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The acceptance of ad hoc ideas on Book of Mormon geography has been a continuing problem in Church history, and for a very good reason. Specifics are generally lacking, and attempts to quantify missing geographic data are frequently met with considerable skepticism. Some Church members find it equally difficult to accept the suggestion that naturally occurring events played a role in anything that is more easily explained by supernatural activity. Fully cognizant that addressing either subject is analogous to welcoming the African killer bees across the southern borders of our country, I offer a new idea on Lehi's transoceanic voyage, an idea that is firmly rooted in recent atmospheric and oceanographic observations.

After traveling for eight years, Lehi's party arrived at what many LDS scholars have assumed was the tip of the Arabian Peninsula, and there the group "beheld the sea" (1 Ne. 17:5). "And . . . the voice of the Lord came unto [Nephi], saying: Arise, and get thee into the mountain" (1 Ne. 17:7). The land travel was completed, and it was time for the serious business of securing material to construct a ship: "And we did work timbers of curious workmanship. . . . after the manner which the Lord had shown unto [Nephi]; wherefore, it was not after the manner of men" (1 Ne. 18:1–2). Details concerning the construction are not known, but eventually a ship was constructed, the party "prepared . . . much fruits and meat . . . and honey in abundance," the ship was loaded, and the Lehi group "put forth into the sea and were driven forth before the wind towards the promised land" (1 Ne. 18:6, 8).

If we assume, as have many Latter-day Saint scholars, that the launching site was somewhere on the Indian Ocean,[1] one of the most serious questions that need answering is simply how this curious ship was able to travel across the Indian and the Pacific Oceans in a direction that is directly opposed by the wind patterns and surface currents of those oceans. The fact is that the tip of the Arabian Peninsula furnished great access to the Indian Ocean twenty-five hundred years ago (as it does today), but it was an unlikely place to begin a voyage that would move eastward through the Indian Ocean, around or through Indonesia, and then across the Pacific Ocean to the Western Hemisphere. During much of the year the predominant currents of the Indian Ocean would carry a ship southward, toward Africa, and the predominant North Equatorial and South Equatorial Currents of the Pacific move in a direction opposite to that needed by Lehi to reach the Western Hemisphere.[2] In the face of such important obstacles as prevailing wind direction and surface ocean circulation patterns, how did Lehi cross the Indian Ocean and then the Pacific Ocean?

The Indian Ocean crossing can be more easily explained. For thousands of years, mariners have exploited the seasonal monsoon circulation in the western Indian Ocean for trade between India and the east coast of Africa.[3] Simply put, monsoonal circulation is produced by differential cooling and heating of the Indian Ocean and adjacent Asian and Indian land masses during different parts of the seasonal cycle. Thus, the cooling of southeast Asia and India during the winter season produces a land mass that is colder than the adjacent ocean. As the warmer atmosphere over the ocean rises, it pulls the cooler air from the continent oceanward. Winds produced by this activity drive the surface ocean currents from the north to the south (fig. 1).

During the summer season, the process reverses. The land is warmer than the ocean, and as the warm air rises over the continent, vertical circulation is produced that pulls the cooler ocean air in over the warmer land. The result is monsoonal rain on land as well as surface ocean currents that move from the south or southwest to the north or northeast, a general ocean-to-land direction that is opposite to that of the winter season (fig. 2). The result of a year of such seasonal changes is summer surface currents that move from south to north and winter surface currents that move from north to south. The surface winds and resulting surface currents peak during August for the north and northeast-moving currents and during February for the south and southwest moving currents.[4] Sailing from India to Africa (northeast to southwest) is improved during the winter season, while a trip to the north or northeast is most easily accomplished during the summer.

Crossing the Indian Ocean from the west to the east is not difficult if a ship is launched in August at the peak of the monsoonal cycle. Perhaps this is when Lehi did sail, just as other mariners had done and would continue to do for thousands of years if they wished to travel eastward. Clearly, monsoonal oceanic circulation could have aided Lehi at the beginning of his migration to the promised land.

The real problem came after sailing across the Indian Ocean into Indonesia. No such monsoonal circulation is available for travel through the East Indies or for crossing the Pacific Ocean; in fact, the major wind and ocean surface currents move in the direction opposite to that traveled by Lehi. What was the method of migration after reaching Indonesia?

If Nephi's brothers had been able to look at a surface current map of the Pacific Ocean (not to be available until at least two thousand years later), they would have raised an even larger objection to the whole idea of sailing to a new home than the protest recorded in the Book of Mormon (1 Ne. 17:17–18). The dominant currents in the general area of the Pacific where Lehi probably sailed—twenty degrees north and south of the equator—are the North and South Equatorial Currents[5] (fig. 1). Both these equatorial currents have strong movement from east to west, the opposite of that needed by Lehi.

One possible explanation for the ability to sail eastward across the Pacific Ocean in the area of westward-moving currents involves the existence of a small current that moves just a degree or so either side of the equator in an eastward direction and between the major westward currents. This is the Equatorial Counter Current[6] (fig. 1). The problem for Lehi (or Micronesian sailors for thousands of years) is that because the small area of the Equatorial Counter Current is dominated by light and irregular winds, this area (the Doldrums) is very undependable for sailing. There is evidence that Micronesian sailors relying on winds and surface currents may have used the Doldrums, at least in part, for the eastward-directed exploration of Fiji and Samoa five hundred years before Lehi sailed.[7] But Lehi's ship was "not after the manner of men" (1 Ne. 18:2), and in the absence of any data, the meaning of this comment is difficult to guess. Perhaps it means their ship had no sail or rudder or was based on an unknown design. Possibly eastward travel relied for a large part on surface currents alone. We know too few details about Lehi's circumstances to view the Doldrums area and its principal transporting current as more than a very remote possibility for carrying the ship across 12,000 km or so of hostile Pacific Ocean. But there is a more reasonable means of travel from the east to the Western Hemisphere.

Since the beginning of the twentieth century, men have known that every three to four years, "normal" atmospheric and oceanic circulation in the tropical Pacific is altered, producing the so-called ENSO effect.[8] Oceanic changes during these intervals are referred to as *El Niño* (the *EN* part of *ENSO),* meaning "the [Christ] child" in Spanish, because effects are commonly noted around Christmas time in the eastern South Pacific. Together with related atmospheric effects, called the *Southern Oscillation* (the *SO*), the ENSO climate cycle produces profound physical, biological, and even socioeconomic effects across the tropical Pacific from Indonesia (where we left Lehi) to South and North America. In order to understand the ENSO effect, we must consider the atmospheric and oceanic conditions of the Pacific Ocean.

During what have traditionally been considered times of "normal" atmospheric circulation, southeast trade winds converge on low-pressure areas that dominate in the Indo-Australian region (fig. 1). As this moisture-laden air rises in the low pressure areas, it is cooled, and high precipitation is produced over parts of this region. The air, now depleted of much of its moisture, continues to circulate across the Pacific and descends within a southeastern Pacific area of high pressure which is generally located close to the west coast of South America. The descent of this very dry air causes excessive evaporation. Coupled with a cooling of the ocean-atmosphere boundary layer by widespread upwelling water, this evaporation produces some of the most arid conditions on earth along the coasts of Peru and Ecuador. This pattern is the normal condition.[9]

Periodically, at intervals ranging from two to ten years, this normal pattern undergoes an oscillation called the Southern Oscillation. The normal low-pressure cells of the Indo-Australian region migrate east and replace the high-pressure cells that normally are in place off the west coast of South America. The result is a broad, low-pressure cell that occupies much of the tropical Pacific from the Indian Ocean to the west coast of South America.[10] (fig. 2).

The effect of this atmospheric oscillation on the ocean is profound. Warmer water from the Indo-Australian region begins drifting to the east, spreading throughout the area of atmospheric low pressure, and, most important for Lehi, the movement of the normally weak current in the Doldrums belt increases significantly—El Niño is in action (fig. 2). For a period of twelve to eighteen months, the area of the Equatorial Counter Current is expanded north and south of the equator, this eastward-flowing current is strengthened (fig. 2, arrows that are crossed), and together El Niño and the Southern Oscillation—the ENSO effect—produce important changes in the entire tropical Pacific.[11]

The causes of such a cyclic change in ocean temperature and water circulation are unknown, although the atmospheric and oceanic conditions involved can be modeled and the occurrence of El Niños can be predicted.[12] Recently, however, one explanation for abnormal western Pacific Ocean heating has been proposed. Sophisticated sonar surveys (made during the GLORIA and Sea Marc projects) have mapped large ocean-floor lava flows in this area of the Pacific that exceed 10 km^3. These submarine lava flows are capable of transferring significant amounts of heat from the earth's crust to the surface water.[13] The geologic evidence also supports the idea that this heat transfer occurs semiregularly.[14] Although this activity is not definitely known to be the sole cause of ENSO events, it could be a significant factor. The use of satellite observations coupled with new theories may soon lead to a fuller understanding of the cause.[15]

The climatic effects of the change in the distribution of warmer water and atmospheric lows in the tropical Pacific during ENSO events disrupt weather patterns in a broad area. Rainfall, normally heavy in the Indo-Australian region, is reduced and droughts occur instead. In contrast, the normally arid coasts of western South America become areas of heavy precipitation. Oceanic upwelling, the upward rise of cold, nutrient-rich bottom water along the Peruvian and Ecuadorian coasts, is reduced because of the change in the normal circulation pattern and the infusion of warmer water carried by the Equatorial Counter Current from the west. This intensified eastward-flowing current literally piles water up along the west coast of South America, and the resulting rise in sea level helps push the warmer water poleward, both north and south along the American coasts (fig. 2). Circulation patterns as far north as California are affected. Surface water temperatures in this part of the eastern Pacific may increase several degrees during different intervals of the ENSO cycle. The results of such change may affect weather patterns in much of North America.[16]

On land, the effect of a strong ENSO is drought with resulting crop loss in Australia and catastrophic rains with resulting flooding, landslides, and agricultural losses in South America. Oceanic effects are equally profound. Reduced oceanic upwelling along the west coast of South America adversely affects the fishing industry of both Peru and Ecuador. The normally abundant anchovies are driven away by the warm, nutrient-poor water that replaces the normally cool, nutrient-rich upwelled water, forcing the larger fish that normally feed on the anchovies to leave or starve. A domino effect of sorts continues as a large bird population that depends on the fish for food is affected; during the 1982–83 ENSO, the bird population decreased by some seventeen million birds. The accumulation of guano, the waste-product produced by the normally large bird populations, decreases as the number of birds decreases. As a result, the economy of Peru, which is heavily dependent on both fish and guano (retrieved for fertilizer and other nitrate needs), is thrown into turmoil. Overall, the 1982–83 ENSO resulted in millions of dollars in damages and extensive loss of life.[17] The ENSO events and the resulting economic hardships normally end a year or so after they begin, due either to cooling of the crustal-generated heat of the equatorial Pacific or to atmospheric oscillations in the tropical Pacific—circumstances that can be simulated on a computer but are driven by factors that are poorly understood.

Some 64 years of Pacific wind data have now been analyzed to document historic ENSO events.[18] So far there are no reasons to doubt that ENSO events have been occurring in the tropical Pacific for at least five to six thousand years, or as long as the earth's climate has been similar to what it is today. And the pattern continues. A moderate ENSO event began in 1986, and the last effects of the most recent El Niño were measured in March 1988.[19] Thus while we do not know about the economic impact of an ENSO event occurring some twenty-five hundred years ago, such an event may have provided an enhanced method of migration for Lehi.

If Lehi had sailed from the Arabian Peninsula during the August monsoon of an ENSO year, by the time his ship had been driven into the Indonesian area, El Niño would have intensified the eastward current, thereby enhancing the possibility of the voyage across the Pacific to the Western Hemisphere. The great increase in the strength of the eastward drift of the Equatorial Counter Current commonly affects a broad area of the equatorial Pacific and may extend more than ten degrees north and south of the equator. This ENSO-orchestrated eastward flow of abnormally warm water from the western and central Pacific could have helped the Lehi vessel to cross the Pacific and then travel up the coast of central America.

Monsoon circulation in the Indian Ocean off the tip of the Arabian Peninsula and the development of a strong trans-Pacific, eastward-flowing current during an ENSO event are real physical phenomena. There is evidence that these oceanic-atmospheric phenomena have been continuous at least since climatic "normality" was attained after the melting of the great continental glaciers eight thousand years ago, suggesting that ENSO events were taking place in Lehi's day. What is less certain is whether the Lehi party used these atmospheric-oceanic events as an aid to migration. Perhaps the real question is whether the Lord uses natural events to accomplish his purposes. I am the first to acknowledge that the ideas presented here may be pure fiction if the Lord neither wants nor needs to make use of natural law. However, he commonly seems to work with what is available. For example, he uses less-than-perfect people to do much of his work. Miracles may aid, but apparently the day-to-day routines of perfecting the Saints and accomplishing the other appointed tasks rely on the use of normal people and naturally occurring situations and events. The scientific evidence, not available even ten years ago, suggests that El Niño could provide a plausible mode of migration, a naturally occurring event that could have been used to accomplish the Lord's purposes.

If the migration scenario enhanced by atmospheric and oceanographic effects is valid, we can even go a step further in interpretive speculation concerning the Lehi voyage. Lehi probably sailed from the Arabian Peninsula during August of an ENSO year, the time not only of the optimum northeast monsoon circulation but also of the growing season when "fruits and meat and honey in abundance" could be gathered and loaded on board. Lehi would then have had a reasonable expectation of arriving in the Indonesian area in time to catch an ENSO-intensified Equatorial Counter Current. The El Niño-driven current could have delivered Lehi's group to the west coast of Central America in a much more probable manner than could have been employed during a non-ENSO year. In fact, if an El Niño of about twenty-five hundred years ago was not used for migration, Lehi missed a marvelous opportunity.

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1. Lynn M. Hilton and Hope Hilton, *In Search of Lehi's Trail* (Salt Lake City: Deseret Book Co., 1976), 40, 113–14; Eugene England, "Through the Arabian Desert to a Bountiful Land: Could Joseph Smith Have Known the Way," in *Book of Mormon Authorship: New Light on Ancient Origins,* ed. Noel B. Reynolds, Religious Studies Monograph Series vol. 7 (Provo, Utah: Religious Studies Center, Brigham Young University, 1982), 150, 152, 155, 156.

2. M. Grant Gross, *Oceanography, a View of the Earth.* 4th ed. (Englewood Cliffs, N.J.: Prentice-Hall, 1987), 176–77.

3. Gross, *Oceanography,* 136–37.

4. Gross, *Oceanography,* 136–37; Harold V. Thurman, *Introductory Oceanography,* 5th ed. (Columbus, Ohio: Merrill, 1988), 211–13.

5. Thurman, *Introductory Oceanography,* 211–13; Gross, *Oceanography,* 176–77.

6. Thurman, *Introductory Oceanography,* 211–13; Gross, *Oceanography,* 176–77.

7. Gross, *Oceanography,* 5–6.

8. Mark A. Cane and Stephen E. Zebiak, "A Theory for El Niño and the Southern Oscillation," *Science* 228 (31 May 1985): 1085.

9. S. George H. Philander, "El Niño Southern Oscillation Phenomena," *Nature* 302 (24 March 1983): 295–96.

10. Philander, "El Niño," 295; K. R. Sperber and others, "Southern Oscillation Simulated in a Global Climate Model," *Nature* 329 (10 September 1987): 140–42.

11. George H. Philander, *El Niño, La Niña, and the Southern Oscillation,* International Geophysics Series 46 (San Diego: Academic Press, 1990), 9–11.

12. T. Barnett and others, "On the Prediction of the El Niño of 1986–1987," *Science* 241 (8 July 1988): 192–96.

13. Herbert R. Shaw and James G. Moore, "Magmatic Heat and the El Niño Cycle," *Eos: Transactions, American Geophysical Union* 69 (8 November 1988): 1553, 1564–65.

14. Shaw and Moore, "Magmatic Heat," 1553, 1564–65.

15. Robert E. Cheney and Laury Miller, "Mapping the 1986–1987 El Niño with GEOSAT Altimeter Data," *Eos: Transactions, American Geophysical Union* 69 (2 August 1988): 754–55; Nicholas E. Graham and Warren B. White, "The El Niño Cycle: A Natural Oscillator of the Pacific Ocean-Atmosphere System," *Science* 240 (3 June 1988): 1293–1302.

16. David Halpern and others, "Oceanographic Observations of the 1982 Warming of the Topical Eastern Pacific," *Science* 221 (16 September 1983): 1173; Richard A. Kerr, "The Weather in the Wake of El Niño," *Science* 240 (13 May 1988): 883; Gross, *Oceanography* 145–46, 327.

17. Thomas Y. Canby, "El Niño's Ill Wind," *National Geographic* 165 (February 1984): 144–51.

18. Kim D. B. Whysall, Neill S. Cooper, and Grant R. Bigg, "Long-term Changes in the Tropical Pacific Surface Wind Field," *Nature* 327 (21 May 1987): 216–19.

19. Graham and White, "The El Niño Cycle," 1293–1302; Kerr, "The Wake of El Niño," 883.