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IN MEMORIAM YVES TARDY (1939–2022)

Yves Tardy (1939–2022) passed away this year. He began his professional career in the “Centre de Sédimentologie et Géochemie de la Surface” headed by Georges Millot at the University of Strasbourg, France. As a geologist, geochemist, soil scientist, and enthusiastic teacher, he trained an outstanding group of students and researchers. He was instrumental in the transition of the study of solids in soils and alterites toward the study of natural waters, as early as in his PhD thesis (1969). In the dominating ideas of the time, kaolinite and even more gibbsite minerals were considered as indicators of tropical climates. However, after Dejou at INRA in Clermont-Ferrand, Tardy found them in granitic arenas of the French Massif central; thus, they form presently. In the French Vosges mountains, he identified aluminous vermiculites that were mineralogically different, but geochemically equivalent to kaolinite in terms of the Si/Al ratio. This is what he called “disguised monosialitization”, a concept referring to the definitions given in the study of laterites by the German geochemist Harrassowitz, and later generalized by Georges Pédro. On the basis of the experimental weathering studies by the latter, and specifically the mol ratio $\text{SiO}_2/(\text{sum of bases})$ in solutions, Tardy focused on the chemical composition of natural waters. This allowed him to show the actuality of rock weathering and soil formation. Soils and alterites are not simply the heritage of a long history.

The same processes are active today, with slow, but indeed measurable rates, non-negligible even at the scale of human life. He then elaborated the idea that major, minor, and trace elements migrate different distances according to their solubilities and pedoclimatic conditions. This is what he called “ion chromatography in landscapes,” a precursor of the concept of “critical zones.” Reactions between alterites and soils and solutions must not be considered only as mass transfer. Chemical equilibria must also be considered. The calorimeter must complete the balance. Tardy then introduced in France the application of solutions/mineral equilibria, developed by Robert M. Garrels in the USA, generalizing the well-known oxido-reduction (corrosion) diagrams designed by Marcel Pourbaix in Belgium. Tardy then played a pioneering role by importing and adapting the first computer geochemical models developed by Harold C. Helgeson at Berkeley for metallogeny, just 50 years ago, when they were still embryonic, as even the Fortran language was not yet stabilized. He initiated the Water-Rock Interaction group in the IAGC, which held its first meeting in Prague in 1974 and still exists. As early



as the 1980s, he launched with Henri Martin, professor at the Catholic University of Louvain in Belgium, and Udo Schwertmann, professor at the University of München in Germany, and was the first President of the European Network of Laterites and Global Environments (EUROLAT) in the very first European program “Help and stimulation for research”, created in 1985 that accompanied the first generation of post-doctoral exchanges in the Europe of 12 countries at the time.

The interdisciplinary PIRAT (Programme interdisciplinaire de recherches sur les altérations tropicales) program aimed to study the impact of

climate change on weathering, sedimentation, and carbon fluxes, relying on three joint studies: lateritic profiles, paleolakes, and large river watersheds. Thus, several generations of French and foreign students benefited from this support. Major results were obtained, e.g., about the hydroclimatic conditions of formation of minerals in laterites, impacts of hydroclimatic variations on lacustrine sedimentation, the role of rock weathering as a sink of atmospheric CO_2 and fluxes of inorganic carbon in solution exported by rivers to the ocean. All of these results are recorded in three fundamental treatises, of which Tardy is the author or leader: Tardy Y (1986) *Le cycle de l'eau. Climats, paléoclimats et géochimie globale*. Masson, 338 pp; Tardy Y (1997) *Petrology of laterites and tropical soils*. Balkema, 408 pp; Tardy Y and 5 coauthors (2009) *Carbon and water cycles, Amazon River Basin applied geochemistry*. Atlantica, 479 pp.

With his expertise in the field of African soils and evaporitic environments, Tardy developed a school in France on natural salts and brines, e.g., Chott El Jerid (Tunisia), Lake Chad (central Africa).

These then formed the foundation of the new school that Tardy laid, combining soil and water analyses with geochemical and hydrological modeling, with a constant eagerness to keep a strong anchorage in field studies—in Africa, especially for laterites of which he was particularly fond; in Europe; and in Brazil, with the monitoring of the chemical composition of large rivers. Yves Tardy was a scientist of international reputation and a fantastic leader of all the French and foreign teams he created and stimulated over so many years, and the teams who have followed, developed, and diversified the tracks he opened.

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