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A detailed study of the effects of cold Jupiters on the formation and composition of terrestrial planets

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Whether or how giant planets affect the formation and orbital assembly of terrestrial planets has been a longstanding question in planetary astrophysics. In our solar system, Jupiter and Saturn have played a fundamental role in defining the extent and architecture of the asteroid belt, and have been crucial to promoting terrestrial planet formation by confining the process to interior to 1.9 (au). Among exoplanets, there are systems like GJ 876 where three cold-giant planets have created an empty inner region similar to the asteroid belt and have contributed to the formation of a super-Earth in a 2-day orbit. The existence of these systems strongly indicates that cold Jupiters play a significant part in the formation and final assembly of planets interior to their orbits. To explore the extent of the effects of these planets, we have carried out more than 1200 simulations of the last stage of terrestrial planet formation for different values of the mass, orbital elements, numbers, and migration-rate of (cold-) giant planets. Results demonstrate that in all systems, there is always an asteroid-belt analog. However, whether terrestrial-class planets can form interior to this region depends strongly on the number, mass, and orbital elements of the cold Jupiters. Our simulations show that, interestingly, terrestrial planets can also form in some systems without giant planets; however, the process is not as efficient as in systems with cold Jupiters. Finally, results indicate that while giant planets may affect the inventory of water-carrying objects, they play no role in the mechanics of the transfer and transport of water to rocky planets. Water delivery is in fact due to the successive collisions among planetary embryos, a process that occurs even when no giant planet exists. We will present the results of our study and discuss their implications.

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