Environmental fate, transport, and bioavailability of CeO_2 nanoparticles in stream mesocosms

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Emissions from wastewater treatment facilities ("press"-type exposures) and accidental spills ("pulse"-type exposures) are two possible entry routes of engineered nanomaterials into aquatic environments. Significant uncertainty exists regarding the processes governing transport and environmental fate of these novel materials. Outdoor, 1870L recirculating stream mesocosms were treated with either 1) a one-time addition (pulse) of acetate-coated cerium dioxide nanoparticles (CeO_2 NPs) to achieve aqueous concentration of 10 mg NPs/L or 2) a 25-day continuous exposure (press) of the same amount of CeO_2 NPs as 1), a third stream served as a control. Mesocosms were lined with unglazed ceramic tiles and stocked with fish, invertebrate, plant and microbial species. CeO_2 NPs are known to be insoluble, so total Ce concentrations measured by ICP-MS served as a proxy for CeO_2 concentrations. Results suggested rapid aggregation of CeO_2 NPs in the pulsed dose. Aqueous concentrations were between 0.24-0.37 mg/L 12-76 hours after NP addition, declining to 0.02 mg/L by cessation of the experiment on day 30. Aqueous Ce concentrations in the press-dosed stream averaged 1.2 mg/L on day 15 (12% of target) and 1.1 mg/L (11% of target dose) on day 25. Five days after completion of NP dosing in press mesocosms (day 30 of experiment), aqueous concentrations of Ce had declined to an average of 0.46 mg/L, which was still higher than any Ce concentration measured in the pulse-dosed stream. Consequently, the concentration of Ce in periphyton was lower in the press-dosed stream on day 30 (average of 9.08 μg/g of dry sample) than in the pulse-dosed stream (average of 13.11 μg/g). The press dose resulted in longer-range transport of NPs, such that periphyton concentrations of Ce in the lower reaches of the press-dosed stream were nearly double those observed for the pulse-dosed stream (6.4 μg/g vs. 3.3 μg/g, respectively), likely because of a reduced particle-particle interaction and subsequent aggregation relative to the pulse addition. These results suggest that exposure scenarios may play a significant role in determining the environmental fate, transport, and bioavailability of stable metal oxide nanomaterials.

Development of fertile magma at El Teniente, Chile: Implications for porphyry-style mineralisation

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El Teniente porphyry Cu-Mo deposit is located in the Andean Cordillera in the central Chilean porphyry belt, which is host to a number of world-class late Miocene-Pliocene porphyry copper deposits. El Teniente is considered one of the world's largest copper deposit in terms of contained metal, with a total identified resource of over 16 billion metric tonnes (Gt) at 0.554 % Cu [1] and 7.8 Gt at 0.018 % Mo [2].

A series of calc-alkaline intermediate to felsic porphyritic sills and dikes, collectively termed the Teniente Plutonic Complex, are spatially associated with magmatic-hydrothermal breccias and veins that host mineralization at El Teniente. They were emplaced between 7.1-4.9 Ma, although previous work has suggested a 7.10 ± 0.41 Ma age for a sample of the porphyry may be inherited [3,4].

Samples from the Teniente Plutonic Complex have been analysed for Rb/Sr and Sm/Nd isotopic compositions. ε_{Nd} values are consistently positive, ranging from 2.4 to 3.2, whereas $^{87}Sr/^{86}Sr_i$ values are between 0.70388 and 0.70421. When compared to other intrusive rocks from Central Chile [5], El Teniente rocks display broadly similar trends, implying that a geologic event led to an abrupt decrease in ε_{Nd} values ca. 5 Ma. The isotopic data reflect localized assimilation of crustal material into the mantle wedge as a result of subduction erosion adjacent to a zone of ridge subduction [5], rather than intra-crustal contamination, consistent with a subduction-erosion model [6]. The data suggest the Teniente Dacite Porphyry and associated mineralization was emplaced as several discrete intrusions over a ca. 1 million year period. This process has implications for the relationships between porphyry emplacement and Cu-Mo mineralization in central Chile.

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