The role of clay mineralogy and electrolytes in determining the stability of clay pellets in dry saline lakebeds of the USA and SE Australia

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Dry lakebeds are some of the major source areas for aeolian dust in the continents of Africa, N. America and Australia (Washington et al. 2004, Gill and Gillette 1991, McTainsh 1989). This dust exerts a range of impacts downwind from the source areas, including effects on human health, pollution in cities, landscape processes and the potential addition of nutrients to the oceans.

Suspended clay and fine sand, as well as dissolved salts, are carried into the lakebeds by streams, and in the N. American examples, these sediments are transported by snowmelt, runoff and wave erosion. The drying of lakes by evaporation increases the concentrations of Na and Ca salts, which flocculates the suspended clays and leads to the deposition of clay and fine silt. As a lakebed dries out it fractures into mounds of stable clay pellets. These mounds can be slowly abraded by wind, resulting in a layer of loose, coarse sand-sized clay pellets on the lakebed (Fig. 1).

Despite the strong links between known source areas and the passage and properties of aeolian dust downwind, little is known about the specific processes that cause lacustrine clay pellets to disintegrate into smaller sized materials that can supply large dust plumes. In a previous study (Greene et al., 2006) clay pellets were sampled from a range of dry saline lakebeds in N. America and SE Australia (Fig. 2). These included samples of loose pellets collected from the lakebed surface of Diamond Lake, Wyoming, USA, and from 4m below the crest of a lunette at Corop, N. Victoria, Australia. These pellets at Corop had been previously saltated from an adjacent lakebed, and are an example of “source-bordering parna” (Cattle et al. 2009). The rate of disintegration of these clay pellets in water was studied using a Malvern Mastersizer 2000 laser particle size analyzer. The results demonstrated contrasts in the kinetics of disintegration for materials from different source areas. These contrasts in disintegration behavior between the various sediments could be partly explained by differences in the electrolyte content (measured as electrical conductivity (EC) of 1:5 soil-water extracts) and extent of Na^+ saturation (measured as exchangeable sodium percentage (ESP)) (Rengasamy et al., 1984) of the samples.

Subsequent analyses using X-ray diffraction (XRD) of the pellets, however, also indicated that the samples contain different relative amounts of smectite and illite. Previous studies by Greene et al. (1978) have demonstrated that clay particle assemblages comprised of smectite particles are more resistant to disruption in water than assemblages of illite particles. It is therefore proposed that these differences in the proportions of smectite to illite occurring in the lakebed sediments may also be largely responsible for the differences in kinetics of disintegration between samples.

Thus the current conceptual models of physico-chemical controls on the stability and/or disintegration of aggregated clay materials need to be modified to take into account the unique properties of lake bed sediments; in particular their mineralogy and electrolyte composition. Further studies of the disruption kinetics of lake bed sediments from additional sources and having a wide range of different mineralogies are required. This knowledge will assist in management decisions related to possible prevention of harmful dust plumes from point sources such as desiccated inland playas and mudflats.

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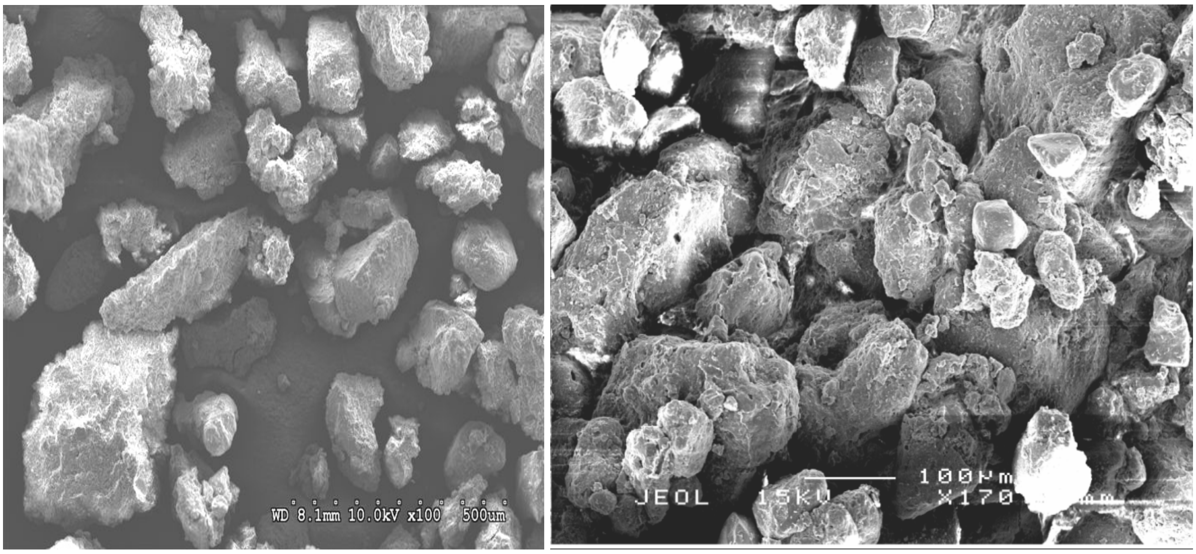
Fig. 1. Layer of loose, coarse sand-sized, clay pellets resulting from the abrasion of mounds on the lakebed surface of Diamond Lake, Wyoming, USA.



(a) (b)

Fig. 2. Scanning electron micrographs of clay pellets from: a) the lakebed surface of Diamond Lake, Wyoming, USA, and b) a lunette at Corop, N. Victoria, Australia.