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Raman counting of heavy minerals in turbidites: Indus Fan, IODP Expedition 355

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Raman spectroscopy is an innovative tool with tremendous potential. Thorny long-standing problems that cannot be solved confidently with a polarizing microscope alone, such as the determination of opaque heavy minerals or of detrital grains as small as a few microns, can finally be addressed. Heavy-mineral species commonly found in sediments convey specific information on the genesis of their source rocks and are therefore crucial in provenance diagnoses and palaeotectonic reconstructions.
A high-resolution mineralogical study of Indus Fan turbiditic sediments cored during IODP Expedition 355 (Arabian Sea Monsoon) in the Laxmi Basin was carried out to investigate and quantify the different compositional signatures of sand and silt fractions. Silt and sand in turbidite deposits recovered at IODP Sites U1456 and U1457 were chosen as the best natural archive for this source-to-sink study.
An integrated mineralogical dataset was obtained by coupling traditional and innovative single-grain heavy-mineral analyses. Reliable quantitative results even in the medium to fine silt classes, which represent the dominant sediment sizes encountered in the recovered cores, were obtained by point-counting of single grains under the microscope assisted by Micro-Raman spectroscopy.
Preliminary data from the studied turbidites document rich and diverse heavy-mineral assemblages in both sand and silty-sand fractions. Multiple varietal studies of amphibole, epidote and garnet varieties, representing the dominant heavy-mineral trial in orogenic detritus derived from collided ranges such as the Himalaya, were performed to highlight the wide unexplored potential of Raman spectroscopy when applied to provenance studies. Discriminating within the isomorphous series of garnets is possible, and diverse pyralspite and ugrandite garnets are distinguished by the position of characteristic peaks found at high frequencies and caused by Si–O stretching modes (873–880 cm-1 in ugrandites, 907–926 cm-1 in pyralspites; Bersani et al., 2009; Andò et al., 2009). Raman discrimination of amphibole varieties is also possible and the diagnostic position and shape of the more intense OH stretching bands (frequencies between 3600 and 3700 cm-1) are particularly helpful (Vezzoli et al., 2016). Raman discrimination of epidote-group minerals was tackled by using a new data set of the characteristic vibrational modes in the high-frequency region to facilitate distinction from other silicates and distinguish different varieties. A protocol to separate heavy minerals from the silt fraction, starting from a few grams of sediments only, was developed at the Laboratory for Provenance Studies of Milano-Bicocca. An appropriate data base of Raman spectra of detrital minerals is essential to apply this method routinely in future provenance studies of deep-sea turbidites. Such a new methodological approach plays a potentially key role to differentiate among the diverse Himalayan versus Indian Peninsular sources of detritus and opens up a new frontier for future studies of the largely unexplored deep-marine sedimentary record.

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