

The Development Trend of PLA Submarine Stealth Technology

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Topics: Military Technology, Warfare Tactics

1. News Highlights

According to a South China Morning Post report on March 24, researchers from Beijing Institute of Technology have developed a new submarine coating material using rare earth elements. The “active magnetic tiles” that take advantage of the technology, known as “giant magnetostrictive materials,” can generate low-frequency sound waves of 147-decibel that transform passive reflection into active emission. The active magnetic tiles can reflect enemy sonar frequencies and produce low-frequency,

high-decibel echoes, causing enemy sonar operators to mistake the sound for ordinary ocean noise. The report suggests that China’s abundant rare earth resources give it a unique advantage in developing and applying this technology, potentially threatening the US Navy with improved Chinese submarine stealth capabilities.¹ Based on news reports, it appears that China has utilized its ample mineral resources to expand its research and development efforts, resulting in the creation of impressive military technologies.

1. Stephen Chen, “Chinese Scientists Say New Stealth Tech for Submarines Can ‘Cancel Out’ US Navy Sonar,” *South China Morning Post*, March 24, 2023, <https://www.scmp.com/news/china/science/article/3212279/chinese-scientists-say-new-stealth-tech-submarines-can-cancel-out-us-navy-sonar>; Cai Yuting, “Submarine Becomes Water? China Claims Their Stealthy Submarine Coating Can be Disguised as ‘Water’, Making Sonar Echoes Undetectable by the US Navy,” *Newtalk News*, March 28, 2023, <https://newtalk.tw/news/view/2023-03-28/863904>.

2. Security Implications

2-1. Making detection more difficult

To enhance stealth capabilities, submarine development typically focuses on three aspects: 1. propulsion systems, 2. geometric shapes, and 3. surface coating properties. The most advanced submarines today, such as the US Virginia-class and Seawolf-class nuclear-powered attack submarines, produce noise levels only 5 decibels above the average ocean background noise (90db) when submerged.² Conventional diesel-electric submarines, however, produce more noise during operation, as evidenced by the 2003 disaster involving China's Ming-class 361 submarine, which was likely caused by experiments to reduce noise from the conventional propulsion system.³ In addition, submarine propellers are another significant source of noise

during operation.⁴ As for the geometry of submarines, a "teardrop-shaped" hull design is generally adopted to reduce the seawater resistance. Thus, coating properties have become a critical factor in enhancing submarine stealthiness besides propulsion systems. The aforementioned "active magnetic tiles" produce 147-decibel sound waves that fall within the low-frequency range emitted by whales (155 to 188 decibels).⁵ This led to an incident where a PLA Kilo-class submarine was initially mistaken for a whale by the British Queen Elizabeth-class aircraft carrier using sonar detection but was eventually correctly identified through sound reflection spectroscopy.⁶

2-2. Unique characteristics of Rare Earth Elements

Sound travels five times faster in water than in air, making transducers for

2. Wang, Zhipeng, "The Advanced US Submarines are Difficult to Detect, but will 'Quantum Technology' Change the Global Military Balance?" *EToday*, April 11, 2021, <https://forum.ettoday.net/news/1957365>.

3. He, Zeng-yuan, "A Study on the Chinese 361 Submarine Accident," *Naval Academic Monthly*, Vol. 38, No. 6, pp. 77-81, 2004.

4. Lin, Cheng-guei, "Study on the Intelligent Automatic Rudder Control of Submarines Maneuvering Underwater in A Low-noise, Stealthy Manner," *CSBC Quarterly*, Vol. 44, No. 1, pp. 67-86, March 2023.

5. Kieran Mulvaney, "The Loneliest Whale in the World?" *The Washington Post*, January 26, 2017, <https://www.washingtonpost.com/sf/style/2017/01/26/the-loneliest-whale-in-the-world/>.

6. Li, Jingtang, "China Claims to Master New Submarine Technology that Cheats US Navy Sonar without being Detected," *TVBS News*, March 28, 2023, <https://news.tvbs.com.tw/world/2081178>.

emitting sound signals and hydrophones for receiving widely used in anti-submarine detection.⁷ As the speed of sound propagation depends on the medium,⁸ the use of rare earth element coatings that generate low-frequency, high-decibel echoes that may lead to misjudgment becomes a new trend in stealth research.

Rare Earth Elements (REEs), or rare earth metals, are seventeen metal elements and belonging to Group 3 elements on the periodic table, including lanthanum, terbium, and dysprosium, among others. A common analogy is that if oil is “the blood of industry,” then rare earths are the “vitamins of industry.” China boasts abundant rare earth reserves, ranking first

globally in terms of reserves, production, and exports. Lanthanum (La), derived from the Greek word “lanthanon” meaning “hidden,” has high refractive properties and can be applied in various areas, such as piezoelectric, thermoelectric, and magnetoresistive materials. Terbium (Tb), mostly used in high-tech fields, contributes to the magnetostrictive effect, causing changes in the shape and size of soft magnetic materials upon magnetization, thereby altering sound wave reflections. Dysprosium (Dy) also exhibits the magnetostrictive effect.⁹ Since these REEs are produced in China, they allow Chinese research teams to enjoy a competitive advantage.

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7. “NCSIST Introduces New Product: Transducer,” *NCSIST*, https://www.ncsist.org.tw/csistdup/products/product.aspx?product_Id=595&catalog=38.
 8. Lee, Chung-Yi and Tsai, Chi-Shen, “The Propagation of Sound,” *Science Online*, January 6, 2011, <https://highscope.ch.ntu.edu.tw/wordpress/?p=19289>.
 9. “Popular Rare Earth Knowledge: Introduction to Uses of 17 Rare Earth Elements,” *KKnews*, March 27, 2017, <https://kknews.cc/finance/b28n3x6.html>.

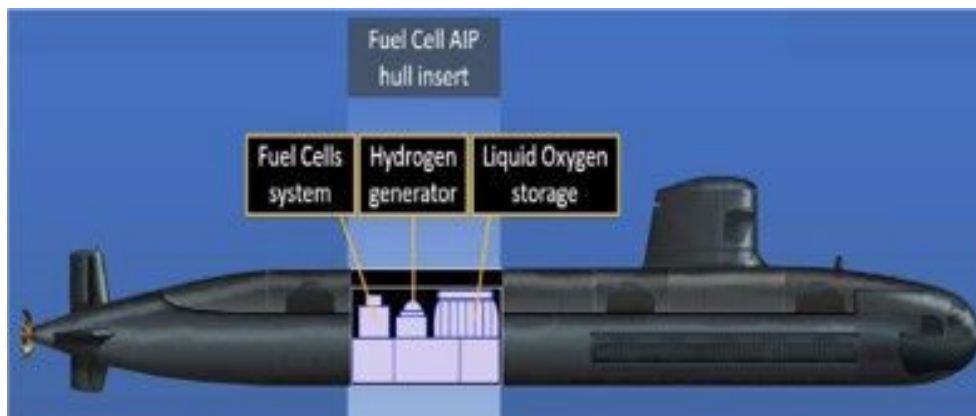
3. Trend Observation

3-1. Improved stealth performance of conventional submarines

According to the contents of the “China Military Power Report” published by the US Department of Defense in 2022, as of 2020, China possessed 6 nuclear-powered attack submarines, 6 ballistic missile submarines, and 44 conventional attack submarines powered by diesel-electric and air-independent propulsion (AIP) systems.¹⁰ The AIP systems are strongly suspected of having been installed on the Chinese Ming-class 361 submarine in 2003, which was involved

in an accident at the time of its testing. Similar equipment, as shown in Figure 1 of the Indian submarine, features an air-independent propulsion system mainly consists of three subsystems: a fuel cell system, a hydrogen generator, and a liquid oxygen storage tank. This description reveals that nearly 80% of Chinese submarines still utilize conventional diesel-electric and AIP systems. If the stealth characteristics of the materials used in the cross-sectional area are further improved, it will undoubtedly become a significant challenge for anti-submarine warfare.

Figure 1: AIP propulsion system



Source: H I Sutton, “AIP Submarines Will Increase The Lethality Of The Indian Navy,” *Forbes*, <https://www.forbes.com/sites/hisutton/2020/07/22/aip-submarines-will-increase-the-lethality-of-the-indian-navy/?sh=1d43d4b641c7>.

10. “Annual Report to Congress: 2022 Military and Security Developments Involving the People’s Republic of China,” *U.S. Office of the Secretary of Defense*, November 29, 2022, <https://www.defense.gov/News/Releases/Release/Article/3230516/2022-report-on-military-and-security-developments-involving-the-peoples-republi/>.

3-2. Anti-submarine operations will be more difficult

Submarines operating and navigating underwater possess excellent stealth and surprise capabilities; they can covertly execute combat missions, such as blockades, ambushes, and mine-laying, in the contested waters or channels. As a result, they have become a force that navies around the world strive to establish. Chinese traditional submarines, starting with the Yuan-class (039A), adopted double-hull structures, coupled with noise-dampening tiles and anti-sonar rubber coatings, while the 039B model employed a Stirling AIP system.¹¹ Now, the Chinese military adopted REEs for the new coating material for submarines and continuously enhances the submarines' stealth capabilities with advanced technologies. For Taiwan, it's imperative to strengthen underwater acoustic measurement and identification to meet the severe challenge from China.

(Originally published in the 77th "National Defense and Security Biweekly", April 14, 2022, by the Institute for National Defense and Security Research.)

(The contents and views in the assessments are the personal opinions of the author, and do not represent the position of the Institute for National Defense and Security Research.)

11. Ying, Shaoji, "Comparison of the Development and Batter Capability of Conventional Submarine Forces Between China and other East Asian Countries," *Naval Academic Bimonthly*, Vol. 51, No. 6, 2017, pp. 36-50.