

INSTRUCTIONS FOR THE WRITTEN TEST

WRITTEN TEST 2 : 2 HOURS

筆試測驗 2 : 2 小時

PLEASE ANSWER ON THE ANSWER SHEET

答案請寫在答案紙上，請忽視中文版頁次

MARKING THE QUESTIONS : 評分標準

If only one answer is required (only one answer) :

- Correct answer chosen : +1 point
- Wrong answer or several answers chosen : 0 point

單選題

答對得 1 分 答錯或選擇多個答案 得 0 分

If several possible answers :

- For each correct answer : + 1 point
- For each wrong answer : -0.5 point

No question can be marked under 0 (zero). If number of negative points exceeds the positive points, the question will be marked zero : $+1-1,5 = 0$

多選題

每答對一個正確選項得 1 分

每答錯一個選項倒扣 0.5 分 (-0.5 分)

每一題最低得 0 分，不會出現負分 如 $+1-1.5 = 0$

IESO 2017 - WRITTEN TEST NUMBER 2

SECTION 1: UNDERSTAND THE INTERACTIONS BETWEEN ATMOSPHERE AND HYDROSPHERE : A SPORTING CHALLENGE ! 了解大氣圈與水圈的交互作用: 一項體育挑戰 !

The “Vendée Globe” is a solo yacht race without assistance, which sets off from Vendée in France and whose objective is to circle the world as fast as possible. Both the start and finish are in Sables d’Olonnes (visible on figure 1A and marked as A in figure 1B). The race began on 6 november, 2016. Armel Le Cleac’h was the winner with a new record of 74 days of non-stop sailing.

“Vendee Globe” 是一項從法國出發且不靠任何外力協助，看誰環繞世界的速度最快的帆船競賽。起點跟終點都是在 Sables d’Olonnes (路線可參見圖 1A，同時在圖 1B 中標示出 A 為起終點)，競賽在 2016 年十一月六日開始，而 Armel Le Cleac’h 以連續不間斷航行 74 天的新紀錄獲得了冠軍。

The difficulty, especially on a solo voyage, is to find the route where the wind is always favorable, namely at the rear of the boat.

揚帆開船有個難處，尤其是獨力航行中，就是總要找出風向最有利的航行路徑，亦即是從船後方吹過來的風向

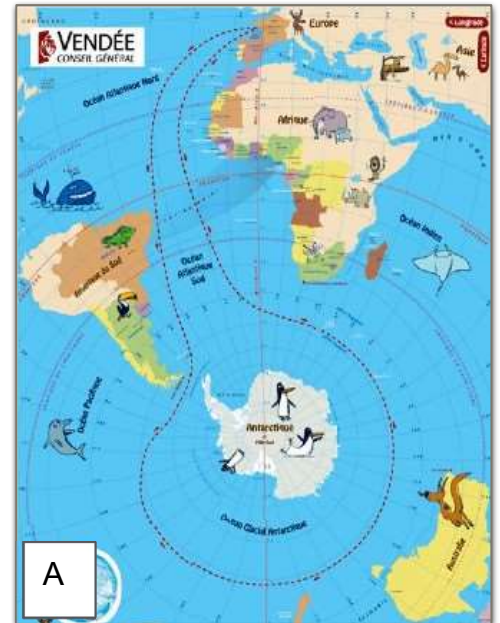


FIGURE 1: (A) Map showing the « Vendée Globe » route. (B) Barometric map of the North Atlantic Ocean and noted points (see question).

圖 1(A) Vendee Globe 帆船航行路徑圖 (B):北大西洋及標示點附近的海平面氣壓分布圖

Question 1: Yachts make the best use of the dominant winds. According to your knowledge of the direction of winds produced by different air masses, indicate which is the fastest route the competitors should take to reach the Cape Verde islands (E). The barometric conditions shown on the map above remain the same for one week: (only one answer possible)

- 1- Trajectory AKGE
- 2- Trajectory AKBE
- 3- Trajectory AKDE
- 4- Trajectory AMPCHE**

問題 1：帆船競賽需要善用盛行風向，根據不同氣圖產生不同風向之相關知識，指出下列哪一條路徑是競賽者可以最快抵達 Cape Verde 島(E 點)的路徑？圖 1B 的氣壓分布條件在一個星期內都維持不變。(單選題)

- 1. 路徑 AKGE
- 2. 路徑 AKBE
- 3. 路徑 AKDE
- 4. 路徑 AMPCHE**

Question 2: Refer to figure 1. At the same time, a sailor decides to take the route Rabat (R)– New York (Y). Which itinerary will be the quickest? (only one answer possible)

- 1- RGDHY
- 2- RBDCY
- 3- RGDPY
- 4- RKDHY**

問題 2：參考圖 1. 若一帆船航行者決定從 Rabat (R 點) 航行至紐約 (Y 點)，下列哪一條路徑最快？(單選題)

- 1. RGDHY
- 2. RBDCY
- 3. RGDPY
- 4. RKDHY**

The figure below shows the competitors' positions after 10 days of racing. A group of yachts (circled) seems to have lagged and is traveling at a slow speed of 2.5 knots (for information, 1 knot (kn) is equivalent to a little less than 2 km/h).

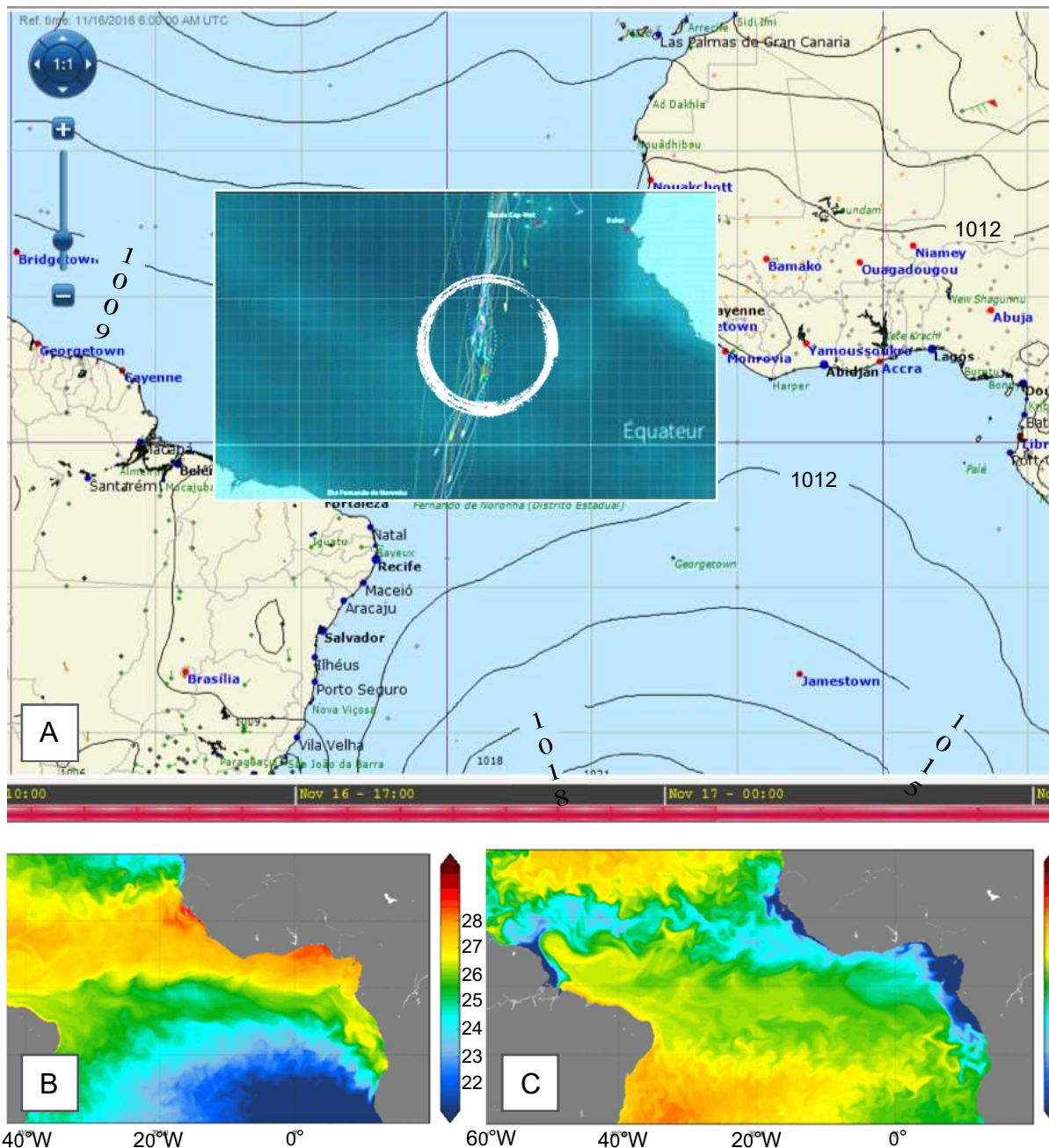


FIGURE 2: Racing zone in the Atlantic Ocean. (A) Barometric chart contour interval is 3 hPa. (B) Map of water temperature in °C. (C) Chart of water salinity in g/l.

較上面的那張圖顯示許多競賽者在 10 天的比賽後所在之位置，有一群競賽者的帆船(環狀區)似乎落後了，並正以每小時 2.5 海涅的低速航行。(1 海涅/小時 大約比 2 公里/小時 略小一些)

圖 2：大西洋的航行競賽區 (A) 氣壓分布圖，等值線間隔是 3 hpa(百帕)
 (B) 海溫分布圖，單位度 C
 (C) 鹽度分布圖，單位 g/l

Question 3: Which of the choices given below best explains the situation of sailors compelled to travel at a slow speed ? (only one answer possible)

- 1- The high water temperature prevents the formation of wind.
- 2- The sailors cross a zone where there are headwinds.
- 3- The water is very salty and its viscosity slows the sailors.
- 4- The sailors are trapped in a zone with very weak winds.

問題 3：下列哪個選項是帆船低速緩慢航行的最佳解釋？

1. 高海溫抑制風的形成
2. 帆船行經頂頭逆風的區域
3. 高鹽度之海水和黏滯性使航行速度減慢
4. 帆船被非常微弱的風侷限在很小的區域內

Question 4: Refer to figure 2C. The intertropical zone has a salinity which is different from the average (green zones). Choose the most evident cause: (only one answer possible)

- 1- The water from the big rivers brings down the salinity of the ocean water.
- 2- In the tropical anticyclonal zones, the air temperature is lower, and thus evaporation weaker.
- 3- Rainfall is more important in the intertropical convergence zone and it brings down the salinity.
- 4- The characteristic strong winds in the intertropical convergence zone produce upwelling, which brings less saline water to the surface.

問題 4. 參考圖 2C 間熱帶地區有一鹽度和平均狀態(綠色區域)差異較大的區域，下列哪一個選項最能說明這種現象發生的原因？(單選題)

1. 大的河川帶來大量河水而降低海水之鹽度
2. 在熱帶反氣旋區域空氣溫度較低，蒸發較弱
3. 間熱帶輻合區的降水較多，可以降低海水鹽度
4. 間熱帶輻合區的強風會引發湧升流，因此可以較低鹽度的海水帶到海面上來

Avoiding areas sheltered from the wind was a preoccupation of all the participants. Kito de Pavant, our sailor for the IESO 2017, remained stuck for several days in the area described in the figures below.

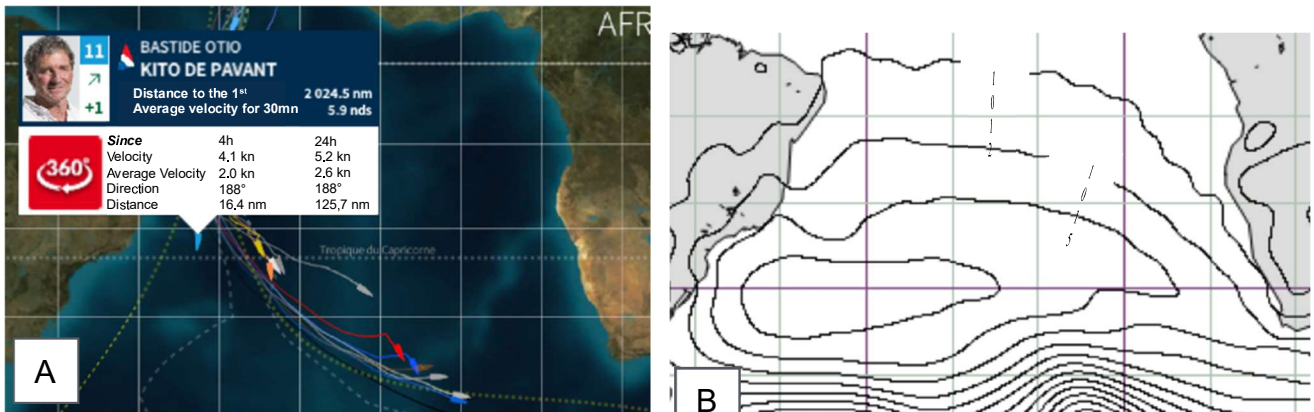


FIGURE 3: Map of the competitor Kito de Pavant's position (blue arrow) and other sailors on 2 December 2016. (A) Position map indicating, among other things, the change of his speed (knot) in the last 24 hours. Distances are indicated in nautical miles (nm), 1 nm = 1.85 km. (B) Barometric map of the race area on 12 December, 2016. Contour interval is 3 hPa.

雖然要極力避開所有參賽者已佔據之位置，導致風被阻擋之區域，2017 IESO 船長 Kito de Pavant 所駕駛之帆船仍然在上圖中之位置附近滯留了好幾天

圖 3. (A) 2016 年 12 月 2 日 參賽者 Kito de Pavant(藍色箭頭)與其他帆船的位置圖，位置圖中也標示出帆船在過去 24 小時速度的改變，距離之單位用海浬(nm)來表示。1 海浬= 1.85 公里。 (B) 2016 年 12 月 2 日競賽區域內海平面氣壓之分布圖，等值線間隔為 3 百帕(hPa)。

Question 5: Describe the problem Kito de Pavant encountered in this area of the race: (only one answer possible)

- 1- His yacht was located in the center of a depression characterized by a lack of wind.
- 2- His yacht was in the center of an anticyclone characterized by a lack of wind.
- 3- His yacht was in the center of a depression characterized by a shallow trough on the ocean surface which hinders the boat's movement.

問題 5. 描述 Kito de Pavant 在該競賽區域所遭遇之問題(單選題)

1. 他的帆船位在風速微弱的低壓中心
2. 他的帆船位在風速微弱的高壓中心
3. 他的帆船位在洋面上一淺槽所在的低壓中心，因此阻礙帆船之移動

Question 6: The winds which circulate around an anticyclone located in the Southern Hemisphere ... (several answers possible)

- 1- rotate clockwise.
- 2- rotate counterclockwise.
- 3- are stronger when they approach the center of the anticyclone.
- 4- are weaker when they approach the center of the anticyclone.

問題 6. 南半球圍繞著反氣旋的風，下列敘述何者正確(多選題)

1. 順時鐘方向旋轉
2. 逆時鐘方向旋轉
3. 越靠近反氣旋中心風速越強
4. 越靠近反氣旋中心風速越弱

While traversing the Drake Passage south of Cape Horn (southern tip of South America) on 26 December 2016, the oceanographic service recorded the water temperature and salinity as a function of depth along a transect between the southern tip of South America and the northernmost point of the Antarctic Peninsula.

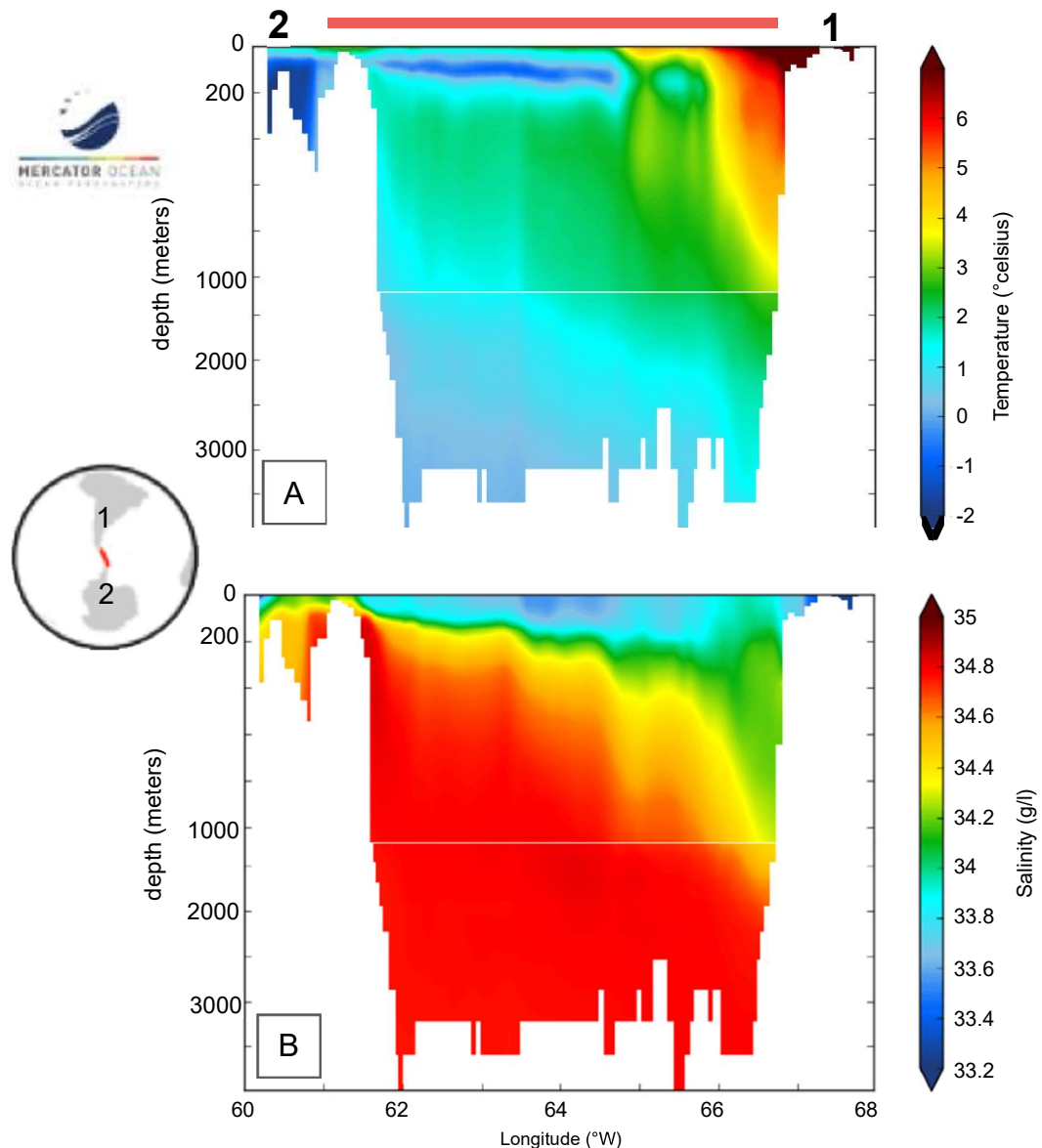


FIGURE 4: Profiles of the change in temperature (A) and salinity (B) of the ocean water on a line along the Drake Passage (visible in the inset showing the planet viewed from the South Pole).

在 2016 年 12 月 26 日穿越南美洲合恩角之南的德雷克海峽時，海洋服務單位沿著南美洲南端至南極洲半島最北端調查，收集了沿著此斷面的海水溫度與鹽度隨著深度變化的資料。
圖四：沿德雷克海峽之海水溫度（A）與鹽度（B）變化的剖面圖。其測線位置參照見左邊圓圈插圖上的紅線。

Question 7: Refer to Figure 4. One can say that, at longitude 62.5°W, ... (only one answer possible).

第七題：（參考圖四）由西經 62.5 度之溫度與鹽度隨水深的變化，一般可說（單選題）

1. 整個水深之溫度梯度與鹽度梯度均屬正常；
2. 只有溫度梯度在至少一個區域是異常；
3. 只有鹽度梯度在至少一個區域是異常；
4. 溫度梯度與鹽度梯度均顯示異常

1- both the temperature and salinity gradients are normal over the whole depth.

2- only the temperature gradient is abnormal in at least one area.

3- only the salinity gradient is abnormal in at least one area.

4- both gradients are abnormal.

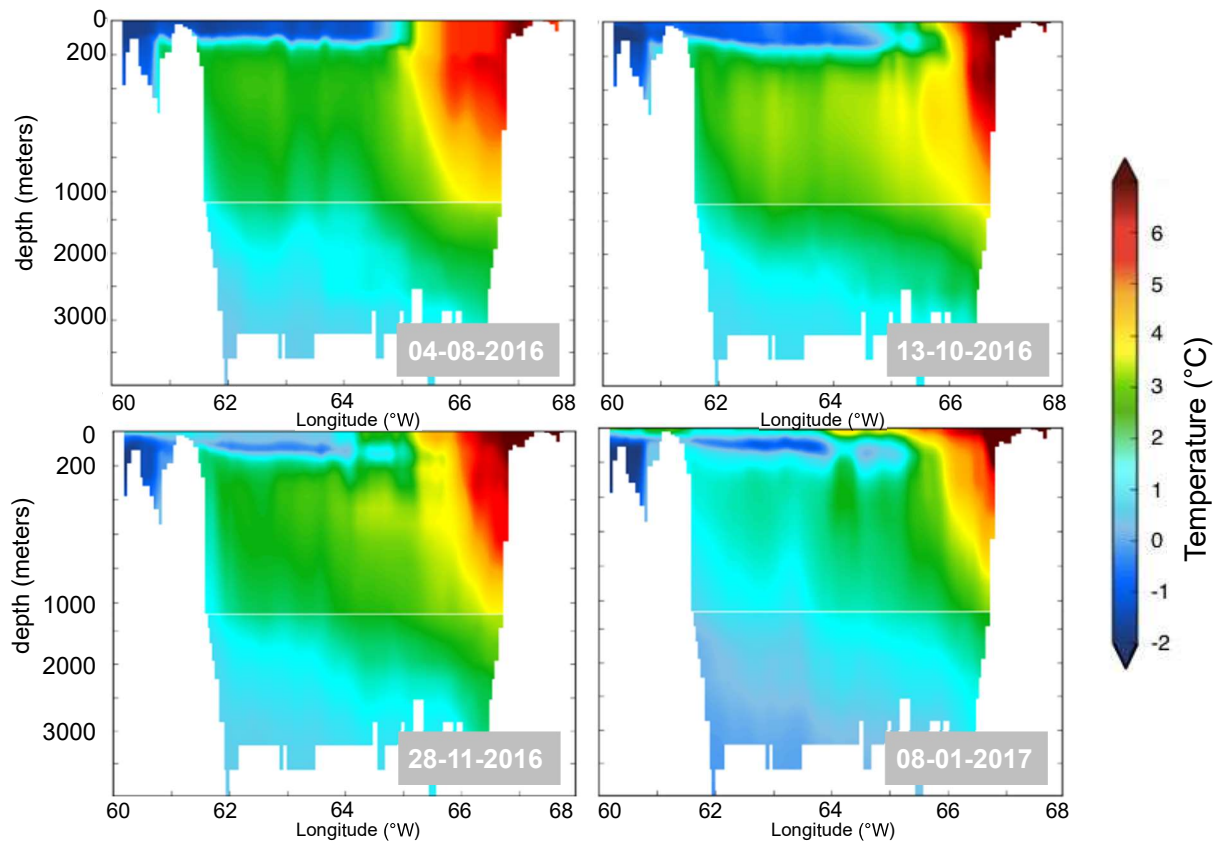


FIGURE 5: Temperature profiles on different dates during August 2016 - January 2017 along transects shown in figure 4.

圖五：：同圖四測線斷面分佈，在 2016 年 8 月至 2017 年 1 月間，不同日期的溫度剖面圖。

Question 8: Refer to figures 4 and 5. Which of the following statements are correct ? (several answers possible)

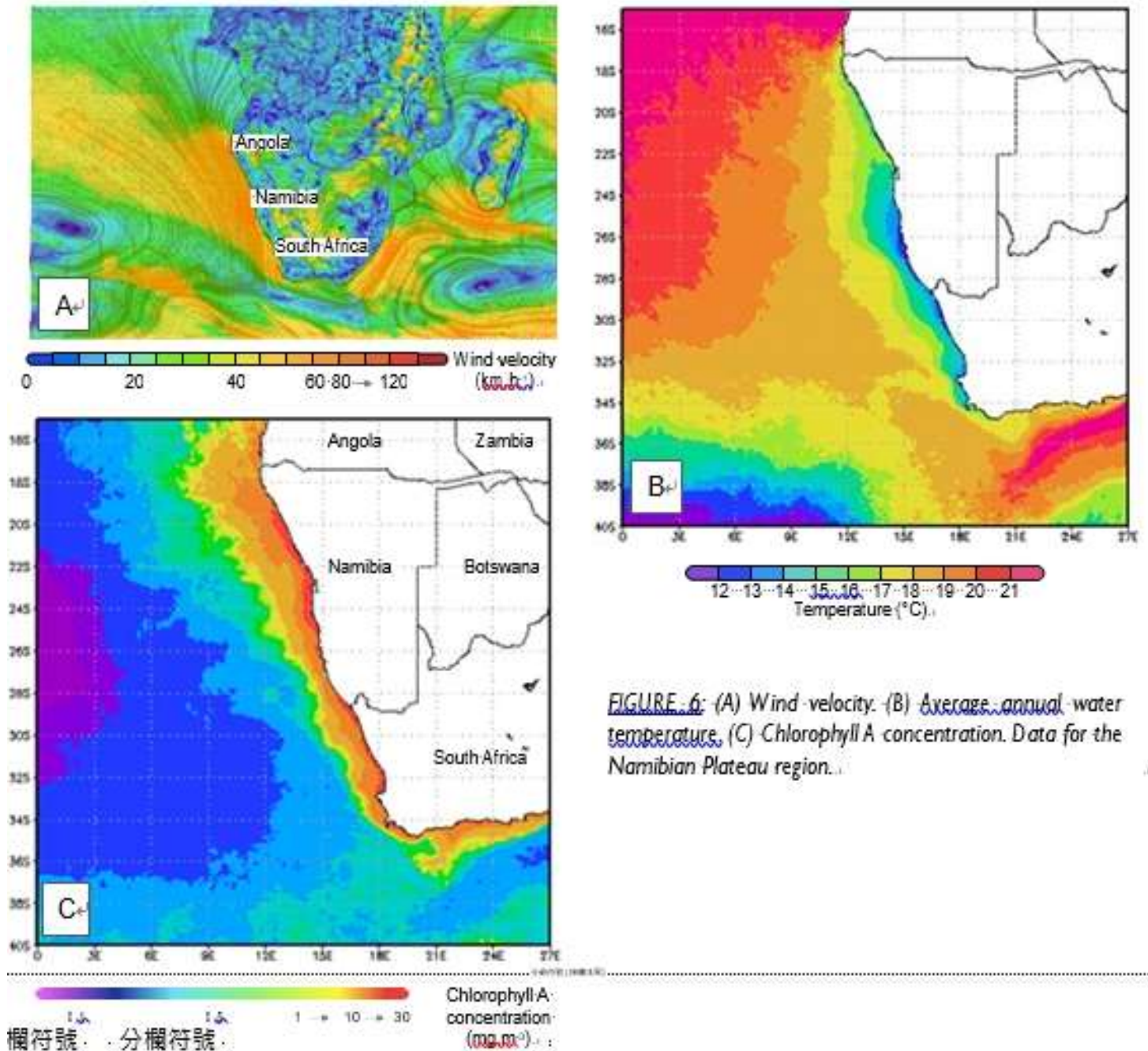
- 1- The water was colder at 3000m depth compared to the surface during August.
- 2- The pack ice (floating ice) was located off the Antarctic coast and reached a longitude of 64.5 °W along the transect during August 2016.
- 3- During January 2017, the pack ice (floating ice) was denser and hence sank.
- 4- The lower layers of the hydrosphere are composed of colder and more saline water because it is denser.

第八題：（參考圖四與圖五）下列何者敘述為真（多選題）

1. 2016 年 8 月期間，在 3000 公尺深之水溫較海表面為低；
2. 2016 年 8 月期間，在南極洲外之浮冰沿著斷面漂至西經 64.5 度；
3. 2017 年 1 月期間，浮冰密度增加，因此下沉；
4. 因為較下層水圈的密度較高，其組成為低溫與高鹽的水。

Passing by the coast of Namibia, the sailors encountered numerous fishing boats heading for the African coast. There are indeed shoals (of fish) in this region.

當通過納米比亞（Namibia）海岸時，船員們碰見了許多航向非洲沿岸的漁船。在該水域的確有魚隻成群出現。



圖六：（A）風速；（B）年平均水溫；（C）葉綠素 A 濃度。

Question 9: Refer to figure 6. Choose all the correct statements below: (several answers possible).

- 1- The ocean water closer to the coast of Namibia is warmer than that farther away.
- 2- This temperature anomaly along the Namibian coast is due to water rising from the depths.
- 3- The driving force of this rising water is the difference in temperature between deep and shallow waters.
- 4- The driving force of this rising water is the force of the wind on the surface.
- 5- The warm water induces high primary productivity, leading to a richness of the food chain (trophic chain) and thus an abundance of fish.
- 6- The high primary productivity is linked to an increase in nutrients concentration, which sustains a rich food chain (trophic chain).

第九題：（參考圖六）下列何者敘述為真（多選題）

1. 靠近納米比亞海岸的海水比離岸較遠海水的溫度為高；
2. 沿納米比亞海岸的溫度異常是由於海水從深處湧升；
3. 此湧升水的推動力來自深、淺海水的溫度差；
4. 此湧升水的推動力為風作用在海水表面；
5. 此溫暖的海水促使初級生產力提高，導致富饒的食物鏈（營養鏈）與豐富的魚群
6. 高初級生產力與營養鹽濃度的增加有關，營養鹽的增加維持了豐富的食物鏈。

Question 10 : The Namibian and Angolan continental plateau is known for its abundance of fossil fuels (oil, gas hydrates). The geography and meteorological and climatic conditions have remained approximately the same for several hundred thousand years. The southwest coast of Africa has remained a desert. Which of the following statements are correct ? (several answers possible)

- 1- The abundance of plankton and the richness of the food chain are necessary elements for the formation of hydrocarbons.
- 2- Oil is formed at the bottom of the Atlantic Ocean and rises due to the upwelling of water.
- 3- The organic matter from the continent (dead animals and vegetative matter) is sedimented on the continental plateau and is the main source of hydrocarbons.
- 4- The organic matter of plankton which is sedimented on the continental plateau must be in anoxic conditions to be transformed into hydrocarbons.

第十題：納米比亞與安哥拉大陸高原以富有化石燃料（石油、天然氣水化物）而著名。它的地理、氣象、氣候條件在過去數十萬年大致維持相同。非洲的西南海岸一直維持為沙漠。以下敘述何者為真（多選題）

1. 充裕的浮游生物與豐富的食物鏈為形成碳氫化合物的必要元素；
2. 石油是在大西洋底部形成，後因湧升流而向上移動；
3. 來自大陸的有機質（死掉的動物與植物性物質）沈積至大陸高原，為碳氫化合物的主要來源；
4. 沈積至大陸高原的浮游生物有機質必定是在缺氧條件轉換至碳氫化合物。

The sailor Kito de Pavant dropped a GPS beacon named IESO2017 into the water upon crossing the Equator on 17 November 2016. This floating beacon drifted solely due to the marine currents and transmitted its latitude and longitude position every hour.

在 2016 年 11 月 17 日航海員 Kito de Pavant 航行通過赤道時佈放一枚命名為 IESO2017 的 GPS 浮標至海洋。此海面浮標只受到海流影響而漂移，並且每小時傳送它的經緯度位置回來。

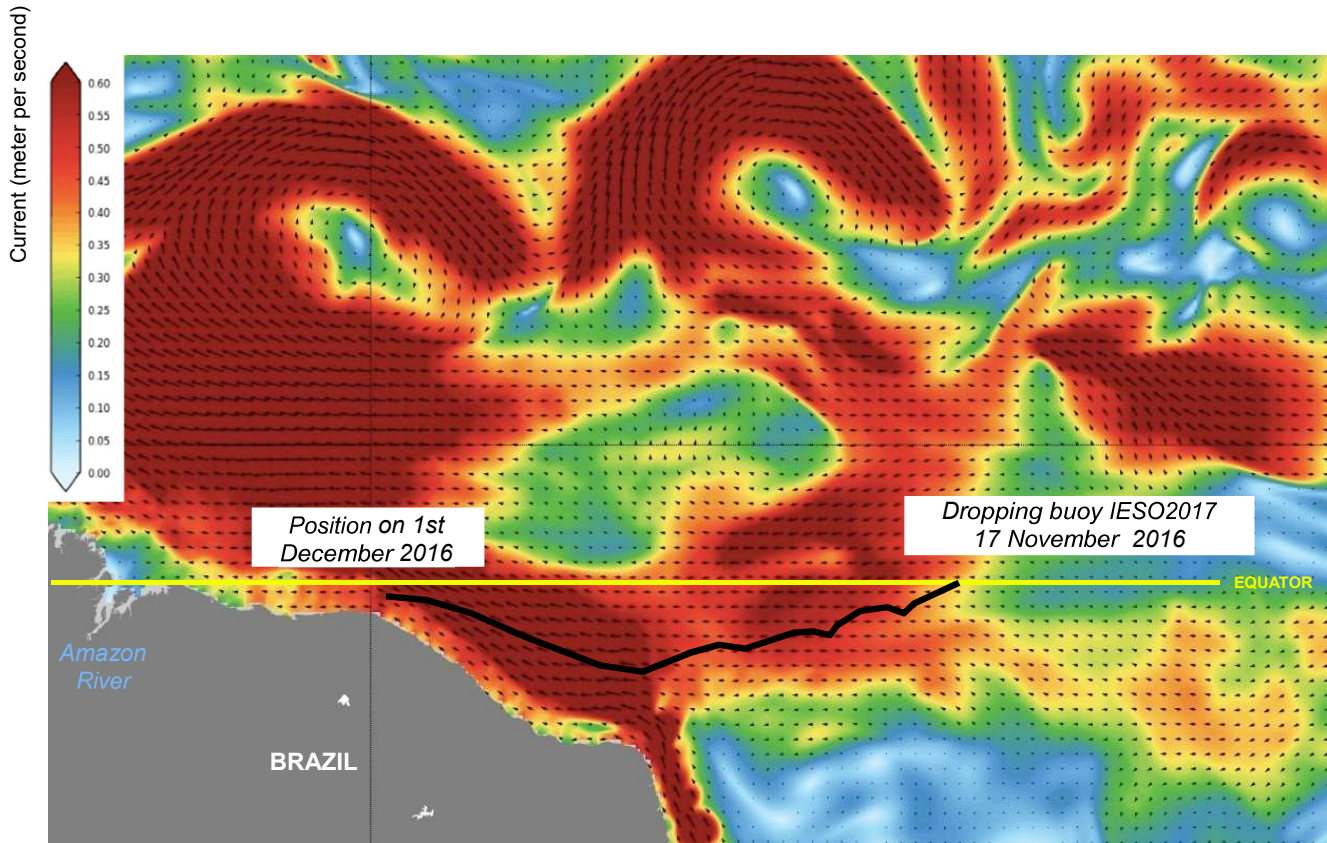


FIGURE 7 : Map of the equatorial Atlantic Ocean. The black line traces the movement of the IESO2017 beacon during 17 November - 1 December 2016. The beacon was placed while crossing the Equator by the skipper Kito de Pavant. The colors indicate the force of the currents, and the arrows specify the direction. The current appearing on this map is called the “Equatorial current”.

圖七：赤道大西洋圖。圖中黑線標示 IESO2017 在 2016 年 11 月 17 日至 12 月 1 日期間的浮標運動；該浮標為船長 Kito de Pavant 在通過赤道時佈放。圖中顏色表示流速大小、箭頭標示方向。顯示在此圖上的洋流稱之為「赤道洋流」。

Question 11: Refer to figure 7. Which of the following statements are correct ? (several answers possible)

第十一題：參考圖七。下列敘述何者為真（多選題）

1. 帶動浮標的洋流是由南半球的信風所造成；
2. 帶動浮標的洋流是由大西洋東西兩側的溫度差所造成；
3. 帶動浮標的洋流是由大西洋東西兩側的鹽度差所造成；
4. 帶動浮標的洋流是由大西洋東西兩側的海洋高度差所造成；
5. 此洋流的方向受科氏力影響。

1- The current carrying the beacon is caused by the trade winds of the Southern Hemisphere.

2- The current carrying the beacon is caused by the difference in temperature between the east and western parts of the Atlantic.

3- The current carrying the beacon is caused by the difference in salinity between the eastern and western parts of the Atlantic.

4- The current carrying the beacon is caused by the difference in height of the ocean between the east and western parts of the Atlantic.

5- The direction of the current carrying the beacon is influenced by the Coriolis force.



FIGURE 8: Map showing the end stage of the beacon's journey between 15 December 2016 and 4 January 2017. Each symbol corresponds to a daily position at a fixed time (midnight).

圖八：在 2016/12/15 至 2017/1/4 期間浮標位置圖。圖中圓形表示浮標每天午夜時的位置。

Question 12: Analyzing the path of the beacon close to the South American coast (figure 8), choose the correct statement: (only one answer possible)

- 1- The speed is constant, and the trajectory becomes parallel to the coast.
- 2- The speed is constant, and the trajectory is not influenced by the approach to the coast.
- 3- The speed decreases as the beacon approaches the coast due to fresh water current opposing the oceanic current.
- 4- The speed decreases as the beacon approaches the coast due to a decrease in water depth.
- 5- The speed increases as the beacon approaches the coast due to fresh water current opposing the oceanic current.
- 6- The speed increases as the beacon approaches the coast due to a decrease in water depth.

第十二題：分析浮標靠近南美洲海岸的路徑（見圖八），下列敘述何者為真（單選題）

1. 浮標的速率為常數，且其軌跡變得平行於海岸線；
2. 浮標的速率為常數，且其軌跡不受靠近沿岸的影響；
3. 由於靠近海岸時淡水水流降低了大洋洋流的速度，因此浮標速率降低；
4. 由於水深隨著浮標靠近海岸時逐漸變淺，因此浮標速率降低；
5. 由於靠近海岸時淡水水流降低了大洋洋流的速度，因此浮標速率增加；
6. 由於水深隨著浮標靠近海岸時逐漸變淺，因此浮標速率增加。

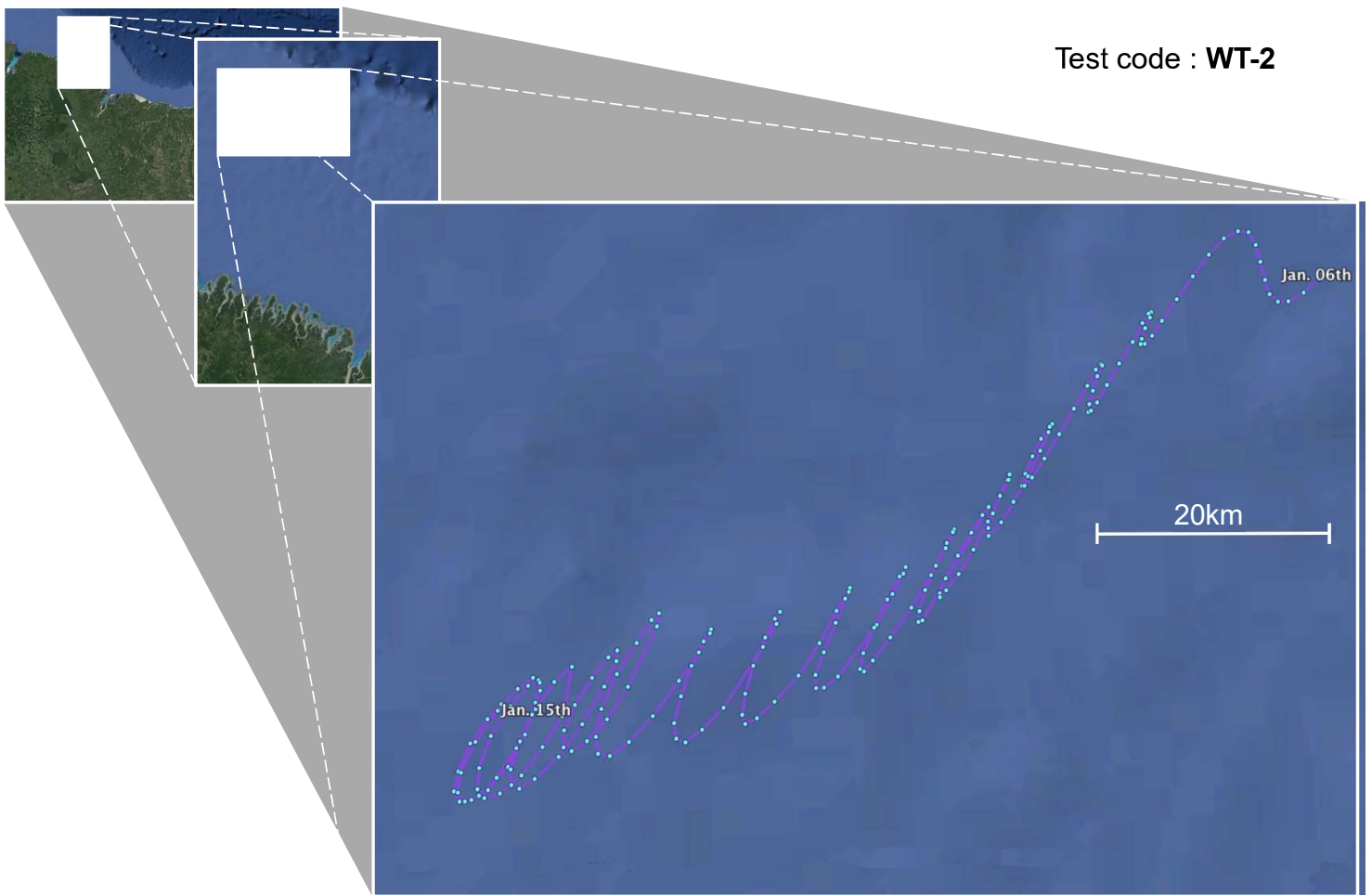


FIGURE 9: Trajectory of the beacon near the South American coast. Geolocation was measured every hour.

圖九：靠近南美洲海岸的浮標軌跡。淺藍色點表示浮標每個小時的地理位置。

Question 13 : Refer to figure 9 and choose the statement which best describes the beacon's behavior. The observed phenomenon seems to be periodic with an average period of... (only one answer possible)

- 1- 6 hours.
- 2- 12 hours.
- 3- 24 hours.

第十三題：（參考圖九）選擇最能形容浮標運動特性的陳述。我們所觀測到的現象似乎為週期性，其平均週期為（單選題）

- 1. 6 小時；
- 2. 12 小時；
- 3. 24 小時；

Question 14 : Among the possible causes listed below, choose the most probable one. This particular pattern of trajectory is due to... (only one answer possible)

- 1- the turbulent currents caused by the difference in salinity between the inland and offshore waters.
- 2- the turbulent currents caused by the difference in temperature between the inland and offshore waters.
- 3- tidal currents.

第十四題：由以下列出的可能原因中，選擇最可能的一個。這個特別模式的軌跡變化是因為（單選題）

- 1. 受內陸和近海水域之鹽度差所造成的湍流；
- 2. 受內陸和近海水域之溫度差所造成的湍流；
- 3. 潮流。

SECTION 2: STANDING ON THE EARTH, GAZING AT THE PLANETS

第二部分：站在地球上，觀望行星

During the race, the sailor Kito de Pavant had the opportunity to observe different phases of the Moon. How can we understand what he was able to see?

在競賽期間，水手 Kito de Pavant 觀察到不同的月相。我們如何理解他能看見什麼？

(Latitude = 緯度 Longitude = 經度)

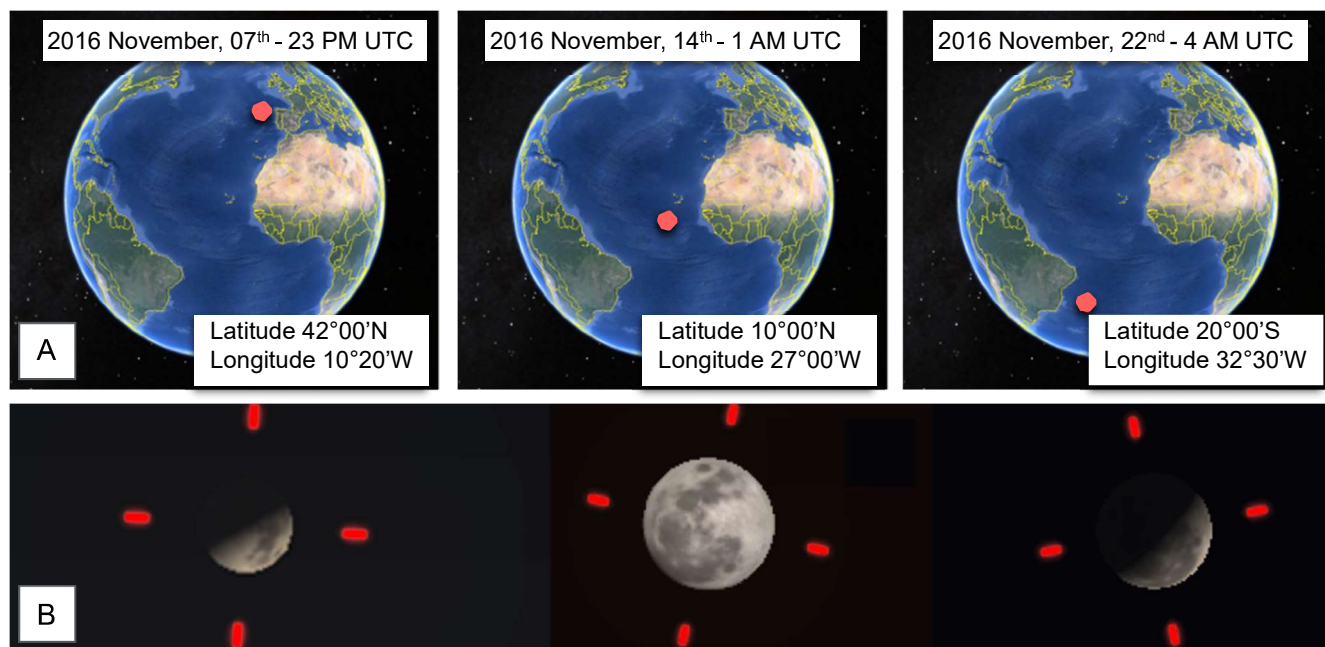


FIGURE 10: (A) Position of the sailor Kito de Pavant during November 2016. (B) The images of the moon that the skipper could see from the corresponding positions.

(A) 水手 Kito de Pavant 在 2016 年 11 月的位置。(B) 船長在對應位置可見之月球影像。

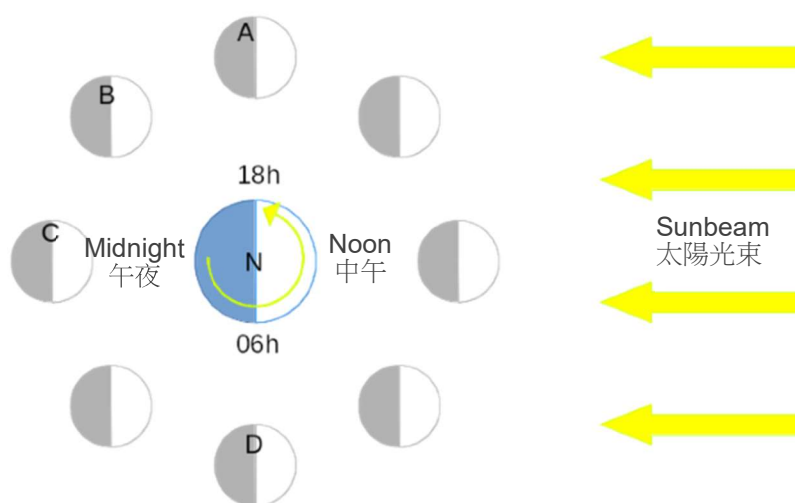


FIGURE 11: Phases of the Moon as a function of the three bodies (the Sun, the Earth, and the Moon).

月相是三天體（太陽、地球、月球）的函數

Question 15: Refer to figure 11. During the night from 7 to 8 November, the position of the Moon relative to the Earth–Sun reference system is... (only one answer possible)

依據圖 11，在 11 月 7 日至 8 日晚上，月球相對於地-日參考系統是：（只有一個可能答案）

- 1- A
- 2- B
- 3- C
- 4- D

Question 16: During the night of 14 to 15 November, the Moon reached 90°. This situation... (several answers possible)

當 11 月 14 至 15 日晚上，月球達到 90°，這狀態...（可能有數個答案）

- 1- can be witnessed only when one is located between the tropics. 2- is
- 2- only possible when the Moon is full.
- 3- is possible anywhere on the Earth each time the Moon is full.
- 4- is extremely rare and occurs at most twice a year for a given location.

- 1- 只有在熱帶的人能觀察到
- 2- 只有滿月時才可能
- 3- 每一次滿月，全球各地都可以。
- 4- 十分稀罕，在一地一年最多發生兩次

Question 17: The Moon seen by the sailor on the nights of 7 and 22 November was very similar. This is because... (Only one answer)

在 11 月 7 日與 22 日晚上，水手看見的月亮十分相似，其原因為：（只有一個可能答案）

- 1- The Moon's synodic period of revolution is on the order of 14 days.
- 2- The Moon's sidereal period of revolution is on the order of 28 days. Therefore, one finds the same phase at the halfway point of 14 days.
- 3- The first and last quarters appear identical because they are not observed in the same hemisphere.
- 4- The first and last quarters appear identical because they are not observed during the same time of the night.

- 1- 月球公轉之同步週期依序是 14 天。
- 2- 月球公轉之恆星公轉週期依序是 28 天。因此。我們可以在其一半之 14 天發現相同的月相
- 3- 第一與最後象限之外貌是一樣的，因為它們無法在 同一個半球被觀察到。
- 4- 第一與最後象限之外貌是一樣的，因為它們無法在晚上同時被觀察到

Question 18: The full moon of 14 November was observable between 18:00 and 6:00 hours. Choose the correct statement: (only one answer possible)

在 11 月 14 日 18:00 與 6:00 之間觀察到滿月，選取正確的敘述（只有一個可能答案）

- 1- This is always the case with a full moon.
- 2- This is extremely rare. Most of the time, it can be seen starting at noon.
- 3- This is solely because one is located close to the Equator.

- 1. 在滿月就一定會有這現象。
- 2. 這十分稀罕，多數時候可以在中午時開始被看見
- 3. 這是單獨事件，因為一個人需位於赤道附近

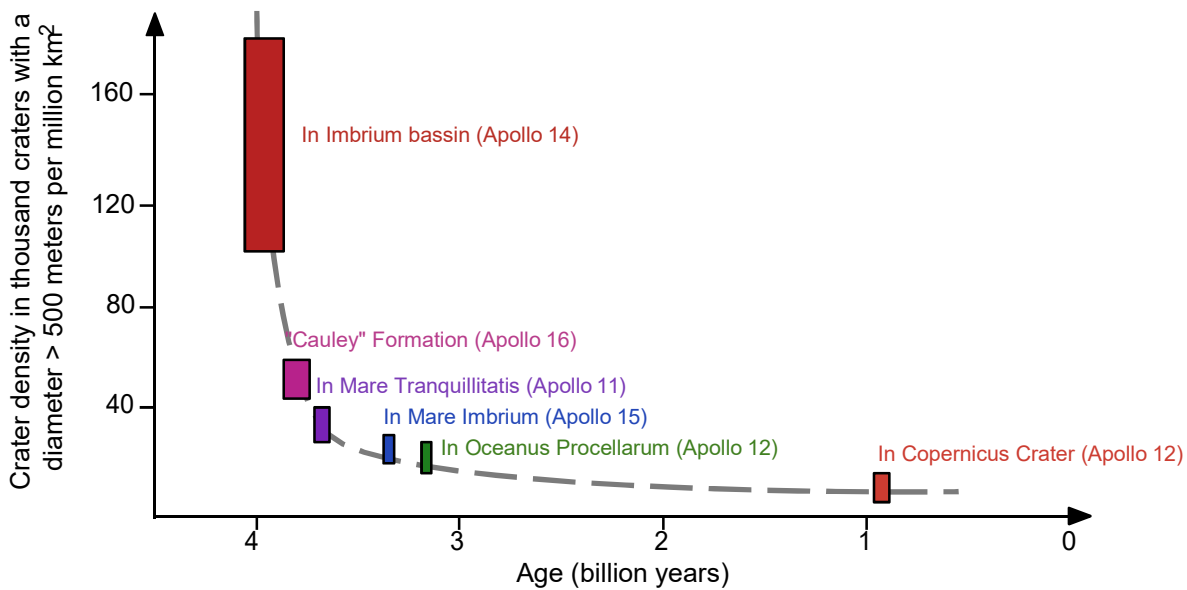


FIGURE 12: Number of craters on the lunar surface and the age of the surface. The dashed curve is the best fit for the observational data (rectangles).

本圖顯示月球表面坑洞數量與表面年齡之關係。虛線是觀測數據（長方形）之最佳擬合結果。

Question 19: Figure 12 indicates a hyperbolic relationship between the lunar crater density and the age of the impacted surface. Which of the following variables effect the exact profile of this inverse relationship ? (several answers possible)

問題 19：圖 12 顯示在月球坑洞密度與其撞擊表面年齡之間顯示一雙曲線關係。下列哪一因素影響？（可能有數個答案）

- 1- the decreasing number of impacting objects since the origin of the Solar System.
- 2- tectonics, which regenerates the planetary surface.
- 3- the distance from the planet to the asteroid belt and the Kuiper belt.
- 4- the period of revolution and the period of rotation of the planet under consideration.
- 5- the temperature of the impacted surface.
- 6- the size of the impacted planet.

- 1- 從太陽系起源以來，撞擊天體的數量減少
- 2- 構造運動重塑了行星表面
- 3- 行星至小行星帶與庫伯帶的距離。
- 4- 需要考慮行星的公轉週期與自轉週期
- 5- 被撞擊表面的溫度
- 6- 被撞擊行星的大小。

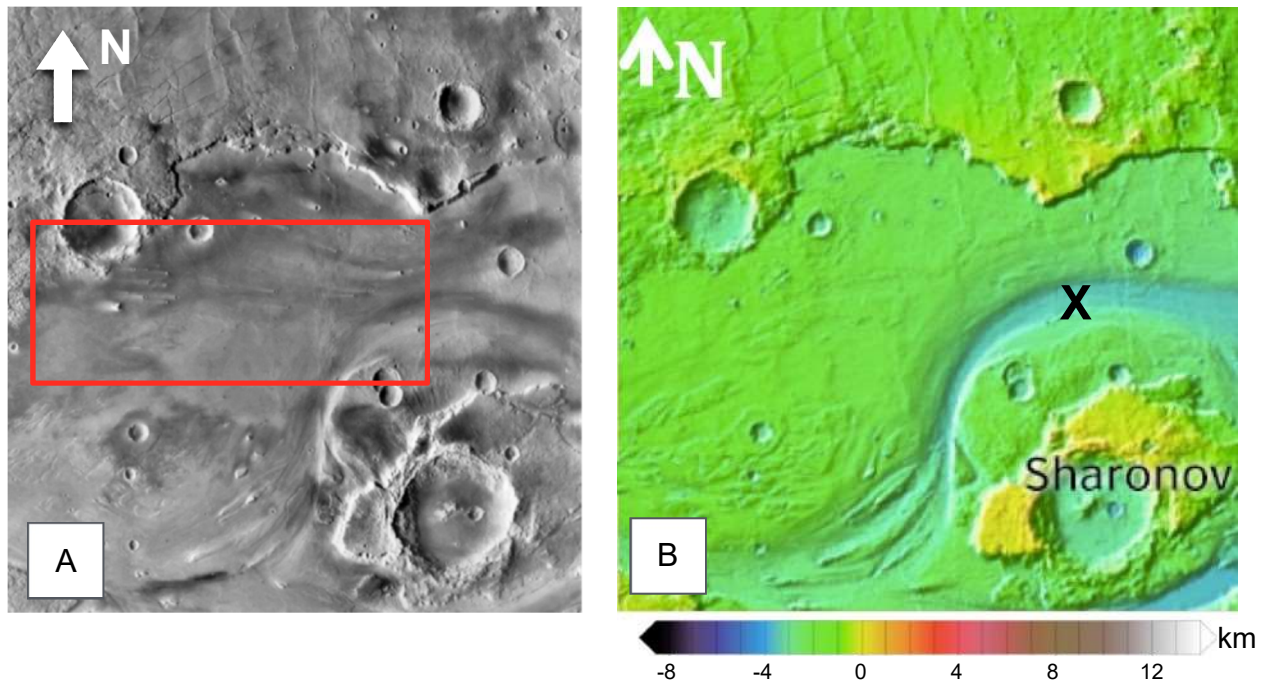


FIGURE 13: Position of the Kasei Valles on the planet Mars. (A) Satellite imagery of the region. The Sharonov crater has a diameter of 100 km. (B) Topographic image of the same region.

火星上 Kasei 峽谷位置。(A)衛星影像區，Sharonov 坑洞直徑 100 公里。(B)同一地區之地形圖。

Question 20: The river that formed the Kasei Valles at point X flows towards: (only one answer possible)

在形成 Kasei 峽谷之河流中 X 點，其流向之方向是：(只有一個可能答案)

- | | |
|----------------|---------------------|
| 1- the south 南 | 5- the southeast 東南 |
| 2- the north 北 | 6- the northwest 西北 |
| 3- the east 東 | 7- the southwest 西南 |
| 4- the west 西 | |

Question 21: There are small streaks linked to the small craters bounded by the red box in figure13A. The accepted explanation is the presence of winds. What are their directions? (only one answer possible)

問題 21：圖 13A 中紅色方格內，有許多小流痕與小坑洞牽連，被接受的解釋是風的存在。其風向為何？(只有一個可能答案)

- 1- towards the west and northwest.
- 2- towards the west and southwest.
- 3- towards the east and northeast.
- 4- towards the east and southeast.

- 1- 流向西方與西北方
- 2- 流向西方與西南方
- 3- 流向東方與東北方
- 4- 流向東方與東南方

Question 22: Refer to figure 13. The following geological events can be identified as:

問題 22: 依據圖 13, 下列能被確認的地質事件為:

- A- Flow of the river 河川的水流
- B- Small craters 小坑洞
- C- Large craters in the northwest 在西北方的大坑洞
- D - Fracture in the north 在北方破裂
- E- Wind streak. 風痕

Among the relative chronologies (oldest to the youngest) of these events, choose the correct order: (only one answer possible)

在這些事件的相對地形（從最老至最年輕）中，選取正確的順序：（只有一個可能答案）

- 1- A / B / C / D / E 3- D / C / A / B / E
- 2- A / C / D / E / B 4- C / D / B / E / A

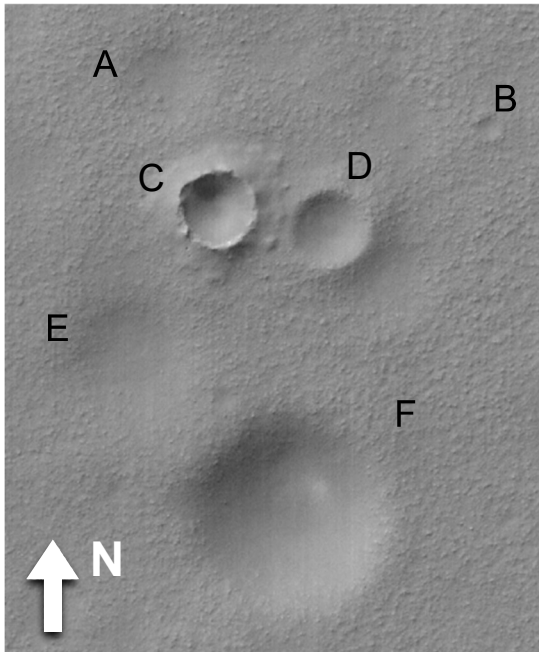


FIGURE 14: Satellite imagery of the Martian region named Sonia Planum. Imagery acquired by the Mars Orbiter Camera (MOC) of the Mars Surveyor (MGS) mission. 火星上 Sonia Planum 地區的衛星影像。影像由火星巡測（MGS）任務火星軌道號相機（MOC）所拍攝。

Question 23: Refer to figure 14. Which is the correct sequence of the relative ages (oldest to the youngest) of the craters ? (only one answer possible)

問題 23: 依據圖 14, 何者是坑洞相對年齡之正確順序(從最老到最新)? (只有一個可能答案)

- 1- A / B / C / D / E / F 5- A / E / F / B / D / C
- 2- E / F / D / C / B / A 6- C / D / B / F / E / A
- 3- C / D / B / A / E / F 7- D / A / E / C / B / F
- 4- F / E / A / B / D / C 8- B / D / E / F / A / C

Question 24: There are fewer craters on Venus, Earth, and Mars, compared to the Moon or Mercury... (only one answer)

問題 24: 與月球或水星相比，金星、地球與火星的坑洞較少... (只有一答案)

- 1- because fewer meteorites struck these planets.
- 2- due to volcanism that has regenerated the surfaces.
- 3- because the Earth has been protected by the Moon.
- 4- due to erosion.

- 1- 因為較少隕石撞擊這些天體
- 2- 由於火山事件重塑表面
- 3- 因為地球被月球保護
- 4- 由於侵蝕

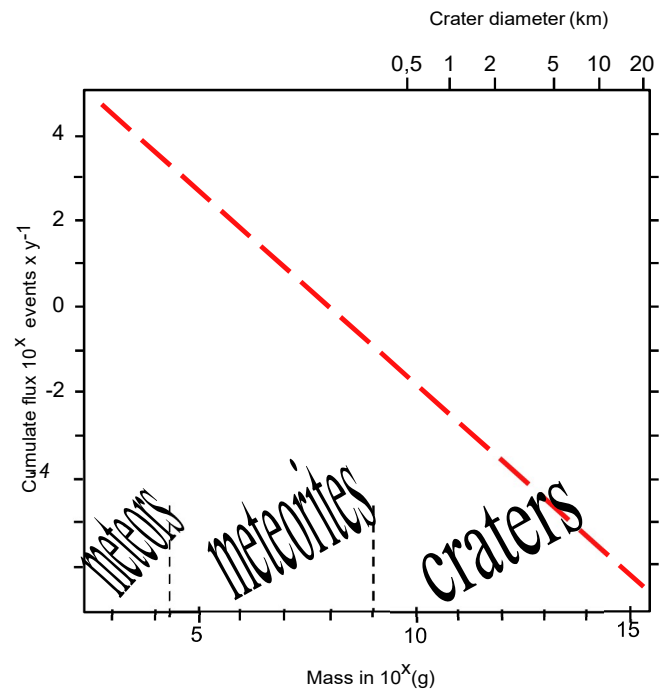


FIGURE 15: 在 Hughes 比例尺中，天體質量、坑洞直徑、撞擊重現率是彼此相關的。數值示天體約以 15.4 km/sec 的速度趨近地球。
Source: Hughes (1992) Space Science Reviews

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Question 25: According to the Hughes scale (figure 15), a body that creates a crater of 5 km diameter on Earth, corresponds a mass of... (only one answer)

問題 25：依據 Hughes scale (圖 15)，一天體在地球上撞擊出一直徑 5 公里的坑洞，對應的質量是…(只有一答案)

- 1- 100 Kilotons
- 2- 0.1 Megaton
- 3- 10 Megatons
- 4- 1 Gigaton

Question 26: One such body impacts the Earth at a frequency of... (only one answer)

問題：26：一個這樣的天體撞擊地球的頻率為… (只有一答案)

- 1- once every century. 每世紀一次
- 2- once every 10,000 years. 每 10,000 年一次
- 3- 3- once every million years. 每百萬年一次

Question 27: Choose the factors that determine the size of an impact crater on the Earth : (several answers possible)

問題 27：選取決定撞擊地球坑洞大小的因素：(可能有數個答案)

- 1- the shape of the body. 天體的形狀
- 2- the mass of the body. 天體的質量
- 3- the amount of ice on the body. 天體中冰的含量
- 4- the speed of the body. 天體的速率
- 5- the density of forest at the site of impact. 在撞擊點的森林密度
- 6- the weather 天氣

Question 28: Refer to figure 15. An impact of magnitude $M=5.5$, less than 100 km from the seismological station, induced vibrations of an amplitude that was too large to be precisely recorded (saturation phenomenon). The annual frequency of impacts of magnitude “M” on Mars is expressed as $R(M) = 100 \times 10^{(3.5-M)}$; the radius of Mars

is 3376 km. Calculate the annual probability that such an event will occur: (only one answer)

問題 28：依據圖 15，一個規模 $M=5.5$ 的撞擊，從地震測站方圓小於 100 公里的地震，其震幅會縮減太大而無法被精確紀錄（飽和現象）。在火星上，規模「 M 」之年度撞擊頻率可以表為 $R(M) = 100 \times 10^{(3.5-M)}$ ；火星半徑為 3376 公里。計算如此事件發生之年度機率：（只有一答案）

- 1- 2.9%
- 2- 100%
- 3- 33%
- 4- 0.02%

SECTION 2 : A SURPRISING SATELLITE AROUND SATURN 令人驚奇的環繞土星之衛星

Enceladus is one of the seven major satellites of Saturn. Table 1 shows some remarkable characteristics of this body. Note that its extremely clear surface has facilitated the observation of complex topography, reflecting geology that is difficult to explain for an object of this size. The aim is to study a possible geological current geological activity.

Enceladus 是土星七顆主要衛星之一。表一顯示這顆衛星的一些特徵。注意它十分清爽的表面含有可見的複雜地形，反映了很難在這樣大小的天體所能解釋的地質現象。本目標是探究目前可能在進行中的地質活動。

Characteristics of Enceladus (Enceladus 的特徵)					
Physical parameters 物理參數				Chemical parameters 化學參數	
Diameter (km) 直徑	Density (g x cm^{-3}) 密度	Gravity (m x s^{-2}) 重力	Temperature of the surface (K) 表面溫度(K)	Composition in volume 組成體積	Atmosphere 大氣
500	1.2	0.06	73	10% silicates 90% water	Trace (H_2O)

TABLE 1: Physical and chemical parameters of Enceladus. (Enceladus 之物理與化學參數)

Question 29: Considering that Enceladus has experienced differentiation, calculate the radius of the silicate core of this satellite: (only one answer)

問題 29：考慮 Enceladus 經歷過分化，計算這顆衛星的矽核心半徑: (只有一答案)

- 1- 85 km.
- 2- 100 km.
- 3- 115 km.
- 4- 140 km.

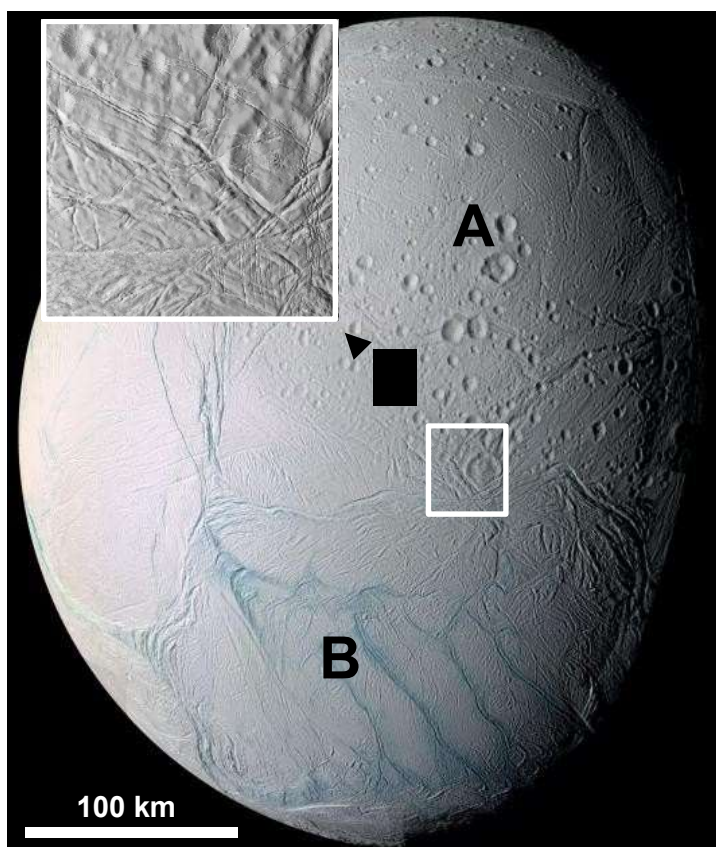


FIGURE 16 : Satellite Imaging of Enceladus obtained by the Cassini probe flying at 1000 km altitude on 14 July 2005 (source: planet- terre.ens-lyon). **Zone A** refers to a major part of the planet, marked by numerous impact craters. **Zone B** corresponds to the south pole of the satellite, where topographic relief and numerous wrinkles may be seen.

卡西尼號太空船在 2005 年 7 月 14 日以 1000 公里的高度飛過 Enceladus 所拍攝到的影像(來源: planet- terre.ens-lyon). **Zone A** 是星球主要部分，標記著許多撞擊坑洞。 **Zone B** 對應了衛星的衛星的南極區，地形揭露 relief 與大量可見的紋路。

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The zoom presented as inset in figure 16 indicates that the structures of zone B intersect with the craters. Zone B is therefore more recent as suggested by the total absence of craters. Scientists hypothesize that there must be internal activity regularly renewing part of the surface of Enceladus.

在圖 16 中框起來的放大圖中，顯示 zone B 的結構與坑洞之交互作用。由於 Zone B 整體缺少坑洞，被建議是最近形成的。科學家假設必然有內部活動規律性的重塑 Enceladus 表面的部分區域。

Question 30: Using the Earth as an analogy, identify the parameters required to determine the present internal activity of Enceladus: (several answers possible)

問題 30：類比於地球，確認一些需要的參數來決定 Enceladus 目前的內部活動：(可能有數個答案)

1- Atmospheric pressure at the surface of Enceladus from the probe.

從探測器偵測到在 Enceladus 表面之大氣壓

2- Surface temperature from the probe.

從探測器偵測到的表面溫度

3- Surface chemistry to detect possible volcanic rocks.

表面化學來偵測可能的火山岩石

4- Magnetic field.

磁場

In terms of the characteristics of Enceladus, the only energy that can maintain tectonics seems to be solar energy. The documents below give some specificities on its thermal state.

藉著 Enceladus 的特徵，被保持在板塊中的能量似乎只有太陽能。下列這些文件提供一些它的熱能狀態訊息。

Question 32: The numerous wrinkles on the surface at the South Pole are correlated with detectable thermal anomalies. This observation makes it possible to deduce that the wrinkles are... (only one answer)

問題 32: 在南極表面有大量皺紋般的紋路，與偵測到的熱異常有關。這觀測使它可能減少皺紋的是…(只有一答案)

- 1- recent tectonic structures made visible by the presence of recently formed ice.
- 2- recent tectonic structures whose thermal anomaly does not allow for water to exist.
- 3- very old structures and are an evidence of the erosion caused by a past flow of water on the surface of the satellite.
- 4- current waterways on the surface of the satellite.

- 1- 由最近形成之冰的存在而被看見
- 2- 最近的地構結構之熱異常無法讓水存在
- 3- 為一個古老的構造，且是一個過去衛星表面被水流侵蝕的證據。
- 4- 目前在衛星表面之水道

The Cassini probe flew over the mysterious south pole of Enceladus to perform chemical measurements. For this purpose, it activated its Ion and Neutral Mass Spectrometer (INMS) to detect water in its gaseous phase as well as its Cosmic Dust Analyzer (CDA) particle detector to detect particles of water ice.

卡西尼偵測器飛過 Enceladus 神秘的南極，執行一項化學測量。對此目的，它啟動它的離子與中性質譜儀(INMS)去偵測氣態中的水，以及啟動它的宇宙塵分析儀(CDA)粒子偵測器去偵測水冰粒子。

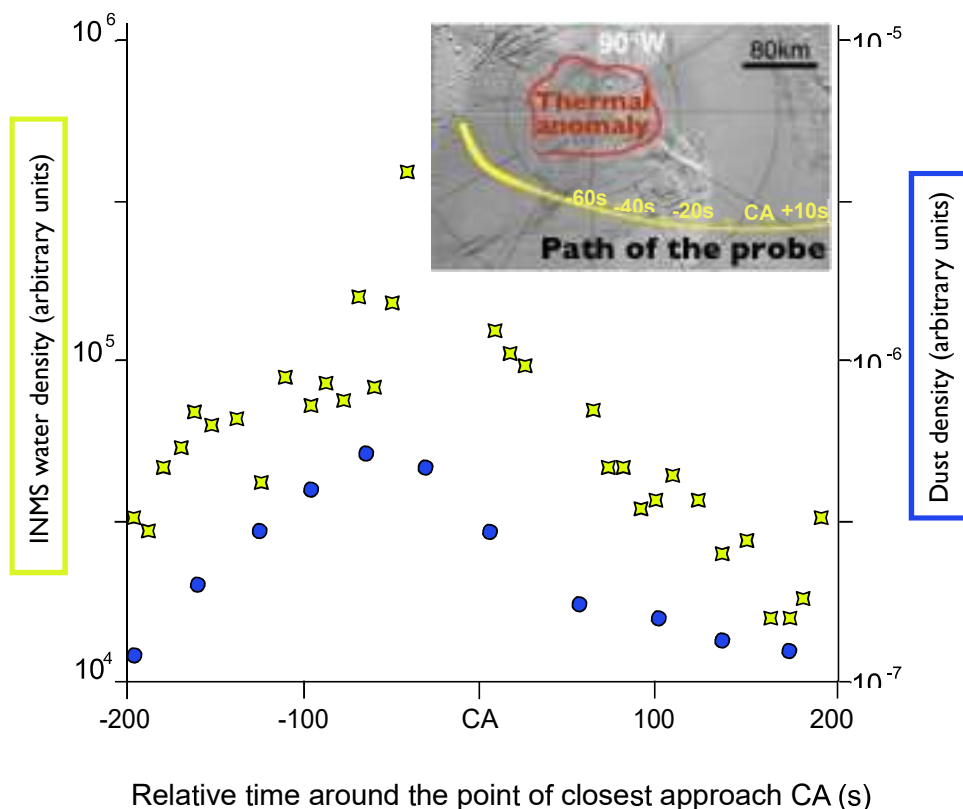


FIGURE 18 : Graph showing the measurements made by the instruments onboard the Cassini spacecraft. The thumbnail picture indicates the probe's flight path near the South Pole. Point closest approach (CA) is the probe's point of passage closest to the ground. Yellow plots correspond to INMS water density and the blue ones to the dust density. Modified from NASA/JPL/University of Michigan/Max Planck Institut 2005 ©

圖 18 :本圖顯示狀裝置在卡西尼號太空船上的測量儀，很棒的圖顯示偵測器接近南極的飛行路徑。最接近的點（CA）是偵測器最接近地面的通過點。黃色路徑代表 INMS 水密度與藍色對應的塵密度。 Modified from NASA/JPL/University of Michigan/Max Planck Institut 2005 ©

Question 33: Refer to figure 18. The measurements from the Cassini probe indicate that: (several answers possible)

問題 33: 依據圖 18，從卡西尼號偵測器的測量顯示：（可能有數個答案）

- 1- The probe recorded the homogeneous presence of particles and water vapor along its path.
- 2- The probe recorded a diffuse zone (of over 100 km) where particles and water vapor were detected in high concentrations. The zone corresponds to the lowest position of the probe.
- 3- The probe recorded a constricted zone where water vapor and dust are highly concentrated. The zone corresponds to an area near the thermal anomaly of the South Pole.
- 4- Outside the zone of high concentration, there is always a small amount of water vapor and particles. Enceladus has a thin atmosphere.

- 1- 偵測器記錄到粒子與水蒸氣均勻的存在路徑中
- 2- 偵測器記錄到一個彌散區（超過 100 公里），偵測到粒子與水蒸氣高度濃縮。此區代表偵測器的最低位置。
- 3- 偵測器記錄到一個水蒸氣與塵高濃度壓縮區，此區代表靠近南極熱異常附近的區域。
- 4- 高濃度區外，一定有一小量的水蒸氣與粒子。Enceladus 有一個稀薄的大氣。

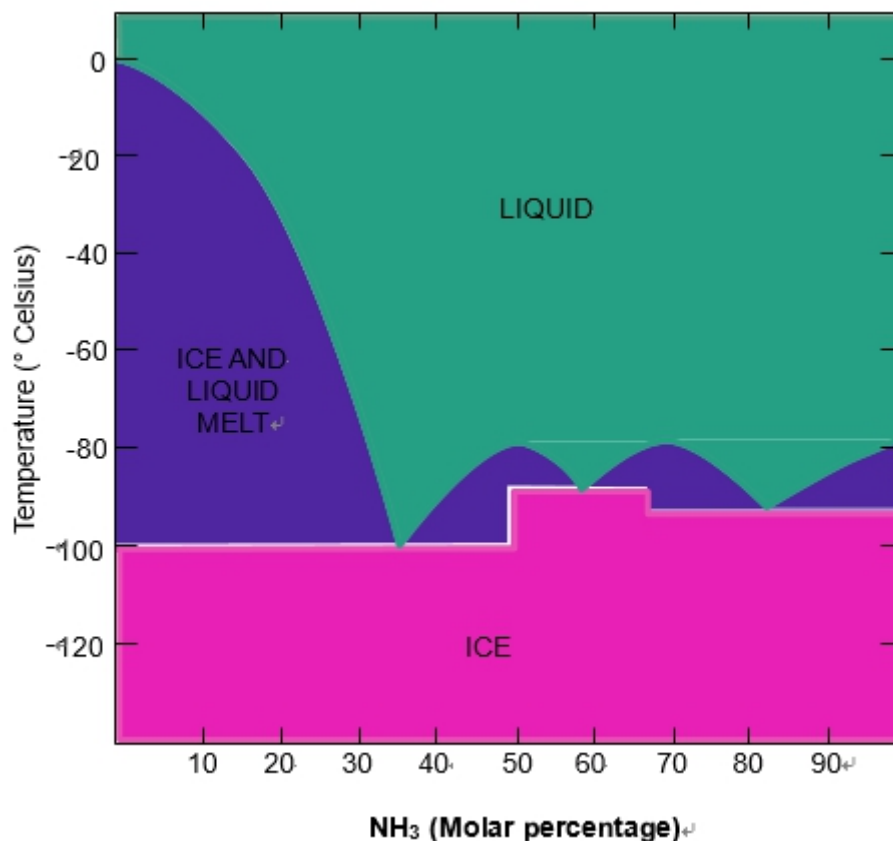


FIGURE 19: Diagram showing the phase changes of an H_2O-NH_3 mixture. The mixture is eutectic, in that it is a mixture of two pure compounds behaving like a single pure compound with respect to its changes of state. The experimental pressure corresponds to that at the surface of the satellite.

本圖顯示 H_2O-NH_3 混合物的相變化。混合物是共晶態，是兩種純複合物的混合體，其行為像一個單獨純複合物隨著其狀態變化一樣。實驗的壓力代表衛星的表面。

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Question 34: Refer to the figure 19. Select the mixture that would allow for the minimum melting temperature:

問題 34: 依據圖，選取 讓溶解溫度最低的混合物：

- 1- A mixture containing 90% ammonia and 10% water.
- 2- A mixture containing 35% ammonia and 65% water.
- 3- A mixture containing 65% ammonia and 35% water.
- 4- A mixture containing 80% ammonia and 20% water.

- 1- 一混合物包含 90% ammonia 與 10% 水
- 2- 一混合物包含 35% ammonia 與 65% 水
- 3- 一混合物包含 65% ammonia 與 35% 水
- 4- 一混合物包含 80% ammonia 與 20% 水

Question 35: Is the minimum melting temperature, inferred from figure 19, compatible with the conditions of Enceladus ? (several answers possible)

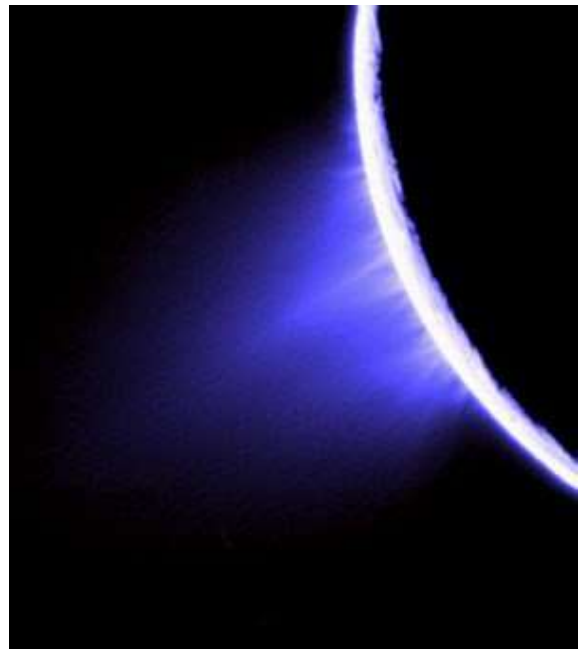
問題 35: 從圖 19 推論，兼顧 Enceladus 的條件，最低的溶解溫度為何？(可能有數個答案)

- 1- The average temperature measured on the surface of Enceladus allows for the melting of the water-ammonia mixture.
- 2- The temperature measured very locally at the level of the South Pole anomalies allows for the rapid appearance of liquid.
- 3- No surface condition on Enceladus allows for the appearance of a liquid containing water.
- 4- The presence of water projected into the atmosphere indicates that internal conditions must allow for its appearance in liquid or gaseous phase.

- 1- 測量到的 Enceladus 平均表面溫度，可容許水-ammonia 混合物溶解
- 2- 在南極異常層面非常局部性的溫度測量所得到的溫度，可讓液體快速出現
- 3- 在 Enceladus 的表面條件，無法讓包含水的液體出現
- 4- 存在進入大氣中的水，顯示內在條件必須讓液態或氣態相出現

FIGURE 20 : Photograph of a cryo-volcanic (cryo means ice) eruption on the surface of Enceladus. Analyses indicate that water vapor and ice are ejected. NASA/JPL/Space Science Institute

在 Enceladus 上一個 cryo-volcanic (cryo 意思是冰)爆發。分析顯示水蒸氣與冰被噴出。



Question 36: Refer to figure 20. Which of the concluding sentences below are justified ? (several possible answers)

問題 36: 依據圖 20。下列哪一個結論句子是有理的？(可能有數個答案)

- 1- The northern part is marked by ancient volcanism and the southern part is an ancient ocean.
- 2- The surface of Enceladus is heterogeneous. It shows that solar radiation erases the craters by causing a change of state in the ice which reforms a smooth surface.
- 3- The surface of Enceladus indicates that only one part of the southern hemisphere is recent. It is now frozen and will gradually accumulate impact craters.
- 4- The surface of Enceladus indicates a very peculiar form of volcanism at the South Pole. Water vapor is ejected into the atmosphere and liquid water spreads over the surface to solidify.
- 5- The southern part of the satellite is marked by active tectonics maintained by an unexplained source of internal energy.
- 6- Despite its size Enceladus has an atmosphere, which is maintained by cryo-volcanism.

- 1- 北部標記為古火山區，南部則為古海洋區
- 2- Enceladus 的表面是異質的，證明太陽輻改變了冰的狀態，抹除了坑洞，重塑成平滑表面
- 3- Enceladus 的表面顯示只有南半球的一部份是最近形成的。現在它是冰凍的，將會逐漸累積隕石撞擊坑
- 4- Enceladus 的表面顯示在南極區有個非常特殊的火山機制型。水蒸氣被噴發到大氣中，液態水散佈在固態表面
- 5- 衛星被活動構造標記南部維持著地形，是被不可解釋的內部能源所提供的
- 6- 儘管 Enceladus 的大小有一個大氣，這大氣被冰火山機制維持著