The Master Passed Away
(28/12/2024)

Late on 29 December 2024, I received a message from my friend and colleague, Dr Shengyu Wu, informing me that our mentor, Peter Vail, had passed away peacefully. Reflecting on the profound influence Peter Vail had on my professional career, I would like to share something valuable I learned from him during his visit to Balikpapan, East Kalimantan, Indonesia in 1989.

In fact, following the Total CFP (presently TotalEnergies) discoveries, in Mahakan offshore (Indonesia) I had invited Peter and his beloved wife, Carolyn to spend a few days with the Total Indonesia exploration team in Balikapan.

The purpose of his visit was to guide Total Indonesia's geoscientists in applying sequential stratigraphy to the regional seismic lines of the Mahakam offshore acquired by Total Indonesia. His presence, generosity and insights left a lasting impression on all Total geoscientists, shaping the way they approach petroleum exploration not only in the region, but worldwide.

Watching P. Vail working on the 2D regional seismic lines of the Mahakan, all the geoscientists present (from left to right: Jean Luc Piazza, Ghislain Chopin de Janvry,

François Jugla, Aussie Gautama, presently Advisor to President Director at Pertamina International EP, Peter Vail, Yves Grosjean, CJ assistant of Prof. Albert Bally de Rice University, and Bernard Loiret) discovered, as I did, a lot of very important things. Personally, I can say:

1) Peter R. Vail belongs to the Atomistic School of geology rather than the Peripatetic School.

This classification stems from Vail's foundational work in sequential stratigraphy, which emphasises the importance of discrete, episodic events - such as sea-level changes, unconformities and depositional sequences - in shaping the Earth's geological record. This perspective is closely related to the atomistic view, which suggests that geological history is driven by a series of discontinuous, quantifiable processes, and reflects the influence of ideas from Democritus' atomism - where change occurs through discrete events rather than gradual continuity.

In contrast, the Peripatetic (Aristotelian) School tends to emphasise continuous, gradual processes and the inherent interconnectedness of geological phenomena, favouring a more holistic and fluid interpretation of the Earth's evolution.

Celâl Şengör (1979, 1982, 1991) categorised geologists into these philosophical schools, associating figures such as H. Stille with discontinuity (atomism) and E. Argand with continuity (peripatetic). Vail's emphasis on discontinuities, sequence boundaries and event stratigraphy clearly aligns him with the atomistic school and reinforces his association with the 'discontinuity' perspective in geological thought.

The main geological ideas that separate these two schools have been summarised by Sengör (1991):

A) Atomist school *(Democrite)*

***Hutton, James* (1726-1797):**

No stratigraphy on a global scale.

***Lyell, Charles* (1797-1875):**

The alternation of orogenic episodes and periods of dormancy on the scale of the whole Earth is only the consequence of the confusion between geological time and the age given by the rocks (e.g. Silurian / Silurian system).

***Suess, Eduard* (1831-1914):**

Mountain ranges rise slowly and semi-continuously. Orogenic episodes are neither global nor synchronous. However, stratigraphic correlations on a global scale are possible thanks to eustatic events.

***Argand, Emile* (1879-1940):**

Orogeny is continuous, but its records are not. An unconformity reflects the end of a deposit, not the end of orogeny.

B) Peripatetic School *(Aristotle)*

Werner, A. G. **(1749-1817):**

Stratigraphy is on a global scale.

Elie de Beaumont, L. **(1798-1874):**

Global stratigraphy is the consequence of the existence of orogenic episodes on a global scale, alternating with periods of dormancy.

Chamberlain, T. C. **(1843-1928):**

Mountain ranges are uplifted during critical periods in the Earth's history, which alternate with periods of tectonic quiescence.

Stille, H. **(1876-1966):**

Orogeny is limited to short-lived (300k years) synchronous global tectonic phases. During the Phanerozoic, for example, only 1/40 of the time was orogenic.

2) Whether consciously or unconsciously, Peter Vail was a devoted follower of Karl Popper's philosophy of science.

Vail's approach to geology, particularly in the development of sequence stratigraphy, reflects Popper's principle of falsifiability - the idea that scientific theories must be testable and open to refutation. By proposing geological models based on observable stratigraphic sequences and encouraging their refinement or rejection by empirical data, Vail demonstrated a commitment to the iterative process of hypothesis testing and critical evaluation that is a hallmark of Popper's scientific method.

His willingness to challenge established geological paradigms and adapt theories in response to new seismic and stratigraphic evidence embodies Popper's view that science advances through bold conjectures and rigorous attempts at disproof.

I recall how often Peter would say to me, *"Carlos, you are absolutely right – if a geoscientist does not understand the geological context of an exploration block, he cannot interpret the seismic lines of the area in geological terms."* In Popperian terms, this reflects the notion that theory precedes observation.

Indeed, if a geoscientist does not know what deltaic progradation looks like, he will never be able to identify it on a seismic line. Similarly, without understanding the relationship between sequence boundaries and relative sea level drops, it is impossible to recognise unconformities.

3) P. Vail used seismic lines primarily to test or falsify theoretical knowledge, rather than simply to confirm accepted geological hypotheses.

This methodological approach has been particularly evident since 1991, when Vail and his students at Rice University proposed the Neogene stratigraphic signature based on seismic data.

Rather than seeking confirmation of existing models, Vail emphasised the use of seismic interpretation as a tool to challenge and refine geological assumptions. By comparing theoretical frameworks with observable seismic patterns, Vail and his students sought to identify discrepancies and adjust their understanding accordingly. This iterative process exemplifies the application of Karl Popper's philosophy, reinforcing the belief that scientific progress is based on the ability to disprove, rather than merely validate, hypotheses.

The 1991 Neogene study was a pivotal moment, illustrating how seismic stratigraphy could provide new insights into depositional processes and basin evolution. Through this work, Vail demonstrated that seismic data, when critically analysed, could reshape long-standing geological paradigms and contribute to a more dynamic and testable stratigraphic model.

Watching P. Vail interpret seismic lines through a geological lens was a powerful illustration of his rational, hypothetic-deductive approach to science. Vail's method stood in stark contrast to the preferences of certain geoscientists with a more naive inductivist perspective, who often criticised him for what they perceived as the imposition of models on the data. These critics argued that his interpretations were overly influenced by pre-existing theories, rather than emerging directly from unbiased observations.

However, this criticism overlooked a key principle of scientific inquiry - that *all observation is theory-laden*. Vail recognised that without a guiding theoretical framework, seismic lines could not be meaningfully interpreted. Those who insisted on approaching seismic data as a tabula rasa - a blank slate - risked missing crucial geological insights that could only be gained by applying established stratigraphic and depositional models.

Vail's approach demonstrated that the interpretation of seismic data required more than passive observation; it required active engagement with theoretical knowledge so that predictions could be tested and refined against the data. His success underlined the importance of balancing theory with observation - using models not as rigid templates, but as flexible tools for exploring the subsurface and challenging existing paradigms.

To conclude these notes, I want to share something I learned from Peter at a Chinese restaurant – a lesson I will never forget:

4) The most important stratigraphic events do not happen during relative sea level rise but rather during the stillstand sea level period after a marine ingression.

I vividly remember a particular evening after a work session at Total Indonesia's office in Balikpapan. I was in a Chinese Restaurant with a good bottle of Burgundy that Caroline and myself almost finished when Peter arrived. With his characteristic enthusiasm, he approached me and said, *"Carlos, I want to try to explain you the sequence of geological events that I believe occurs following a relative sea-level rise – following a marine ingression.*

Below are the key messages I learned from Peter – insights I have consistently used in my tentative geological interpretation of the seismic lines and in all my short courses since then:

(i) As relative sea level rises, the space available for sediment deposition (accommodation) behind the shelf edge increases, causing the shoreline to migrate landwards. This process increases terrigenous influx as sediments fill the expanding accommodation space.

(ii) During a relative sea-level rise, significant deposition does not occur. Instead, the rise results in minor erosion of the pre-existing topography, forming a ravinement surface, i.e a subtle but critical marker of marine ingression.

(iii) Deposition primarily takes place during the periods of relative sea-level stability that follow marine ingressions. This period of sediment accumulation precedes the next sea-level rise, with no intervening relative sea-level fall.

(iv) This is why, in sequential stratigraphy, we refer to eustatic paracycles – sequences of relative sea-level rises without any intervening sea-level falls – rather than eustatic cycles, which are bounded by two relative sea-level falls that lower the sea level below the basin margin.

(v) Between each eustatic paracycle, as sediments accumulate, the shoreline and associated coastal deposits advance seaward. However, this progradation does not return the shoreline to its previous seaward extent, as there is typically a deficiency in terrigenous influx.

(vi) On a larger scale, transgressions – as commonly referred to by many geoscientists – exhibit a retrogradational geometry. This geometry reflects the superposition of increasingly smaller sedimentary regressions (progradational intervals) separated by ravinement surfaces. These surfaces mark periods of relative sea-level rise, with increasing magnitudes (accelerating rises) leading up to a significant sea-level fall.

(vii) One can speak of marine transgression to designate an advance of the sea on the continent. In this case a marine transgression (passing beyond) is synonymous with marine ingression (enter in).

However, one can not speak of sedimentary transgression, since no sediment transgresses the continent. Within a stratigraphic cycle, whether it is a continental encroachment cycle or a sequence-cycle, all sequence-paracycles, which form them, are progradational intervals that correspond to sedimentary regressions.

(viii) A set of increasingly important marine ingressions (relative sea level rises in acceleration) and increasingly smaller sedimentary regressions creates a sedimentary interval with a retrogradational geometry (thickening continentward) that certain geoscientists call " Transgressions ".

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