Estimation of water depth based on numerical modeling of deformations caused by dropstones

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Abstract

The occurrence of dropstones in glacial environments provides evidence of deglaciation processes, imprinting soft-sediment deformation structure (SSDS) in the sedimentary substrate. The deformational morphology is influenced by multiple factors, such as the size and shape of the dropstone, physical properties of the basin, and water depth. Besides the paleoenvironmental importance of the water depth determination, there are also valuable economic applications, such as evaluation of salt saturation in evaporitic environments and of iron saturation in primitive oceans, targeting hydrocarbon reservoirs and iron ore deposits, respectively. In this regard, our study aims to develop a numerical model to estimate the water depth based on the SSDS resulted from the dropstone impact. The numerical modeling was performed using the iSALE (Simplified Arbitrary Lagrangian Eulerian) hydrocode, a software for impact studies and sediment deformation models, such as landslides. We applied this software by modifying the physical parameters of the water as well as the density and dimensions of the dropstones. For the integration of the dropstone movement with the water column, Newton's equations are used considering the density of the medium, gravity and the buoyant force, since the dropstone is described as a dense and uniform sphere. Because it is a model that considers several variable physical parameters, such as temperature, density, salinity and viscosity of water, the Euler-Lagrange equations are used, since they provide an equation for each movement of the body, considering only the energy of the medium. The expected results include the impact velocity of dropstones during their fall, the influence of bottom sediments properties on the resulting SSDS and the influence of dropstone size on the penetration deformation structures in clayey sediments. All these results combine to establish a consistent correlation between the dropstone, the resulting SSDS and the water depth. By accurately estimating the water depth using this numerical model, it will be possible to gain insights into past environmental conditions, which can have significant implications for understanding Earth's history and its geological processes. Additionally, the findings of our study can have practical implications for various industries, such as energy exploration and mining, by providing a better understanding of sedimentary environments.