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西藏班戈县冈瓦纳相冰碛岩的发现及其对北拉萨地块构造演化的启示——来自1∶50000专题地质调查的新证据

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提要:【研究目的】拉萨地块作为构成青藏高原的最主要陆块之一,其构造格局的划分对深入理解特提斯洋的时空分布格局具有重要科学意义。一般来说,拉萨地块可进一步划分为北拉萨、中拉萨和南拉萨地块,但关于各地块基底属性、漂移历史、增生过程及构造亲缘性等仍不明确。**【研究方法】**本文报道了笔者等在北拉萨地块北拉地区开展1∶50000专题地质调查期间,在原划定的中—上侏罗统拉贡塘组中发现了大面积出露的典型冰碛岩与震积岩。**【研究结果】**它们与中拉萨地块申扎地区的上石炭统—下二叠统拉嘎组可对比,是冈瓦纳大陆北缘晚古生代冰期事件的记录。冰碛岩中可见明显冰筏作用形成的冰海相砾石稀散分布在砂质、粉砂质和泥质基质中,具坠石构造。震积岩以震褶岩和震裂岩为主,发育微褶皱、砂(泥)岩脉、同震节理、内碎屑副角砾岩、阶梯状断层和火焰构造等同生或准生地震沉积记录。**【结论】**北拉地区拉嘎组冰碛岩的发现表明,北拉萨地块与中拉萨地块具有类似的基底,它可能是在陆壳基础上逐渐形成的增生型微陆块,其形成与班公湖—怒江洋的俯冲消减密切相关,这为深入理解北拉萨地块的构造属性提供了关键证据。

关 键 词:拉嘎组;冰碛岩;震积岩;构造演化;地质调查工程;藏北湖区

创 新 点:(1)北拉萨地块新发现的冰碛岩是冈瓦纳大陆北缘晚古生代冰期事件的记录。(2)北拉萨地块具有与中拉萨地块类似的基底,它可能是在陆壳基底基础上逐渐形成的增生型微陆块。

中图分类号:P548;P587 **文献标志码:**A **文章编号:**1000−3657(2023)05−1486−09

Identification of Gondwana tillite in the Bange County of Tibetan Plateau and its implications for the tectonic evolution of North Lhasa terrane—New evidence from the 1:50000 thematic geological survey

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Abstract: This paper is the result of geological survey engineering.

[Objective] As the main terrane in the Tibetan Plateau, the division of the Lhasa terrane is significance for the spatial and temporal distribution pattern of the Tethys Ocean. Generally, it can be further divided into the North, Central, and South Lhasa terranes. However, it is still ambiguous about their basement nature, drifting, accretion, and tectonic affinity. **[Methods]** In this paper, based on the 1:50000 geological survey in the Beila area, North Lhasa terrane, the widely exposed and typical tillite and seismite are newly identified from the Middle−Upper Jurassic Lagongtang Formation, northern Tibetan Plateau. **[Results]** They can be compared with the Upper Carboniferous−Lower Permian Lagar Formation in the Xainza area, Central Lhasa terrane, indicating the Late Paleozoic glacial event in the northern margin of the Gondwana. The glacial marine gravels, formed by ice raft, are distributed in the sandy, silty and argillaceous matrix, with falling structure. Seismites are mainly seismic corrugated and shattering, with syngenetic or parasyngenetic seismic sedimentary records of microfolds, sand (mud) veins, coseismic joints, intraclastpara−breccia, steplike faults and flame structures. **[Conclusions]** The identification of the tillite of Lagar Formation indicates that the North Lhasa terrane holds similar basement with the Central Lhasa terrane. It is probably anaccretion−induced micro−block formed gradually on the basis of local continental crust, which is closely related to the subduction process of the Bangong−Nujiang Tethys Ocean. This provides key evidence for further studying the tectonic affinity of the North Lhasa terrane.

Key words: Lagar Formation; tillite; seismite;tectonic evolution; geological survey engineering; lake area of northern Tibet

Highlights: (1) The newly discovered tillites in the North Lhasa terrane are records of Late Paleozoic glacial event in the northern margin of Gondwana. (2) The North Lhasa terrane has a similar basement with the Central Lhasa terrane, and maybe an accretion−induced micro−block formed gradually on the basis of local continental crust.

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1 引　言

拉萨地块位于中—新特提斯构造域的交汇部位，作为构成青藏高原的最主要陆块之一，其构造区划及其构造演化过程，对深入理解特提斯洋的时空分布格局及洋—陆转换过程等具有重要科学意义（图1a；Shi et al., 2007；Pan et al., 2012；Zhu et al., 2016；Wang et al., 2016；Liu et al., 2017；吴福元等，2020；Tang et al., 2020；Wang et al., 2021；吴昊等，2021）。拉萨地块可进一步划分为北拉萨、中拉萨和南拉萨地块（Zhu et al., 2013），但是对各陆块的物质组成、基底属性（时代、空间展布）、构造亲缘性等仍不清晰，尤其是对北拉萨地块的构造属性争议很大，这直接制约了对冈瓦纳大陆北缘特提斯洋演化的深入认识（Zhu et al., 2011, 2013；Pan et al., 2012；王立全等, 2013；张以春等, 2019；刘一鸣等, 2019；Fan et al., 2021；徐琳等，2021；Liu et al., 2022）。晚古生代拉萨地块地处冈瓦纳大陆的北缘，广泛受到冰期的影响而保存了大量冈瓦纳相冰碛岩的记录（尹集祥，1997；张予杰等，2013；白培荣等，2016；杨洋，2019）。然而，相关的冰碛岩以中拉萨地块最为发育，而在北拉萨地块鲜有报道。最近，笔者等在班戈县北拉地区开展1∶50000专题地质调查期间，在原划定的中—上侏罗统拉贡塘组中新识别出了大面积出露的典型冰碛岩（图1b），并将这套地层重新定义为上石炭统—下二叠统拉嘎组，这是在北拉萨地块首次发现的晚古生代冈瓦纳相冰期事件的记录，为深入理解北拉萨地块的构造属性提供了关

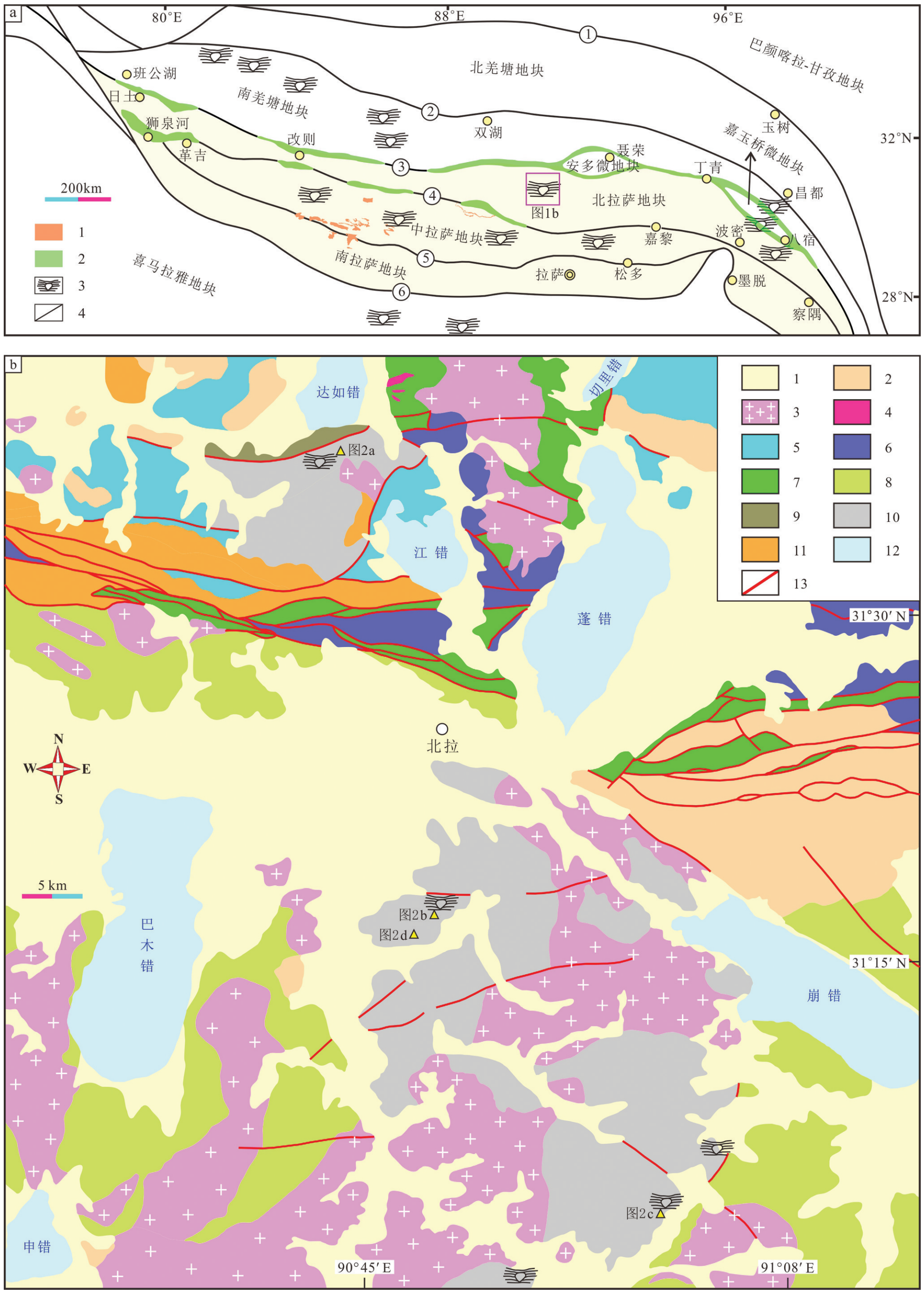

图1 青藏高原大地构造图(a)和北拉地区地质简图(b)(据唐跃等, 2019修改)

a:①—金沙江缝合带;②—龙木错—双湖—澜沧江缝合带;③—班公湖—怒江缝合带;④—狮泉河—永珠—嘉黎蛇绿混杂岩带;⑤—洛巴堆—米拉山断裂带;⑥—印度—雅鲁藏布江缝合带;1—上石炭统—下二叠统拉嘎组;2—蛇绿混杂岩;3—冰碛岩;4—缝合带;b:1—新生代碎屑岩;2—白垩系去申拉组和竟柱山组;3—白垩纪花岗岩;4—侏罗纪闪长岩;5—侏罗系接奴群;6—侏罗系木嘎岗日岩群;7—侏罗纪蛇绿岩;8—中—上侏罗统拉贡塘组;9—中二叠统下拉组;10—上石炭统—下二叠统拉嘎组;11—泥盆系灰岩;12—湖泊;13—断层

Fig.1 Tectonic framework of the Tibetan Plateau (a) and Geological sketch map of Beila area (b)(modified from Tang Yue et al., 2019)

a: ①–Jinshajiang suture zone; ②–Longmuco–Shuanghu–Lancangjiang suture zone; ③–Bangong–Nujiang suture zone; ④–Shiquanhe–Yongzhu–Jialimelange zone; ⑤–Luobadui–Milashan Fault; ⑥–Indus–Yarlung Zangbo suture zone; 1–Upper Carboniferous–Lower Permian Lagar Formation; 2–Ophiolitic melange; 3–Tillite; 4–Suture zone; b: 1–Cenozoic clastic rocks; 2–Cretaceous Qushenla and Jingzhushan formations; 3–Cretaceous granite; 4–Jurassic diorite; 5–Jurassic Jienu Group; 6–Jurassic Mugagangri Group; 7–Jurassic ophiolite; 8–Middle–Upper Jurassic Lagongtang Formation; 9–Middle Permian Xiala Formation; 10–Upper Carboniferous–Lower Permian Lagar Formation; 11–Devonian limestone; 12–Lake; 13–Fault

键证据。

2　区域地质概况

青藏高原处于特提斯构造域东段，是由多地块和板块缝合带组成的巨型拼合体（图1a）。拉萨地块位于青藏高原的核心部位，是组成高原的最主要陆块之一，被班公湖—怒江与印度—雅鲁藏布江缝合带所围限，可进一步被狮泉河—永珠—嘉黎蛇绿混杂带和洛巴堆—米拉山断裂带划分为北拉萨、中拉萨和南拉萨地块（Zhu et al., 2013）。中拉萨地块组成最为复杂，既有前寒武纪基底岩石出露，也可见大量古生代—中生代碳酸盐岩、碎屑岩和火山岩。而北拉萨和南拉萨地块以中—新生代沉积岩和中酸性岩浆岩为主，其中南拉萨地块可见少量前寒武纪基底岩石出露。

填图工作区位于西藏班戈县北拉镇，在大地构造上处于北拉萨地块中部（图1a），区域内岩石主要为侏罗系—白垩系碎屑岩和白垩纪花岗岩（图1b）。本次新发现的上石炭统—下二叠统冈瓦纳相冰碛岩主要为一套含杂砾碎屑岩组合，局部见震积岩。碎屑岩中含有大量花岗岩、砂岩、灰岩等冰海相砾石。中二叠统下拉组出露面积较小，主要由含生物碎屑白云岩组成，与拉嘎组以断层接触。中—上侏罗统拉贡塘组以细碎屑岩为主，局部被岩体侵入并发生角岩化。侏罗系木嘎岗日岩群为一套复理石沉积，局部夹中性火山岩，常含有灰岩、超基性岩和硅质岩等岩块。侏罗系接奴群以细碎屑岩为主，褶皱构造发育。下白垩统去申拉组以中酸性火山岩为主，并夹有碎屑岩红层，以角度不整合关系覆盖于接奴群之上。上白垩统竟柱山组为一套磨拉石建造，角度不整合于蛇绿岩与拉贡塘组之上。

3　冰碛岩

本次填图过程中，在班戈县北拉地区发现了典型的冰碛岩（含砾砂岩与含砾板岩），可见明显冰筏作用的冰海相砾石，具坠石构造（图2a）。冰碛砾石呈稀散状分布，无分选或分选差，呈漂浮状、不协调地出现于以砂质、粉砂质和泥质成分组成的基质中（图2a~c）。冰碛砾石成分复杂，以砂岩、石英岩、花岗岩、玄武岩和灰岩为主，漂砾切穿层理面，并被上覆沉积层所覆盖（图2a~c）。含砾板岩中的冰碛砾石以花岗岩和砂岩为主（图2a），分布不均匀，砾石磨圆较好，多为椭圆状—次圆状，少数为次棱角状，砾径在0.5~5 cm，可见压裂纹（图2a），多具坠石构造，是典型冰川作用的结果。含砾砂岩中的冰碛砾石以砂岩、石英岩、石英脉、灰岩和玄武岩等为主，砾径较小，多在0.2~2 cm，少数可达20~25 cm，磨圆较差，多为次棱角状—次圆状，个别具压坑和冰川压裂纹（图2b、c），具有冰川漂砾沉积和水下重力流沉积的双重特征。此外，冰海相沉积岩产状较稳定，可见水平层理、平行层理和粒序层理，未见有化石出露，为滨岸相—浅海陆棚相沉积。

上石炭统—下二叠统拉嘎组由林宝玉（1983）命名，是一套典型的、与冈瓦纳相冰川有关的浅海相粗碎屑沉积岩，主要岩性为石英砂岩、含砾砂岩、含砾板岩、粉砂岩、页岩夹薄层砾层，含冷水型珊瑚和腕足类化石，与下伏永珠组石英砂岩和上覆昂杰组灰岩或页岩均为整合接触。拉嘎组在中拉萨地块分布广泛，尤以申扎、永珠和木纠错地区最为典型，然而在北拉萨地块鲜有报道。本次在北拉地区发现的冰碛岩，与中拉萨地区分布的拉嘎组冰碛岩完全可对比，这是首次在北拉萨地块中部地区发现的冈瓦纳相冰海沉积。

4　震积岩

本次调查过程中在研究区拉嘎组中发现了典型震积岩，以震褶岩和震裂岩为主，发育微褶皱、砂（泥）岩脉、同震节理、内碎屑副角砾岩、液化卷曲变形、阶梯状断层、条带状构造、拉伸软布丁构造、火焰和水滴构造等同生或准生地震沉积事件（Marco and Agnon, 1995; Rodroguez−Pascua et al., 2000; 杨剑萍等, 2014）。微褶皱纹理构造变形仅限于地震扰动层之内（图2d），属层内变形，形态不规则，尺度较小，无明显定向性，微褶皱纹理多为1~2 cm的褶曲波动，分布不均匀，为沉积物相对较弱的液化表现。震裂岩以塑性角砾岩为主，地震作用触发砂岩局部液化，液化细砂岩向未液化砂岩层流动，穿插、分割并包围未液化层，在此过程中未液化层棱角被液化层磨圆、同化，形成各种形状的塑性角砾，角砾具软沉积变形特征，呈复杂的侧向拉长、变细和弯曲，为典型液化角砾岩（图2d; Plaziat et al., 1990; 乔秀夫和李海兵, 2009）。

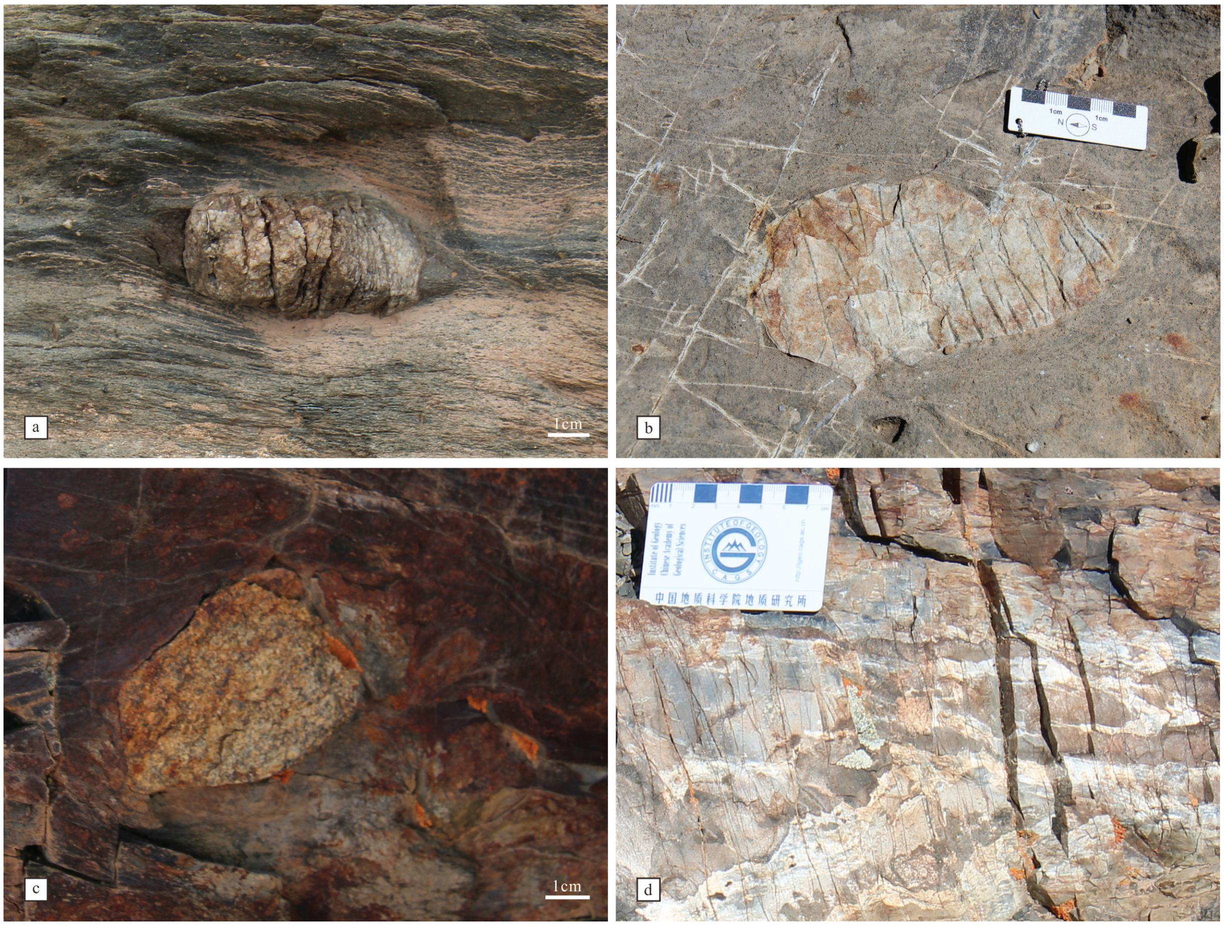

图 2 班戈县北拉地区冰碛岩(a,b,c)与震积岩(d)野外照片
Fig.2 Field photographs of tillite (a, b, c) and seismites (d) from Beila area in the Bange County

此外,在拉嘎组砂岩和粉砂岩中还发现了同震节理,节理层厚度一般为5~20 cm,节理间隔几毫米至几厘米,间距不等,多垂直或大角度斜交砂岩层,并被同期液化砂(泥)岩脉充填,在上、下砂岩层中节理逐渐减弱,大部分节理未穿越上、下已经液化的砂岩层(图2d)。同震节理层可能早于或形成于液化砂体流动过程中。已有资料显示,中拉萨地块拉嘎组震积岩层中已识别出震褶岩和震裂岩,为原地相震积岩,亦是拉嘎组中地震作用的重要记录与标志(刘函等,2018,2020;杨洋,2019),这与本项工作在北拉地区拉嘎组中识别的震积岩的特征一致。

5 地质意义

关于北拉萨地块的基底性质一直存在争议,一种观点认为安多微地块内新元古代—早古生代片麻岩代表了北拉萨地块的基底(Xu et al., 1985; Dewey et al., 1988;Yin and Harrison, 2000),但近年来也有学者指出,安多微地块可能与南羌塘或扬子陆块更具有亲缘性(Zhu et al., 2011, 2013;解超明等, 2014;Liu et al., 2021);另一种观点认为北拉萨地块是班公湖—怒江中特提斯洋俯冲消减过程中,作为裂生微地块从中拉萨地块中分离出来,并逐渐演变为增生型微地块(刘一鸣等,2019),但是其陆壳基底的性质仍不清晰。已有资料显示,北拉萨地块主体以新生地壳为特征,广泛发育上三叠统—侏罗系俯冲增生杂岩、白垩系台坪相、河湖相和磨拉石建造,以及白垩纪中酸性岩浆岩(Zhu et al., 2011; Pan et al., 2012;Sui et al., 2013)。而中拉萨和南拉萨地块内均存在前寒武纪基底,明显不同于北拉萨地块。中拉萨地块前寒武纪基底被奥陶系—二叠系浅海碳酸盐岩或碎屑岩以及上侏罗统—下白垩统边缘海沉积及火山岩覆盖。南拉萨地块主体为

新生地壳，主要由白垩纪—古近纪冈底斯岩基和林子宗组火山岩组成，局部出露前寒武纪基底（Pan et al., 2012; Zhu et al., 2013, 2016）。本次填图工作在班戈县北拉地区识别出大量典型的冰碛岩和震积岩，岩石组合与中拉萨地块的拉嘎组一致，这是首次在北拉萨地块中部识别出确切的冈瓦纳相冰海相沉积，为北拉萨地块中部与中拉萨地块具有类似的基底提供了关键证据。因此，北拉萨地块并非完全由新生地壳和中—新生代盖层组成，可能是在少量陆壳基底基础上逐渐形成的增生型微陆块。

此外，地震事件表明北拉萨地块中部晚石炭世—早二叠世盆地形成于较为活动的构造背景之下。准同生及同生变形表明拉嘎组震积岩沉积过程中经历过多次地震作用，晚古生代沉积盆地可能一直处于活化状态。研究区拉嘎组中拉伸软布丁构造、同震节理与阶梯状断层等指示拉张环境。与伸展背景相关的震积岩常见于大洋中脊裂谷、陆内裂谷和陆缘裂谷等环境（Sims, 1975；梁定益等, 1994; 杜远生, 2011）。虽然在研究区拉嘎组中未识别出对构造背景具有指示意义的基性岩夹层，但前人在南羌塘地块与拉萨地块南侧均识别出二叠纪裂谷型基性岩墙（李奋其等，2012；Zhai et al., 2013）。此外，喜马拉雅地块二叠纪地层中火山岩也显示陆内裂谷特征（朱同兴等, 2002；Chauvet et al., 2008；Zhu et al., 2010）。这些岩浆作用指示冈瓦纳大陆北缘在二叠纪早期发生了裂解事件。伴随着南羌塘地块与拉萨地块的裂解逐步远离冈瓦纳大陆北缘而形成班公湖—怒江洋与印度—雅鲁藏布江洋的初始洋盆。

研究区拉嘎组位于班公湖—怒江蛇绿混杂岩带内部和南侧（图1b）。对于蛇绿混杂岩内部的拉嘎组而言，其与蛇绿岩、侏罗系木嘎岗日岩群和接奴群、中—上侏罗统拉贡塘组、泥盆系和下二叠统灰岩等构造混杂在一起（图1b），组成典型的俯冲增生杂岩，且混杂岩带内构造面倾向多为北倾，其次在研究区内未见到后期明显的逆冲推覆构造，因此该拉嘎组岩块很可能代表了班公湖—怒江洋内的裂离或拆离微地块，在班公湖—怒江洋俯冲消减过程中就位于混杂带之中。而南侧的拉嘎组夹持于班公湖—怒江缝合带和狮泉河—永珠—嘉黎蛇绿混杂带之间，很可能代表了班公湖—怒江洋南向俯冲过程中弧后拉张裂离出来的微地块。

6　结　论

（1）班戈县北拉地区新发现的含冰碛岩和震积岩地层为上石炭统—下二叠统拉嘎组。

（2）北拉萨地块具有与中拉萨地块类似的基底，它可能是在陆壳基底基础上逐渐形成的增生型微陆块。

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【简讯与热点】

《中国地质》继续入选“中国科技核心期刊”核心影响因子在地质学类期刊中排名第4

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Geology in China continuously selected as "Source Journals for Chinese Scientific and Technical Papers and Citations" and the impact factor ranking fourth among geological journals

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2023年9月20日,中国科学技术信息研究所发布了《2023年中国科技期刊引证报告(核心版)自然科学卷》。该报告以《中国科技论文与引文数据库》(CSTPCD)为基础,采用科学客观的研究方法与评价方式,遴选中国自然科学领域各学科分类的重要期刊作为统计来源期刊,共收录了在中国(未含港澳台地区)正式出版的1996种中文期刊和155种英文期刊。《中国地质》入选2023年度《中国科技期刊引证报告(核心版)自然科学卷》,其核心影响因子在入选的39种地质学类期刊中排名第4。

排名	刊名	核心影响因子	排名	刊名	核心影响因子
1	石油实验地质	3.772	21	地质科学	1.340
2	工程地质学报	3.605	22	地质与资源	1.330
3	地质学报	2.652	23	现代地质	1.193
4	**中国地质**	**2.646**	24	中国地质调查	1.188
5	岩石学报	2.621	25	西北地质	1.107
6	地质力学学报	2.484	26	物探与化探	1.101
7	第四纪研究	2.391	27	中国岩溶	1.018
8	地质科技通报	2.308	28	地层学杂志	0.975
9	地质论评	2.294	29	高校地质学报	0.846
10	沉积学报	2.169	30	海洋地质与第四纪地质	0.830
11	岩矿测试	2.164	31	矿物岩石	0.775
12	水文地质工程地质	2.051	32	Acta Geologica Sinica(English Edition)	0.705
13	矿床地质	2.007	33	世界地质	0.688
14	大地构造与成矿学	1.953	34	新疆地质	0.589
15	古地理学报	1.821	35	地质找矿论丛	0.517
16	China Geology	1.782	36	古生物学报	0.460
17	岩石矿物学杂志	1.647	37	微体古生物学报	0.354
18	地质与勘探	1.639	38	物探化探计算技术	0.309
18	地质通报	1.639	39	古脊椎动物学报	0.081
20	中国地质灾害与防治学报	1.591			