

程海个人简历

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教育经历

南京大学，中国 地球化学学士，1982 年 2 月
中国地质科学院，中国 地球化学硕士，1985 年 2 月
南京大学，中国 地球化学博士，1988 年 2 月

工作经历

中国科学院，北京 博士后，1988 年
京都大学，日本 研究员，1989 年
麦考瑞大学，澳大利亚 研究员，1991 - 1992 年
明尼苏达大学，美国 高级研究员，1993 - 2009 年
西安交通大学，中国 教授，2010 年 - 今

近期荣誉

中国国家杰出海外青年基金(2003 年)
The Gary C. Comer Abrupt Climate Change Fellowship (2007 年)
汤森路透中国高被引学者(2014 年)
汤森路透中国国际引用影响奖(2014 年，至今为中国地球科学界唯一获此殊荣者)
三秦友谊奖(2014 年)
地球化学学会和欧洲地球化学协会会士(2015 年)
中国高校十大科学技术进展(2016 年)
高被引学者(2014-2024 年，汤森路透/科睿唯安)
中国高被引学者(2015-2024 年，爱思唯尔)
美国地球物理学会会士(2017 年)
西安交通大学“科技工作先进个人”(2018 年)

美国地球物理学会 Eminiani Lecturer(2019 年)
陕西科学院科学技术奖一等奖(2020 年)
MEL 杰出访问学者奖(2020 年)
国家自然科学基金国际资深科学家奖(2021 年)
2021 年十大考古发现(《Archaeology》杂志)
欧洲地球科学联合会 Milutin Milankovic 奖章(2022 年)
奥地利科学院外籍通讯院士(2022 年)
国务院政府特殊津贴 (2023 年)

协会会员

美国地球物理学会(AGU)
欧洲地球物理学会(EGU)
地球化学学会和欧洲地球化学协会
中国地质学会
中国第四纪研究会

社会兼职

期刊主编: The Innovation Geoscience
期刊副主编: The Innovation(影响因子 33.2), Science Bulletin(影响因子 18.8)
期刊编辑委员会成员: Quaternary Geochronology, Speleology, Journal of Earth Environment, Science China-Earth Sciences, Scientific Reports, Geological Review 和 Quaternary Sciences
欧洲研究委员会地球系统专家组成员
地球化学学会和欧洲地球化学协会会士奖委员会成员
AGU Eminiani Lecturer 评选委员会成员
欧洲地球物理学会(EGU)Milutin Milankovic 奖章评选委员会成员
国家自然科学基金委员会专家组成员
USERN(全球科学教育与研究网络)成员
联合国教科文组织国际喀斯特研究中心科学委员会成员等

人才培养

硕士研究生: 14 人, 博士研究生: 18 人, 博士后: 11 人

技术专长

热离子质谱分析

多接收器电感耦合等离子体质谱分析(MC-ICP-MS)

微量金属分离技术

铀系定年技术

三氧同位素分析

合作技术成果

参与碳酸盐(珊瑚和石笋) ^{231}Pa 定年技术以及火成岩 $^{231}\text{Pa}/^{235}\text{U}$ 测量技术的发展

重新确定用于 U-Th 定年的 ^{234}U 和 ^{230}Th 半衰期

开发铀-钍-镤定年系统

开发 MC-ICP-MS U-Th 定年技术

开发第四纪碳酸盐样品的激光刻蚀和同位素稀释 U-Pb 定年技术

开发三氧同位素分析技术

石笋研究, 古气候重建及其与全球气候变化的关系

国际学者指导与支持

Seraina Badertscher(瑞士), Ronny Boch(奥地利), 蔡演军(中国), 陈仕涛(中国), Hong-Wei Chiang(台湾), Alan Chu(台湾), Kim Cobb(美国), Francisco da Cruz(巴西), David Dominguez-Villar(西班牙), Jeff Dorale(美国), Carolyn Dykoski(美国), Christina Gallup(美国), Ben Hardt(美国), Mayuri Inoue(日本), 姜修洋(中国), Lisa Kanner(美国), Gayatri Kathayat(印度), Megan Kelly(美国), Cutler Kirsten(美国), 孔兴功(中国), Claire Li(台湾), Hongchuan Li(美国), 李瀚瑛(中国), 李向磊(中国), Xuoyan Li(中国), Fuyang Liang(美国), Kris Ludwig(美国), 吕彦斌(中国), 马宸谔(中国), Christian Millo(巴西), Angela Min(美国), Jean-Sebastian Moquet(巴西), 饶治国(中国), Sushmita Ray(美国), Julie Retrum(美国), Stacy Rosner(美国), 沙丽娟(中国), 沈冠军(中国), Chun-Chou Shen(台湾), Erik Smith(美国), Heather Stoll(西班牙), Nicolas M. Strikis(巴西), 谭亮成(中国), 谭明(中国), Rebecca Thomas(美国), Ana M. Vicente(西班牙), 王先锋(美国), 汪永进(中国), 许瑶(中国), 杨焱(中国), 赵侃(中国), 赵欣楠(中国), 张德忠(中国), 朱晓燕(中国), 宁有丰(中国), 宗保云(中国), 杜文静(中国), 赵景耀(中国), 段鹏珍(中国), 卢佳玉(中国), 黎有为(中国), 田野(中国), 张帆(中国), 王毛毛(中国), 董西瑀(中国), 王健(中国), 孟秉霖(中国), 牛晓雯(中国), Yassine Ait Brahim(摩洛哥), Carlos Perez-Mejías(西班牙), Jonathan Baker Lloyd(美国), Gabriella Koltai(匈牙利), Jasper Alexander Wassenbury(德国), Julie B. Retrum(美国), Mirona Chirienco(罗马尼亚), Valdir Felipe Novello(巴西), Ny Riavo G. Voarintsoa(马达加斯加), David Domínguez-Villar(西班牙), Kristina Krklec(克罗地亚), 张海伟(中国), 张普(中国), Sasadhar Mahata(印度), 杨勋林(中国), 易亮(中国), 姚远(中国), 周卫健(中国), 刘卫国(中国), 刘殿兵(中国), 彭

友兵(中国), 张宏斌(中国), 殷建军(中国), Jo Kyoung-nam(韩国), 张涛涛(中国), 段武辉(中国), 班凤梅(中国), 阮骄阳(中国)等。

合作学者

J. Adkins (美国), K.D. Adams (美国), 安芷生(中国), Y. Asmerom (美国), A.S. Auler (巴西), S. Bayari (土耳其), M. Bender (美国), R. Boch (奥地利), W. S. Broecker (美国), G.A. Brook (美国), S.J. Burns (美国), C.D. Charles (美国), P. Clark (美国), K.M. Cobb (美国), F.W. Cruz (巴西), G.H. Denton (美国), D. Domínguez-Villar (西班牙), J.A. Dorale (美国), R. Drysdale (澳大利亚), H.N. Edmonds (英国), R.L. Edwards (美国), V. Ersek (英国), D. Fleitmann (英国), M. Gagan (澳大利亚), C.D. Gallup (美国), D. Genty (法国), 郭正堂 (中国), P. Hearty (澳大利亚), J. Hellstrom (澳大利亚), Inoue (日本), A. Klimchouk (乌克兰), M.S. Lachniet (美国), Z.H. Li (美国), D. McGee (美国), A. Mix (美国), F.H. Nader (黎巴嫩), B. Plessen (德国), R. Potts (美国), H. Qing (加拿大), J. Quade (美国), M.K. Reagan (美国), D.A. Richards (英国), B. Sebastian (德国), C.C. Shen (台湾), A. Sinha (美国), K. Sieh (新加坡), J. Southern (美国), R. Speed (美国), C. Spotl (奥地利), G.S. Springer (美国), L.D. Stott (美国), V.C. Tewari (印度), 谭明 (中国), S. Verheyden (比利时), R.C. Walter (美国), 汪永进 (中国), 王先锋 (美国), J.F. Wehmiller (美国), K.S. Woo (韩国), J. Woodhead (澳大利亚), 吴福元 (中国), 袁道先 (中国), 张平中 (中国), B. Luz (以色列), Q.Z. Yin (美国), Krause, C.E. (澳大利亚), 郑永飞(中国), 陈发虎 (中国), 吕厚远 (中国), 吴乃琴(中国), 鹿化煜(中国), 张虎才 (中国), 胡超涌 (中国) 等

研究概述与研究亮点

程海教授在过去的三十年中, 一直处于铀系(U-series)技术和其他技术发展的前沿, 致力于解决古气候学和全球气候变化研究中诸多基础性问题。作为全球领先的专家之一, 他主要专注于世界各地的洞穴记录研究, 并取得了令人瞩目的成果, 这些成果为我们更清晰地了解地球气候历史提供了支撑, 涵盖了广泛的时间尺度。他的贡献在国际学术界得到了广泛认可, 已发表超过 700 篇学术论文, 包括 30 篇《自然》和《科学》期刊论文, 80 余篇《自然》、《科学》子期刊及《PNAS》、《The Innovation》论文(谷歌学术: H 指数为 125, 引用量超过 95000)。他连续多年(2014-2024 年)被评为“高被引研究学者”(Thomson Reuters/Clarivate Analytics)。在国际地球科学家排名中位列第 8, 详情请见: <https://research.com/scientists-rankings/earth-science>。

U 系-定年技术与方法: 程海教授最广为人知的技术成就之一是他在 U 系定年技术方面的持续改进, 包括 U-Th、U-Pa 和 U-Pb 定年系统。这些改进主要体现在年龄精度的提高、样品需求量的显著减少、U/Th 定年的时间范围的加倍(扩展到更古老的年代)、 ^{231}Pa 和 ^{230}Th 定年系统的完善, 以及 ^{230}Th 和 ^{234}U 半衰期的重新测定, 这些改进已被 U 系定年研究领域广泛接受并应用(如 Cheng *et al.*, 1998, 2000, 2013a; Wang (其学生) *et al.*, 2022; Niu (其学生) *et al.*, 2025)。这些技术进展对地质学、海洋学、大气科学、人类学、考古学和艺术历史研究等多个领域产生了深远的影响。例如, 在过去十年中, 他的研究团队为团队成员和合作者提供了大量的 U 系定年数据, 这些数据帮助全球气候变化古气候研究取得诸多开创性的发现, 同时为亚洲、欧洲及其他地区人类进化的考古记录提供了重要的时间基准。

关键洞穴记录在气候系统中的应用: 基于最先进的 U 系定年技术, 程海在利用洞穴记录重建多个气候领域中最长的气候历史方面发挥了关键作用, 包括最长的东亚 (640 ka, Cheng *et al.*, 2016)

和印度 (280 ka, Kathayat (其学生) *et al.*, 2016) 季风记录, 西中国 (500 ka, Cheng *et al.*, 2012)、中亚 (150 ka, Cheng *et al.*, 2016)、北美 (335 ka, Cheng *et al.*, 2019) 和亚马逊盆地 (250 ka, Cheng *et al.*, 2013b) 最长期的气候记录。这些记录是古气候重建研究中的里程碑, 并在理解、关联和校准全球气候变率方面发挥了重要作用。在他和同事的工作之前, 主要的长时段 (数万到数十万年) 气候记录大部分由海洋和冰芯记录主导。如今, 洞穴记录已成为古气候研究的三大支柱之一。

全球季风与气候的轨道理论: 程海及其同事建立了大量洞穴记录, 表征了全球季风在轨道-年代尺度上的变化, 特别是亚洲 (Cheng *et al.*, 2016) 和南美 (Cheng *et al.*, 2013b) 季风的记录。基于新的相关策略 (Cheng *et al.*, 2006, 2009, 2016, 2020, 2021a), 他将季风记录与冰芯和海洋沉积物记录进行了相关比对, 从而将精确的洞穴年代表转移到其他具有丰富水文气候载体的档案中。作为其中的一个结果, 洞穴数据表明, 格陵兰和南极冰芯年代表在海因里希事件 2 期间分别需要进行+320 年和+400 年的调整 (Dong (其学生) *et al.*, 2022), 这一结论得到了现有火山证据和放射性碳年龄的支持。相关研究还提供了冰期终结的时间和事件顺序, 证明了新见解, 尤其是冰盖初步融化引起的海洋-大气碳和热循环的扰动所导致的正反馈机制 (Cheng *et al.*, 2009, 2016)。由于洞穴记录的绝对年代, 比较地球的辐射强度时避免了循环推理, 证明冰期终结的间隔为四到五个岁差周期, 支持 100-ka 的冰期周期是 4 或 5 个离散岁差周期的平均值 (Cheng *et al.*, 2016)。利用洞穴记录, 他提出了 30 年前关于亚洲季风轨道尺度变化的两个长期未解问题: “中国 100 千年问题”和“海陆岁差相位悖论”, 分别涉及 (1) 中国黄土磁化率记录中的 100-ka 主导周期与中国洞穴 $\delta^{18}\text{O}$ 记录中的几乎纯粹岁差周期 (20-ka) 之间的差异, 以及 (2) 亚洲大陆洞穴记录与环绕亚洲大陆的海洋沉积物记录 (尤其是阿拉伯海) 之间几乎相反的岁差相位 (Cheng *et al.*, 2021b)。他通过新的解释框架“季风系统科学”很好地调和了这些差异, 并展示了黄土、海洋和洞穴记录是互补的, 而非不兼容的, 每种记录分别描述了亚洲季风动力学/热力学的某一特定方面 (Cheng *et al.*, 2021b, 2022)。从轨道动力学和热力学强迫以及低纬度和高纬度气候双重响应的角度, 他提出将全球季风与米兰科维奇气候轨道理论结合, 制定新的轨道假说, 解释冰盖和季风系统的轨道水动力学的双重特性 (Cheng *et al.*, 2021b, 2022)。

安第斯至亚马逊的气候变化: 程海及其同事在南美季风区开展了一系列工作, 已超过十年。他的工作精确表征了南美季风降水事件的时间和特征, 这些降水事件与北大西洋的海因里希事件和亚洲季风弱化事件广泛相关 (Cheng *et al.*, 2013b, 2020, 2021b)。洞穴记录揭示了亚马逊西部和东部之间的轨道尺度降水准双极模式, 在最后一个冰期, 亚马逊西部降水量有所增加, 但亚马逊东部则显著干旱。之后他提出, 亚马逊西部的较高生物多样性, 与“避难所假说”相反, 是在相对稳定的气候条件下维持的。相比之下, 冰期-间冰期气候扰动可能是亚马逊东部生物多样性丧失的实例 (Cheng *et al.*, 2013b)。他还指出, 尽管北大西洋的初始气候变化与亚马逊降水增加基本同步, 但海因里希事件 4 的初始终结在南美季风中显著早于北大西洋, 导致亚马逊河流域的径流在海因里希事件 4 终结前数百年就已大幅减少。因此, 他提出了一个新机制, 认为径流减少可能促进了大西洋经向翻转环流的恢复, 最终触发了海因里希事件 4 的终结 (Cheng *et al.*, 2021a)。

文化变迁与人类进化最后阶段: 在文化变迁与人类进化最后阶段的研究前沿, 程海及其同事的洞穴研究揭示了降水变化与中国朝代/新石器文化兴衰之间的联系。例如, 夏季季风降水在北宋时期充沛, 当时稻米成为中国饮食的主食, 且中国人口增长了三倍 (Zhang, Cheng* *et al.*, 2008); 气候变化在塑造印度次大陆人类文明历史的重要章节中可能发挥了作用 (Kathayat (其学生), Cheng* *et al.*, 2017, 2022); 西藏最早已知的壁画艺术形式——儿童的手印和足迹的年代框架 (Zhang*, Bennett*, Cheng* *et al.*, 2021); 长江三角洲的良渚文化 (世界上最先进的新石器文化之一) 在约 4300 年前一个异常湿润的时期内突然崩溃 (Zhang*, Cheng* *et al.*, 2021); 气候在新亚述帝国兴衰中的重要作用 (Sinha *et al.*, 2019) 及许多其他案例。

^{14}C 校准与大气中放射性碳变化: 程海在利用洞穴沉积物进行 ^{14}C 校准方面做出了重大贡献, 提供了关键的 ^{14}C 数据集, 用于重建大气中 ^{14}C 的时间序列, 推至大约 54,000 年前的 ^{14}C 年代学极

限(Cheng *et al.*, 2018)。精准且准确的 ^{14}C 校准一直被认为是放射性碳年代学的“圣杯”，自诺贝尔奖得主威拉德·利比(Willard Libby)约 70 年前首次提出该方法以来， ^{14}C 校准的准确性和精度一直是科学界关注的焦点。尤其是时间尺度的较老部分，长期以来缺乏精确度和准确性。程海与 R.L. Edwards 和 J. Southon 以及中国同事合作，通过对来自著名的葫芦洞两块石笋的 U-Th 和 ^{14}C 年龄进行比对测量，成功完成了放射性碳时间尺度的全面校准(Cheng *et al.*, 2018)。这一校准提高了年龄估算的精度，并影响了多个领域，比如对尼安德特人和智人重叠时期的估算。此外，程教授的校准还将 ^{14}C 变化与海洋碳循环和地球磁场相联系，例如，与拉尚磁场波动以及海因里希寒冷期 4 相关的高大气 ^{14}C 水平。

近期进展：程海及其学生/博士后共同开发了三氧同位素分析技术，首次从洞穴和海洋样本中获得了一批新的 $^{17}\text{O}_{\text{excess}}$ 数据集，为许多气候系统中的水文气候变化及其潜在动态提供了新的见解（补充了 $\delta^{18}\text{O}$ 的分析）(Sha (其学生) *et al.*, 2020, 2021, 2022, 2024)。近年来，程教授和他的学生们通过使用 U-Pb 定年技术，将洞穴气候记录的时间范围大幅度延伸，突破了传统 U-Th 定年技术的上限（~650 ka），达到了晚中新世（约 360 万年前）(Wang (其学生) *et al.*, 2022)，这一成果为地球长期气候演变的前沿研究提供了突破的可能性(Niu (其学生) *et al.*, 2025)。

科普工作

程海教授的研究一直通过杂志和报纸报道向公众开放。例如，BBC 环境分析师 Roger Harrabin 在 2010 年中国天津举办联合国气候谈判期间，报道了他的研究。在前往北京的苦栗树洞进行实地考察并访问程教授西安实验室的过程中，Harrabin 详细介绍了程海团队的研究成果，包括洞穴记录的研究历史及其结果，指出亚洲夏季季风动力学多年代衰弱趋势主要是由人类活动引起。程海一直积极推动着科普工作的进行，并针对气候变化所面临的挑战与解决方案进行了系列讲座。例如，他在 2021/2022 中国科普创作大会及中国科普作家协会年会上发表了题为《亚洲季风与印中文明史》的讲座；他还撰写了多篇科普文章，2022 年在《人民周刊》上发表的文章《让石笋同位素发声》便是其中之一。

发表论文

已发表超过 700 篇学术论文, 包括 30 篇《自然》和《科学》期刊论文, 80 余篇《自然》、《科学》子期刊及《PNAS》、《The Innovation》论文 (谷歌学术: H 指数为 125, 引用量超过 95000)

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