青海德令哈石底泉辉长岩 LA-ICP-MS 锆石 U-Pb 年龄及地质意义

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内容提要: 本文对青海德令哈市石底泉地区辉长岩进行了年代学、岩石学和地球化学研究,主量元素特征和微量元素分析结果显示辉长岩具有微偏向富镁、富铝、富钠的特点,属于准铝质基性岩类,具幔源型岩浆特征。辉长岩样品 LA-ICP-MS 锆石 U-Pb 同位素分析的结果表明,其年龄值为 2467±13Ma,时代为古元古代。综合分析可以确定石底泉地区辉长岩为基底构造演化阶段裂解背景下,上地幔熔融侵位的产物。它们的形成确定了古元古代早期石底泉地区有强烈的构造岩浆活动,佐证了达肯大坂岩群的时代可能向下延至新太古代晚期。

关键词: 辉长岩;锆石 U-Pb 年龄;地球化学特征;青海德令哈石底泉地区

石底泉地区,位处柴达木盆地北缘,属于南祁连成矿带,苏干湖—全吉山 Pb(Zn)—盐类成矿亚带,大地构造位置位于秦祁昆(秦岭—祁连山—昆仑山)造山系欧龙布鲁克陆块三级构造单元。受多期构造运动影响,岩浆活动频繁,形成了类型各异、规模不等的各类侵入岩,其中以酸性岩为主,基性岩较少,零星分布。基性岩类以往研究程度很低,通常基性岩的年代学和地球化学研究能够对火成岩构造组合提供比较明确的制约(林广春等,2006),然而目前还鲜有对德令哈市石底泉地区基性岩的岩石学和地球化学方面的研究报道,对基性岩形成时代资料也甚少;为此,我们在进行"青海省德令哈市大煤沟地区 J47E015001、J47E016001 两幅 1∶ 5 万区域地质矿产调查"时,重点以德令哈市石底泉地区产出的基性岩为研究对象,开展了详细的野外观察和室内岩石学、地球化学以及激光探针等离子体质谱(LA-ICP-MS)锆石 U-Pb 法同位素年龄测定等分析研究,并对其岩石学、地球化学特征、形成时间、岩浆成因等有关问题进行探讨。

1 地质背景

研究区位于宗务隆山—青海南山晚古生代—早古生代裂陷带以南,大地构造位置位于秦祁昆造山系欧龙布鲁克陆块三级构造单元(图 1a)。多年来不同学者按不同观点对其进行了划分,黄汲清按优冒地槽观划分为欧龙布鲁克台隆(黄汲清等,1965);青藏高原及其邻区大地构造单元初步划分方案(潘桂棠,2002)中,将其划分为全吉微陆块;张雪亭等(2006)通过对青海大地构造格局的详细研究,提出了西域板块的概念,并将其进一步划分为欧龙布鲁克陆块;其后陆松年(2006 年)在对中央造山带的研究中,认为全吉山的地层系统比欧龙布鲁克山发育的更完整、更具代表性,因此将欧龙布鲁克陆块更名为全吉地块;张雪亭等(2007 年)在《青海省区域地质概论》中仍将其划分为为欧龙布鲁克陆块;李荣社等(2008 年)在《昆仑山及邻区地质》一书将昆仑山及邻区的构造单元进行了划分,划分为欧龙布鲁克陆块。

研究区内出露的地层主要有古元古代达肯大坂岩群($Pt_1D.$)、南华纪—震旦纪麻黄沟组(NhZm)、枯柏木组(NhZk)、石英梁组(NhZs)、红藻山组(NhZhz)、寒武纪中晚寒武世欧龙布鲁克组($\epsilon_{2-3}o$)、奥陶纪早奥陶世多泉山组(O_1d)、新近纪上新世狮子沟组(N_2s)等。区内基性—超基性侵入岩体不发育,仅于石底泉南山一带有古元古代辉长岩体小面积出露。本文所研究的辉长岩体是本次工作从前人划分古元古代达肯大坂岩群中新解体出的地质体。整体产出在 F4 断裂构造北部。因其时代独特,岩性单一,又与石底泉南山推覆构造有关(图 1b)。

辉长岩长轴呈北西—南东向透镜体形态展布

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(图 2)，两侧受断裂控制，出露面积仅 0.17km²。南侧与新近纪狮子沟组呈断层接触，北侧与震旦—南华纪全吉群地层均呈断层接触关系，侵入于古元古代达肯大坂岩群中。由于后期构造作用影响，岩石体中发育强劈理化变形，内部次级小断裂发育；岩石普遍具绿泥石化、绿帘石化、粘土化、碎裂岩化蚀变现象(图 3)。本次工作对该基性岩进行了详细路线调查。

2　岩石特征

辉长岩岩体岩石类型较单一，主要由辉长岩构成，岩性组合为中细粒辉长岩；岩石蚀变较强，后期构造叠加作用明显。其岩石学特征如下：

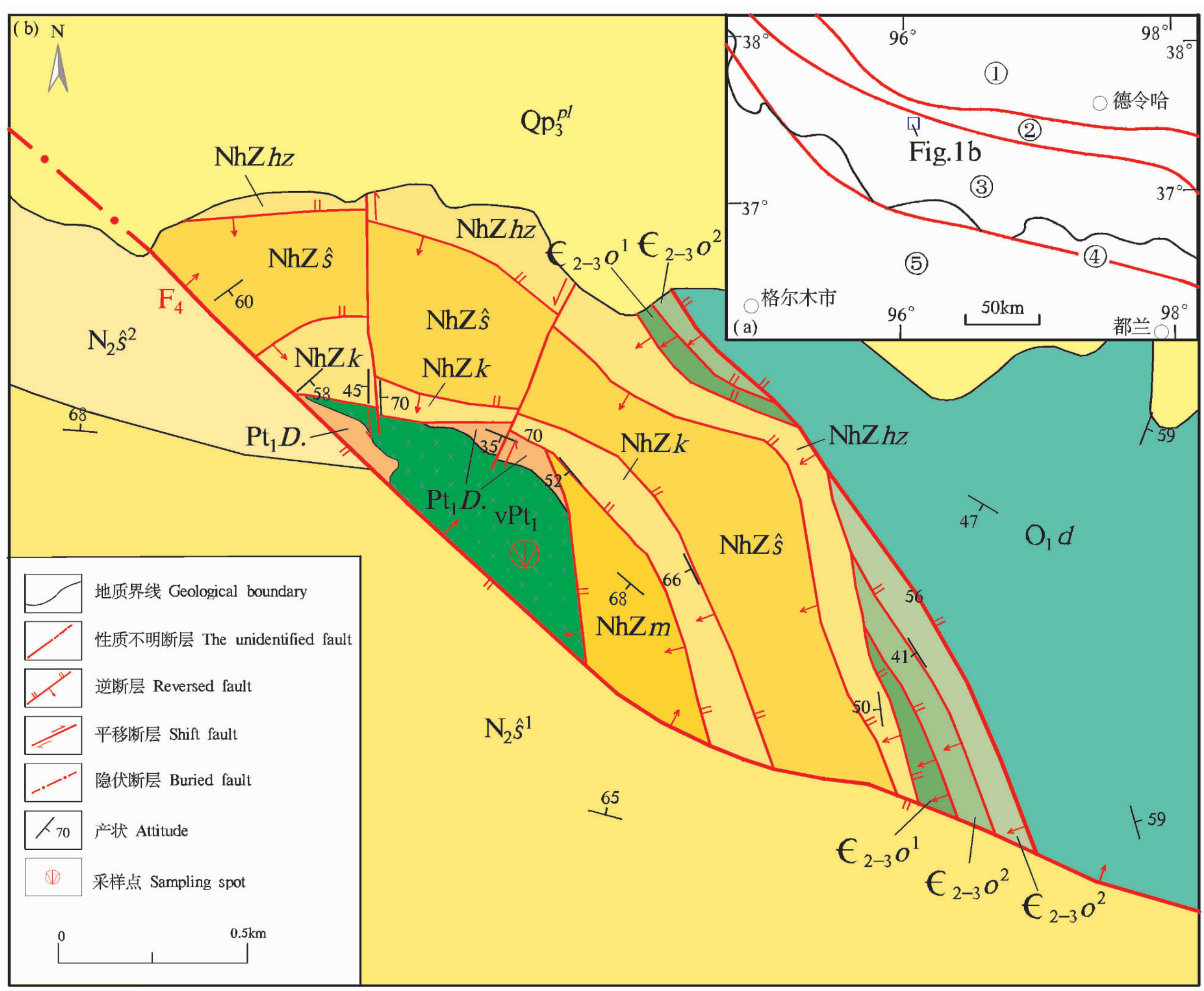

图 1 青海德令哈石底泉地区地质简图

Fig. 1 Geological sketch map of Shidiquan area, Delingha, Qinghai

Qp_3^{pl}—第四纪洪积物；N_2s^2—狮子沟组上岩段；N_2s^1—狮子沟组下岩段；O_1d—多泉山组；$Є_{2-3}o^3$— 欧龙布鲁克组上岩段；$Є_{2-3}o^2$—欧龙布鲁克组中岩段；$Є_{2-3}o^1$—欧龙布鲁克组下岩段；NhZhz—红藻山组；NhZs—石英梁组；NhZk—枯柏木组；NhZm—麻黄沟组；Pt_1D—达肯大坂岩群；νPt_1—辉长岩。① 南祁连地块；② 宗务隆山—青海南山晚古生代—早古生代裂陷带；③ 欧龙布鲁克陆块；④ 赛什腾—锡铁山—哇洪山早古生代结合带；⑤ 柴达木陆块

Qp_3^{pl}—Quaternary Proluvium; N_2s^2—Upper Shizigou Formation; N_2s^1—Lower Shizigou Formation; O_1d—Duoquanshan Formation; $Є_{2-3}o^3$—Upper Oulongbuluke Formation; $Є_{2-3}o^2$—Middle Oulongbuluke Formation; $Є_{2-3}o^1$— Lower Oulongbuluke Formation; NhZhz—Hongzaoshan Formation; NhZs—Shiyingliang Formation; NhZk—Kubaimu Formation; NhZm—Mahuanggou Formation; Pt_1D—Dakendaban Group; νPt_1—Gabbro. ① South Qilian block. ;② Zongwulong monntain—Qinghai south mountain fault—subsiding geosyacline Paleozoic to Early Mesozoicera. ;③ Olongbuluke block;④ Saishiteng—Xitie mountain—Wahong mountain suture zone to Early Paleozoic. ;⑤ Qaidam block

图 2 青海德令哈石底泉地区辉长岩体产出形态特征

Fig. 2 Morphological characteristics of the gabbro in Shidiquan area, Delingha, Qinghai

图 3 青海德令哈石底泉地区辉长岩岩石特征

Fig. 3 Rock character of the gabbro in Shidiquan area, Delingha, Qinghai

中细粒辉长岩:呈中细粒辉长结构,嵌晶结构,块状构造。岩石由斜长石、角闪石、普通辉石组成。斜长石含量在 60% 左右,成分为 An≈60 ~ 80 的拉培长石。呈半自形板状,少数呈它形粒状,粒径大小在 2 ~5mm 中粒级,发生了轻度绢云母化,聚片双晶清楚。与暗色矿物混杂分布。少数呈嵌晶结状包于暗色矿物之间。暗色矿物约占 40% 左右。成分以角闪石为主,其次有辉石,均呈它形粒状,粒径大小主要在 1 ~5mm 的中细粒级。个别到 6 ~7mm,且晶体中含有斜长石,呈嵌晶结构。一般的与斜长石混杂分布。呈辉长结构。暗色矿物多已发生纤闪石化。少数可能是易剥辉石发生了绿泥石化。多发生了退变。辉石退变呈角闪石,辉石包于角闪石之中,角闪石又发生了纤闪石化或具黑云母边(图 4)。

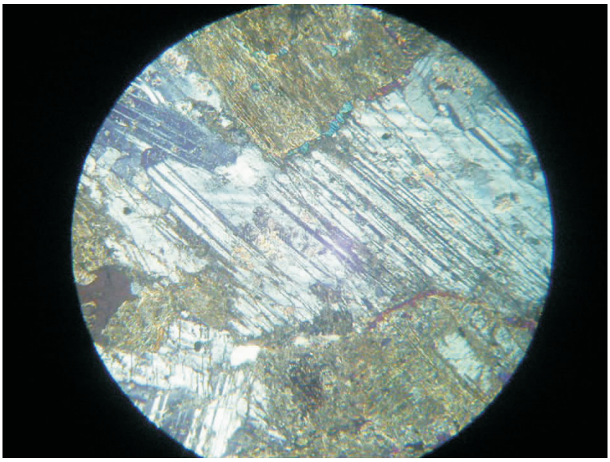

图 4 青海德令哈石底泉地区辉长岩显微照片
(d = 5mm 正交)

Fig. 4 Microscopic features of the gabbro in Shidiquan area, Delingha, Qinghai
(d = 5mm cross-polarized light)

3 岩石化学特征

辉长岩岩石化学分析结果见表 1。在 TAS SiO_2—($Na_2O + K_2O$) 图解中,样品均落在亚碱性系列范围(图 5a),说明该辉长岩以亚碱性为主,3 件样品均落在亚碱性辉长岩区(图 5a),化学成分分类与矿物分类基本相同。

岩石的 SiO_2 含量 48.57 ~ 50.22% ,属基性岩类; Fe_2O_3 含量小于 FeO,TFeO 的含量为 5.77% ~ 7.52% ,MgO 含量为 9.11% ~ 9.87% ,微偏向富镁

表 1 青海德令哈石底泉地区中细粒辉长岩岩石化学成分(%)一览表

Table 1 Petrochemical contents(%) of the medium—fine grained gabbro in Shidiquan area, Delingha, Qinghai

样号	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	P_2O_5	烧失	Σ
D2431-YQ1	50.22	18.07	2.65	5.14	9.28	7.88	2.3	0.69	0.31	0.11	0.03	2.83	99.51
D2431-YQ2	49.82	16.93	1.14	4.74	9.11	12.58	2.01	0.34	0.38	0.1	0.04	0.41	97.6
D2431-YQ3	48.57	16.63	1.14	5.15	9.87	11.92	2.13	0.23	0.35	0.1	0.04	0.68	96.81

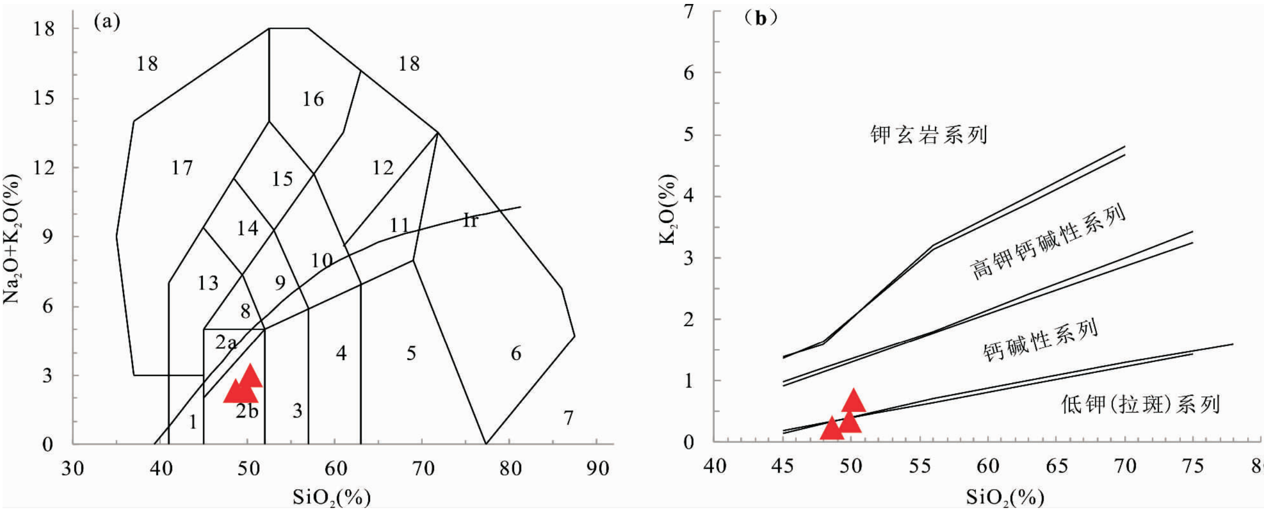

图 5 青海德令哈石底泉地区辉长岩:(a) TAS SiO_2—(Na_2O+K_2O)图解 (b) SiO_2—K_2O 图解(橄榄粗玄岩译名据章邦桐等,2011)

Fig. 5 TAS SiO_2—(Na_2O+K_2O) diagram(a) and SiO_2—K_2Odiagram (b) (the translation of Shoshonite is from Zhang Bangtong et al. ,2011#) of the gabbro in Shidiquan area, Delingha, Qinghai

的特征,CaO 含量7.88% ~12.58%之间;Na_2O 含量为2.01% ~2.30%,普遍 >2%以上;Al_2O_3 含量为16.63% ~18.07%,含量明显较高,显示富铝特点,MgO 含量介于9.11% ~9.87%,变化不大,$Mg^{\#}$变化于0.69 ~0.74之间,其中 $Mg^{\#}=n(Mg)/[n(Mg)+n(TFe)]$(邓晋福等,2015a,b);其中 TiO_2 含量为0.31% ~0.38%,平均值低于火山弧拉斑玄武岩。全碱(Na_2O+K_2O)含量低(2.35% ~2.99%),且 Na_2O/K_2O 比值3.33 ~9.26,属于低钾富钠的基性岩类,在 SiO_2—K_2O 图解中(图5b)落入由低钾拉斑玄武岩系列向钙碱性玄武岩过渡区域内,A/NCK 值0.64 ~0.96均小于1,属于准铝质基性岩类,具幔源型岩浆特征。

4 岩石地球化学特征

4.1 稀土特征

由表2可见,辉长岩岩石稀土总量较低,∑REE 在 27.96×10^{-6} ~ 29.12×10^{-6}之间;轻重稀土之比 LREE/HREE = 7.63 ~ 7.84,$(La/Yb)_N$ = 6.41 ~ 7.37,反映岩石轻稀土微弱富集,轻重稀土分馏较为明显,δEu 为1.61 ~1.82,均大于1,具铕正异常特征,暗示存在斜长石的堆晶作用。Sm/Nd = 0.22 ~ 0.25,与地幔源区岩浆成分相一致。

在以球粒陨石(里德6个球粒陨石平均值(增田, 1973))为标准化的配分模式图中(图6),样品曲线呈轻稀土微弱富集重稀土亏损的右倾斜型分布形式,样品具强烈的正铕异常特征,这两种分配型式基本分别与萨德伯里边缘相和中央相层状辉长岩(据 Crocket,1979)的稀土配分型式相似。特征反映 Eu 正异常明显,反映分离结晶作用的堆积相富集

表2 青海德令哈石底泉地区辉长岩稀土元素含量($\times10^{-6}$)及特征值表

Table 2 Analytical results and characteristic values of REE of the gabbro in Shidiquan area, Delingha, Qinghai

样品号	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
D2431-XT1	4.80	11.10	1.42	5.45	1.24	0.69	1.05	0.18	0.88	0.14	0.44	0.06	0.43
D2431-XT2	4.90	12.10	1.37	5.02	1.24	0.65	1.16	0.20	0.77	0.14	0.43	0.06	0.46
D2431-XT3	4.75	11.92	1.36	5.90	1.28	0.63	1.08	0.18	0.83	0.15	0.42	0.07	0.49

样品号	Lu	Y	∑REE	LREE	HREE	LREE/HREE	Sm/Nd	$(La/Yb)_N$	δEu	δCe
D2431-XT1	0.08	4.28	27.96	24.70	3.26	7.58	0.23	7.37	1.82	0.99
D2431-XT2	0.09	4.08	28.59	25.28	3.32	7.63	0.25	6.97	1.65	1.08
D2431-XT3	0.08	4.19	29.12	25.83	3.30	7.84	0.22	6.41	1.61	1.09

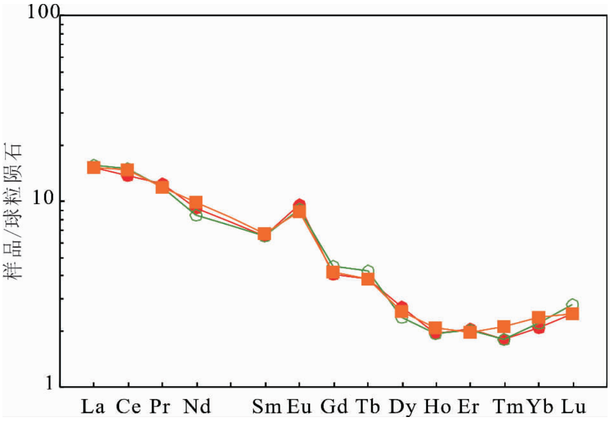

图 6 青海德令哈石底泉地区辉长岩体稀土元素球粒陨石标准化的配分图

Fig. 6 Chondrite normalized REE patterns of the gabbro in Shidiquan area, Delingha, Qinghai

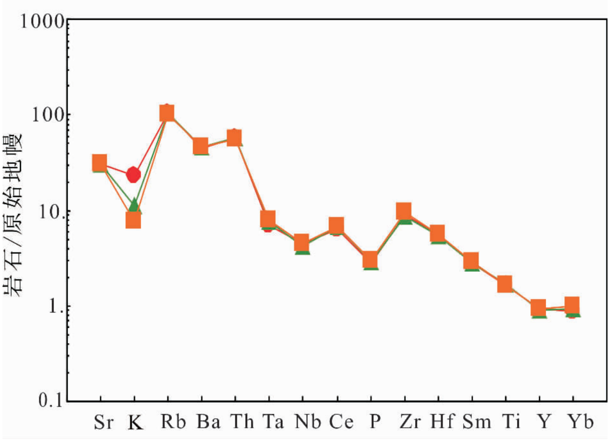

图 7 青海德令哈石底泉地区辉长岩微量元素比值蛛网图

Fig. 7 Trace elements spidergram of the gabbro in Shidiquan area, Delingha, Qinghai

Eu 的特征。综合而言,辉长岩与堆晶层状辉长岩的特征十分相似。

4.2　微量元素特征

辉长岩岩石微量元素分析结果见表 3,在以原始地幔为标准化的微量元素比值蛛网图中(图 7),曲线呈双隆起右倾的型式,其中强不相容元素 Rb、Ba、Th 具较强的富集,中等不相容元素 Nb、Ce、Hf、Zr、Sm 及弱不相容元素 Ti、Y、Yb 等具较强亏损或中等亏损,其中 P 元素亏损明显,形成"凹"谷,Rb 元素明显富集,形成凸起;经计算,样品的$(Rb / Yb)_N$比值 >1。

5　成岩时代

本次工作对辉长岩进行了锆石 U-Pb 同位素测年,样品编号样品号:D2431-U-Pb1(E96°09′25″,N37°30′40″),样品岩性:中细粒辉长岩,从锆石阴极发光图片(如图 8)来看,该样品中筛选的锆石类型较为单一,锆石形态主要呈长柱状、短柱状形态,长轴直径约 100 ~300μm,Th/U 介于 0.5 ~1.47 之间,均大于 0.4,条带状—扇形分带,具岩浆锆石特征。

利用 LA-MC-ICP-MS 方法进行锆石 U-Pb 微区定年。测试定年的打点锆石共 30 颗,其分析结果见表 4,由表可见,1 ~30 号点$^{206}Pb/^{238}U$和$^{207}Pb/^{235}U$表面年龄较为一致,给出了 2467 ±13Ma 的年龄值,其锆石 U-Pb 同位素谐和图见图 9。

综上所述,30 颗锆石打点给出的 2467 ±13Ma 的年龄值很可能是辉长岩成岩结晶过程中形成的锆石,也即该类辉长岩的成岩年龄为古元古代。

6　讨论

6.1　构造环境分析

前述岩石化学分析辉长岩岩石 $Na_2O > K_2O$,岩石具低钾富钠幔源型岩浆特征;稀土配分型式为轻稀土微弱富集重稀土亏损的右倾斜型分布形式,δEu 为 1.61 ~1.82,均大于 1,具铕正异常特征,暗示存在斜长石的堆晶作用。与堆晶层状辉长岩的特征十分相似,类似于大陆玄武岩;而微量元素特征及蛛网图曲线型式呈双隆起右倾的型式,其中强不相容元素 Rb、Ba、Th 具较强的富集,中等不相容元素 Nb、Ce、Hf、Zr、Sm 及弱不相容元素 Ti、Y、Yb 等具较强亏损或中等亏损,其中 P 元素亏损明显,形成"凹"谷,Rb 元素明显富集,形成凸起;经计算,样品的(Rb / Yb)N 比值 >1。综合分析,表明辉长岩岩浆

表 3 青海德令哈石底泉地区辉长岩微量元素含量($\times 10^{-6}$)和特征值表

Table 3 Analytical results and characteristic value of Trace elements of the gabbro in Shidiquan area, Delingha, Qinghai

样品编号	Ba	P	Sr	Ti	Zr	Rb	Nb	Hf	Ta	Th	U
D2431-Dy1	314	268	650	2160	101	65.8	3.17	1.73	0.29	4.84	0.70
D2431-Dy2	320	278	645	2172	98	66.2	2.98	1.67	0.28	4.81	0.71
D2431-Dy3	324	286	653	2156	108	64.7	3.20	1.72	0.29	4.83	0.70

样品测试单位:有色金属西北矿产地质测试中心

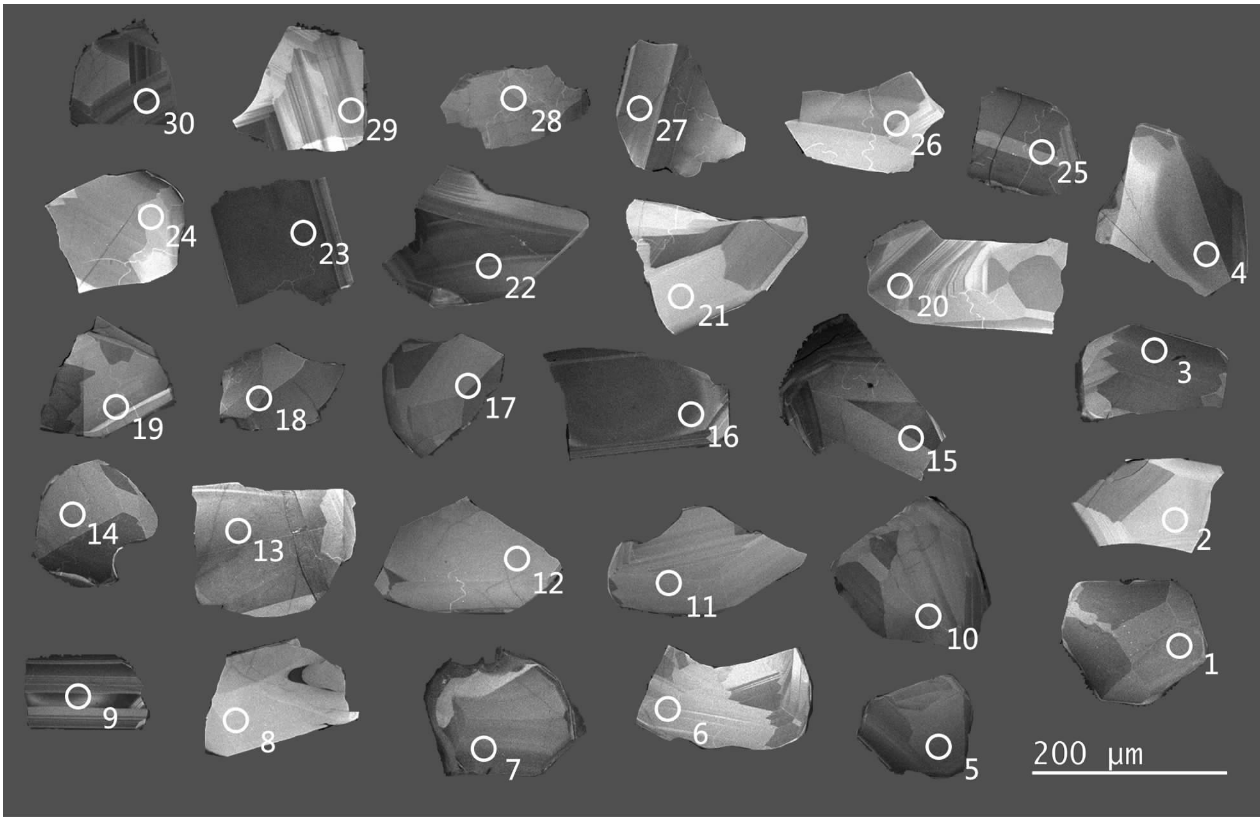

图 8　青海德令哈石底泉地区辉长岩 U-Pb 锆石阴极发光图片

Fig. 8　Cathodoluminescence image of zircons from the gabbro in Shidiquan area, Delingha, Qinghai

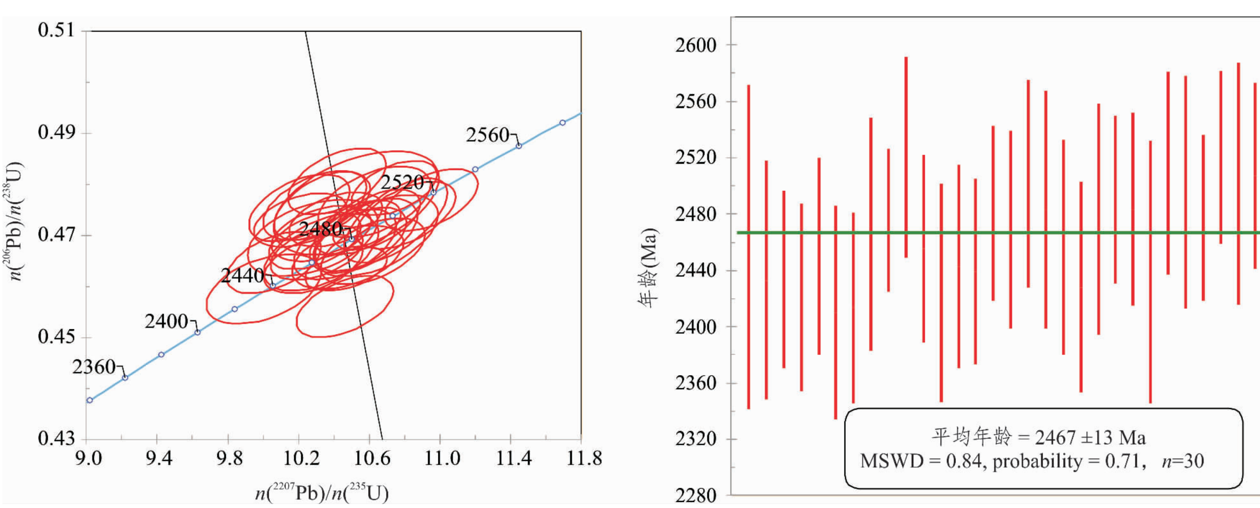

图 9　青海德令哈石底泉地区辉长岩锆石 U-Pb 同位素谐和图

Fig. 9　U-Pb concordia diagram of the zircons from the gabbro in Shidiquan area, Delingha, Qinghai

来源于地幔源区，显然为伸展环境下地幔岩浆分离上侵结晶的产物。将辉长岩 3 组样品投于 $R1$—$R2$ 图解中(图 10)进行构造环境判别，结果样品较集中分布于地幔分离环境区(1 区)，基本说明辉长岩形成于伸展性构造环境。结合本区区域地质分析，辉长岩可能为古元古代裂陷槽内中基性火山(达肯大坂岩群)喷发，进入壳幔分离阶段，而基性火山活动的结束，标志着裂陷槽的闭合，随之而来的是部分地壳物质重熔上侵，造成了 2467 ± 13Ma 的基性岩浆底侵——古元古代辉长岩，也是柴北缘克拉通化的

表 4 青海德令哈石底泉地区辉长岩 LA-ICP-MS 锆石 U-Pb 测年分析结果

Table 4 LA-ICP-MS U-Pb isotope dating analysis of zircons from the gabbro in Shidiquan area，Delingha city，Qinghai

测点编号	元素含量($\times 10^{-6}$)			Th/U	同位素比值						年龄(Ma)						谐和度(%)
	Pb	Th	U		$n(^{207}Pb)/n(^{206}Pb)$		$n(^{207}Pb/n(^{235}U)$		$n(^{206}Pb)/n(^{238}U)$		$n(^{207}Pb)/n(^{206}Pb)$		$n(^{207}Pb)/n(^{235}U)$		$n(^{206}Pb/n(^{238}U)$		
					测值	1σ	测值	1σ	测值	1σ	测值	1σ	测值	1σ	测值	σ	
D2431-1-01	73	69	77	0.90	0.1601	0.0054	10.5263	0.3817	0.4764	0.0083	2456	58	2482	34	2511	36	98
D2431-1-02	79	88	85	1.03	0.1579	0.0040	10.0009	0.2641	0.4595	0.0056	2433	42	2435	24	2437	25	99
D2431-1-03	235	251	247	1.02	0.1569	0.0029	10.3208	0.2121	0.4759	0.0054	2433	31	2464	19	2509	24	98
D2431-1-04	230	215	273	0.79	0.1565	0.0031	10.0606	0.2163	0.4647	0.0049	2420	33	2440	20	2460	22	99
D2431-1-05	291	264	321	0.82	0.1593	0.0033	10.4099	0.2143	0.4731	0.0044	2450	35	2472	19	2497	19	98
D2431-1-06	149	144	166	0.87	0.1558	0.0035	10.2039	0.2331	0.4754	0.0054	2410	38	2453	21	2507	23	97
D2431-1-07	301	288	344	0.84	0.1561	0.0031	10.2093	0.2144	0.4731	0.0043	2413	34	2454	19	2497	19	98
D2431-1-08	62	59	70	0.84	0.1610	0.0040	10.3295	0.2643	0.4668	0.0062	2466	41	2465	24	2469	27	99
D2431-1-09	359	454	308	1.47	0.1619	0.0030	10.5342	0.1965	0.4716	0.0044	2476	25	2483	17	2491	19	99
D2431-1-10	219	207	254	0.81	0.1662	0.0035	10.4604	0.2240	0.4562	0.0049	2520	35	2476	20	2423	22	97
D2431-1-11	141	144	158	0.91	0.1599	0.0032	10.3025	0.2121	0.4666	0.0044	2455	33	2462	19	2469	19	99
D2431-1-12	102	108	105	1.02	0.1570	0.0036	10.3005	0.2477	0.4758	0.0056	2424	39	2462	22	2509	24	98
D2431-1-13	186	214	173	1.23	0.1587	0.0034	10.3262	0.2304	0.4705	0.0044	2443	36	2464	21	2486	20	99
D2431-1-14	174	166	198	0.84	0.1584	0.0030	10.2917	0.2121	0.4690	0.0046	2439	33	2461	19	2479	20	99
D2431-1-15	268	210	344	0.61	0.1624	0.0031	10.5474	0.2150	0.4693	0.0050	2481	31	2484	19	2480	22	99
D2431-1-16	202	191	229	0.83	0.1613	0.0034	10.4633	0.2356	0.4683	0.0056	2469	35	2477	21	2476	24	99
D2431-1-17	192	172	211	0.81	0.1644	0.0037	10.6180	0.2399	0.4669	0.0053	2502	37	2490	21	2470	23	99
D2431-1-18	207	211	211	1.00	0.1626	0.0041	10.4776	0.2566	0.4658	0.0051	2483	42	2478	23	2465	23	99
D2431-1-19	177	167	205	0.81	0.1601	0.0036	10.2831	0.2290	0.4645	0.0047	2456	38	2461	21	2459	21	99
D2431-1-20	107	105	114	0.92	0.1574	0.0035	10.4159	0.2249	0.4805	0.0053	2428	37	2472	20	2530	23	97
D2431-1-21	79	86	77	1.12	0.1620	0.0040	10.6254	0.2599	0.4765	0.0057	2476	41	2491	23	2512	25	99
D2431-1-22	262	205	337	0.61	0.1633	0.0030	10.4692	0.1887	0.4636	0.0036	2490	30	2477	17	2455	16	99
D2431-1-23	633	668	650	1.03	0.1625	0.0028	10.6387	0.2012	0.4731	0.0047	2483	34	2492	18	2497	21	99
D2431-1-24	93	97	96	1.00	0.1584	0.0043	10.2767	0.2997	0.4696	0.0062	2439	47	2460	27	2482	27	99
D2431-1-25	278	273	299	0.91	0.1650	0.0036	10.7494	0.2379	0.4730	0.0068	2509	36	2502	21	2496	30	99
D2431-1-26	140	150	143	1.05	0.1638	0.0041	10.5657	0.2480	0.4699	0.0059	2495	41	2486	22	2483	26	99
D2431-1-27	283	343	255	1.34	0.1621	0.0028	10.7403	0.1992	0.4793	0.0044	2477	29	2501	17	2524	19	99
D2431-1-28	163	157	180	0.87	0.1662	0.0030	10.9502	0.2157	0.4770	0.0049	2520	31	2519	18	2514	21	99
D2431-1-29	93	109	89	1.23	0.1643	0.0042	10.6402	0.2820	0.4700	0.0065	2502	43	2492	25	2483	29	99
D2431-1-30	279	191	380	0.50	0.1650	0.0032	10.8076	0.2269	0.4740	0.0054	2507	33	2507	20	2501	24	99

注:样品由西北大学大陆动力学国家重点实验室测定。

一个过程。

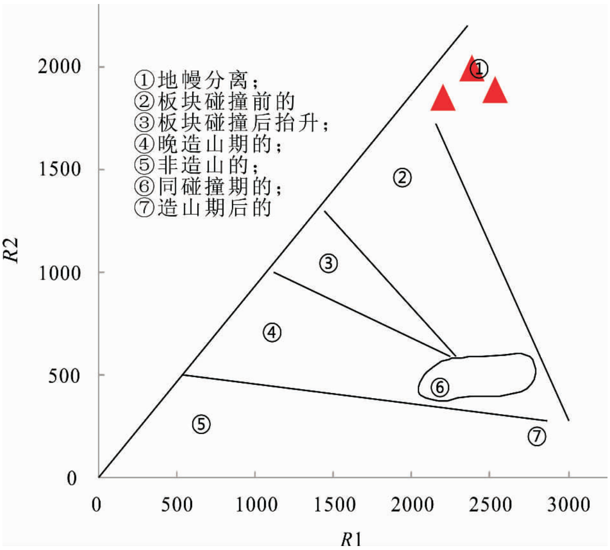

图 10 青海德令哈石底泉地区辉长岩 *R*1—*R*2 图解

Fig. 10 *R*1—*R*2 diagram of the gabbro in Shidiquan area, Delingha, Qinghai

6.2 地质意义

柴北缘构造带自太古宙—古元古代早期古陆核形成以后,在漫长的地史发展过程中,经历了较为复杂的演化过程。在柴北缘狭长的构造带,基底岩系的物质组成中,就有太古宙晚期(?)—古元古代早期达肯达肯大坂岩群,但一直缺失有确凿证据的太古代的地质记录,然而辉长岩的最新同位素测年资料显示,达肯大坂岩群的时代可能下延至新太古代晚期。达肯大坂岩群是区内分布的最古老的主要地质体,构成了欧龙布鲁克微陆块的变质基底。达肯大坂岩群下部的海相基性火山岩建造和上部的变质碎屑岩－碳酸盐岩沉积建造构成,现存岩石为一套以各类片麻岩为主,夹斜长角闪(片)岩、石英片岩及大理岩、石英岩的层状无序的中—深变质岩组合❶。陆松年等(2002)在达肯大坂岩群的紫红色二长花岗片麻岩及其中的斜长角闪岩包体中分别获得了 2415Ma 和 2412 ± 14Ma 的单颗粒锆石 U-Pb 年龄,本文报道又在直接侵入达肯大坂岩群的辉长岩中获得的了 2467 ± 13Ma 锆石 U-Pb 同位素年龄,表明达肯大坂岩群的时代可能向下延至新太古代晚期。

7 结论

(1)石底泉地区辉长岩样品 LA-ICP-MS 锆石 U-Pb 同位素分析的结果表明,其年龄值为 2467 ± 13Ma,确定其时代为古元古代。

(2)石底泉地区辉长岩体,岩石化学成分表明辉长岩具有微偏向富镁、富铝、富钠的特点,属于准铝质基性岩类,具幔源型岩浆特征。

(3)石底泉地区辉长岩为基底构造演化阶段裂解背景下,上地幔熔融侵位的产物。它们的形成确定了古元古代早期石底泉地区有强烈的构造岩浆活动,佐证了达肯大坂岩群的时代可能向下延至新太古代晚期,有助于对石底泉地区古元古代岩浆活动规律进行更深刻的了解。

致谢:诚挚感谢审稿专家对本文提出的宝贵意见。感谢陕西地矿第一地质队地调所所长孙健和同事赵振英、田振等同志大力支持和帮助,在此一并致以衷心的感谢。

注 释 / Note

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LA-ICP-MS Zircon U-Pb Dating and Geological Significance of Shidiquan Gabbro in Delingha, Qinghai

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Objectives: The study area is located in the south of late Paleozoic to early Mesozoic rift zone in Zongwulong Mountain—Qinghai Nanshan, and its tectonic position lies in the third grade tectonic unit of Oulongbuluke Block in Qinling—Qilian—Kunlun orogenic belts. The rocks in this district consist of mainly acid rocks and much less mafic rocks. Up to now, little study on petrology and geochemistry of mafic rocks in Shidiquan district in Delingha city has been reported, and the formation age of mafic rocks is still unknown as well. Therefore, the author of this paper intends to take mafic rocks that crop out in Shidiquan district as research objects. Through detailed field observation as well as petrology analysis, geochemistry analysis and U-Pb isotopic dating method, we will discuss the problems of petrology, geochemical characteristics, formation time and magma origin in the study area in depth.

Methods: A gabbro sample, which weighs about 40 ~ 55kg, was collected in Shidiquan area for isotopic dating, with its geographical coordinate of E96°09′25″, N37°30′40″. Zircon separation was carried out using conventional methods, and zircon grains were then hand-picked under a binocular microscope. Afterwards, zircon grains with fine crystalline shape and transparency were mounted in epoxy mounts and next been polished to section the crystals in half for further analysis. These steps were undertaken at the Langfang Rock and mineral testing technology, Co. Ltd, Hebei province, China. Later, Then zircon grains were taken cathodoluminescence (CL) images by using scanning electron microscope to reveal their internal structures. Zircon U - Pb isotopic ages were analyzed using the laser ablation-multicollector inductively coupled-plasma mass spectrometry (LA-MC-ICP-MS) at the at the State Key Laboratory of Continental Dynamics, Northwest University, China. Analytical instruments include Agilent7500a type four stage rod mass spectrometer, Geolas200M laser ablation system and excimer laser with wavelength of 193nm. The diameter of laser beam was 30 μm and the depth of it is 20 ~ 40 μm. and using He as acarrier gas. Zircon age is calculated using standard zircon 91500 as an external standard, the element content of the United States by the national standard material board synthetic silicate glass NIST610 as external standard, SiO_2 content for internal standard calibration. Zircon content and isotopic data by China University of Geosciences Liu Yongsheng bo scholar research and development of ICPMSDataCal program and Ludwig Kr Isoplot for data processing and drawing, the Tom Andersen method for correction of common lead.

Results: LA-ICP-MS zircon U-Pb dating of the gabbro shows an Paleoproterozoic age of 2467 ± 13Ma. The analyses of major and trace elements show that the Shidiquan gabbros have characteristic of slightly rich in Mg, Al and Na.

Conclusions: The Shidiquan gabbro samples belong to the aluminum basite and are derived from mantle magma. Comprehensive analyses suggest that the Shidiquan gabbro is the product of uprising melt from upper mantle during the breakup of the continental basement. This study provide the evidence that the strong magmatic activity has occurred in the paleoproterozoic in the Shidiquan area and confirmed that the age of the Dakendaban Group may extend down to the late Neoarchean.

Keywords: Gabbro Geochemistry Zircon U-Pb dating Shidiquan area

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