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Late Permian climatic stability: Determination of Kungurian to Tatarian (260 Ma – 250 Ma) palaeowinds direction from lacustrine sediments (Lodève basin, France).

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Global climate changes result from multiple interactions between internal parameters to the Earth's system such as atmosphere, hydrosphere, cryosphere, biosphere and lithosphere and external parameters such as the variations of the Earth's orbital parameters, the solar constant or meteorite impacts. At geological scale, the history of the Earth's climate is characterized by major ice ages (Cambrian, Ordovician, Permian-Carboniferous and Quaternary) separated by periods of warmer climates. Regarding the Earth's system, three major parameters may influence global climate changes over times in order of several millions years: plate tectonics (especially mountain building), chemical composition of the atmosphere and oceanic circulation. Most of questions arise from the complex interaction between the factors that govern the Earth's climate, and from the difficulty to reconstruct palaeoenvironments from geological data. Therefore additional palaeoclimatic data together with numerical modeling of atmospheric circulation are needed to provide new insights on Earth's past. Numerical models have already described palaeowind circulation patterns on large surface square grids (400 km x 400 km), but to date, they have not been constrained by palaeowind geological indicators.

The Permian (295 Ma- 245 Ma) is a remarkable period in the Earth's climate history, marked by the end of the Permo-Carboniferous ice age. With regards to tectonics Permian times correspond to the gravity collapse of the Hercynian chain that was responsible for the development of a Basin and Range-type province, characterized by many intramontane continental grabens. Permian climate modeling has recently emphasized the role of the Hercynian chain altitude onto the repartition of humid and arid zones in the Northern Hemisphere.

Sedimentary recording of Permian palaeowind circulation has been analyzed in some scattered areas from aeolian deposits, (Nevada (USA) and England). However, Permian aeolian deposits are scarce and do not allow a large scale approach of palaeowind circulation, as lacustrine deposits do, because of their extensive preservation at the present continents surface. Indeed lacustrine environment have a great sensitivity to climate variation and provides an excellent indicator of palaeoclimatic conditions within continents. As wind induces waves, the wave ripples in such an environment may constitute a pertinent marker of atmospheric palaeocirculation. In order to determine the significance of the wave ripple orientation, the wave ripple patterns must interpreted with regards to hydrodynamics and palaeobathymetry. We show that under certain conditions palaeowind circulation can be deduced from the analysis of wave ripples direction in space and time. Lacustrine sedimentation is widespread during Permian times (295 Ma- 245 Ma) and is well preserved on the Earth's surface. We firstly identified wave deposits in a lacustrine Permian basin (Salagou formation, 260 Ma – 250 Ma) located in the southern French Massif Central (Lodève basin), which belongs to the western European Hercynian chain. We deduced the palaeowind direction from the statistical analysis of the wave ripples orientation. In the case of the Salagou formation, dominant wind was blowing in N-S to N020˚ direction and was maintained through the deposition of 2000 m of strata over 10 Ma. We finally emphasize the importance of such geological data to constraint numerical modeling of Earth's past climates, especially with regards to Permian times.