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创刊词

海洋是生命的摇篮,是文明的纽带。地球上最早的生命诞生于海洋,海洋里的生命最终进化成了人类,人类的文化融合又通过海洋得以实现。人因海而兴。

人类对海洋的探索从未停止。从远古时代美丽的神话传说,到麦哲伦的全球 航行,再到现代对大洋的科学钻探计划,海洋逐渐从人类敬畏崇拜幻想的精神寄 托演变成可以开发利用与科学研究的客观存在。其中,上个世纪与太空探索同步 发展的大洋科学钻探计划将人类对海洋的认知推向了崭新的纬度:深海(deep sea) 与深时(deep time)。大洋钻探计划让人类知道,奔流不息的大海之下,埋藏的 却是亿万年的地球历史。它们记录了地球板块的运动,从而使板块构造学说得到 证实;它们记录了地球环境的演变,从而让古海洋学方兴未艾。

在探索海洋的悠久历史中,从大航海时代的导航,到大洋钻探计划中不可或 缺的磁性地层学,磁学发挥了不可替代的作用。这不是偶然,因为从微观到宏观, 磁性是最基本的物理属性之一,可以说,万物皆有磁性。基于课题组的学科背景 和对海洋的理解,我们对海洋的探索以磁学为主要手段,海洋磁学中心因此而生。

海洋磁学中心,简称 CM^2 ,一为其全名"Centre for Marine Magnetism"的缩写,另者恰与爱因斯坦著名的质能方程 $E = MC^2$ 对称,借以表达我们对科学巨匠的敬仰和对科学的不懈追求。

然而科学从来不是单打独斗的产物。我们以磁学为研究海洋的主攻利器,但 绝不仅限于磁学。凡与磁学相关的领域均是我们关注的重点。为了跟踪反映国内 外地球科学特别是与磁学有关的地球科学领域的最新研究进展,海洋磁学中心特 地主办 CM² Magazine,以期与各位地球科学工作者相互交流学习、合作共进!

"海洋孕育了生命,联通了世界,促进了发展"。21 世纪是海洋科学的时代, 由陆向海,让我们携手迈进中国海洋科学的黄金时代。

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1. 在全球变暖背景下海洋涡旋活动的长期演化



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摘要:中尺度海洋涡旋是气候系统的重要组成部分,影响海洋环流、热吸收、气体交换、碳 封存和营养物质输送。我们对海洋涡旋活动持续变化的大部分认知是基于卫星观测,但是观 测记录的长度有限,因此很难区分人为变化和自然变化。作者利用气候模型中海洋成分中的 可变分辨率非结构化网格来提高涡旋发生区域的网格化分辨率,作者可以研究海洋涡旋活动 对人为气候变化的长期响应特征。结果发现涡旋动能在大部分涡旋集中的地区向极地方向偏 移,在北半球黑潮出现增强,而巴西和马尔维纳斯海流和南极绕极流和墨西哥湾流出现下降。 模型的变化特征与北大西洋经向翻转流降低有关,进而加剧阿加勒斯岛的减弱以及南半球西 风带南移。

ABSTRACT: Mesoscale ocean eddies, an important element of the climate system, impact ocean circulation, heat uptake, gas exchange, carbon sequestration and nutrient transport. Much of what is known about ongoing changes in ocean eddy activity is based on satellite altimetry; however, the length of the altimetry record is limited, making it difcult to distinguish anthropogenic change from natural variability. Using a climate model that exploits a variable-resolution unstructured mesh in the ocean component to enhance grid resolution in eddy-rich regions, we investigate the long-term response of ocean eddy activity to anthropogenic climate change. Eddy kinetic energy is projected to shift poleward in most eddy-rich regions, to intensify in the Kuroshio Current, Brazil and Malvinas currents and Antarctic Circumpolar Current and to decrease in the Gulf Stream. Modelled changes are linked to elements of the broader climate including Atlantic meridional overturning circulation decline, intensifying Agulhas leakage and shifting Southern Hemisphere westerlies.



Figure 1. Magnitudes of simulated geostrophic ocean surface velocities. A snapshot of geostrophic velocities calculated from sea surface heights simulated by AWI-CM-1-1-MR for CMIP6 historical simulations. The equatorial region highlighted by grey lines (3° S to 3° N) is replaced with monthly mean velocity after linear interpolation to five-day mean time steps. Background image: NASA Earth Observatory.

Figure 2. Regional eddy kinetic energy change. Observed and simulated area-integrated regional eddy kinetic energy anomalies normalized relative to conditions during the observational period (1993–2020). Sigma (σ) represents the standard deviation of conditions during the observational period (1993–2020) in each basin, respectively. a, The Gulf Stream. b, The Kuroshio Current. c, The Agulhas Current. d, BMC. e, ACC.

2. 尼安德特人饮食谜题:来自牙釉质 Zn 同位素的视角

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Jaouen K., Villalba-Mouco V., Smith G M., et al. A Neandertal dietary conundrum: Insights provided by tooth enamel Zn isotopes from Gabasa, Spain [J]. PNAS, 2022, 119, 43 e2109315119. https://doi.org/10.1073/pnas.2109315119

摘要:对尼安德特人饮食的描述主要依赖于对骨骼和牙齿胶原蛋白的氮同位素分析。然而, 由于伊比利亚半岛旧石器时代遗址的胶原蛋白保存不良,很少从骨头或牙齿中恢复氮同位素 数据。锌同位素已被证明是在缺乏有机质保存的情况下重建营养水平的可靠方法。在这里, 我们对西班牙 Gabasa 的一个更新世食物网的牙釉质中测量了锌(Zn)、锶(Sr)、碳(C)和氧(O) 同位素以及微量元素,以表征旧石器时代中期的尼安德特人的饮食和生态。基于在尼安德特 人牙釉质中观察到的极低的 δ⁶⁶Zn 值,我们的结果支持了其他地区标本的 δ¹⁵N 同位素值所 提出的尼安德特人是食肉动物的解释。进一步的研究可以帮助确定这种同位素特性(食物网 中最低的 δ⁶⁶Zn 和最高的 δ¹⁵N)是否由尼安德特人的代谢和/或饮食特异性引起。

ABSTRACT: The characterization of Neandertals' diets has mostly relied on nitrogen isotope analyses of bone and tooth collagen. However, few nitrogen isotope data have been recovered from bones or teeth from Iberia due to poor collagen preservation at Paleolithic sites in the region. Zinc isotopes have been shown to be a reliable method for reconstructing trophic levels in the absence of organic matter preservation. Here, we present the results of zinc (Zn), strontium (Sr), carbon (C), and oxygen (O) isotope and trace element ratio analysis measured in dental enamel on a Pleistocene food web in Gabasa, Spain, to characterize the diet and ecology of a Middle Paleolithic Neandertal individual. Based on the extremely low δ^{66} Zn value observed in the Neandertal's tooth enamel, our results support the interpretation of Neandertals as carnivores as already suggested by δ^{15} N isotope values of specimens from other regions. Further work could help identify if such isotopic peculiarities (lowest δ^{66} Zn and highest δ^{15} N of the food web) are due to a metabolic and/or dietary specificity of the Neandertals.

Figure 1. (A) Location of the Gabasa site as well as other Neandertal sites mentioned in the text.(B) Detailed map of the Gabasa region. San Estaban de Litera and Benabarre are nearby modern cities.

Fig. 2. Enamel δ^{66} Zn values per mammalian taxon for different dietary groups from Gabasa, Spain given as boxplots. Note that subsamples taken from one single tooth reflect differences in dietary ⁶⁶Zn values. See text for detailed discussion about the low Neandertal δ^{66} Zn value.

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3. 南极臭氧亏损对南大洋气溶胶的影响

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Bhatti Y A., Revell L E., McDonald A J. Influences of Antarctic ozone depletion on Southern Ocean aerosols [J]. Journal of Geophysical Research: Atmospheres, 2022, 127, e2022JD037199. https://doi.org/10.1029/2022JD037199_

摘要:通常认为南大洋是一个原始的、远离人为源的气溶胶环境。本文在为 CMIP6 进行的 历史模拟中,研究了由于平流层臭氧消耗而导致的南大洋上空气溶胶负荷异常。本文探讨了 臭氧亏损通过增强紫外线诱导海洋二甲基硫化物 (DMS)的产生对气溶胶的直接影响,以及 通过南半球西风急流的变化对气溶胶通量的间接影响。研究表明,风是驱动南方夏季气溶胶 变化的关键因素,它导致气溶胶的光学深度比臭氧空洞形成前增加了 24%。与前人观点不 同,本研究显示臭氧损耗和增强的紫外线通量对气溶胶的直接影响并不明显。我们的结果表 明,平流层臭氧消耗间接增加了海洋气溶胶通量,因此,南大洋夏季气溶胶环境不能代表臭 氧空洞前的情况。

ABSTRACT: The Southern Ocean is often identified as a pristine aerosol environment, being distant from anthropogenic sources. We investigate anomalies in aerosol loading over the Southern Ocean due to stratospheric ozone depletion in historical simulations performed for the sixth Coupled Model Intercomparison Project. We explore direct influences of ozone depletion on aerosols via enhanced ultraviolet-induced production of oceanic dimethyl sulfide (DMS), and indirect influences via changes in the Southern Hemisphere westerly jet, which impacts wind-driven aerosol fluxes. We identify wind as the key driver of change for austral summertime aerosol, leading to increases in aerosol optical depth of up to 24% compared with the pre–ozone hole era. In contrast to previous studies, direct impacts on aerosol from ozone depletion and enhanced ultraviolet fluxes are less obvious. Our results show that the Southern Ocean summertime aerosol environment cannot be considered to be representative of pre–ozone hole conditions because stratospheric ozone depletion

has indirectly increased marine aerosol fluxes.

Figure 1. Sixth Coupled Model Intercomparison Project multi-model median (a) Change in Southern Ocean near-surface westerly winds in December–February in 1995–2014 relative to the 1940–1960 mean. The black solid line represents the 1995–2014 mean sea ice extent, and hatching shows the 1940–1960 sea ice extent, defined as grid cells with a sea ice concentration \geq 15%. (b–f) As for (a), but showing (b) absolute changes in near-surface atmospheric dimethyl sulfide (DMS) concentrations, (c) absolute changes in near-surface sea spray aerosol (SSA) concentrations, (d) absolute changes in aerosol optical depth at 550 nm, (e) relative changes in near-surface atmospheric DMS concentrations, (f) relative changes in near-surface SSA concentrations. Hatching indicates where the differences are not statistically significant (95% level of confidence, Student's *t*-test).

Figure 2. (a) Change in total column ozone in SON in 1995–2014 relative to the 1940–1960 climatology. The black solid line represents the 1995–2014 mean sea ice extent, and hatching shows the 1940–1960 sea ice extent. (b–d) As for (a), but showing (b) changes in near-surface (10 m) westerly winds, (c) relative changes in oceanic dimethyl sulfide (DMS) concentrations, (d) relative changes in near-surface (20 m) atmospheric DMS concentrations. Hatching indicates where the differences are not statistically significant (95% level of confidence, Student's *t*-test).

Figure 3. (a) Change in Southern Ocean sea ice extent during SON in 1995–2014 relative to the 1940–1960 climatology. Contours show area of sea ice melt $\geq 10\%$. (b) As for (a), but showing changes in near-surface (10 m) westerly winds, (c) as for (a), but showing relative changes in aerosol optical depth, (d) As for (a), but showing relative changes in atmospheric dimethyl sulfide (DMS), (e) as for (a), but showing relative changes to sea-salt aerosol. (f) Percent change in the 5 year rolling mean of sea ice, Aerosol optical depth (AOD), dimethyl sulfide (DMS) and sea spray aerosol (SSA) relative to 1940–1960, averaged within the sea ice melt contours shown in (a-e). The r^2 values for AOD, DMS and SSA within the contours of sea ice loss are shown.

4. 太平洋东北部全新世中晚期海表温度与生产力的变化

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Cheung A., Sandwick S., Du X., et al. Middle to Late Holocene Sea surface temperature and productivity changes in the northeast Pacific [J]. Paleoceanography and Paleoclimatology, 2022. https://doi.org/10.1029/2021PA004399

摘要:太平洋东北部海表温度和初级生产力的变化具有深远的意义。除了影响区域和全球的 温度和水文气候外,还控制着海洋生态系统,进而影响区域经济。然而,我们对太平洋东北 部海温的变化和受控因素,以及超过观测记录时间尺度上的生产力的了解仍然十分的有限。 本文中,作者利用来自太平洋东北部,跨越25.2°N到59.6°N7个点位的海洋沉积物记录, 表述了9000-1000 BP的海表温度和生产力的千年尺度变化。作者对样品时空演化的动力学 进行了研究,并将这些数据与瞬时气候模型输出进行比较,以确定潜在的驱动因素。通过热 平衡分析和最优指纹分析,作者对驱动力的空间模式进行了特征分析,结果显示,东北太平 洋海温在空间上发生了变化,高纬度地区比低纬度地区表现出更大的量级变化,这与之前研 究认为的全新世期间海温在区域上具有同步性和一致性不同。本文分析结果没有发现初级生 产者群落和碳素输出一致性变异的证据,因此强调了识别环境条件、生产者和碳素输出之间 的复杂相互作用。模型与代理的不一致说明需要更高分辨率的模型框架,同时也表明在代理 记录中观测到的变化可以用温室气体和轨道强迫的组合来解释。作者认为,复杂的海表温度 变化和海洋生态系统对强迫变化的响应是导致模式预测不一致的重要因素。

ABSTRACT: Variations of the sea surface temperature (SST) and primary productivity in the northeast Pacific have far-reaching implications. In addition to influencing the regional and global temperature and hydroclimate, these conditions also control marine ecosystems and their services, which subsequently impact regional economies. Yet, our understanding of the variability and controls of northeast Pacific SST and productivity on timescales exceeding observational records remains limited. Here, we use marine sediment records from seven locations, spanning 25.2°N to 59.6°N, in the northeast Pacific to characterize the millennial-scale variability of SST and

productivity from 9000-1000 years BP. We explore the dynamics of their spatiotemporal evolution and compare these data with transient climate model outputs to identify potential drivers. Through a heat budget analysis and optimal fingerprinting analysis, we characterize the spatial pattern of forcings. We find that SST varied spatially in the northeast Pacific, with higher latitudes exhibiting greater magnitude changes than lower latitudes, which differs from previous work suggesting regional synchronicity and coherence during the Holocene. Our analysis did not find evidence for coherent variability of primary producer community nor carbon export, highlighting the difficulty of identifying the complex interactions between environmental conditions, producers, and carbon export. Model-proxy disagreement demonstrates the need for higher resolution model frameworks but shows nonetheless that observed variability in the proxy records can be explained by a combination of greenhouse gas and orbital forcing. We suggest that the complex SST variations and marine ecosystem responses to forced changes are important factors that can drive disagreements in model projections.

Figure 1. Observations and proxy locations. Observed averaged mean annual a) sea surface temperature in 1981-2020 (Reynolds et al., 2002), b) chlorophyll-a in 2003-2020 (NASA Goddard Space Flight Center, 2018), c) coccolithophores in 2003-2020 (Bracher et al., 2017; Losa et al., 2017), and d) diatoms in 2003-2020 (Bracher et al., 2017; Losa et al., 2017). Circles represent locations of a) SST, b) C_{org}, c) C_{37total}, and d) Si proxy records (indicated by core names) analyzed in this study.

Figure 2. a) EW0408-85JC, b) ODP1034, c) ODP1019, d) Santa Barbara Basin, e) Soledad Basin. Lines with circles represent the dataset at original resolution, thick lines represent 200-year binned composites, and shaded areas represent 95% confidence interval of each 200-year composites, which accounts for chronological and analytical uncertainties. The circle indicates modern mean annual SST estimate based on OISST, and the error bar indicates 95% confidence interval based on bootstrap averaging.

5. 中国 4.2 ka 气候事件下黍类和稻米人口统计上的相反模式

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He K., Lu H., Jin G., et al. Antipodal pattern of millet and rice demography in response to 4.2 ka climate event in China [J]. *Quaternary Science Reviews, 2022, 295, 107786.* https://doi.org/10.1016/j.quascirev.2022.107786

摘要:人口和农业对突发气候事件的响应仍然是一个激烈争论的问题,特别是与4.2ka 事件 相关的社会崩溃。中国的区域人口和黍类-稻米农业之间的长期相互作用为研究这个问题提 供了一个机会。在这里,我们利用一个新的放射性碳定年数据库和来自中国不同地区的新石 器时代-青铜时代的考古植物学数据,探讨人口和农业对4.2ka 事件的响应和复原力。在4300-3500 cal a BP 期间,中国的区域人口在显示出一种相反的模式,即北部及西北部(NW)的 繁荣和南部及东南部(SE)的衰退。这一模式与黍类和稻米农业的繁荣和崩溃同时发生。我 们的研究显示,干旱引起的农田扩大和跨欧亚的文化交流促进了中国西北部黍类农业和人口 的可持续性,而降温和洪水事件以及社会危机的综合影响造成了中国东南部稻米农业和人口 的下降。人类社会对4.2ka 事件的不同响应和复原力被归因于气候异常和不同地区的文化交 流。总之,在全新世中期至晚期,具有高度阶层分化和等级制度的复杂社会比开放交流低阶 层的社会更容易受到突发性气候事件的影响。

ABSTRACT: The response of population and agriculture to abrupt climate events remains a matter of heated debates, especially the societal collapses related to the 4.2 ka event. Long-term interaction between regional demography and millet-rice agriculture in China provide a unique opportunity to study this issue. Here using a newly database of radiocarbon dates and archaeobotanical data spanning the Neolithic-Bronze Age from different regions in China, we address the response and resilience of demography and agriculture to the 4.2 ka event. Regional populations show an antipodal pattern of boom in north and northwest (NW) and bust in south and southeast (SE) China during 4300–3500 cal a BP. This pattern coincided with the prosperity and breakdown of millet and rice agricultures contemporaneously, respectively. Our study reveals that drought-induced

enlargement of farmland and trans-Eurasian cultural exchange promoted the sustainability of millet agriculture and population in NW China, and combined effects of cooling and flooding events and social crises caused a decline in rice agriculture and population in SE China. The diverse response and resilience of human societies to the 4.2 ka event has been attributed to both climatic anomalies and cultural exchange across different regions. In sum, the complex societies with high stratification and hierarchies were more vulnerable to abrupt climate events than low stratified societies open to exchanges during the middle to late Holocene.

Figure 1. Shift in cropping patterns during and after the 4.2 ka event across the six regions in China. The histogram with error bar and scatter diagram indicates the percentage and ubiquity of the macrobotanical staple crops. The pink and blue shades denote the stages during and after the 4.2 ka event, respectively.

Figure 2. Comparison between climate records, cultural traits, agricultural levels and population dynamics in China. (a) Climate records in NW China, including alkenone inferred summer temperature (ST) from Qinghai Lake (Hou et al., 2016) and pollen-based mean annual precipitation (PANN) reconstructed from Hulun Lake (Xiao et al., 2018) and Gonghai Lake (Chen et al., 2015b). (b) West Asian cultural traits, including the emergence of copper metallurgy (Li, 2015), percentage of animals in north China (Dong et al., 2021) and agricultural levels of wheat & barley (n = 316). (c) Radiocarbon-inferred population in north-northwest (NE) China and agricultural levels of millet (n = 260). (d) Radiocarbon-inferred population in south-southeast (SE) China and agricultural levels of rice (n = 283). (e) Environmental records in SE China, including relative sea level (RSL) reconstructed from Yushan site (Wang et al., 2018), alkenone based sea surface temperature (SST) from core MD06-3040 (Kajita et al., 2018), and extreme precipitation events indicated by magnetic minerals (IRMsoft-flux) from Heshang Cave (Zhu et al., 2017).

6. 边缘海大陆破裂模式

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Mohn G., Ringenbach J C., Nirrengarten M., et al. Mode of continental breakup of marginal seas [J]. Geology, 2022, 50(10), 1208-1213. https://doi.org/10.1130/G50204.1_

摘要:本文研究了西太平洋三个主要边缘海(南海、珊瑚海和伍德拉克盆地)的洋陆过渡带 (COT)结构,以确定大陆破裂过程中的构造-岩浆作用。COT 形成于最终裂谷过程中局部变 形的低角度正断层系统的活动。伸展与岩浆活动同时发生,包括在这些盆地的远端部分的火 山活动、岩脉和岩床。COT 表现出陆壳与火成岩洋壳在时空上的并置,整体结构不同于贫 岩浆或富岩浆被动边缘原型。我们认为这种破裂模式是由于附近俯冲带的作用所造成的高伸 展速率导致的边缘海特征。在边缘海的背景下,这种破裂模式和由此产生的 COT 结构突出 了大陆破裂机制的多样性。

ABSTRACT: We investigated the continent-ocean transition (COT) structure of three main marginal seas in the western Pacific Ocean (South China Sea, Coral Sea, and Woodlark Basin) to determine the tectono-magmatic processes acting during continental breakup. The COT formed from the activity of a low-angle normal fault system localizing deformation during final rifting. Extension was contemporaneous with magmatic activity, including volcanic edifices, dikes, and sills in the distalmost parts of these basins. The COT shows a sharp juxtaposition in space and time of continental crust against igneous oceanic crust, and its overall structure differs from that of magma-poor or magma-rich passive-margin archetypes. We propose that this mode of breakup is characteristic of marginal seas due to the high extension rates imposed by kinematic forces of nearby subduction zones. Revealed in the context of marginal seas, this mode of breakup and the resulting COT structures highlight the underestimated diversity of continental breakup mechanisms.

Stage 1: Final rifting and onset of MORB magmatism

Stage 2: Continental breakup and formation of the first igneous crust

Stage 3: Steady-state seafloor spreading

Figure 1. Conceptual model of a marginal sea breakup mode.

7. 综合浅层地球物理学、考古学和档案照片,揭示埋藏在美国北卡罗来纳州皮埃蒙特 Ingleside 种植园的过去

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Cowan E A., Seramur K C., Costa J W., et al. Integration of shallow geophysics, archaeology and archival photographs to reveal the past buried at Ingleside Plantation, Piedmont North Carolina (USA) [J]. Archaeological Prospection, 2022, 1-12.

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摘要:由电阻率断层扫描和梯度仪测量支持的探地雷达用于绘制建筑物和基础设施的地图, 记录 Jacob Forney 家族三代人的连续房产使用情况。Jacob Forney 家族最初在北卡罗来纳州 的偏僻乡村当农民,后来在美国东南部的政府和工业中崛起。在 Ingleside,内战前的种植园 住宅被保存了下来,邻近的房产相对来说没有受到干扰。地球物理调查的背景是档案照片、 包括专著和报纸文章在内的书面记录,以及对种植园夏季厨房内石头壁炉的考古发掘。新发 现的早期木屋的位置有一个石砌地窖,与美国独立战争的皮埃蒙特战役(1781 年)有关。 此外,一条历史悠久的道路、厨房花园和早期地下建筑的柱坑都在地下成像。外部夏季厨房 和卫生间与建于 1817 年的种植园有关。潜在厕所的几个污水池拱顶长满了树木。地球物理 调查的结果记录了美国南部一个家庭土地利用的演变,并且可以与历史上的特定事件联系起 来,这是历史考古学的目标。

ABSTRACT: Ground penetrating radar supported by electrical resistivity tomography and gradiometer surveys were used to map buildings and infrastructure documenting sequential property use by three generations of the Jacob Forney family who began as farmers in the backcountry of North Carolina and rose to prominence in government and industry within the Southeastern United States. At Ingleside, the antebellum plantation house has been preserved, and the adjacent property remains relatively undisturbed. Context for the geophysical surveys was provided by archival photographs, written accounts including monographs and newspaper articles, and an archaeological

excavation of the stone hearth within the plantation's summer kitchen. The location of an early log home with a stone-lined cellar with ties to the Piedmont Campaign of the American Revolution (in 1781) was newly discovered. In addition, a historic road, kitchen garden, and the postholes from an early post-in-the-ground building were imaged within the subsurface. The external summer kitchen and privy are associated with the plantation house constructed in 1817. Several cesspool vaults of potential privies are ingrown with trees. The results of the geophysical surveys document the evolving land use within one family in the American South and can be connected to a specific event in history, a goal of historical archaeology.

Figure 1. (a) Depth slice from 0.2 to 0.3 m showing likely outline of Structure 3. (b) Ground penetrating radar (GPR) depth slice from 0.7 to 0.8 m showing outline of debris in cellar. (c) Hill shade map of gradiometer data in G-13 showing magnetic anomalies that coincide with the high amplitude GPR reflections in the cellar. An iron spike buried approximately 10 cm (shown in inset) beneath the surface is recorded by a point source magnetic anomaly.

8. 袋鼠骨骼的形态分类揭示了澳大利亚西北部晚更新世时期的古生态变化

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Mein E., Manne T., Veth P., et al. Morphometric classification of kangaroo bones reveals paleoecological change in northwest Australia during the terminal Pleistocene [J]. Scientific reports, 2022.

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摘要:标本鉴定是考古学研究的支柱。区分生物多样性区域中密切相关的野生动物颅后骨骼 元素的可能会成为理解过去人类觅食行为的障碍。形态计量学越来越多地被用于对古动物遗 骸进行分类,然而,这些方法在区分野生动物群体方面的潜力尚未完全实现。在这里,我们 展示了传统形态计量学方法对袋鼠(一个大型且高度多样的有袋动物科)脚部和脚踝骨骼进 行分类的适用性。使用多重判别分析,我们对澳大利亚西北部 Boodie Cave 的考古标本进行 了分类,并确定了在更新世末期两种当地灭绝的大型动物物种的存在。皮尔巴拉地区此时出 现的带状兔袋鼠和北方钉尾袋鼠,为上一个冰河时代末期生态和人类对气候变化的反应提供 了独立证据。传统的形态计量学为古动物标本分类提供了一种方便、廉价和非破坏性的工具, 在其他多样的野生动物群中具有巨大的应用潜力。

ABSTRACT: Specimen identification is the backbone of archeozoological research. The challenge of differentiating postcranial skeletal elements of closely related wild animals in biodiverse regions can prove a barrier to understanding past human foraging behaviours. Morphometrics are increasingly being employed to classify paleozoological animal remains, however, the potential of these methods to discriminate between wild animal groups has yet to be fully realised. Here we demonstrate the applicability of a traditional morphometric approach to taxonomically classify foot and ankle bones of kangaroos, a large and highly diverse marsupial family. Using multiple discriminant analysis, we classify archaeological specimens from Boodie Cave, in northwest Australia and identify the presence of two locally extinct macropod species during the terminal Pleistocene. The appearance of the banded hare-wallaby and northern nail-tail wallaby in the Pilbara

region at this time provides independent evidence of the ecological and human responses to a changing climate at the end of the last Ice Age. Traditional morphometrics provides an accessible, inexpensive, and non-destructive tool for paleozoological specimen classification and has substantial potential for applications to other diverse wild faunas.

Figure 1. Taxonomic classification of macropod pes bones by discriminant analysis. (a) macropod genera in Boodie Cave over time; (b–d) classification of large macropod astragali (left), calcanea (middle) and fourth metatarsals (right) by genus; (e–g) classification of medium macropod astragali (left), calcanea (middle) and fourth metatarsals (right) by genus; (h–j) classification of small macropod astragali (left), calcanea (middle) and fourth metatarsals (right) by genus; (right) by genus; (h–j) classification of small macropod astragali (left), calcanea (middle) and fourth metatarsals (right) by genus; (right) by genus; (h–j) classification of small macropod astragali (left), calcanea (middle) and fourth metatarsals (right) by genus.

9. 32.5 亿年前的板块运动与偶极子磁场

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Brenner A R., Fu R R., Kylander-Clark A R C., et al. Plate Motion and a Dipolar Geomagnetic Field at 3.25 Ga [J]. Proceedings of the National Academy of Sciences, 2022, 119(44), e2210258119.

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摘要:古地磁记录是地球的地球物理历史档案,其可以重建地质历史时期板块运动,以及可 通过地磁发电机过程探究地球深部过程。我们报告了一个来自西澳大利亚东皮尔巴拉克拉通 的 32.5 亿年前的可靠的古磁极。综合前人在 3.34 - 3.18 Ga 之间东皮尔巴拉的结果,此古地 磁极使时间分辨的最古老的岩石圈运动重建得以实现,该结果显示了 160 My 之间速率至少 为 0.55°/My 的纬向漂移和旋转。这种类型、速率和持续时间的运动很难通过真极移或静止 盖层模型来解释,因此其强烈支持 3.25 Ga 的盖层移动相关的地球动力学过程。此外,该结 果包括了最古老的地磁极性反转记录,反映了太古宙的一个稳定核心磁场发电机形成的偶极 磁场。

ABSTRACT: The paleomagnetic record is an archive of Earth's geophysical history, informing reconstructions of ancient plate motions and probing the core via the geodynamo. We report a robust 3.25-billion-year-old (Ga) paleomagnetic pole from the East Pilbara Craton, Western Australia. Together with previous results from the East Pilbara between 3.34 and 3.18 Ga, this pole enables the oldest reconstruction of time-resolved lithospheric motions, documenting 160 My of both latitudinal drift and rotation at rates of at least 0.55°/My. Motions of this style, rate, and duration are difficult to reconcile with true polar wander or stagnant-lid geodynamics, arguing strongly for mobile-lid geodynamics by 3.25 Ga. Additionally, this pole includes the oldest documented geomagnetic reversal, reflecting a stably dipolar, core-generated Archean dynamo.

Figure 1. Minimum-motion reconstruction of the East Pilbara from ~3.34 to 3.18 Ga.

10. 黄土高原黄土沉积与亚洲干旱化在千年至几十千年尺度上解耦

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Peng F., Nie J., Stevens T., et al. **Decoupled Chinese Loess Plateau dust deposition and Asian** aridification at millennial and tens of millennial timescales [J]. Geophysical Research Letters, 49, e2022GL099338.

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摘要:通常而言,中国黄土高原(CLP)黄土沉积速率(DAR)的增加与亚洲内陆干旱化加 剧有关。然而,目前尚不清楚两者在何种时间尺度及区域上相关。本研究中,作者证明了 CLP 南部黄土 DAR 变化与 130 ka 以来的干旱化之间缺乏相关性。表明在千年乃至几十千年的尺 度上,高 DAR 与亚洲内陆干旱化加剧之间存在直接联系。相反,作者认为黄土 DAR 变化 更可能由干湿循环和相关松散沉积物的产生以及河流、冰川过程决定的。

ABSTRACT: It is generally assumed that increased dust accumulation rate (DAR) on the Chinese Loess Plateau (CLP) is associated with intensified inland Asian aridification. However, the timescales and area that any such association operates over is unclear. In this study, we demonstrate a lack of correlation between the southern CLP loess DAR variations and aridification over the past 130 ka, which does not support a direct link between high DAR and intensified inland Asian aridification over millennial to tens of millennial timescales. Instead, we propose that loess DAR variation is more likely determined by wet-dry cycles and associated loose sediment production and availability via fluvial and glacial processes.

Figure 1. A: Dust accumulation rates (DARs) calculated from high-resolution luminescence ages over the past 130 ka alongside the benthic δ 180 (dashed line) record (Lisiecki and Raymo, 2005). B: Average DARs within MIS 1-4 of each loess sequence at NW and SE CLP loess sites (Table S2). The color and location of each loess sequence correspond with that in A. Xifeng site is not used in panel B due to its incomplete ages over MIS 2-4. C: Aridity index of inland Asia from Han et al. (2020) and Herzschuh (2006). The DAR of each loess sequence in A and B was obtained by linear interpolation between published ages. The vertical lines in A and C are boundaries of marine isotope stages (MIS).

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Farmer J R. Deepening the Late Quaternary's Deep Ocean Carbon Mysteries [J]. Geophysical Research Letters, 2022, 49(13), e2022GL099161. https://doi.org/10.1029/2022GL099161

摘要: 深海是表层碳循环中最大的碳储库,其碳储库变化足够改变大气中的二氧化碳浓度, 进而改变地球气候。虽然深海碳储量自上个冰河时期以来得到了充分的研究,但相对于 100 万年前的中更新世转型期(MPT),深海是否对冰期旋回周期及强度的贡献,还知之甚少。 Qin 等(2022)提供了跨越 MPT 的太平洋深海碳酸盐离子饱和度(碳含量的指标)的重建。 有趣的是,他们的研究结果表明,横跨 MPT,太平洋深海碳酸盐离子饱和度的下降与大西 洋深海碳酸盐离子饱和度下降的时间有所不同。这些结果表明,整个海洋的碳封存对 MPT 气候变化有着更微妙的贡献。

ABSTRACT: Changes to the carbon content of the deep ocean, the largest reservoir in the surficial carbon cycle, are capable of altering atmospheric carbon dioxide concentrations and thereby Earth's climate. While the role of the deep ocean's carbon inventory in the last ice age has been thoroughly investigated, comparatively little is known about whether the deep ocean contributed to the change in the pacing and intensity of ice ages around 1 million years ago during the Mid-Pleistocene Transition (MPT). Qin et al. (2022, https://doi.org/10.1029/2021GL097121) provide new reconstructions of deep ocean carbonate ion saturation, a proxy for carbon content, from the deep Pacific Ocean across the MPT. Intriguingly, their results show that a reduction in deep Pacific carbonate ion saturation across the MPT occurred at different intervals from carbonate ion saturation decline in the deep Atlantic Ocean. These results suggest a more nuanced contribution of whole-ocean carbon sequestration to the climate changes reconstructed across the MPT.

Figure 1. The modern distribution of salinity (contoured) and carbonate ion saturation state $(\Delta[CO_3^{2-}] \text{ in } \mu\text{mol } \text{kg}^{-1}, \text{ colorbar})$ in the Atlantic and Pacific Oceans with sediment core reconstructions of $\Delta[CO_3^{2-}]$ change during the mid-Pleistocene (stars). The superscript number next to each star indicates the reconstructed $\Delta[CO_3^{2-}]$ change between 1.0 and 0.9 Ma, with the subscript number indicating the reconstructed $\Delta[CO_3^{2-}]$ change between 0.9 and 0.7 Ma. Data sources: DSDP 607 B/Ca (Lear et al., 2016; Sosdian et al., 2018), ODP 1267 B/Ca (Farmer et al., 2019), and IODP U1490 *T. sacculifer* size-normalized weight (Qin et al., 2022). Plot created using Ocean Data View (Schlitzer, 2021) and hydrographic data from GLODAPv2.2021 (Lauvset et al., 2021).

12. 大量碎屑锆石 U-Pb 年龄揭示了晚中新世全球降温导致了中国黄土高原的形成

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Zhang H., Lu H., He J., et al. Large-number detrital zircon U-Pb ages reveal global cooling caused the formation of the Chinese Loess Plateau during Late Miocene [J]. Science Advances, 2022, 8(41).

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摘要:由于粉尘来源的不确定性,中国黄土高原(CLP)景观的形成和演化一直存在争议。我 们基于 37100 多个碎屑锆石 U-Pb 年龄,结合矿物组合和同位素分析,对 CLP 的沙尘来源贡 献进行了定量估计。研究结果表明,CLP 是在~8 个百万年(Ma)的时间内逐步形成的,主要 由青藏高原东北部的物质组成,不同风成粉砂来源的相对贡献在~2.6 Ma 和 1.5~1.2 Ma 发生 了逐步转变。我们推断,这些变化是由全球逐步变冷所驱动的,全球变冷在冰寒气候粉尘源 区引起了干旱化,增加了粉砂的产生,并在扩大的干旱地区引起了粉尘风化。我们认为全球 降温是晚新生代 CLP 形成和演化的主要驱动力,而不是区域构造变形。

ABSTRACT: The formation and evolution of the landscape of the Chinese Loess Plateau (CLP) is debated because of uncertainties regarding dust provenance. We present a quantitative estimation of dust source contributions to the CLP, based on more than 37,100 detrital zircon U-Pb ages, combined with mineral assemblages and isotope analyses. Our results reveal that the CLP was stepwise formed by ~8 million years (Ma) and is mainly composed of material from the Northeastern Qinghai-Tibetan Plateau, with stepwise shifts in relative contributions of different eolian silt sources occurring at ~2.6 Ma and 1.5 to 1.2 Ma. We infer that these changes were driven by stepwise global cooling, which induced aridification and enhanced silt production in glaciated-cold climate dust source regions, as well as dust ablation in the expanded arid regions. We propose that global cooling, rather than regional tectonic deformation, was the main driver of the formation and evolution of the CLP during late Cenozoic.

Figure 1. Comparison of variations in provenance contributions on the CLP with regional and global paleoenvironmental records. Relative contributions of the NQTP sources (A and D), GAMs sources (B and E), and Ordos Block (OB) sources (C and F) to Jiaxian-Mizhi site (this study) (A to C), Luochuan site (this study, shown as solid diamonds), and Chaona site(shown as open diamonds) (D to F) based on cross-correlation coefficients results derived from the PDPs (note the reversed y axes for the NQTP sources). (G to I) Sr (G), Nd (H), and Hf (I) isotope composition of the CLP (see Materials and Methods and table S1 for details). (J) Ratios of hornblende to other heavy minerals of the eolian deposits at Lingtian on the CLP. (K to N) Percentages of the >30- μ m grain-size fraction and the magnetic susceptibility record of the Jiaxian [K; L, this study] and Chaona sites (M and N) (69). (O) Average dust accumulation rate of the CLP (this study; see Materials and Methods for details). (P) The LR04 stacked benthic foraminiferal δ 180 record (10-point Locally Estimated Scatterplot Smoothing).

13. 温带气候和日长的长程可预测性

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Scaife A A., Hermanson L., van Niekerk A., et al. Long-range predictability of extratropical climate and the length of day [J]. Nature Geoscience, 2022, 1-5. https://doi.org/10.1038/s41561-022-01037-7

摘要:角动量守恒是大气结构和变化的基础,对区域天气和气候有重要影响。大气层角动量 总量也与地球的自转率直接相关,因此也与一天的长度有关。然而,日长和大气角动量波动 的长程可预测性是未知的。这里我们表明,大气角动量和日长的波动可以预测到一年以上, 这为地表气候的长程预测提供了一个大气来源。利用一个动态气候模式的集合预报,我们证 明了大气角动量场信号的长程可预测性,这些信号由于大气中的波均流相互作用而缓慢而连 贯地向极地传播。这些可预测的信号也被证明是通过北大西洋涛动和温带急流先于温带气候 的变化。这些结果延长了日长预测的时间,提供了一个来自大气层内的长程可预测性的来源, 并提供了大地测量和气候预测之间的联系。

ABSTRACT: Angular momentum is fundamental to the structure and variability of the atmosphere and therefore has an important influence on regional weather and climate. Total atmospheric angular momentum is also directly related to the rotation rate of the Earth and, hence, the length of day. However, the long-range predictability of fluctuations in the length of the day and atmospheric angular momentum is unknown. Here we show that fluctuations in atmospheric angular momentum and the length of day are predictable out to more than a year ahead and that this provides an atmospheric source of long-range predictability for surface climate. Using ensemble forecasts from a dynamical climate model, we demonstrate long-range predictability of signals in the atmospheric angular momentum field that propagate slowly and coherently polewards due to wave-mean flow interaction within the atmosphere. These predictable signals are also shown to precede changes in extratropical climate via the North Atlantic Oscillation and the extratropical jet stream. These results extend the lead time for length-of-day predictions, provide a source of long-range predictability from within the atmosphere and provide a link between geodesy and climate prediction.

Figure 1. Variability and predictability of length of day. a, Variations in the length of day (LOD) showing the prominent interannual variability of around 0.5×10^{-3} s in observations (black) and the first year of ensemble mean model predictions starting in November each year (red). b, Correlation of predicted seasonal length-of-day anomalies in the ensemble mean with length-of-day anomalies from single model ensemble members (black), with radio telescope observations of Earth's rotation (blue) and with atmospheric reanalysis (red). The perfect model predictability (black) is smoother than the prediction skill against observations (red, blue) due to averaging of the correlations with each ensemble member in the model case. Note the non-monotonic variation with lead time and the peaks at leads of 3 and 15 months in winter. Statistical significance at the 95% level according to a one-sided t test for positive correlations is shown by the dotted line.

Figure 2. Mechanism of wave-driven atmospheric anomalies. a, Predicted anomalies in AAM (black, $1024 \text{ kg m}^2 \text{ s}^{-1}$) and wave-driven acceleration (blue, 10^{-4} m s^{-2}) from all waves (solid) and stationary waves (dotted) as a function of latitude, for the difference between the highest and lowest predicted AAM years. Anomalies are plotted from late spring/early summer (April–June) when ENSO anomalies decline to zero and the direct effect of ENSO from the tropics is small. Note how the wave driving accelerates the flow on the poleward side of the AAM anomaly in each hemisphere and how the stationary wave component is small compared with the total, implying that transient waves supply most of the wave-driven body force. b–d, A schematic of the wave-driven poleward propagation process for a positive perturbation to the AAM and zonal winds. b, The climatological jets (dashed line), spectrum of transient waves (wavy lines), climatological eddy momentum flux divergence (c) and as the jet perturbation migrates poleward (d). Note that the same mechanism operates if the sign of anomalies is reversed.

14. 过去半个世纪东亚夏季风的年际到多年变化

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摘要:东亚夏季风(EASM)对东亚过去、现在和未来的生态系统和社会都起着至关重要的作用。然而,由于东亚地区的仪器数据长度较短,在年际到几十年间的尺度上,东亚夏季风的变化仍然存在很大的不确定性。本研究将现代气象研究中的 EASM 环流指数扩展到过去半个世纪(1470-1998 CE)的古气候,以加强对古气候中 EASM 变率的理解和现代气象研究。基于与 EASM 相关的三种主要样品记录(树年轮、洞穴堆积物和历史文献数据)的共同信号重构了 EASM 指数。重建的 EASM 指数在年际到多年时间尺度上捕捉到"梅雨降水"与华南地区西南部异常的同步变化,是现代气象中明显且有充分记录的动态格局。对重建的 EASM 指数的分析表明,年际到多年际的 EASM 变率与太平洋-日本遥相关模式密切相关,这是太平洋年际涛动负相位与北太平洋西部异常反气旋环流之间的桥梁,同时这也表明,近 30 年(1992-2021 CE)的东亚夏季风变率处于过去半个世纪和自然变率范围内。

ABSTRACT: The East Asian summer monsoon (EASM) plays a crucial role for ecosystems and societies in East Asia past, present, and future. However, substantial uncertainties remain regarding EASM variability on interdecadal to multidecadal timescales because of the short length of instrumental data in East Asia. This study extended the EASM circulation index in the modern meteorological studies to the paleoclimate over the past half-millennium (1470–1998 CE) to reconcile the understanding of the EASM variability in paleoclimate and modern meteorological studies. The EASM index is reconstructed based on the common signal from the three main types

of the proxy records (the tree rings, speleothems, and historical documentary data) related to EASM. The reconstructed EASM index captures the simultaneous changes of the "*Meiyu* precipitation" and the southwesterly anomalies in South China on interdecadal to multidecadal timescales, which is a dynamic pattern visible and well-documented in the modern meteorology. Analysis of the reconstructed EASM index suggests that the interdecadal to multidecadal EASM variability is closely associated with the Pacific-Japan teleconnection pattern, which acts as a bridge between the negative phase of the Pacific Decadal Oscillation and the anomalous anticyclonic circulation over the western North Pacific. It also indicates that the EASM variability over the recent 30 years (1992–2021 CE) falls within the range of natural variability over the past half-millennium.

Figure 1. Comparison of the instrumental Wang and Fan (WF) East Asian summer monsoon (EASM) index over the period 1898–2021 CE (a) with the three types of proxy records (the tree ring δ^{18} O records in Changting (No. 6) (Xu, Zheng, et al., 2013) (b), and the speleothem δ^{18} O records in the Wuya cave (No. 13) (Tan et al., 2020) (c), and in the Jiuxian cave (No. 19) (Cai et al., 2010) (d), the Yu Xue Fen Cun in Yangtze River region (No. 20) (Ge et al., 2008) (e), and the historical documents in Osaka (No. 21) (Mizukoshi, 1993) (f)). *r* is the correlation coefficient between the instrumental EASM index with the proxy records during the common period. N_{eff} is the effective degree of freedom in the common period. All correlations are significant at the 90% level based on a one-tailed Student's *t*-test.

Figure 2. Composite of the reconstructed extended summer (MJJAS) precipitation anomalies (shading) (a), the data assimilation-based summer (JJA) precipitation (shading) and 850-hPa wind anomalies (vector) (b), the data assimilation-based summer sea level pressure (shading, in Pa) and 200-hPa wind anomalies (vector) (c), the reconstructed data assimilation-based summer 700-hPa Omega vertical velocity (Ω , shading) and vertical integral moisture transport (vector) (d) for the 18/15 strong/weak East Asian summer monsoon (EASM) events corresponding to the (weak-strong) EASM case. The white area indicates that the correlation does not exceed the 90% significant level based on a one-tailed Student's *t*test. The black arrow is the correlation at the 90% significant level based on a one-tailed Student's *t*-test. Gray arrows indicate a one-tailed Student's *t*-test failure. The green box indicates the middle and lower Yangtze River region (27–35°N, 105–122°E) in China. "C"/"A" indicates the cyclonic/anticyclonic anomalies. "–"/"+" indicates the low/high sea level pressure anomalies.