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江南造山带东段赣东北广丰地区翁家岭组凝灰岩SHRIMP锆石U-Pb年龄及地质意义

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提要：本文通过对赣东北广丰地区翁家岭组凝灰岩样品中的锆石进行研究，首次测得了翁家岭组凝灰岩SHRIMP锆石U-Pb年龄（841.2±5.1）Ma，约束了翁家岭组形成的时代，明确该套沉积岩为田里片岩之上、桃源组（上墅组）之下的一套地层。根据最新获得的大量高精度年龄数据，确定翁家岭组在层位上与梵净山群、四堡群、冷家溪群、双桥山群相当；覆于翁家岭组之上的桃源组是与侵入到梵净山群、四堡群、冷家溪群、双桥山群的火山侵入岩以及浦江地区“平水群”、江山市“章村组”同时期的火山侵入或喷出产物。江南造山带自西向东在830 Ma期间曾广泛发育一期岩浆活动事件。

关　键　词：江南造山带；翁家岭组；凝灰岩；SHRIMP锆石U-Pb定年

中图分类号：P597^{+}.3；P534.3　　**文献标志码**：A　　**文章编号**：1000-3657 (2015)01-0096-09

Zircon SHRIMP U-Th-Pb dating of the Wengjialing Formation in the eastern segment of the Jiangnan orogenic belt in northeast Jiangxi Province and its geological implications

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Abstract: Zircon dating of tuff bedding from the Wengjialing Formation in the east segment of the Jiangnan orogenic belt within northeast Jiangxi Province is reported for the first time in this paper (841.2±5.1 Ma), which constrains the age of the Wengjialing Formation, suggesting that it lies above Tianli schist and beneath the Taoyuan Formation. In combination with a large number of high precision ages obtained for the Jiangnan orogenic belt recently, the authors hold that the Wengjialing Formation corresponds to the Fanjingshan Group, the Sibao Group, the Lengjiaxi Group, and the Shuangqiaoshan Group. The Taoyuan Group overlying the Wengjialing Formation was formed in the same period as the volcanic rocks which intruded into the Fanjingshan Group, the Sibao

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Group, the Lengjiaxi Group, and the Shuangqiaoshan Group, and also occurred simultaneously with the "Pingshui Group" in Pujiang City, Zhejiang Province, and the "Zhangcun Formation" in Jiangshan City, Zhejiang Province. At 830 Ma, a magma event was widely developed from west to east in the Jiangnan orogenic belt.

Key words: Jiangnan orogenic belt; Wengjialing Formation; tuff; SHRIMP zircon U-Pb dating

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1　前　言

江南造山带作为扬子陆块和华夏陆块的拼接带,经历多期构造活动影响,构造和地层组合复杂,尤其是江南造山带东段赣东北的怀玉地区。其横跨扬子陆块和华夏陆块两个大地构造单元,位于江山—绍兴断裂带的北侧,属于两大陆块的聚合构造带部位,对于认识扬子陆块和华夏陆块的拼接和演化的过程具有重要的研究意义,因此众多地质工作者从构造分区、地层时代、构造演化等不同方面对其进行了深入的研究[1-14]。怀玉地层区[9]赣东北广丰地区发育田里片岩、翁家岭组、桃源组(现上墅组)等前寒武纪地层,其中田里片岩和桃源组研究较深,其地层时代和构造意义得到了确定[12,15-16],但翁家岭组却缺乏精确的年代数据,而对于广丰地区翁家岭组地层时代的厘定直接关系到对华夏陆块和扬子陆块俯冲碰撞以及江南造山带演化过程的认识,是查明华南地区前寒武纪构造演化的重要组成部分,具有重要的意义。本文通过高精度SHRIMP锆石U-Pb定年首次厘定了翁家岭组的地层时代,进而完善了怀玉地层区地层时代的标定。

2　地层背景

翁家岭组标准剖面位于江西广丰县下溪镇(现为西坊乡)翁岭村,为赣东北地质队于1977年区域地质调查时所创立,与下伏前震旦系田里片岩呈角度不整合接触,与上覆桃源组呈假整合接触。1:20万上饶幅区域地质调查报告❶将翁家岭组统归为震旦系漆工群,《江西省区域地质志》[17]将翁家岭组划归震旦系志棠组,《江西省岩石地层单元汇编及应用研究》❷采用了翁家岭组的地层名称。管太阳等[18]同样将翁家岭组视为田里组之上、桃源组之下的一套地层,认为其时代为青白口系。胡世玲等[19]、郝杰等[20]在研究田里片岩时都沿用了翁家岭组这一名称,并认为其为晋宁造山期的磨拉石建造。樊光明等[21]通过微古化石和地球化学数据分析认为翁家岭组为一套角度不整合于田里岩组和上墅组之上的地层,不仅否定了原意上的翁家岭组,而且还提出了该地层应为罗村组的新认识。江西省地质调查院完成的1:25万上饶市幅区域地质调查报告❸仍将翁家岭组视为田里组之上、桃源组(上墅组)之下的一套地层(表1)。

翁家岭组是一套紫红、黄绿色粉砂岩、粉砂质泥岩,仅见于广丰县翁岭村翁家岭一带(图1)。与下伏田里片岩呈角度不整合接触,其上覆地层分为3个组[9]:以粗面玄武岩、流纹质火山角砾岩、凝灰岩为主的桃源组(上墅组);泥岩、粉砂质泥岩、中部夹浅紫色灰岩瘤及底部以紫红色砾岩为主的罗村组;砾岩、杂砂岩夹粉砂岩、黄绿色粉砂质泥岩、页岩为主的听门组。关于广丰地区前寒武纪地层的时代,Li等[15]认为田里片岩的沉积年限为1.5~1.04 Ga,绿片岩化变质时间在1.04~1.02 Ga和0.97~0.94 Ga;Li等[22]获得了桃源组的地层时代为0.83 Ga。Wang等[23]在桃源组火山岩锆石中获得了820 Ma的SHRIMP U-Pb年龄。本文将给出翁家岭组中凝灰岩高精度的SHRIMP锆石U-Pb年龄,一方面限制了地层时代,对翁家岭组在广丰地层区地层柱中的位置做了标定;另一方面,为江南造山带沉积和构造演化的对比提供了新的数据。

3　岩相学及采样层位

翁家岭组为紫红色、黄绿色砾岩、砂砾岩、粉砂岩、千枚状页岩、硅质板岩,上部含泥质白云岩、灰

❶江西省地矿局区域地质调查大队. 1:20万上饶幅区域地质调查报告. 1984.

❷江西地矿局. 江西省岩石地层单元汇编及应用研究. 1991.

❸江西省地质调查院. 1:25万上饶市幅区域地质调查报告. 2002.

表1 翁家岭组地层认识过程(据文献[21]修改)

Table 1 Corresponding classification of the Wengjialing Formation (after reference [21])

层位		赣东北队(1977)		江西省地矿局(1984)		江西省地矿局(1991)		江西省地矿局(1994)		樊光明等(1999)		江西省地质调查院(2002)		本文	
新元古界	震旦系	听门组	震旦系	志堂组	震旦系	听门砂砾岩	震旦系	听门组	震旦系		震旦系	听门组	南华系	听门组	南华系
	青白口系	罗村组		上墅群	青白口系	罗村组		罗村组	青白口系	罗村组 双井段 翁家岭段	青白口系	罗村组 翁家岭组	青白口系	罗村组 上墅组 翁家岭组	青白口系
		桃源组				桃源火山岩		桃源组		上墅群		上墅组			
		翁家岭组				翁家岭组		翁家岭组							
中元古界	蓟县系	田里组		双桥山群(田里岩组)		田里组		田里岩组		田里岩组		田里岩组		田里岩组	

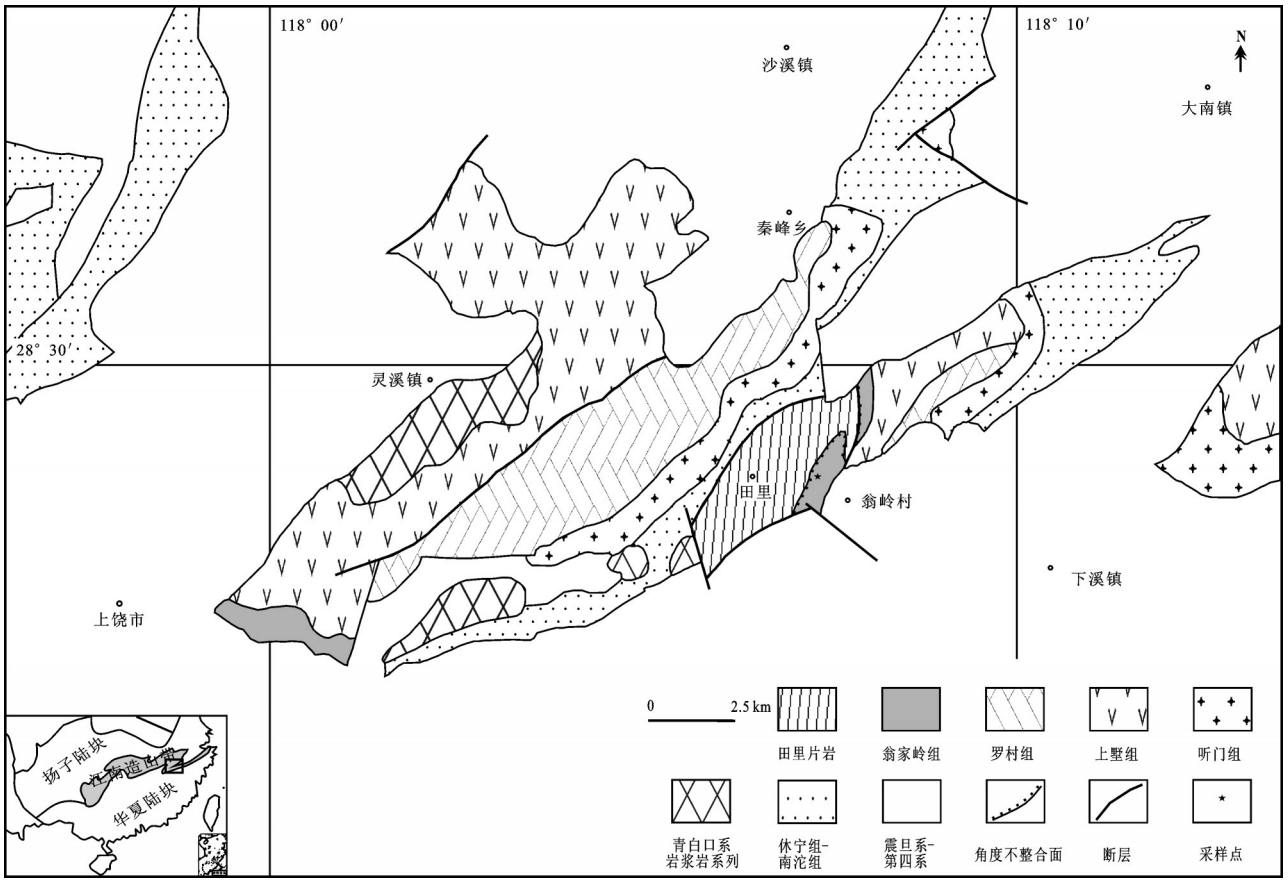

图1 研究区区域地质简图及采样位置

Fig.1 Simplified geological map of the study area, showing sampling sites

岩透镜体,底部含有大量的粗安岩砾石,以角度不整合覆于田里片岩之上。采样位置位于标准剖面江西广丰县下溪乡翁岭村,地理坐标:N28°28′02″,E118°08′36.6″。采样层位为一套粉砂岩中所夹凝灰岩。镜下观察为凝灰结构、纹层状构造。岩石由玻屑、火山尘组成。玻屑主呈弧面棱角状、Y形、鸡骨状等,与火山尘混杂分布,已脱玻为隐晶状长英质并具轻微粘土化等呈假像,部分玻屑具褐铁矿化,玻屑边界多较清楚。岩石因玻屑、火山尘相对富集差异分布显纹层状构造。岩石后期被碳酸盐、石英、钠长石、绿泥石、褐铁矿等呈网脉状交代较明显(图2)。

4　分析方法

锆石的分离在河北廊坊区域地质调查所实验室进行,锆石的阴极发光图像在北京离子探针中心HITACHI S-3000N扫描电镜上完成的,锆石U-Pb年龄测定在北京离子探针中心的SHRIMP-II上进行,详细的分析流程参考Lance[24-25]。年龄测定时仪器质量分辨率约为5000 (1%峰高),一次离子流O^{-2}强度为4 nA。一次离子流束斑直径为25~30μm,每个数据点测定由5次扫描构成。测定质量峰为$^{90}Zr^{16}O^{+}$、$^{204}Pb^{+}$、背景值、$^{206}Pb^{+}$、$^{207}Pb^{+}$、$^{208}Pb^{+}$、$^{238}U^{+}$、$(^{232}Th^{16}O)^{+}$和$(^{238}U^{16}O)^{+}$。分别采用标准锆石TEM和M257进行元素间的分馏校正及U含量标定;其中TEM具有U-Pb谐和年龄,其$^{206}Pb/^{238}U$年龄为(416.8±1.1)Ma,但U、Th及Pb含量不均一;标准锆石M257的$^{206}Pb/^{238}U$年龄为840 Ma。原始数据的处理和锆石U-Pb谐和图的绘制采用Ludwig博士编写的Squid和Isoplot程序[26]。普通铅校正根据实测的^{204}Pb进行,普通铅的组成根据Stacey给出的模式计算得到[27]。表2中年龄的误差为1σ绝对误差,同位素比值的误差为1σ相对误差;文中所使用$^{206}Pb/^{238}U$年龄加权平均值为95%的置信度。

5　分析结果

锆石的阴极发光图像(CL)特征(图3):所采锆石虽形态不尽相同,但是均显示出典型的岩浆生长振荡环带和韵律结构,属于岩浆结晶的产物。靶台上锆石样品在锆石的CL图像显示下,对照可见光下的特征进行选样,排除裂隙发育和较多包裹体的锆石颗粒。全部样品的锆石晶型完好,为浅黄色-无色透明钝圆形或柱状的晶体。锆石粒度多在100~200 μm。

锆石的U、Th含量及Th/U比值:翁家岭组凝灰岩样品(WJL130318-3)共测试了21个数据点,其中U含量变化范围为93×10^{-6}~299×10^{-6};Th含量变化范围为78×10^{-6}~385×10^{-6};Th/U值变化范围为0.68~1.76

图2　翁家岭组凝灰岩的野外露头及镜下特征

Fig.2　Photographs of the outcrop and microscopic chbaracteristics of tuff from the Wengjialing Formation

表2 翁家岭组样品WJL130318-3锆石SHRIMP U-Th-Pb同位素测定结果

Table 2 SHRIMP U-Th-Pb isotopic compositions of tuff (WJL130318-3) for zircons from the Wengjialing Formation

测点	$^{206}Pb_c$ /%	U /10^{-6}	Th /10^{-6}	$^{232}Th/^{238}U$	$^{206}Pb^*$ /10^{-6}	$^{206}Pb/^{238}U$ 年龄/Ma	$^{207}Pb/^{206}Pb$ 年龄/Ma	不谐和度 /%	$^{207}Pb^*/^{206}Pb^*$ 比值/σ%		$^{207}Pb^*/^{235}U$ 比值/σ%		$^{206}Pb^*/^{238}U$ 比值/σ%		误差相关系数
1.1	0.09	148	219	1.53	18.2	860±9	817±35	-5	0.08145	1.2	1.632	1.6	0.1453	1.1	0.670
2.1	0.03	301	199	0.68	36.0	840±7	815±21	-3	0.07249	0.91	1.401	1.3	0.1402	0.93	0.715
3.1	0.01	104	104	1.04	12.2	826±9	856±41	3	0.0675	1.8	1.275	2.1	0.1370	1.2	0.551
4.1	--	172	239	1.44	20.9	858±9	805±32	-6	0.07046	1.2	1.389	1.6	0.1429	1.1	0.665
5.1	--	116	107	0.95	14.0	851±9	845±53	-1	0.0724	1.5	1.420	1.9	0.1422	1.1	0.600
6.1	2.14	226	385	1.76	22.5	688±6	787±100	12	0.0505	4.1	0.772	4.2	0.1110	0.98	0.234
7.1	--	128	106	0.86	15.5	848±9	888±38	4	0.0747	1.4	1.462	1.8	0.1420	1.1	0.621
8.1	--	136	112	0.85	16.4	846±9	894±48	5	0.0701	1.4	1.361	1.8	0.1408	1.1	0.606
9.1	0.07	208	277	1.37	25.0	843±8	821±34	-3	0.07313	1.2	1.421	1.5	0.1409	1.0	0.662
10.1	0.07	179	172	0.99	21.4	838±8	802±33	-4	0.07059	1.2	1.357	1.6	0.1395	1.0	0.647
11.1	0.25	112	92	0.85	24.9	1472±16	1513±28	3	0.09203	1.1	3.252	1.5	0.2563	1.1	0.715
12.1	0.11	146	180	1.27	17.9	859±8	812±28	-6	0.07517	1.2	1.491	1.6	0.1439	1.0	0.663
13.1	0.19	142	114	0.83	16.7	828±8	765±42	-8	0.07532	1.2	1.440	1.6	0.1386	1.0	0.652
14.1	0.96	181	245	1.40	21.7	835±8	744±67	-12	0.07313	1.2	1.405	1.5	0.1394	1.0	0.654
15.1	--	93	78	0.87	11.0	831±10	889±36	6	0.0739	1.6	1.415	2.0	0.1389	1.3	0.619
16.1	--	113	118	1.08	13.6	844±9	854±32	1	0.0723	1.4	1.405	1.8	0.1409	1.1	0.612
17.1	0.22	282	294	1.08	33.4	833±9	803±29	-4	0.07604	0.86	1.463	1.4	0.1396	1.2	0.801
18.1	0.89	154	155	1.04	18.9	851±8	836±64	-2	0.06901	1.4	1.345	1.7	0.1414	1.0	0.600
19.1	--	171	141	0.85	20.2	828±8	816±30	-2	0.07314	1.1	1.394	1.5	0.1382	1.0	0.667
20.1	0.18	181	180	1.03	21.6	839±10	774±35	-8	0.07462	1.2	1.444	1.7	0.1403	1.2	0.733
21.1	--	299	300	1.04	35.4	833±7	833±21	0	0.07549	0.83	1.453	1.2	0.1396	0.92	0.743

注：Pb_c代表正常部分；Pb^*代表放射部分。

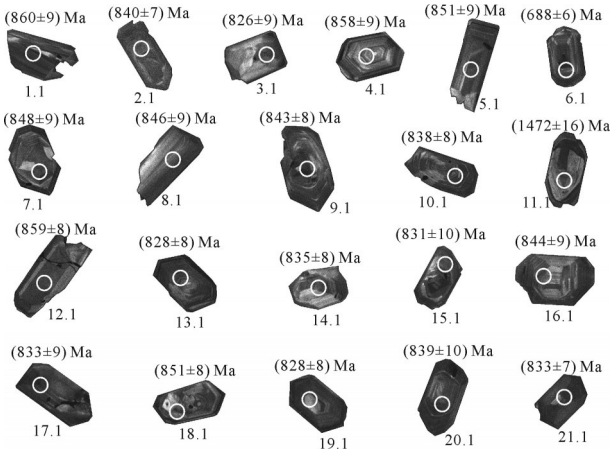

图3 翁家岭组凝灰岩样品的锆石CL图像

Fig.3 Cathodoluminescence images of zircons from tuff

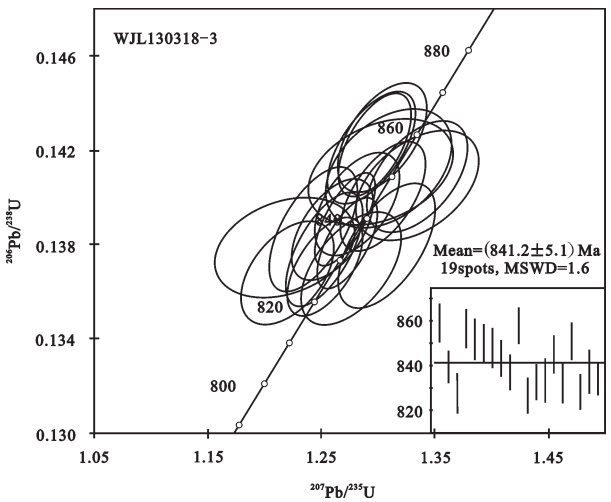

图4 翁家岭组凝灰岩锆石U-Pb年龄谐和图

Fig. 4 Zircon U-Pb concordia diagrams of tuff from the Wengjialing Formation

(表2)。大量的研究表明，岩浆锆石的U、Th含量较高，Th/U比值较大(一般大于0.5，多数在1.0上下)。大部分锆石分析点均位于明显的岩浆环带部位。

锆石U-Pb年龄：21个数据点均位于谐和线上，1个数据点(6.1)^{204}Pb数值较高，可能是这颗锆石在制样过程被污染的原因，故导致这个数据的准确度降低，偏离主群，时代较年轻；1颗锆石(11.1)较老，应为继承锆石。其余19个数据点的$^{206}Pb/^{238}U$年龄加权平均值为(841.2±5.1)Ma，对应的MSWD=1.6(图4)，这一年龄应代表了翁家岭组的形成时代。

6 讨 论

江南造山带呈向北西弧形突出延伸近2000 km，构造复杂，地质体出露多为孤立的块体，进行这些地质体的对比，进而推演其演化过程一直是关注此区域地质学者研究的重点。近年来随着研究方法的进步，获得了大量的高精度年龄数据：(1) 贵州梵净山群火山岩SHRIMP锆石U-Pb年龄为(840±11)Ma[28]，其沉积岩最小碎屑锆石峰值年龄为(872±

3)Ma[29];侵入梵净山群中的白云母花岗岩LA-ICP-MS锆石U-Pb年龄为(838±1)Ma[30],其SHRIMP锆石U-Pb年龄则为(835±5)Ma[31];(2)桂北地区侵入四堡群、被丹洲群覆盖的镁铁-超镁铁岩锆石SHRIMP U-Pb年龄为(827±7)Ma;侵入四堡群、被丹洲群覆盖的本洞和元宝山花岗岩体的年龄为(819±9)Ma和(824±4)Ma[32];四堡群斑脱岩锆石SHRIMP U-Pb年龄为(841±5)Ma[33]和(842±13)Ma[34];(3)湖南境内冷家溪群沉积岩碎屑锆石最小年龄峰值约为866 Ma[35-36];冷家溪群斑脱岩中锆石的SHRIMP U-Pb加权平均年龄为(822±10)Ma,覆盖在其上面的板溪群张家湾组斑脱岩中锆石年龄为(802±7)Ma[37];高角度不整合于冷家溪群之上、平行不整合伏于板溪群横路冲组的沧水铺群银珠坝组英安质火山碎屑岩中锆石的SHRIMP U-Pb年龄为(814±12)Ma[38]、(821±13)Ma[39];(4)赣东北广丰地区上覆于翁家岭组之上的桃源组(上墅组)的地层时代为820~830 Ma[22-23];广丰以北江南造山带广泛发育双桥山群,其斑脱岩锆石SHRIMP U-Pb年龄为(831±5)Ma(横涌组)、(829±5)Ma(安乐林组)、(824±5)Ma(修水组)[12-13],其变安山岩、变流纹岩及变凝灰岩LA-ICP-MS锆石U-Pb年龄分别为(822±6)Ma,(821±4)Ma和(830±4)Ma[40],地层沉积时限为815~850 Ma[12-13,41-44];(5)浙江浦江地区"平水群"[45]陈塘坞组凝灰岩锆石SHRIMP U-Pb年龄为(820±11)Ma、(830±6)Ma[46],江山市"章村组"❶凝灰岩锆石SHRIMP U-Pb年龄为(821±7)Ma、(832±8)Ma。

综合以上地层年龄数据,可以得出(1):翁家岭组在层位上与梵净山群、四堡群、冷家溪群、双桥山群相当;(2)覆于翁家岭组之上的桃源组是与侵入到梵净山群、四堡群、冷家溪群、双桥山群的火山侵入岩以及浦江地区"平水群"、江山市"章村组"同时期的火山侵入或喷出的产物。

7　结　论

(1)江南造山带东段赣东北广丰地区翁家岭组凝灰岩锆石SHRIMP U-Pb年龄加权平均值为(841.2±5.1)Ma,该套沉积岩属新元古代地层。

(2)根据最新获得的大量高精度年龄数据,确定翁家岭组在层位上与梵净山群、四堡群、冷家溪群、双桥山群相当。

(3)覆于翁家岭组之上的桃源组是与侵入到梵净山群、四堡群、冷家溪群、双桥山群的火山侵入岩以及浦江地区"平水群"、江山市"章村组"同时期的火山侵入或喷出产物。江南造山带自西向东在830 Ma期间曾广泛发育一期岩浆活动事件。

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