Numerous environmental factors affect the processes and outcomes of dolomitization. Shallow peritidal and restricted marine environments, for example, are typically associated with more abundant and more stoichiometric dolomite than deeper subtidal environments. Higher fluid Mg/Ca ratios resulting from the precipitation of gypsum are often invoked to explain this observation, even when evidence of evaporites is absent. In this study, high-temperature dolomitization experiments show that the concentrations of major cations, such as Na, K, Mg, and Ca, also impact dolomite stoichiometry and reaction rate in marine-like fluids. Nearly 200 laboratory experiments were conducted whereby natural aragonite ooids were dolomitized at 215°C in synthetic solutions reflecting a wide range of diagenetic fluids (e.g., mixed freshwater-marine, marine, and marine evaporative). In all experiments, aragonite was rapidly replaced first by a protodolomite (very high magnesium calcite) phase, which is later replaced by ordered dolomite. Fluid [NaCl] and [KCl] correlate positively with stoichiometry of the initial protodolomite product (43-48 mol% MgCO₃), but negatively with reaction rate. In contrast, [Mg] and [Ca] correlate positively with both reaction rate and protodolomite stoichiometry (41-45 mol% MgCO₃). The rate at which cation ordering developed was unaffected by [NaCl], [KCl], [Mg], or [Ca]. These findings provide the basis for an alternative explanation for the relationship between restricted marine conditions and higher dolomite abundance and stoichiometry without the need to invoke precipitation of calcium-bearing evaporites. The observations presented here add to our understanding of the fundamental controls on dolomite stoichiometry and reaction rate, and further demonstrate that dolomite stoichiometry may be a useful proxy in our effort to elucidate the origin of ancient dolomites.