650.07660.12330.001419102019562620052026710.3480.07980.00880.62200.00840.05710.000749554947502261730.3930.08630.00990.69340.00720.05830.000753365357541260740.4390.88220.00990.68500.00440.010051055530106183774750.7820.08340.00090.6180.00240.010748654906506251760.4560.07840.00890.6190.0013517554612670456780.7110.8840.00090.6550.0180.0530.0008453365348541310791.0130.13580.00411.25560.02560.00750455118584303810.5210.8280.00990.65950.0180.00752565447622254830.4870.08130.00990.65950.0075256544	68	0.957	0.1233	0.0013	1.0984	0.0143	0.0646	0.0007	749	8	753	10	762	24	1
70 0.475 0.3450 0.0036 5.8665 0.0766 0.1233 0.0014 1910 20 1956 26 2005 20 2 71 0.348 0.0798 0.0008 0.6282 0.0084 0.0571 0.0007 495 5 495 7 497 26 0 72 0.595 0.0794 0.0008 0.6234 0.0022 0.0583 0.0007 533 6 535 7 541 26 0 74 0.439 0.0823 0.0009 0.6852 0.0126 0.0604 0.0017 510 5 530 10 618 37 4 76 0.465 0.0784 0.0008 0.6198 0.0082 0.013 511 5 546 12 670 45 6 78 0.711 0.0834 0.0009 0.6595 0.018 0.0578 0.0018 821 9 826 17 840 40 1 </td <td>69</td> <td>0.748</td> <td>0.0857</td> <td>0.0009</td> <td>0.6970</td> <td>0.0102</td> <td>0.0590</td> <td>0.0008</td> <td>530</td> <td>5</td> <td>537</td> <td>8</td> <td>566</td> <td>29</td> <td>1</td>	69	0.748	0.0857	0.0009	0.6970	0.0102	0.0590	0.0008	530	5	537	8	566	29	1
71 0.348 0.0798 0.0008 0.6282 0.0084 0.0571 0.0007 493 5 495 7 497 26 0 72 0.595 0.0794 0.0008 0.6270 0.0084 0.0573 0.0007 433 5 494 7 502 26 1 73 0.433 0.0863 0.0009 0.6852 0.0092 0.0583 0.0007 533 6 535 7 542 27 1 75 0.782 0.0822 0.0009 0.6852 0.0142 0.0001 510 5 530 10 618 37 4 76 0.465 0.0784 0.0009 0.6198 0.0013 517 5 546 12 670 45 6 78 0.711 0.0862 0.0009 0.6525 0.018 0.0583 0.0008 533 6 534 8 541 31 0 3 3 3 3 3 3 3 3 3 3 3 3 <td< td=""><td>70</td><td>0.475</td><td>0.3450</td><td>0.0036</td><td>5.8665</td><td>0.0766</td><td>0.1233</td><td>0.0014</td><td>1910</td><td>20</td><td>1956</td><td>26</td><td>2005</td><td>20</td><td>2</td></td<>	70	0.475	0.3450	0.0036	5.8665	0.0766	0.1233	0.0014	1910	20	1956	26	2005	20	2
72 0.595 0.0794 0.0008 0.6270 0.0084 0.0573 0.0007 493 5 494 7 502 26 1 73 0.393 0.0863 0.0009 0.6934 0.0092 0.0833 0.0007 533 6 535 7 541 26 0 74 0.439 0.0822 0.0009 0.6850 0.0044 0.0010 510 5 530 7 542 27 1 75 0.782 0.0823 0.0009 0.6852 0.0126 0.0004 0.0017 510 5 530 10 618 37 4 76 0.455 0.0784 0.0007 0.466 0.0744 5 546 12 670 45 6 77 0.317 0.0834 0.0009 0.6925 0.018 0.0013 511 5 546 12 670 45 6 78 0.711 0.0862 0.0256 0.0013 513 5 511 8 84 30 33	71	0.348	0.0798	0.0008	0.6282	0.0084	0.0571	0.0007	495	5	495	7	497	26	0
73 0.393 0.0863 0.0009 0.6934 0.0092 0.0583 0.0007 533 6 535 7 541 26 0 74 0.439 0.0852 0.0099 0.6850 0.0094 0.0583 0.0007 527 5 530 7 542 27 1 75 0.782 0.0823 0.0099 0.6852 0.0126 0.0604 0.010 510 5 530 10 618 37 4 76 0.465 0.0784 0.0008 0.6198 0.0012 0.017 0.0013 517 5 546 12 670 45 6 78 0.711 0.0638 0.0009 0.0255 0.0188 0.0013 821 9 826 17 840 40 1 80 0.633 0.0799 0.008 0.6548 0.011 0.0595 0.008 495 5 511 8 584 30 33 81 0.521 0.0828 0.0093 0.6555 0.0007 525	72	0.595	0.0794	0.0008	0.6270	0.0084	0.0573	0.0007	493	5	494	7	502	26	1
74 0.439 0.0852 0.0009 0.6850 0.0094 0.0583 0.0007 527 5 530 7 542 27 1 75 0.782 0.0823 0.0009 0.6852 0.0126 0.0604 0.0010 510 5 530 10 618 37 4 76 0.465 0.0784 0.0009 0.7119 0.0177 0.0619 0.0013 517 5 546 12 670 45 6 78 0.711 0.0862 0.0009 0.6925 0.0108 0.0533 0.0008 533 6 534 8 541 31 0 91 1.013 0.1388 0.0111 1.2556 0.0256 0.0071 0.013 513 5 511 8 584 30 3 81 0.521 0.0828 0.009 0.6555 0.0188 0.0075 5007 533 17 534 28 14 15 521 61 0 82 0.413 0.0849 0.0090	73	0.393	0.0863	0.0009	0.6934	0.0092	0.0583	0.0007	533	6	535	7	541	26	0
75 0.782 0.0823 0.0009 0.6852 0.0126 0.0604 0.0010 510 5 530 10 618 37 4 76 0.465 0.0784 0.0008 0.6198 0.0082 0.0574 0.0007 486 5 490 6 506 25 1 77 0.317 0.0834 0.0009 0.7119 0.0157 0.0619 0.0013 517 5 546 12 670 45 6 78 0.711 0.0822 0.0014 1.2556 0.0256 0.0013 821 9 826 17 840 40 1 80 0.0521 0.0188 0.0578 0.0016 5113 5 514 15 521 61 0 81 0.521 0.0828 0.0009 0.6595 0.0188 0.0077 504 5 509 7 534 28 1 84 0.278 0.0784 0.0099 0.6257 0.0407 0.0579 0.0037 486 6 493 <	74	0.439	0.0852	0.0009	0.6850	0.0094	0.0583	0.0007	527	5	530	7	542	27	1
76 0.465 0.0784 0.0008 0.6198 0.0082 0.0574 0.0007 486 5 490 6 506 25 1 77 0.317 0.0834 0.0009 0.7119 0.0157 0.0619 0.0013 517 5 546 12 670 45 6 78 0.711 0.0822 0.0009 0.6925 0.0108 0.0583 0.008 533 6 534 8 541 31 0 79 1.013 0.1358 0.0014 1.2556 0.0256 0.0671 0.0013 821 9 826 17 840 40 1 80 0.063 0.0799 0.0008 0.6595 0.1188 0.0578 0.0016 513 5 514 15 521 61 0 82 0.413 0.0849 0.0009 0.6595 0.0879 0.0007 504 5 509 7 534 14 2 83 0.487 0.0813 0.0009 0.6597 0.0037 486	75	0.782	0.0823	0.0009	0.6852	0.0126	0.0604	0.0010	510	5	530	10	618	37	4
77 0.317 0.0834 0.0009 0.7119 0.0157 0.0619 0.0013 517 5 546 12 670 45 6 78 0.711 0.0862 0.0099 0.6925 0.0108 0.0583 0.0008 533 6 534 8 541 31 0 79 1.013 0.1358 0.0014 1.2556 0.0256 0.0671 0.0013 821 9 826 17 840 40 1 80 0.063 0.0799 0.0008 0.6548 0.011 0.0595 0.0008 495 5 511 8 584 30 3 81 0.521 0.0828 0.0009 0.7083 0.0092 0.0605 0.0007 525 6 544 7 622 25 4 83 0.487 0.0819 0.0009 0.6257 0.0477 0.0037 486 6 493 32 526 141 2 85 0.788 0.0839 0.0008 0.6570 0.0077 488	76	0.465	0.0784	0.0008	0.6198	0.0082	0.0574	0.0007	486	5	490	6	506	25	1
78 0.711 0.0862 0.0009 0.6925 0.0108 0.0583 0.0008 533 6 534 8 541 31 0 79 1.013 0.1358 0.0014 1.2556 0.0256 0.0671 0.0013 821 9 826 17 840 40 1 80 0.063 0.0799 0.0008 0.6548 0.0101 0.0595 0.008 495 5 511 8 584 30 3 81 0.521 0.0828 0.0009 0.6595 0.018 0.007 525 6 544 7 622 25 4 83 0.487 0.0813 0.009 0.6257 0.0407 0.0579 0.0037 486 6 493 32 526 141 2 85 0.758 0.0839 0.009 0.6899 0.020 0.0596 0.018 520 6 533 17 590 67 3 86 0.420 0.0787 0.0008 0.6513 0.013 0.0579	77	0.317	0.0834	0.0009	0.7119	0.0157	0.0619	0.0013	517	5	546	12	670	45	6
79 1.013 0.1358 0.0014 1.2556 0.0256 0.0671 0.0013 821 9 826 17 840 40 1 80 0.063 0.0799 0.008 0.6548 0.0101 0.0595 0.008 495 5 511 8 584 30 3 81 0.521 0.0828 0.0009 0.6595 0.0188 0.0578 0.0016 513 5 514 15 521 61 0 82 0.413 0.0849 0.0009 0.7083 0.0092 0.0605 0.0007 504 5 509 7 534 28 1 84 0.278 0.0784 0.0009 0.6257 0.407 0.0579 0.0037 486 6 493 32 526 141 2 85 0.758 0.0839 0.0009 0.6899 0.020 0.0579 0.0007 488 5 489 6 493 25 0 87 0.994 0.0816 0.0008 0.0579 0.0007	78	0.711	0.0862	0.0009	0.6925	0.0108	0.0583	0.0008	533	6	534	8	541	31	0
80 0.063 0.0799 0.008 0.6548 0.0101 0.0595 0.008 495 5 511 8 584 30 3 81 0.521 0.0828 0.009 0.6595 0.0188 0.0578 0.0016 513 5 514 15 521 61 0 82 0.413 0.0849 0.009 0.7083 0.092 0.6055 0.0007 525 6 544 7 622 25 4 83 0.487 0.0813 0.0008 0.6515 0.093 0.0579 0.0037 486 6 493 32 526 141 2 85 0.758 0.0839 0.009 0.6899 0.0220 0.0596 0.0018 520 6 533 17 590 67 3 86 0.420 0.0787 0.0008 0.6190 0.081 0.0579 0.0007 488 5 489 6 493 25 0 87 0.994 0.0816 0.0008 0.6513 0.013 <	79	1.013	0.1358	0.0014	1.2556	0.0256	0.0671	0.0013	821	9	826	17	840	40	1
81 0.521 0.0828 0.0009 0.6595 0.0188 0.0578 0.0016 513 5 514 15 521 61 0 82 0.413 0.0849 0.0009 0.7083 0.092 0.0605 0.0007 525 6 544 7 622 25 4 83 0.487 0.0813 0.0008 0.6515 0.0093 0.0581 0.0007 504 5 509 7 534 28 1 84 0.278 0.0784 0.009 0.6257 0.0407 0.0579 0.0037 486 6 493 32 526 141 2 85 0.758 0.0839 0.009 0.6899 0.0220 0.0596 0.0018 520 6 533 17 590 67 3 86 0.420 0.0787 0.008 0.6513 0.0103 0.0579 0.0008 505 5 509 8 526 32 1 88 0.687 0.1195 0.0013 1.1408 0.0217	80	0.063	0.0799	0.0008	0.6548	0.0101	0.0595	0.0008	495	5	511	8	584	30	3
82 0.413 0.0849 0.0009 0.7083 0.0092 0.0605 0.0007 525 6 544 7 622 25 4 83 0.487 0.0813 0.0008 0.6515 0.0093 0.0581 0.0007 504 5 509 7 534 28 1 84 0.278 0.0784 0.0009 0.6257 0.0407 0.0579 0.0037 486 6 493 32 526 141 2 85 0.758 0.0839 0.0009 0.6899 0.0220 0.0596 0.0018 520 6 533 17 590 67 3 86 0.420 0.0787 0.0008 0.6190 0.0081 0.0570 0.0002 55 509 8 526 32 1 88 0.687 0.1195 0.0013 1.1408 0.0217 0.0692 0.0012 728 8 773 15 906 36 6 89 0.826 0.0863 0.0009 0.6577 0.0093 0.0585	81	0.521	0.0828	0.0009	0.6595	0.0188	0.0578	0.0016	513	5	514	15	521	61	0
83 0.487 0.0813 0.0008 0.6515 0.0093 0.0581 0.0007 504 5 509 7 534 28 1 84 0.278 0.0784 0.0009 0.6257 0.0407 0.0579 0.0037 486 6 493 32 526 141 2 85 0.758 0.0839 0.0009 0.6899 0.0220 0.0596 0.0018 520 6 533 17 590 67 3 86 0.420 0.0787 0.0008 0.6190 0.0081 0.0570 0.0007 488 5 489 6 493 25 0 87 0.994 0.0816 0.0088 0.6513 0.0103 0.0579 0.0007 534 5 509 8 526 32 1 88 0.687 0.1195 0.013 1.1408 0.0217 0.0692 0.0017 534 5 536 7 547 26 1 90 0.331 0.0847 0.009 0.6771 0.0090	82	0.413	0.0849	0.0009	0.7083	0.0092	0.0605	0.0007	525	6	544	7	622	25	4
84 0.278 0.0784 0.0009 0.6257 0.0407 0.0579 0.0037 486 6 493 32 526 141 2 85 0.758 0.0839 0.0009 0.6899 0.0220 0.0596 0.0018 520 6 533 17 590 67 3 86 0.420 0.0787 0.0008 0.6190 0.0081 0.0570 0.0007 488 5 489 6 493 25 0 87 0.994 0.0816 0.0008 0.6513 0.0103 0.0579 0.0008 505 5 509 8 526 32 1 88 0.687 0.1195 0.0013 1.1408 0.0217 0.692 0.0012 728 8 773 15 906 36 6 89 0.826 0.0863 0.0009 0.6577 0.0093 0.589 0.0007 534 5 525 7 530 26 0 91 0.495 0.0863 0.0099 0.0589 0.0007	83	0.487	0.0813	0.0008	0.6515	0.0093	0.0581	0.0007	504	5	509	7	534	28	1
85 0.758 0.0839 0.0009 0.6899 0.0220 0.0596 0.0018 520 6 533 17 590 67 3 86 0.420 0.0787 0.0008 0.6190 0.0081 0.0570 0.0007 488 5 489 6 493 25 0 87 0.994 0.0816 0.0008 0.6513 0.0103 0.0579 0.0008 505 5 509 8 526 32 1 88 0.687 0.1195 0.0013 1.1408 0.0217 0.0692 0.0017 534 5 536 7 547 26 1 90 0.331 0.0847 0.0009 0.6771 0.0990 0.0589 0.0007 534 5 525 7 530 26 0 91 0.495 0.0863 0.0099 0.6789 0.0007 534 6 537 7 549 25 1 92 0.282 0.0864 0.0099 0.6965 0.0095 0.584 0.0007	84	0.278	0.0784	0.0009	0.6257	0.0407	0.0579	0.0037	486	6	493	32	526	141	2
86 0.420 0.0787 0.0008 0.6190 0.0081 0.0570 0.0007 488 5 489 6 493 25 0 87 0.994 0.0816 0.0008 0.6513 0.0103 0.0579 0.0008 505 5 509 8 526 32 1 88 0.687 0.1195 0.0013 1.1408 0.0217 0.0692 0.0012 728 8 773 15 906 36 6 89 0.826 0.0863 0.0009 0.6957 0.0093 0.0585 0.0007 534 5 525 7 530 26 0 90 0.331 0.0847 0.0099 0.6771 0.0090 0.0589 0.0007 534 6 539 8 562 27 1 92 0.282 0.0864 0.0099 0.6965 0.0095 0.0584 0.0007 535 6 537 7 546 26 0 93 0.521 0.0865 0.0099 0.0581 0.0008	85	0.758	0.0839	0.0009	0.6899	0.0220	0.0596	0.0018	520	6	533	17	590	67	3
87 0.994 0.0816 0.0008 0.6513 0.0103 0.0579 0.0008 505 5 509 8 526 32 1 88 0.687 0.1195 0.0013 1.1408 0.0217 0.0692 0.0012 728 8 773 15 906 36 6 89 0.826 0.0863 0.0009 0.6957 0.0093 0.0585 0.0007 534 5 536 7 547 26 1 90 0.331 0.0847 0.0009 0.6771 0.0090 0.0580 0.0007 534 6 539 8 562 27 1 92 0.282 0.0864 0.0099 0.6966 0.091 0.0585 0.0007 534 6 537 7 549 25 1 93 0.521 0.0865 0.0099 0.6965 0.0095 0.0584 0.0007 535 6 537 7 546 26 0 94 0.404 0.0821 0.0008 0.6576 0.0988	86	0.420	0.0787	0.0008	0.6190	0.0081	0.0570	0.0007	488	5	489	6	493	25	0
88 0.687 0.1195 0.0013 1.1408 0.0217 0.0692 0.0012 728 8 773 15 906 36 6 89 0.826 0.0863 0.0009 0.6957 0.0093 0.0585 0.0007 534 5 536 7 547 26 1 90 0.331 0.0847 0.0099 0.6771 0.0090 0.0580 0.0007 524 5 525 7 530 26 0 91 0.495 0.0863 0.0099 0.7008 0.099 0.0589 0.0007 534 6 539 8 562 27 1 92 0.282 0.0864 0.0099 0.6965 0.095 0.0584 0.0007 535 6 537 7 549 25 1 93 0.521 0.0865 0.0099 0.0584 0.0007 535 6 537 7 546 26 0 94 0.404 0.0821 0.0008 0.6576 0.0098 0.581 0.0008	87	0.994	0.0816	0.0008	0.6513	0.0103	0.0579	0.0008	505	5	509	8	526	32	1
89 0.826 0.0863 0.0009 0.6957 0.0093 0.0585 0.0007 534 5 536 7 547 26 1 90 0.331 0.0847 0.0099 0.6771 0.0090 0.0580 0.0007 524 5 525 7 530 26 0 91 0.495 0.0863 0.0099 0.7008 0.099 0.0589 0.0007 534 6 539 8 562 27 1 92 0.282 0.0864 0.0099 0.6966 0.091 0.0585 0.0007 534 6 537 7 549 25 1 93 0.521 0.0865 0.0099 0.6965 0.098 0.0581 0.0007 535 6 537 7 546 26 0 94 0.404 0.0821 0.0088 0.6576 0.098 0.0581 0.0008 509 5 513 8 534 30 1 95 0.434 0.0866 0.0099 0.7012 0.0584	88	0.687	0.1195	0.0013	1.1408	0.0217	0.0692	0.0012	728	8	773	15	906	36	6
90 0.331 0.0847 0.0009 0.6771 0.0090 0.0580 0.0007 524 5 525 7 530 26 0 91 0.495 0.0863 0.0099 0.7008 0.099 0.0589 0.0007 534 6 539 8 562 27 1 92 0.282 0.0864 0.0099 0.6966 0.091 0.0585 0.0007 534 6 537 7 549 25 1 93 0.521 0.0865 0.0099 0.6965 0.095 0.0584 0.0007 535 6 537 7 546 26 0 94 0.404 0.821 0.0088 0.6576 0.0098 0.0581 0.0008 509 5 513 8 534 30 1 95 0.434 0.0866 0.0099 0.7012 0.0102 0.0584 0.0007 533 5 535 7 544 26 0 96 0.391 0.0862 0.0099 0.6938 0.0094	89	0.826	0.0863	0.0009	0.6957	0.0093	0.0585	0.0007	534	5	536	7	547	26	1
91 0.4951 0.0001 534 6 539 8 562 27 1 92 0.282 0.0864 0.0009 0.6966 0.0091 0.0585 0.0007 534 6 537 7 549 25 1 93 0.521 0.0865 0.0009 0.6965 0.0095 0.0584 0.0007 535 6 537 7 546 26 0 94 0.404 0.821 0.0088 0.6576 0.0098 0.0581 0.0008 509 5 513 8 534 30 1 95 0.434 0.0866 0.0009 0.7012 0.0102 0.0584 0.0007 533 5 535 7 544 26 0 97 0.647	90	0.331	0.0847	0.0009	0.6771	0.0090	0.0580	0.0007	524	5	525	7	530	26	0
91 0.105 0.0001 0.1000 0.0001 0.1000 0.0001 0.1000 0.0001 0.1000 0.0001 0.1000 0.0001 535 6 537 7 546 26 0 94 0.404 0.0821 0.0008 0.6576 0.0098 0.0581 0.0008 509 5 513 8 534 30 1 95 0.434 0.0866 0.0009 0.7012 0.0102 0.0584 0.0007 533 5 535 7 544 26 0 96 0.391 0.0864 0.0009 0.6957 0.0102 0.0584 0.0007 533 <	91	0.495	0.0863	0.0009	0.7008	0.0099	0.0589	0.0007	534	6	539	8	562	27	ĩ
93 0.521 0.0865 0.009 0.6965 0.0095 0.0584 0.0007 535 6 537 7 546 26 0 94 0.404 0.0821 0.0008 0.6576 0.0098 0.0581 0.0008 509 5 513 8 534 30 1 95 0.434 0.0866 0.0099 0.7012 0.0102 0.0584 0.0007 535 6 540 8 558 29 1 96 0.391 0.0862 0.0099 0.6938 0.0094 0.0584 0.0007 533 5 535 7 544 26 0 97 0.647 0.0864 0.0099 0.6957 0.0102 0.0584 0.0008 534 6 536 8 545 29 0 98 0.715 0.0868 0.0099 0.7007 0.0104 0.0586 0.0008 537 6 539 8 551 30 1 99 1.205 0.1424 0.0015 1.3459 0.0339	92	0.282	0.0864	0.0009	0.6966	0.0091	0.0585	0.0007	534	6	537	7	549	25	1
94 0.404 0.0821 0.0008 0.6576 0.0098 0.0581 0.0008 509 5 513 8 534 30 1 95 0.434 0.0866 0.0009 0.7012 0.0102 0.0588 0.0008 535 6 540 8 558 29 1 96 0.391 0.0862 0.0009 0.6938 0.0094 0.0584 0.0007 533 5 535 7 544 26 0 97 0.647 0.0864 0.0009 0.6957 0.0102 0.0584 0.0008 534 6 536 8 545 29 0 98 0.715 0.0868 0.0009 0.7007 0.0104 0.0586 0.0008 537 6 539 8 551 30 1 99 1.205 0.1424 0.0015 1.3459 0.0339 0.0686 0.0017 858 9 866 22 886 50 1 100 0.255 0.1850 0.00321 0.0331 0.0010	93	0.521	0.0865	0.0009	0.6965	0.0095	0.0584	0.0007	535	6	537	7	546	26	0
94 0.404 0.	94	0.404	0.0821	0.0008	0.6576	0.0098	0.0581	0.0008	509	5	513	8	534	30	1
96 0.391 0.0862 0.0009 0.6938 0.0094 0.0584 0.0007 533 5 535 7 544 26 0 97 0.647 0.0864 0.0009 0.6957 0.0102 0.0584 0.0008 534 6 536 8 545 29 0 98 0.715 0.0868 0.0009 0.7007 0.0104 0.0586 0.0008 537 6 539 8 551 30 1 99 1.205 0.1424 0.0015 1.3459 0.0339 0.0686 0.0017 858 9 866 22 886 50 1 100 0.255 0.1850 0.0022 2.1272 0.0331 0.0834 0.0010 1094 13 1158 18 1279 24 6	95	0.434	0.0866	0.0000	0.7012	0.0102	0.0588	0.0008	535	6	540	8	558	29	1
97 0.647 0.0864 0.0009 0.6957 0.0102 0.0584 0.0008 534 6 536 8 545 29 0 98 0.715 0.0868 0.0009 0.7007 0.0104 0.0586 0.0008 537 6 539 8 551 30 1 99 1.205 0.1424 0.0015 1.3459 0.0339 0.0686 0.0017 858 9 866 22 886 50 1 100 0.255 0.1850 0.0022 2.1272 0.0331 0.0834 0.0010 1094 13 1158 18 1270 24 6	96	0 301	0.0862	0.0009	0.6938	0.0004	0.0584	0.0007	533	5	535	7	544	26	0
98 0.715 0.0069 0.0099 0.0102 0.0086 0.0008 534 0 536 6 545 29 0 98 0.715 0.0868 0.0009 0.7007 0.0104 0.0586 0.0008 537 6 539 8 551 30 1 99 1.205 0.1424 0.0015 1.3459 0.0339 0.0686 0.0017 858 9 866 22 886 50 1 100 0.255 0.1850 0.0022 2.1272 0.0331 0.0834 0.0010 1094 13 1158 18 1279 24 6	07	0.571	0.0864	0.0009	0.6950	0.0094	0.0584	0.0007	535	5	535	/ 8	545	20 20	0
99 1.205 0.1424 0.0015 1.3459 0.0339 0.0686 0.0017 858 9 866 22 886 50 1 100 0.255 0.1850 0.0022 2.1272 0.0331 0.0834 0.0010 1094 13 1158 18 1270 24 6	21 QQ	0.047	0.0004	0.0009	0.0937	0.0102	0.0586	0.0008	537	6	530	o Q	551	27 30	1
27 1.203 0.1424 0.0013 1.3437 0.0030 0.0017 636 9 600 22 680 30 1 100 0.255 0.1850 0.0027 2.1277 0.0331 0.0834 0.0010 1.004 13 1158 18 1270 24 6	20 00	1 205	0.1424	0.0009	1 3/150	0.0104	0.0500	0.0017	920	0	557 866	0 22	886	50	1
(1)	100	0.255	0.1850	0.0013	2 1272	0.0331	0.0834	0.0010	1094	13	1158	18	1279	24	6



图 4 石英岩碎屑锆石 U-Pb 年龄谐和图 Fig. 4 U-Pb concordia diagrams for detrital zircon of the quartzite





一套浅变质海相碎屑岩,同时还常发育有中一高级 变质岩系^[11,16]。根据其中发现的珊瑚、腕足类等化石 组合,其时代被认定为中泥盆世^[11,25],而对于其中中 一高级变质岩系的时代归属则存在争议^[12,16,39-40]。龙 晓平根据阿勒泰市东南约40 km处采集的石榴矽线 片麻岩碎屑锆石年轻年龄^[27](约为465 Ma) 以及阿 勒泰市西北侵入阿勒泰组的塔尔浪花岗质侵入体 年龄^[10](约为412 Ma)认为塔尔浪及哈拉苏南的阿勒 泰组形成时代介于中奥陶世和早泥盆世之间。阿 勒泰市西部典型递增变质带中石英岩样品的碎屑 锆石U-Pb年龄结果显示最年轻的碎屑锆石形成于 早志留世(443 Ma),该变质沉积岩原岩应在早志留 世或之后沉积形成,而直接侵入该变质带中的英云 闪长岩的侵位年龄为409 Ma^[41],限定了沉积时代 的下限。因此,该石英岩及同层位的变质沉积岩原 岩的沉积时代应在早志留世至早泥盆世之间,其后 发生变质作用,形成递增变质带。该结果直接限定 了阿勒泰市西部递增变质带变质沉积原岩的沉积 时限。

5.2 递增变质带中变质沉积岩的物源分析

阿尔泰地区自寒武纪以来已处于活动陆缘阶 段,广泛发育岩浆活动,形成大量侵入岩,并具有不 同的峰期:500 Ma,470~460 Ma,410~380 Ma,360 Ma^[8-9,42-46]。石英岩样品中多数碎屑锆石具有岩浆 成因并具有寒武纪以及更年轻的年龄,主要集中于 寒武纪及早奥陶世 (471~540 Ma)(图 5),可能主要来 源于本区内的同时期侵入岩,是该时期岩浆强烈活 动的反映。前寒武纪锆石主要集中于新元古代 (542~971 Ma),类似的古老前寒武纪锆石同样出现 于阿尔泰地区其他变质沉积岩中[22-23,47-48]。样品中 还出现少量 古元古代和太古宙的碎屑锆石,这些碎 屑锆石常具有较好的磨圆,推测经历了长时间的搬 运与磨蚀。阿尔泰地区的哈巴河群、可可托海地区 的康布铁堡组中的变质沉积岩以及阿舍勒盆地泥 盆纪火山岩中[9,48-49],同样存在古元古代和太古宙的 碎屑锆石。在阿尔泰地区并未发现与这些前寒武 纪碎屑锆石对应的古老陆块,这些前寒武纪碎屑锆 石被认为来自隐伏的古老基底岩石[12,47,50]或区外古 老陆块[23]。

6 结 论

(1)递增变质带夹层石英岩中碎屑锆石的最小 年龄为(443±5) Ma,反映了该石英岩原岩的最大沉 积时限,结合直接侵入其中的英云闪长岩年龄,推 测石英岩原岩的沉积时限可能为早志留世—早泥 盆世之间,应代表了阿勒泰市西部典型递增变质带 变质沉积原岩的沉积时限。

(2)石英岩样品中多数碎屑锆石具有寒武纪以 及更年轻的年龄,应与区域内同时期的岩浆活动有 关;而古老的前寒武纪碎屑锆石可能来源于隐伏的

质

中

古老基底岩石或区外古老陆块。

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