Abstract
Biogenic silica diagenesis leads to abrupt changes in the physical properties of host sediment across the depth of an opal-A to opal-CT transition zone. Predicting the present-day diagenetic state of this reaction boundary, i.e., active versus arrested opal-A to opal-CT transition zones, is imperative to constraining the diagenetic factors that impact dramatic variations in the physical state of sediment. This study assesses whether there are present-day signatures of active silica diagenesis in the interstitial water, and corroborates the potential for pore-water chemistry for distinguishing between ongoing precipitation of diagenetic opal and arrested reaction fronts. Interstitial-water chemistry, mineralogy, and thermodynamic analyses of the Ocean Drilling Program Sites 794 and 795 demonstrate that solubility equilibrium is reached with respect to opal-CT in the transition zones accommodated by the Neogene biosiliceous sediments in the Sea of Japan. Even though the dissolution of biogenic opal is triggering reverse-weathering processes, the equilibrium reached with respect to diagenetic opal strongly suggests that the dissolved silica depression across the transition zones is essentially influenced by ongoing transformation of opal-A to opal-CT. Owing to abrupt petrophysical variations linked to opal-CT precipitation, the interstitial profiles of major ions and primary parameters have also been impacted by silica diagenesis. The extremely low dissolved-silica diffusion fluxes in the sediment, the very low permeability of the sediment capturing silica diagenetic transformations, and the marked pore-water loss at the depth of the transition zone all support the fact that the dissolved species have not been diffused in the sediment at rates comparable to those by pore-water advection due to sediment porosity drop. Adveective and diffusive mechanisms, however, appear to have ceased recently because they have failed to smooth out the traces of ongoing biogenic silica diagenesis.

Methods
The results of pore-water inorganic-chemistry analysis for the studied boreholes, derived from the ODP open-access database, were used as the main source of thermodynamic
assessments conducted in this work. Deep-sea sediment samples obtained from opal-A and opal-CT depositional masses along the investigated sites were analysed to extract complementary mineralogical data.

Figure 1. Diagenetic opal (cristobalite) diffraction intensity and saturation state vs. depth, Sites 794 and 795 (modified from Varkouhi et al., 2020).
Results and discussion

The relative abundance of tridymite and cristobalite displays the presence of diagenetic opal in the sediment overlying the petrophysical front at Sites 794 and 795 in the form of low-intensity diffractions. Excluding a few examples of vivid fluctuations in the opal-CT abundance, a spectrum of low-intensity peaks is widely observed across the opal-A to opal-CT transition (Fig. 1). In spite of the dominance of low-intensity peaks at the depth of the reaction front for both sites, the mean normalised opal-CT content is nearly twice that of the opal-A interval sealing the transition. The fluctuation of opal-CT diffraction peaks within the frontiers of the diagenetic interval suggests a non-uniform transition from biogenic to diagenetic opal at these two sites. The silica concentration and the saturation status indicate the present-day dissolution of biogenic opal in the pore water across the opal-A- and opal-CT-rich intervals, while supersaturation with diagenetic opal at the transition which suggests the solubility control with respect to this silica polymorph and its precipitation (Fig. 1). Physical-property changes under silica diagenesis have also impacted the pore-water level of other cations and chemical delegates. The solubility equilibrium touched by the diagenetic silica implies that the authigenic reactions competing with opal-A diagenesis, including the reverse weathering have not highly reduced the present-day precipitation rate of opal-CT at the studied sites. Plummetsed sediment diffusivity and permeability and the sudden water expulsion due to transformation of opal-A to opal-CT suggest that silica has not been diffused in the sediment at rates comparable to those by advection although none of both means of transport has erased the signature of silica diagenesis, including the silica depression across the transition.

Conclusions

This work used interstitial-water chemistry to arbitrate the present-day state of silica diagenetic reactions across the opal-A to opal-CT transition zone penetrated by the Ocean Drilling Program Sites 794 and 795. The solubility equilibrium reached with opal-CT demonstrated ongoing precipitation of this silica polymorph at the diagenetic front, where ion transport mechanisms have failed to smooth out the dissolved silica sink.

References

