Chlorite Vermiculitization in the Oregon Dunes National Recreation Area, Oregon

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Abstract

The source of the dunes that comprise the Oregon Dunes National Recreation Area, situated between Florence and Coos Bay, Oregon, is currently being investigated. The hypothesis currently in favor entails aeolian sand blown in from the south off the continental shelf. Recent X-ray diffraction analyses show that vermiculite is present in the dunes. This is believed to occur through chlorite vermiculitization. The source of the chlorite is likely to the south of the dunes, where its concentration is at the highest. This supports the idea that the provenance of the sediments in the dunes is likely continental shelf aeolian detritus, blown in by strong winter winds during sea level low stand periods.

Introduction and Background

The Oregon Dunes National Recreation Area is situated between Florence to the north and Coos Bay to the south (see figure 1). The dune sand's geographic constraints are Heceta Head to the north (just north of Heceta Beach) and Cape Arago to the south (just off the map). Within these boundaries the dunes are approximately seventy kilometers long with a variable width of a maximum five kilometers. The climatic conditions of the dunes vary seasonally. In the winter months, the rainfall is high and the winds are from the south. The summer months bring about a nearly opposite wind direction from the north.

Figure 1: Oregon Dunes National Recreation Area is situated between Florence to the north and Coos Bay to the south.

The origin of the dunes is still under study (Stock et al., in progress). There has been two hypotheses suggested, both of which involve sea level fluctuations. The high sea level hypothesis entails the rising sea level forcing the sand on shore in beach environments, and subsequently the sand being blown onto the terrace and up to the foothills of Oregon's Coast Range. The low stand theory involves sand being blown from the exposed continental shelf during low stands. This would also allow loess to be blown in, while the high stand theory would not allow this due to the high-energy environment of the beach forcing. These two ideas would produce different ^{14}C (the only ones obtained thus far) dates, and the latter idea is supported due to the oldest date being ^{14}C dead at ~40,000 radio carbon years before present, with other dates not expected to be significantly older. This date corresponds to low sea level stands.

If the sand, silt, clay were blown in from the shelf, the sediments would leave mineralogical signatures indicating a provenance from the shelf. Recent X-ray diffraction studies have indicated that vermiculite is present in sediments associated with the dunes. It is believed that the vermiculite is the weathering product of detrital chlorite from the shelf. This paper will study the vermiculitization of chlorite, the interpolated process by which the vermiculite is weathered from chlorite.

Source of chlorite

Figure 2 (Karlin, 1980) sows were the possible chlorite source is from. If the low sea level hypothesis is correct, then the winds during the time of emplacement would have to be going to the NE. This is supported by ongoing research of paleowind movement. Micks (personal communication, 1998) reports preliminary paleowind (~40,000 ybp) vectors as N33°E. In addition to the direction, the winter winds are three times stronger then than they are now.

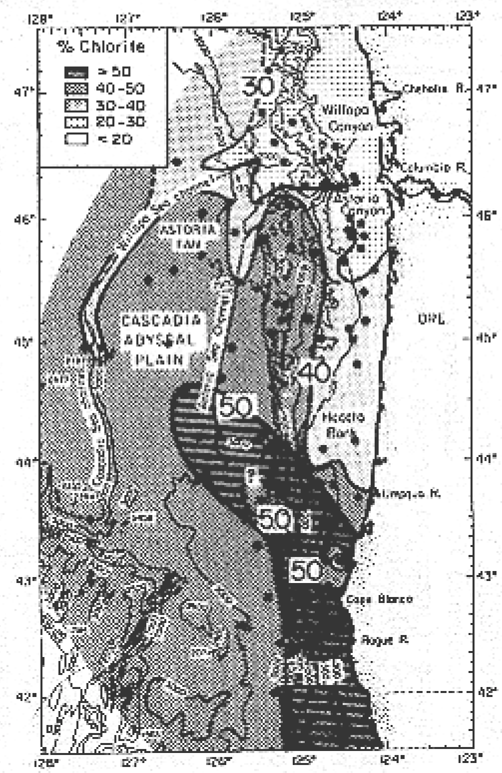

Figure 2: Chlorite distribution map. Modified from Karlin, 1980

As shown in figure 2, the highest levels of chlorite is concentrated to the south of Cape Arago, then trailing off the shoreline at approximately N40°W. If this data are correct, then the source of the chlorite is likely from the south of Coos Bay, blown in by the strong paleowinds directly off the continental shelf.

Chlorite vermiculitization

The hydroxyl-interlayered vermiculites have been recognized to be an chlorite weathering product (Douglas, 1977; Grim, 1962; Calle and Susquet, 1988; Moore and Reynolds, 1997). Ross and Kodama (1974) suggest that there is likely two stages in the chlorite-vermiculite transition, one of which is applicable to the dune (the other being part of metamorphism). It is acidic weathering giving rise to the transition. They state that the chlorite's hydroxide sheet must first be structurally disordered for the vermiculitization to occur. In pedogenic weathering, the oxidization of ferrous iron likely plays a major role in the initiation of structural disorder. The oxidized iron is required for the selective removal of the hydroxide sheet. The pH of the modern soil profiles in the dunes are sometimes quite low in the A horizon, often in the low fours, with iron pans also occurring (Beckstrand, unpublished).

In this literature search, the rate of vermiculitization has not been resolved experimentally. However, there are examples of known depositional times of chlorite and subsequent amount of vermiculitization. Argast (1991) detailed the vermiculitization of three meters of chlorite in a aeolian periglacial sand dune in Indiana which had been deposited about 13,000 ybp. In this study, there was involvement of a chlorite/vermiculite intermediary phase. The ferrous iron is oxidized and is subsequently retained in the sediment as goethite and as crystalline and noncrystalline grain coatings. The vermiculite from depths shallower than 64cm is partially expandable and is completely collapsed by

K-saturation or heat treating. The hydroxy-Al vermiculite that is present is typical of the intense weathering under the acidic conditions that are prevalent at the dune surface. In addition, high-Fe chlorites can alter rapidly to discrete vermiculite without forming interstratified chlorite/vermiculite intermediaries.

Discussion

The process of chlorite vermiculitization in the Oregon Dunes National Recreation Area is just beginning to be understood. This new research supports other data that suggests that the sediment source for the dunes was to the south. Grain size trends also support this hypothesis (Beckstrand, unpublished). The understanding of this system is crucial. It is the largest coastal dune system on the West Coast, and is possibly part of a much larger, regional dunal system that the scope of is in the embryonic state of understanding. On a local scale, the dunes are threatened by introduced vegetative predators that threaten the open dune system. There have been estimates that the dunes could be completely vegetated within the next fifty to one hundred years (Peterson, personal communication).

The primary area that is in need of additional study is the amount of time involved with the vermiculitization process. This would require SEM and electron microprobe analysis to find the ferrous iron content of the detrital chlorite, which is a strong influence on the transformation process.

Conclusions

The vermiculites present in the Oregon Dunes National Recreation Area are the secondary weathering product of detrital chlorite. The source of the chlorite is the continental shelf to the southwest of the dunes, where previous research indicates chlorite concentrations to be the highest on Oregon's continental shelf (Karlin, 1980). In addition to the chlorite provenance, grain size trends (Beckstrand, unpublished) and paleowind vectors (Micks, personal communication) support the southerly source hypothesis.

The chlorite vermiculitization in the Oregon Dunes National Recreation Area is in need of additional study. The X-ray diffraction patterns are in need of improvement, therefore additional field and lab work are necessary. The composition of the detrital chlorite is important to the speed at which the vermiculitization occurs, thus unaltered chlorite would need to be tested for the ferrous iron content.

While we do have a preliminary picture of how the dunes were emplaced, there needs to be additional work done with the clays in the dunes to fully understand the sediment mechanics before this significant recreation and wildlife habitat is lost.

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