



## 南海深海物理过程与地质过程的关系探讨\*

宋海斌

中国科学院地质与地球物理研究所, 中国科学院油气资源研究重点实验室, 北京 100029

SONG Hai-bin

Key Laboratory of Petroleum Resources Research, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

- 摘要
- 参考文献
- 相关文章

Download: PDF (1362KB) HTML (1KB) Export: BibTeX or EndNote (RIS) Supporting Info

**摘要** 南海东北部沉积物波等特殊的沉积现象与深海物理过程密切相关, 海洋地质研究推断其与上升爬坡流、等深流、浊流作用有关, 而南海东北部海洋遥感观测到的最显著现象则是广泛发育的非线性内波的西向传播和涡旋的西向漂移。南海东北部涡旋、内潮?内波的形成演变与地形地貌有密切关系, 重要的地形地貌如海脊(恒春海脊与吕宋水下火山弧)和陆架坡折, 主要受构造过程控制。南海现代深海物理过程的建立及演变涉及到海盆本身的演化, 也涉及到南海北部张裂大陆边缘的演化与东部俯冲大陆边缘的演化。构造过程、沉积过程与深海物理过程密切相关, 对其关系的综合研究必将深化南海深海过程演变的认识。地震海洋学发展迅猛, 但尚处于初级阶段, 新的发现可能会改变人们的传统认识, 可望揭示地球系统流体部分与固体部分相互作用的本质, 为地球系统科学的突破做出贡献。

**关键词:** 南海 物理过程 构造过程 沉积过程 地震海洋学

**Abstract:** Special sedimentary phenomena such as sediment waves in the northeastern South China Sea (SCS) are closely related with physical processes in deep sea. Marine geological studies infer that sediment waves are caused by upward flow, contour current and turbidite current, while westward propagation of nonlinear internal waves and westward movement of meso-scale eddies are main features observed by satellite in the region. The evolutions of eddies and internal tides/internal waves are controlled by seafloor relief, and key features are submarine ridges (Hengchun Ridge and Luzon submarine volcanic arc) and continental shelf edge, which are mainly controlled by tectonic processes. The setup and evolution of modern physical process in SCS Deep are related to the formation and development of deep sea basin, northern rifted margin and eastern subduction margin of the SCS. Comprehensive studies of interactions among tectonic, sedimentary and physical processes will ensure a better understanding of evolution of SCS Deep. Recently, seismic oceanography has developed fast, though still in its preliminary stage. New discoveries may change our traditional knowledge about the deep ocean, grasp the nature of interactions between fluid Earth and solid Earth, and make major contributions to Earth system sciences.

**Keywords:** South China Sea, physical process, tectonic process, sedimentary process, seismic oceanography

收稿日期: 2011-02-08;

基金资助:

国家自然科学基金项目(91028002, 41076024); 国家基础研究发展规划项目(2011CB403503)

**作者简介:** 宋海斌(1968—), 男, 浙江省绍兴市人, 主要从事海洋地球物理研究。E-mail: hbsong@mail.iggcas.ac.cn

\* 感谢主要合作者Pinheiro教授、Ruddick教授、耿建华教授、王东晓、尚晓东研究员等与作者有益的讨论与帮助。感谢汪品先院士、中海油湛江分公司众多领导、边缘海—南海国家重点基础研究发展计划(“973”)项目首席科学家李家彪研究员等多年来的支持。感谢黄瑞新教授、甘子钧研究员、杨海军教授等对作者物理海洋学方面的指点。

引用本文:

宋海斌 .南海深海物理过程与地质过程的关系探讨\*[J] 热带海洋学报, 2012,V31(3): 10-20

SONG Hai-Bin .On relationship between physical process and geological process in South China Sea Deep[J] Journal of Tropical Oceanography, 2012,V31(3): 10-20

链接本文:

http://www.jto.ac.cn/CN/10.3969/j.issn.1009-5470.2012.03.002 或 http://www.jto.ac.cn/CN/Y2012/V31/I3/10














### Service

- ▶ 把本文推荐给朋友
- ▶ 加入我的书架
- ▶ 加入引用管理器
- ▶ Email Alert
- ▶ RSS

### 作者相关文章

- ▶ 宋海斌

- [2] WANG P, PRELL W L, BLUM P. Proc ODP, Init Repts [R/CD]. USA: Ocean Drilling Program. College Station: Texas A & M Univ, 2000, 184: 1-77. 
- [3] 邵磊, 李学杰, 耿建华, 等. 南海北部深水底流沉积作用[J]. 中国科学: D 辑, 2007: 37. 
- [4] 钟广法, 李前裕, 郝沪军, 等. 深水沉积物波及其在南海研究之现状[J]. 地球科学进展, 2007, 22(9): 907-913.
- [5] 宋海斌, 耿建华, WONG H K, 等. 南海北部东沙海域天然气水合物的初步研究[J]. 地球物理学报, 2001, 44(5): 687-695.
- [6] 丁巍伟, 李家彪, 韩喜球, 等. 南海东北部海底沉积物波的形态、粒度特征及物源、成因分析[J]. 海洋学报, 2010, 32(2): 1-10.
- [7] L?DMANN T, WONG H K, BERGLAR K. Upward flow of North Pacific deep water in the northern South China Sea as deduced from the occurrence of drift sediments [J]. Geophysical Research Letters, 2005, 32: L05614. doi: 10. 1029/2004GL021967. 
- [8] STOMMEL H. The abyssal circulation [J]. Deep-Sea Research, 1958, 5(1): 80-82. 
- [9] 苏纪兰. 中国近海水文[M]. 北京: 海洋出版社, 2004: 1-367.
- [10] HSU M K, LIU A K. Nonlinear internal waves in the South China Sea [J]. Can J Remote Sens, 2000, 26(2): 72-81.
- [11] ORR M H, MIGNEREY P C. Nonlinear internal waves in the South China Sea: Observation of the conversion of depression internal waves to elevation internal waves [J]. J Geophys Res, 2003, 108(C3): 3064. doi: 10.1029/2001JC 001163. 
- [12] ZHAO ZHONGXIANG, KLEMAS V, ZHENG QUANAN, et al. Remote sensing evidence for baroclinic tide origin of internal solitary waves in the northeastern South China Sea [J]. Geophys Res Lett, 2004, 31: L06302. doi: 10.1029/ 2003GL019077. 
- [13] RAMP S R, TANG T Y, DUDA T F, et al. Internal solitons in the northeastern South China Sea. Part I: Sources and deep water propagation [J]. IEEE J Oceanic Eng, 2004, 29: 1157-1181. doi: 10.1109/JOE.2004.840839. 
- [14] DUDA T F, LYNCH J F, IRISH J D, et al. Internal tide and nonlinear internal wave behavior at the continental slope in the northern South China Sea [J]. IEEE J. Oceanic Eng, 2004, 29 (4): 1105-1130. 
- [15] LIEN R C, TANG T Y, CHANG M H, et al. Energy of nonlinear internal waves in the South China Sea [J]. Geophys Res Lett, 2005, 32: L05615. doi: 10.1029/2004GL022012. 
- [16] ZHAO Z, ALFORD M H. Source and propagation of internal solitary waves in the northern South China Sea [J]. J Geophys Res, 111, 2006: C11012. doi: 10.1029/ 2006JC003644. 
- [17] KLYMAK J M, PINKEL R, LIU C T, et al. Prototypical solitons in the South China Sea [J]. Geophys Res Lett, 2006, 33: L11607. doi: 10.1029/2006GL025932. 
- [18] ZHENG QUANAN, SUSANTO R D, HO C R, et al. Statistical and dynamical analysis of generation mechanisms of solitary internal waves in the northern South China Sea [J]. J Geophys Res, 2007, 112: C03021. doi: 10.1029/2006 JC003551.
- [19] LI XIAOFENG, ZHAO ZHONGXIANG, PICHEL W G. Internal solitary waves in the northwestern South China Sea inferred from satellite images [J]. Geophys Res Lett, 2008, 35: L13605. doi: 10.1029/2008GL034272. 
- [20] 蔡树群, 甘子钧, 龙小敏. 南海北部孤立子内波的一些特征和演变[J]. 科学通报, 2001, 46(15): 1245-1250.
- [21] FARMER D, LI QIANG, PARK J H. Internal wave observations in the South China Sea: The role of rotation and non-linearity [J]. Atmos Ocean, 2009, 47(4): 267-280. 
- [22] BUIJSMAN M C, KANARSKA Y, McWilliams J C. On the generation and evolution of nonlinear internal waves in the South China Sea [J]. J Geophys Res, 2010: C02012. doi: 10. 1029/2009JC005275. 
- [23] GAO ZHENZHONG, ERIKSSON K A. Internal tide deposits in an Ordovician submarine channel: Previously unrecognized facies? [J]. Geology, 1991, 19: 734-737. 2.3.CO;2 target="\_blank"> 
- [24] 高振中, 何幼斌, 刘成鑫, 等. 深水牵引流沉积的研究历程、现状与前景[J]. 古地理学报, 2006, 8(3): 332-338.
- [25] 张兴阳. 深水牵引流形成的床形单元组合[J]. 古地理学报, 2000, 2(2): 28-36.
- [26] WANG GUIHUA, SU JILAN, CHU P C. Mesoscale eddies in the South China Sea observed with altimeter data [J]. Geophys Res Lett, 2003, 30 (21): 2121. doi: 10.1029/2003 GL018532. 
- [27] BROECKER W S. The biggest chill [J]. Nat Hist Mag, 1987, 97: 74-82.
- [28] BROECKER W S. The great ocean conveyor [J]. Oceanography, 1991, 4: 79-89.
- [29] LOZIER M S. Deconstructing the Conveyor Belt [J]. Science, 2010, 328: 1507-1511. doi: 10.1126/science.1189250 
- [30] GARRETT C. Internal tides and ocean mixing [J]. Science, 2003, 301: 1858-1859.
- [31] RICHARDSON P L, BOWER A S, ZENK W. A census of Meddies tracked by ?oats [J]. Prog Oceanogr 2000, 45(2): 209-250.
- [32] ARMI L, HEBERT D, OAKLEY N, et al. The history and decay of a Mediterranean salt lens [J]. Nature, 1988, 333: 649-651. 
- [33] ARMI L, HEBERT D, OAKLEY N, et al. Two years in the life of a Mediterranean salt lens [J]. Journal of Physical Oceanography, 1989, 19: 354-370. 2.0.CO;2 target="\_blank"> 
- [34] 李家彪. 中国边缘海形成演化与资源效应[M]. 北京: 海洋出版社, 2008: 1-509. 

- [35] HALL R. Oceanic: changing patterns of land and sea [M]//METCALFE I, SMITH J M B, MORWOOD M, et al. Faunal and Floral Migrations and Evolutions in SE Asia-Australasia. Lisse: A A. Balkema: Swets & Zeitlinger Publishers, 2001: 35-56. 
- [36] 陈林, 宋海斌, 许鹤华, 等. 张裂大陆边缘形成演化的动力学模拟[J]. 地球物理学报, 2009, 52(11): 2781-2787. doi: 10.3969/j. issn.0001-5733.2009.11.012
- [37] 宋海斌. 南海基底构造格架及张裂大陆边缘的综合地球物理研究[R]. 北京: 中国科学院地球物理研究所博士后报告, 1998: 1-141.
- [38] 陈林. 南海张裂大陆边缘数值模拟研究[D]. 北京: 中国科学院地质与地球物理研究所博士论文, 2009: 1-165.
- [39] HOLBROOK W S, P?RAMO P, PEARSE S, et al. Thermohaline fine structure in an oceanographic front from seismic reflection profiling [J]. Science, 2003, 301: 821-824. 
- [40] RUDDICK B. Sounding out ocean fine structure [J]. Science, 2003, 301: 772-773. 
- [41] RUDDICK B, SONG HAIBIN, DONG CHONGZHI, et al. Water column seismic images as maps of temperature gradient [J]. Oceanography, 2009, 22(1): 192-205. 
- [42] 宋海斌, 董崇志, 陈林, 等. 用反射地震方法研究物理海洋?地震海洋学简介[J]. 地球物理学进展, 2008, 23(4): 1156-1164.
- [43] 董崇志, 宋海斌, 拜阳, 等. 地震海洋学研究进展[J]. 地球物理学进展, 2010, 25(1): 109-123. doi: 10.3969/j.issn. 1004-2903.2010.01.017
- [44] NAKAMURA Y, NOGUCHI T, TSUJI T, et al. Simultaneous seismic reflection and physical oceanographic observations of oceanic fine structure in the Kuroshio extension front [J]. Geophys Res Lett, 2006, 33?: L23605. doi: 10.1029/2006GL 027437
- [45] 宋海斌, PINHEIRO L M, 王东晓, 等. 海洋中尺度涡与内波的地震图像[J]. 地球物理学报, 2009, 52(11): 2775- 2780.
- [46] PINHEIRO L M, SONG HAIBIN, RUDDICK B, et al. Detailed 2-D imaging of the Mediterranean outflow and meddies off W Iberia from multichannel seismic data [J]. Journal of Marine Systems, 2010, 79: 89-100. 
- [47] HOLBROOK W S, FER I. Ocean internal wave spectra inferred from seismic reflection transects [J]. Geophys Res Lett, 2005, 32: L15604. doi: 10. 1029/2005GL023733. 
- [48] KRAHMANN G, BRANDT P, KLAESCHEN D, et al. Mid-depth internal wave energy off the Iberian Peninsula estimated from seismic reflection data [J]. Journal of Geophysical Research, 2008, 113, C12016. doi: 10. 1029/ 2007JC004678.
- [49] SONG H B, DONG C Z, RUDDICK B, et al. Researches on internal wave spectra of northeastern South China Sea from one reflection seismic profile: Seismic Oceanography - ESF Expl. Workshop, Conf Proc [C]. Barcelona: Seismic Oceanography Conf. proc, 2008.
- [50] 董崇志, 宋海斌, 郝天珧, 等. 南海东北部海洋内波的反射地震研究[J]. 地球物理学报, 2009, 52(8): 2050-2055.
- [51] 宋海斌, 拜阳, 董崇志, 等. 南海东北部内波特征——经验模态分解方法应用初探[J]. 地球物理学报, 2010, 53(2): 393-400.
- [52] WOOD W T, HOLBROOK W S, SEN M K, et al. Full waveform inversion of reflection seismic data for ocean temperature profiles [J]. Geophys Res Lett, 2008, 35: L04608. doi: 10. 1029/2007GL032359. 
- [53] PAPPENBERG C, KLAESCHEN D, KRAHMANN G, et al. Ocean temperature and salinity inverted from combined hydrographic and seismic data [J]. Geophys Res Lett, 2010, 37: L04601. doi: 10. 1029/2009GL042115. 
- [54] 董崇志. 海水温盐结构反演与南海内波的地震海洋学研究[D]. 北京: 中国科学院地质与地球物理研究所博士论文, 2010: 1-128. 
- [55] 宋洋, 宋海斌, 陈林, 等. 利用地震数据反演海水温盐结构 [J]. 地球物理学报, 2010, 53(11): 2696-2702. doi: 10. 3969/ j. issn. 001-5733. 2010. 11. 017.
- [56] SHEEN K L, WHITE N J, HOBBS R W. Estimating mixing rates from seismic images of oceanic structure [J]. Geophys Res Lett, 2009, 36: L00D04. doi: 10. 1029/2009GL040106.
- [57] KLAESCHEN D, HOBBS R W, KRAHMANN G, et al. Estimating movement of reflectors in the water column using seismic oceanography [J]. Geophys Res Lett, 2009, 36: L00D03. doi: 10. 1029/2009GL038973.
- [58] SONG HAIBIN, PINHEIRO L M, TONG C H. Seismic imaging of submarine springs (OS21B-04): AGU Western Pacific Meeting, Taiwan, June, 2010 [C]. Taipei: AGU, 2010. 
- [59] VSEMIROVA E A, HOBBS R W, HOSEGOOD P. Mapping turbidity layers using seismic oceanography methods [J]. Ocean Sci, 2012, 8: 11-18. 
- [60] SONG HAIBIN, PINHEIRO L M, RUDDICK B, et al. Seismic Oceanography: a new geophysical tool to investigate the thermohaline structure of the oceans [C]//MARCELLI M. Oceanography. Croatia: InTech Press, 2012: 113-128.
- [61] SONG HAIBIN, PINHEIRO L M, RUDDICK B, et al. Meddy, spiral arms, and mixing mechanisms viewed by seismic imaging in the Tagus Abyssal Plain (SW Iberia) [J]. Journal of Marine Research, 2011, 69(4-6): 827-842. 
- [62] SONG HAIBIN, BAI YANG, PINHEIRO L, et al. Analysis of ocean internal waves imaged by multichannel reflection seismics, using Ensemble Empirical Mode Decomposition [J]. Journal of Geophysics and Engineering, 2012, 9(3): 302-311. 

- [1] 刘芳, 向荣, 张兰兰, 陈木宏. 台风过境前后南海北部水体浮游有孔虫群落变化[J]. 热带海洋学报, 2012,31(4): 90-95
- [2] 李玉, 赵美训, 张海龙, 邢磊, 杨红梅, 戴民汉, 王磊. 2009年冬季南海北部生物标志物对表层浮游植物生物量/群落结构的指示作用[J]. 热带海洋学报, 2012,31(4): 96-103

- [3] 阚光明, 邹大鹏, 刘保华, 李官保. 便携式海底沉积声学原位测量系统研制及应用 \* [J]. 热带海洋学报, 2012,31(4): 135-139
- [4] 刘昕, 王静, 程旭华, 闫桐. 南海叶绿素浓度的时空变化特征分析 \* [J]. 热带海洋学报, 2012,31(4): 42-48
- [5] 夏少红, 林伟, 陈建涛, 徐辉龙, 丘学林. 海陆地震联测流动台站布设及信号分析 \* [J]. 热带海洋学报, 2012,31(3): 48-57
- [6] 丘学林, 赵明辉, 徐辉龙, 李家彪, 阮爱国, 郝天珧, 游庆瑜. 南海深地震探测的重要科学进程: 回顾和展望 \* [J]. 热带海洋学报, 2012,31(3): 1-9
- [7] 徐辉龙, 夏少红, 孙金龙, 丘学林, 曹敬贺. 南海北部海陆联合深地震探测及其地质学意义 \* [J]. 热带海洋学报, 2012,31(3): 21-27
- [8] 孙金龙, 徐辉龙, 詹文欢, 曹敬贺. 南海北部陆缘地震带的活动性与发震机制 [J]. 热带海洋学报, 2012,31(3): 40-47
- [9] 朱俊江, 丘学林, 徐辉龙, 詹文欢, 赵明辉, 卫小冬, 孙金龙, 杨睿, 夏少红, 黄海波. 南海北部洋陆转换带地震反射特征和结构单元划分 \* [J]. 热带海洋学报, 2012,31(3): 28-34
- [10] 吴振利, 阮爱国, 李家彪, 李昭兴, 丘学林, 丁巍伟. 南海西南次海盆广角地震探测 \* [J]. 热带海洋学报, 2012,31(3): 35-39
- [11] 张云帆, 胡登科, 王万银, 邱之云, 李付成. 南海南北陆坡地壳拉张特征对比 [J]. 热带海洋学报, 2012,31(3): 137-143
- [12] 张伙带, 谈晓冬, 周蒂, 黎铭汉, 陈汉宗, 汤贤赞. 南海北部陆缘下侏罗统古地磁与岩石磁学结果 \* [J]. 热带海洋学报, 2012,31(3): 103-112
- [13] 高红芳. 南海西北海盆晚中新世以来浊积体地震相特征及海平面变化 [J]. 热带海洋学报, 2012,31(3): 113-119
- [14] 张翠梅, 刘晓峰, 任建业, 苏明. “构造 - 沉积分析” 及其在沉积盆地中的应用 [J]. 热带海洋学报, 2012,31(3): 128-136
- [15] 陈静, 陶贫, 王彦林, 金丹, 林秋金. 基于 Biot-Stoll 模型声速反演中的参数选择——以南海南部沉积物为例 [J]. 热带海洋学报, 2012,31(1): 50-54