Mechanism and time scale of change of carbon and oxygen isotopic compositions related to subaerial exposure

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Shallow-marine carbonate sediments are subjected to various types of diagenesis in near-surface environments. Allan and Matthews (1982) found out specific patterns of stable carbon and oxygen isotopic compositions related to meteoric diagenesis, and pointed out that the patterns are useful for postulating stratigraphic positions of a subaerial exposure surface (SES). However, the detailed mechanism and time scale of the isotopic alterations related to subaerial exposure are not fully understood.

As a result of examinations of the Late Quaternary carbonate sediments of the Ryukyu Islands, Japan, diagenetic alterations on carbonate mineral and isotopic compositions occur within about 10,000 years after the depostion. The changes of $\delta^{13}C$ and $\delta^{18}O$ are correlated with an increase by meteoric diagenesis of Low-Mg calcite (LMC) content. The change rates with an increase of 10% of LMC content are -1.29‰$\delta^{13}C$ and -0.56‰$\delta^{18}O$ at the horizon just below SES, and -0.71‰$\delta^{13}C$ and -0.50‰$\delta^{18}O$ at the lower horizon. These isotopic alterations continue until the perfect stabilization of primary sediments into 100% LMC, even after the deposition of the overlying strata. Consequently, the specific patterns of $\delta^{13}C$ and $\delta^{18}O$ related to subaerial exposure are established when the primary sediments are fully stabilized. Therefore, the magnitude of negative shifts in $\delta^{13}C$ is related to the degree of mineralogical stabilization and the content of organic matter within SES rather than length of the period of subaerial exposure.