Sediments of the Sheepbed unit, Gale Crater, were analyzed by the CheMin X-ray diffraction instrument on the Curiosity Rover. The sediments consist of typical basalt minerals (Fe-forsterite, augite, pigeonite, plagioclase), as well as Fe oxide/hydroxides, Fe-sulfides, amorphous material, and a phyllosilicate. The phyllosilicate has a broad 001 peak at ~1.0 nm, consistent with a poorly ordered smectite. However, in the absence of diagnostic tests possible on Earth, its identity is not clear. The position of the 06L diffraction band is generally used to distinguish dioctahedral from trioctahedral smectite, but it is beyond CheMin’s range of 2θ. The measured position of the 02L diffraction band (~22.5° 2θ by CheMin), implies that the smectite is trioctahedral. The exact position and shape of the 02L band is determined by the cations in the ‘M’ sites of the smectite; to constrain those cations, we sought analogs among terrestrial smectites, emphasizing those developed from basaltic precursors.

A potential analog for the Sheepbed smectite is ‘griffithite,’ a variety of trioctahedral smectite in altered basalt of the Topanga formation, Griffith Park, Los Angeles. ‘Griffithite’ has an 02L diffraction band that is close in position and shape to that of the Sheepbed smectite, although ‘griffithite’ has a very sharp 001 peak, indicating a high degree of layer ordering not seen in the Sheepbed smectite. A typical chemical formula for ‘griffithite,’ determined by electron microprobe, is (Ca0.59 Na0.03) (Mg4.28 Fe1.83) (Si6.64 Al1.36) O20 (OH)4, normalized to Si+Al=8. This formula is consistent with a fully trioctahedral Fe-Mg smectite with Ca and Na as interlayer cations. In the Topanga basalt, four types of ‘griffithite’ are present: fine-grained, filling cracks and vesicles; coarse-grained, filling vesicles; coarse-grained, replacing olivine phenocrysts; and coarse-grained, replacing glassy mesostasis. The fine-grained ‘griffithite’ formed first, and the last three varieties may be contemporaneous. One sample shows agate (α-quartz) that was precipitated between the episodes of deposition of the fine-grained and coarse-grained ‘griffithite.’

‘Griffithite’ is not unique as a possible terrestrial analog – some clay minerals from the Doushantou formation, China, have similar 02L diffraction bands, and many basalts contain smectites in vesicles and as replacements after olivine. Similar trioctahedral smectites occur also in the nakhlite martian meteorites – as veinlets and replacements of olivine. By understanding the formation of these terrestrial clays, we hope to constrain the nature and mechanism of formation of the Sheepbed clay mineral.
materials and properties.

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Additional Details

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