Modern plate tectonics began on our planet Earth at least 2.2 billion years ago (Ga)

Understanding the geodynamic processes of the Early Earth is crucial because they have strong implications for the habitability of the Earth but also for other planets. A study conducted by an international team of researchers including Camille François and Emmanuelle Javaux (Early Life Traces & Evolution-Astrobiology Lab/ULiège) and Vinciane Debaille (Laboratoire G-Time/ULB) shows that modern plate tectonics began at least 2.2-2.1 Ga ago. The results are published in *Scientific Reports* (1)

The Earth, 4.56 billion years old, is the only planet in the solar system with a lithosphere composed of plates that interact with each other. This process, called plate tectonics, help us to explain the global dynamics of the Earth's lithosphere and thus phenomena that can occur such as earthquakes, volcanoes or mountains building. This phenomenon has played an important role in the evolution of our planet but may also have a significant impact on its sustained habitability. However, plate tectonics on Earth did not always function as today. Characterizing the transition from ancient to modern-style geodynamics regime, including plate tectonics, is therefore important to understand the evolution of our own planet but also to compare our model to other rocky planets in our solar system and test their habitability.

A study involving several laboratories, including the Early Life Traces & Evolution-Astrobiology Lab at the ULiège and the Laboratoire G-Time of the ULB, has revealed the fact that "modern" plate tectonics was functional for several billion years (Ga), by studying 2.1 Ga old eclogites from the Democratic Republic of the Congo (Craton du Congo). Eclogites are metamorphic rocks that form under relatively low temperature and high pressure conditions (because great depths). This type of rock is an important source of information for studying the evolution of plate tectonics, because on modern Earth, these rocks are generally only produced in the geodynamic setting of subduction, a process that occurs when an oceanic lithospheric plate (dense, thin and cold because in contact with water) meets a continental lithospheric plate (less dense and thicker). When both plates meet, the oceanic plate sinks under the continental plate into the Earth's mantle. Today, it occurs at several locations on the modern Earth, for example, along the western coast of South America, leading to the formation of the Andes, a chain of volcanic mountains, and strong earthquakes.

The protolith (the rock of origin before its transformation by pressure and temperature) of this eclogite, a gabbro (a magmatic rock, the main component of the lower layer of the oceanic crust), was formed 2.2 billion years ago (Ga) in a narrow basin opening in a continental environment, then was buried at great depth in the mantle by subduction at more than 55 km, before being exhumed to the surface during a complete cycle of formation and closure of an ocean (called a Wilson cycle) lasting about 130 Ma. *This discovery evidences a modern-style plate tectonics operating since at least 2.2 -2.1 billion years ago (Ga). It highlights the fundamental differences between the ancient Earth, without plate tectonics, and the modern Earth as we know it today.* The appearance of plate tectonics had important impacts on Life evolution on our planet, with an increased supply of nutrients, increased diversity of ecological niches and geographic isolation leading to increased biodiversity, variable climatic conditions and oceanic circulation, as well as volcanic gases of different composition that may have influenced the composition of our atmosphere.

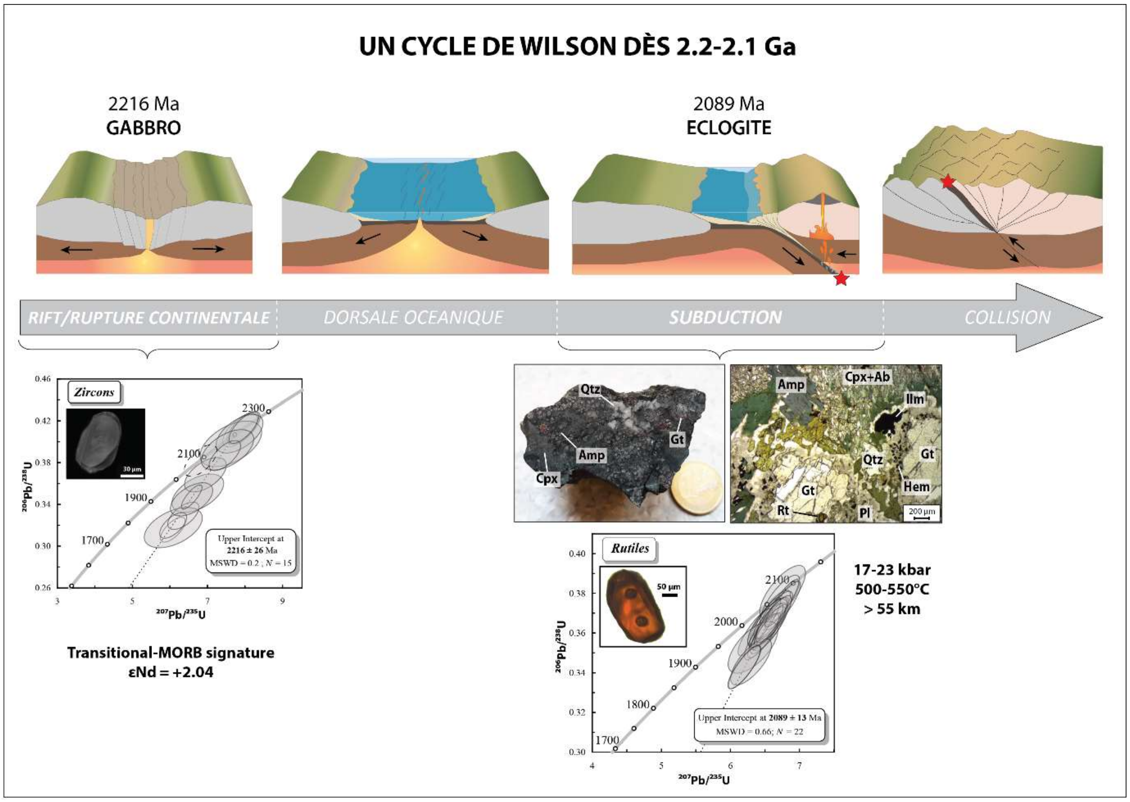

Diagram showing the Wilson cycle of about 130 Ma from the Paleoproterozoic period. Sample of eclogite studied, from the Democratic Republic of Congo, and U-Pb dating obtained on magmatic zircons (2216 ± 26 Ma) and on metamorphic rutiles (2089 ± 13 Ma). Thermobarometric estimates give the subduction pressure peak between 17 and 23 kbar and between 500 and 550°C. Geochemical analyses show a Transitional MORB signature and an initial εNd of +2.04 at 2.2 Ga.

Scientific reference

(1) François, C., Debaille, V., Paquette, J.L., Baudet, D., Javaux, E.J. (2018*). The earliest evidence for modern-style plate tectonics recorded by HP–LT metamorphism in the Paleoproterozoic of the Democratic Republic of the Congo. Scientific Reports*, *8*(1), 15452.

Laboratories involved in this study :

- Early Life Traces & Evolution-Astrobiology Lab ULiège
- Laboratoire G-Time, ULB
- Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS, IRD, OPGC
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