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Hydrocarbon reserves of the South China Sea: Implications for regional energy security

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ABSTRACT

The countries such as China, Vietnam, Philippines, Malaysia, Indonesia and Brunei that border South China Sea region have immense stakes in exploring and exploiting the natural resources of the region including hydrocarbon. More than the hydrocarbon reserves, the South China Sea is home to World's high-networth trade route that brings the interests of non-geographic entities to this region. Further, the purported reserves of hydrocarbon in the region are in the orders of Persian Gulf but are not yet properly explored and the reserves recovered owing to territorial and non-claimant stakeholder's influences/interventions. This paper is a synopsis of information on the hydrocarbon reserves of the South China Sea region, and evaluates the territorial and extra-territorial interests in the light of energy security and equitable development and utilization of natural resources from a geological perspective. We also suggest several measures for future consideration and implementation.

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1. Introduction

According to an estimate of the U.S. Energy Information Administration (EIA) the total liquid fuels consumption in Asian countries other than the Organization for Economic Cooperation and Development (OECD) may increase at an annual growth rate of 2.6% (<https://www.eia.gov/>). This is a growth from 20% of world consumption in the year 2008 to about 30% of world consumption by the year 2035. Similarly, the non-OECD Asia natural gas consumption grows by 3.9% annually, from 10% of world gas consumption in the year 2008 to 19% by the year 2035 (<http://logos.national>

[interest.in/2013/09/oil-and-gas-reserves-in-the-south-china-sea/](http://logos.nationalinterest.in/2013/09/oil-and-gas-reserves-in-the-south-china-sea/)). It is interesting to note that out of these growth estimates, China itself accounts for about 43% of the growth. With Southeast Asian domestic oil production projected to stay flat or decline as consumption rises, the need for access to imported/offshore oil sources becomes greater (<http://logos.nationalinterest.in/2013/09/oil-and-gas-reserves-in-the-south-china-sea/>). As could be found elsewhere, the countries concerned employ a multi-pronged strategy to reduce the draining of precious foreign exchange exchequer for servicing import bills, augment domestic exploration and production. These efforts are made in addition to switching to alternate energy sources (Ramkumar et al., 2019).

Exploration activities since the 20th Century have unequivocally indicated the South China Sea (SCS) region (Fig. 1) to be one of the most prolific hydrocarbon producing regions of the World (Fig. 2 and Fig. 3), rivalling Persian Gulf region or any other comparable region. However, a slew of issues including, but not limited to, strategic, political, economic and administrative paradigms thwart realization of fullest potential of the resources available in this region. Energy

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security has become a top national security priority throughout the region over the past decade due to the combination of extremely high and volatile energy prices, China has rapidly emerged as a huge oil and gas importer, Japan and Northeast Asia continues to depend on imported oil and gas, and Southeast Asia has become a net oil and gas importer (<http://maritimeawarenessproject.org/2016/06/28/the-role-of-energy-in-disputes-over-the-south-china-sea/>). These have led to a chain of diplomatic, administrative and at times, military activities of various stakeholders (Fravel, 2011) and remain as a potential flashpoint (Owen and Schofield, 2012) of confrontation. In this short communication, we review the geological, geostrategic and geopolitical issues of hydrocarbon reserves and exploration and make an attempt to present a way forward.

2. Regional geology

The SCS is one of the largest marginal seas of Asia and is located in the western Pacific region (Fig. 1), bound between Vietnam, Philippines and Borneo (Yu et al., 2017). The SCS is one of the largest sedimentary basins of eastern Asia with a complex tectonic history and is considered as a key region as it is located at the junction of the Eurasian Plate, the Pacific Plate and the India-Australian Plate and has therefore been central to investigations on the Pacific Tectonic Domain and the Tethyan Tectonic Domain (Shu-Ling et al., 2010; Wang et al., 2019). The SCS is tectonically delimited by the Indochina block on the west, Philippines sea plate on the east and Yangtze block in the north (Metcalfe, 2006). The SCS basin consists of the central oceanic basin and the east, south, west and north continental (or island) margins (Gongcheng et al., 2017). It is surrounded by the Paleozoic Sundaland continental basement complex on the west and SW and chain of volcanic islands on the east. The tectonic plates surrounding the South China Sea Basin are considered to have undergone clockwise rotation, subduction and extrusion process from the Early Cenozoic to the Late Miocene. Several complexities remain in understanding evolutionary history of the SCS, including the multiple orientations of structural lineation, the irregular geometry of the oceanic crust (Fig. 1), the broad and highly broken transitional continental margin, and the conspicuous discrepancy between the east and the west. These require integration of continental and oceanic geological data (Ru et al., 1994). The SCS is located in the continental margin of Eurasia plate, where different geological blocks/tectonic plates interact which made its dynamic mechanism a focal point of discussion for many decades (Xue et al., 2016; Xiao et al., 2019). The continental breakup that began during the latest Cretaceous in the northeast of SCS propagated toward south and west and lasted for about 40 MY duration. A recent review by Barckhausen et al. (2014) summarize the stages, duration and rates of seafloor spreading and evolutionary history of SCS.

The southern part of SCS is underlain by foreland continental crust, termed Sundaland which is buried below the SCS (Hutchison et al., 2010). The Sundaland covers both onshore (Indochina Block) and offshore (Sunda Shelf) and the latter extends to a water depth of 200m. The Sunda Shelf has an average crustal thickness between 25 and 30 km and locally thin (16 km) at certain locations (i.e. beneath the deeper Malay basins; Holt, 1998). The Sunda continental shelf includes west Baram line, Lupar line and many islands (i.e. Natuna) (Hutchison, 1996, 2005). The basement continental rocks that underlain the Sunda Shelf are Precambrian metamorphic rocks and their composition is similar to neighboring landmasses (west Sarawak, Indochina and Peninsular Malaysia -Hutchison, 1989). The reported crystalline basement from Nansha Block is pre-Carboniferous metamorphic complex which is mainly composed of schists, phyllite, slate and quartzite (Zhou et al., 1995). The Triassic geology mainly includes widespread sedimentary

rocks and granites related to the Indosinian Orogeny (Middle–Upper Triassic). In addition, it is also premised that the shelf contains some older sutures represented from onland outcrops (Hutchison, 1989). The continental slope of SCS ranges from 200 to 1000m depth which is narrow and steep. The slope consists of draping sediments and is not faulted except the slope zones of the Sarawak Basin. The continental rise called as “Dangerous Grounds” starts at ~500m bathymetry at the margin of seafloor spreading or the continent–ocean boundary at ~3500m bathymetry (Hutchison, 2004). The Dangerous grounds consist of thin continental crust of thickness thinned to 8–25 km (Holt, 1998; Hutchison et al., 2001). The oceanic crust begins at a water depth of 3000m, and extends over 5000m (Sorkhabi, 2013). According to the data collected from ODP leg 184, the geology of SCS is made up of Eocene to Quaternary sediments. A total of 853m thick hemiplegic muds and silts were reported (Wu et al., 2014). Stratigraphy of the southern part of SCS has been interpreted based on seismic analysis (Mohd Idrus et al., 1995; Abdul Manaf and Wong, 1995). Accordingly, five sequences are recognized, such as basement rocks with composite of Mesozoic and older sedimentary and igneous rocks with localized metamorphic belts (Sequence 1); Upper Paleocene to Lower Oligocene early rift sequence of coarsening upward non-marine and younger coastal plain deposits (Sequence 2); Syn-rift sequences of shallow open marine to open marine sequence (Sequence 3 and Sequence 4); and Middle Miocene to Recent ponded sediments (Sequence 5). Several sea-floor edifices and cuestas reached the shallow water and were colonized by carbonate build-ups. Carbonate build-ups are common in three regions within SCS (Hutchison, 2014); namely, the Central Luconia Province (Epting, 1980), Miocene isolated platforms (Rankey et al., 2019), the Spratly islands (Hutchison and Vijayan, 2010), and within the NW Borneo Trough (Hutchison, 2010). Amongst many basins within the SCS, the Malay Basin, the Central Luconia, the Baram delta province, the Sarawak Basin and Sabah Basin are important due to their petroleum potential. The Malay Basin consists of sedimentary sequences of Oligocene to Recent (Ghosh et al., 2010) age. These sedimentary deposits show affinity to alluvial, fluvial-lacustrine and subtidal to coastal plain depositional environments (Ahmed Satti et al., 2016). The Baram Delta province consists of alternating sandstones and mudstones (Mazlan Madon, 1999).

3. Hydrocarbon resources

Since the exploration in the early 20th century, hundreds of Cenozoic oil and gas fields have been discovered to the tune of more than ten billion tons (Gongchen et al., 2017), making the SCS region one of the giant oil and gas areas (Fig. 3) of the world. The Tables 1 and 2 present area-wise and country-wise estimates of hydrocarbons. The region has proven oil reserves estimated at about 7.5 billion barrels, and oil production is currently over 1.3 million barrels per day. Malaysian production accounts for about one-half of the region's total. Total production from the SCS region has increased gradually over the past few years, primarily as additional production from China, Malaysia and Vietnam (<https://www.globalsecurity.org/military/world/war/spratly-oil.htm>).

Natural gas might be the most abundant hydrocarbon resource in the South China Sea (Fig. 2). Most of the hydrocarbon fields explored in the SCS region contain natural gas, and not oil (Fig. 3). Estimates by the USGS and others indicate that about 60%–70% of the region's hydrocarbon resources are gas (<https://www.globalsecurity.org/military/world/war/spratly-oil.htm>). Estimates of the natural gas resources vary widely. One Chinese report (<https://www.globalsecurity.org/military/world/war/spratly-oil.htm>) estimates that there are 225 billion barrels oil equivalent of

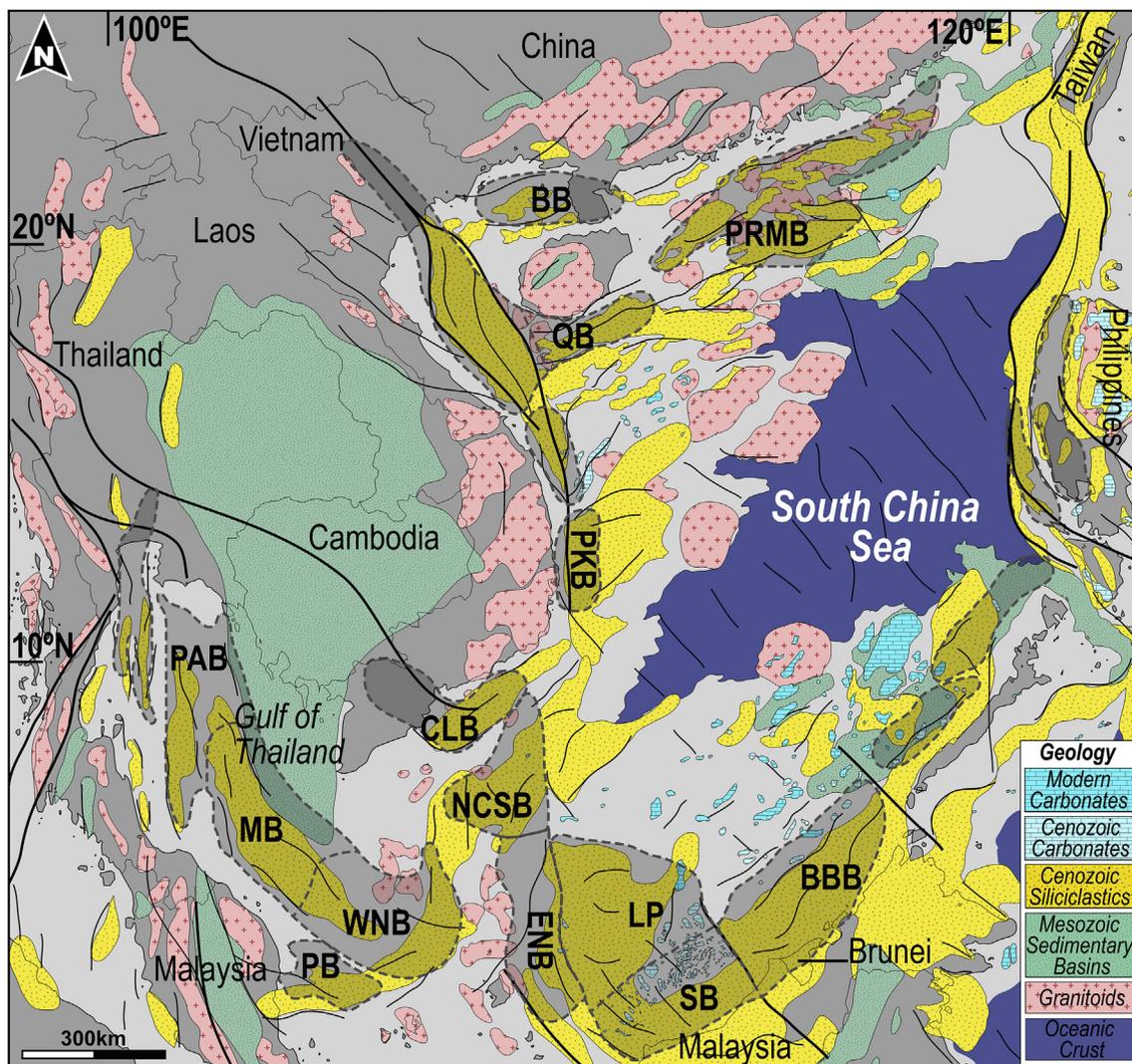


Fig. 1. Map showing the location of South China Sea region. Geology of the region, basin boundaries, distribution of basin boundaries, gas-oil and exploration blocks are also shown in the figure. Most of the offshore petroleum resources are located in the widespread Cenozoic siliciclastic basins. Important gas reserves are stored in Cenozoic carbonate reservoirs, especially in the Malaysian waters (Luconia Platform and Sarawak Basin). Near the continental shore, fractured granite resources are also reported, for instance, in the Cuu Long Basin. The petroleum provinces are shown in grey shades contoured by dark grey dashed lines. BB, Beibuwan Basin; BBB, Baram-Balabac Basin; CLB, Cuu Long Basin; ENB, East Natuna Basin; LP, Luconia Platform; MB, Malay Basin; NCSB, Nam Con Son Basin; PAB, Pattanin Basin; PB, Penyu Basin; PKB, PhuKhanh Basin; PRMB, Pearl River Mouth Basin; QB, Qiongdongnan Basin; SB, Sarawak Basin; WNB, West Natuna Basin.

hydrocarbons in the Spratly Islands alone. If 70% of these hydrocarbons are gas, total gas resources would be almost 900 Tcf. Malaysia is not only the biggest oil producer in the region, it is also the dominant natural gas producer as well, and until recently has been the primary source of growth in regional gas production. The USGS has placed the total discovered reserves and undiscovered resources in the offshore basins of the South China Sea at 266 Tcf.

4. Opportunities and challenges

Optimistic Chinese estimates of the SCS region's oil potential show as high as 213 billion barrels, which is comparable with any high-value hydrocarbon producing region of the World, including the Persian Gulf region. According to an estimate (<https://www.hydrocarbons-technology.com/features/feature-countries-with-the-biggest-oil-reserves/>) more than 80% of the World's proven hydrocarbon reserves occur in 10 countries, with Venezuela (297.57 billion barrels of oil) leading the quantum of reserves, whereas the countries Saudi Arabia (265.4 billion barrels), Canada

(173.1 billion barrels), Iran (157 billion barrels), Iraq (140.3 billion barrels), Kuwait (101.5 billion barrels), United Arab Emirates (97.8 billion barrels), Russia (80 billion barrels), Libya (48.47 billion barrels) and Nigeria (37.14 billion barrels) follow suit. In comparison, the Persian Gulf region dominates all other regions of the World. In this regard, the estimate of 11 billion barrels of oil and 190 trillion cubic feet of natural gas in proved and probable reserves, located along the margins of the South China Sea, besides another 12 billion barrels of oil and 160 trillion cubic feet of natural gas that remains to be proved conclusively, puts the total recoverable reserves of SCS region in close competition with the Persian Gulf region. Many of the countries rely on imports of fossil fuel to meet their domestic demands. Further, despite claims and intensive exploration activities since 1970's no one has struck a head-turning deposit of oil or gas in the 3.5-million-square-km (1.4-square-mile) sea, except Philippines, that has struck a major field that supplies nearly 15% of its domestic demand. This information, together with the data that shows that an estimated US\$3.37 trillion worth of global trade accounting a third of the global maritime trade and 80% of China's energy imports and 39.5% of

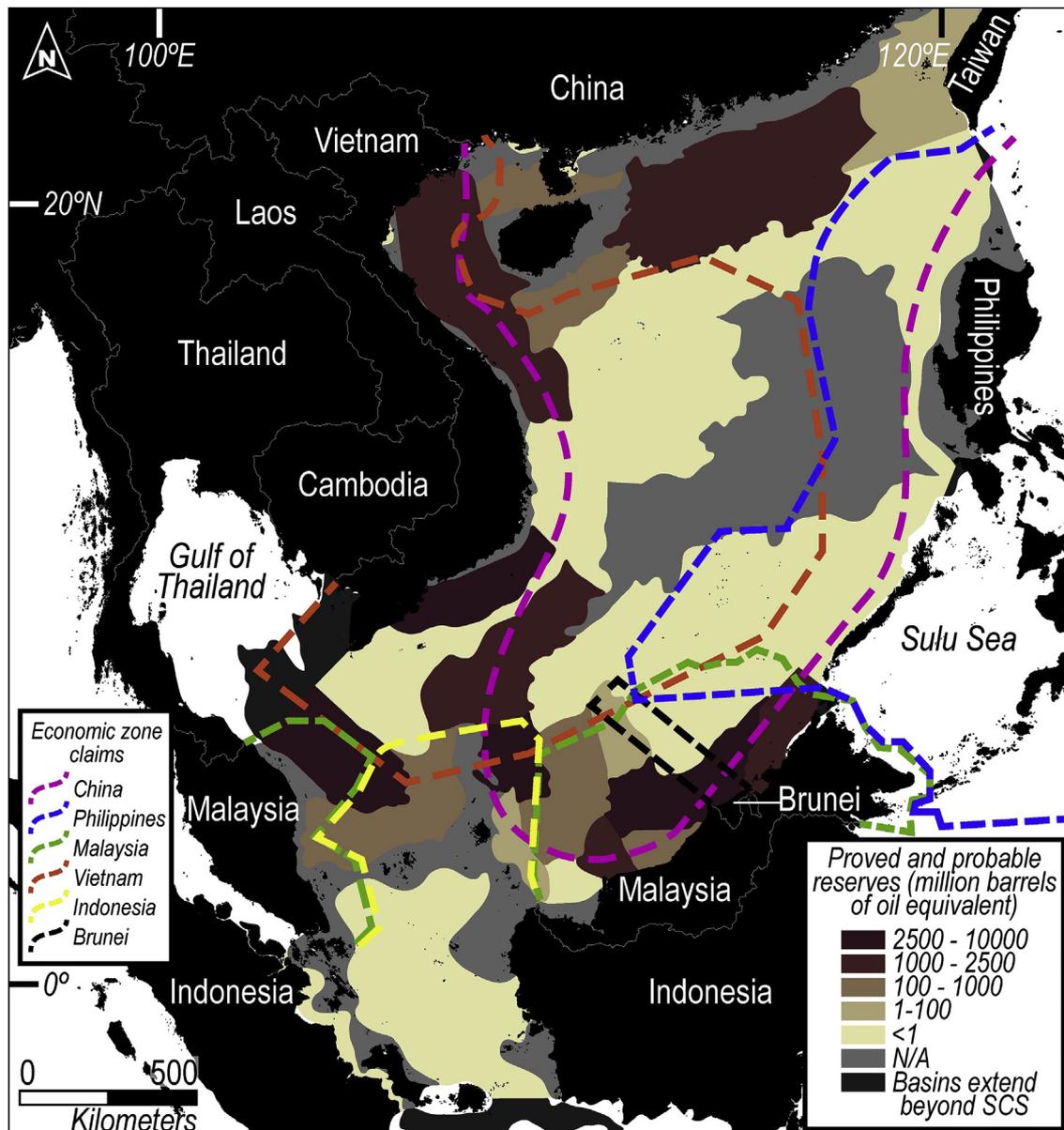


Fig. 2. Map showing proven and probable claims in the South China Sea. (Data source: United States Energy Information Administration [EIA]) are shown in color-coded geometries with solid fill. The map illustrates that while significant amounts of proven and probable natural resources (estimated 190 trillion cubic feet of natural gas and 11 billion barrels of oil) are available in this region particularly in the offshore areas bordering Vietnam and Malaysia, the South China Sea faces development challenges in the form of boundary disputes for claiming exclusive economic zones (EEZs), especially by China, Vietnam and Philippines. The boundaries for claims by bordering countries are shown with color-coded dashed lines (data source: Asia Maritime Transparency Initiative [amti.csis.org]).

China's total trade passes through the South China Sea annually (https://en.wikipedia.org/wiki/Territorial_disputes_in_the_South_China_Sea), makes it a geostrategic vantage point from maritime trade safety as well. It also necessitates all the stakeholders to contribute toward holistic development and maintenance of peace, in order to avoid this region becoming the cause of flashpoint. There has already been a realization in the world order that the stakes of non-claimant stakeholders such as Japan, South Korea, India, Singapore, Australia and United States who have a national interest in ensuring that the critical sea lanes in the South China Sea remain open and secure (<http://maritimeawarenessproject.org/2016/06/28/the-role-of-energy-in-disputes-over-the-south-china-sea/>).

Competition for oil and gas resources has repeatedly triggered standoffs between claimants in the South China Sea in recent years. The last serious attempt to cooperate on this front was the trilateral

Joint Marine Seismic Undertaking of 2005–2008, which was allowed to expire amid political controversy and questions about its constitutionality in the Philippines. Since late 2016, the Philippine and Chinese governments have been discussing joint development of hydrocarbons (<https://amti.csis.org/a-blueprint-for-cooperation-on-oil-and-gas-production-in-the-south-china-sea/>).

5. The way ahead

Owing to the high stakes involved, there is confidentiality and disagreements on the actual resources available in the SCS. Only concerted efforts to enact mutual confidence building measures through scientific and administrative cooperation could dispel the myths to make the muddy geopolitical waters clear. The claims and counterclaims, involvement of activities of countries whose

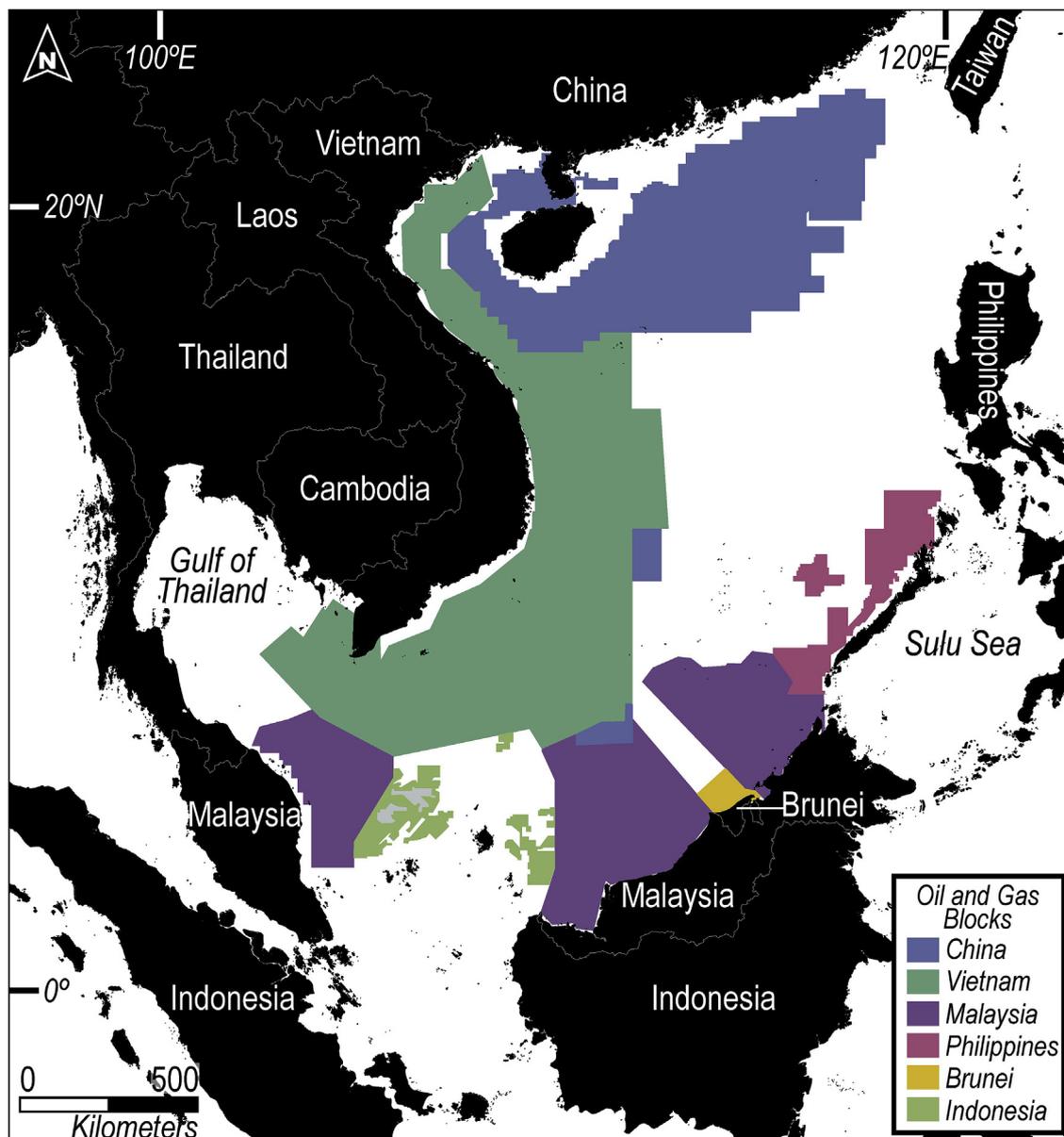


Fig. 3. Map showing the distribution of gas and oil fields in the South China Sea. Oil and gas blocks in the South China Sea that are currently licensed by the surrounding Southeast Asian claimants are shown in color-coded geometries (Data source: Asia Maritime Transparency Initiative [amti.csis.org]).

Table 1
Region-wise estimate of oil and gas in the South China Sea.

Region of South China Sea	Potential Oil and Gas Reserves (million barrels)
Southern China	1500
South of Hainan Island	210
Gulf of Tonkin	95
South Vietnam	2847
Sunda Shelf	180
Borneo/Sarawak	9260
Philippines	409

Source: Swire Institute of Marine Science and Department of Ecology and Biodiversity, University of Hong Kong: <ftp://ftp.fisheries.ubc.ca/l.teh/destructive%20fishing/South%20china%20sea.pdf>.

territory is located far away from the SCS, especially under the garb of freedom of navigation but with an eye on purported hydrocarbon resources of this region, could turn out to be hydrocarbon-

flashpoint. Though few think-tanks have termed this region to be the potential Asia’s Palestine (<https://www.americansecurityproject.org/resources-in-the-south-china-sea/>), given the roles played by global and wannabe global powers in hydrocarbon and geostrategic interests, frictions or flare-ups could not be entirely ruled out (<http://maritimeawarenessproject.org/2016/06/28/the-role-of-energy-in-disputes-over-the-south-china-sea/>).

On another perspective, despite the promise, and augmented exploration efforts, there has not yet been any significant discovery worth the geostrategic and geopolitical tensions prevailing. Thus, cooperation on disputed oil and gas resources is more difficult, both legally and politically, than for fisheries or environmental management. Unlike for fish, there is no provision in the United Nations Convention on the Law of the Sea (UNCLOS) mandating that states cooperate to manage oil and gas resources in a semi-enclosed sea like the SCS (<https://amti.csis.org/a-blueprint-for-cooperation-on-oil-and-gas-production-in-the-south-china-sea/>).

Table 2
Country-wise proved and probable reserves of oil and gas in the South China Sea.

Country	Crude oil and liquids reserves (million barrels)	Natural gas reserves (trillion cubic feet)
Brunei	1500	15
China	1300	15
Indonesia	300	55
Malaysia	5000	80
Philippines	200	4
Thailand	–	1
Vietnam	3000	20

Source: U.S. Energy Information Administration: South China Sea, updated on February 2013

Nevertheless, it is possible for claimants to cooperate on oil and gas development in the South China Sea in a manner that would be both equitable and consistent with international law as well as the laws of all involved parties. The term “Joint development” arrangement is that the claimants agree to set aside territorial claims “without prejudice” for future resolution and jointly develop energy resources in a contested area, are quite common globally, including in Asia. For example, the Malaysia-Thailand Joint Development Area (JDA) has been in operation in the Gulf of Thailand since the mid-1990’s in a maritime zone claimed by both countries (<http://maritimeawarenessproject.org/2016/06/28/the-role-of-energy-in-disputes-over-the-south-china-sea/>). Doing so would require considerable creativity and a greater willingness to compromise. Such an agreement would need to be framed so that all parties could claim it was consistent with their interpretations of both domestic and international law (<https://amti.csis.org/a-blueprint-for-cooperation-on-oil-and-gas-production-in-the-south-china-sea/>). Qi (2019) has narrated a number of choices, practices and policy initiatives with reference to joint development in the region.

A possible template for such an agreement is the 25-nation multinational anti-piracy naval task force that has been operating in the Gulf of Aden and northern Arabian Sea since 2008. The coalition operates in parallel but often with some coordination with other independent anti-piracy operations conducted by China, India, Iran, and Russia. All told, countries operating together or independently include nearly all the key Asian oil importers and rival powers. While this option might be a bridge too far in the current tense atmosphere, thinking through the requirements of a joint-protection regime could lay the groundwork for the launch of such a program at a more opportune time (<http://maritimeawarenessproject.org/2016/06/28/the-role-of-energy-in-disputes-over-the-south-china-sea/>).

One of the suggestions that may provide hydrocarbon-incentives and lasting peace in the SCS region is to refrain from employing hydrocarbon exploration as a political tool by stakeholders and non-stakeholders. Deepwater exploration and production requires additional technology, resources such as semisubmersible rigs, drill ships and platform and drilling equipment to withstand the harsher conditions of deeper waters, multiples of financial risks and international cooperation, which can be achieved only through accepting mutual, assured benefit for all the stakeholders.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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