INITIAL OPPORTUNITY ROVER RESULTS AT ENDEAVOUR CRATER, MARS. S. W. Squyres[1], and the Athena Science Team [1]Cornell University, Ithaca, NY 14853.

After more than 7 years of operations and 33 km of traversing, the Mars Exploration Rover Opportunity has reached Endeavour Crater. Endeavour is ~22 km in diameter, and is formed in Noachian materials that predate the sulfate-rich sedimentary rocks that Opportunity has explored for most of its mission. Endeavour was chosen as a target because the rocks there record an ancient epoch in martian history.

Opportunity arrived at Endeavour Crater on sol 2681 of its mission, at a low-lying segment of the rim, ~700 m in length, named Cape York (Fig. 1). Shoemaker Ridge forms the spine of Cape York, and rises to ~25 m above the terrain to the east. It is the type locality for the Noachian materials of the Endeavour Crater rim, which we call the Shoemaker formation. Opportunity first arrived at Spirit Point, the southern tip of Cape York, and then traversed northward 851 m before stopping at Greeley Haven at the northern end of Cape York to spend the martian winter.

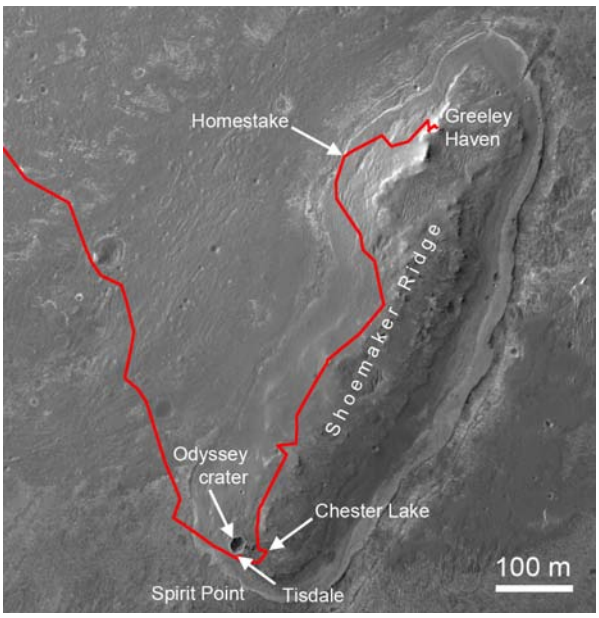

Fig. 1: Opportunity's traverse along the rim segment of Endeavour Crater named Cape York. Major features discussed in the text are indicated. Image acquired by the Mars Reconnaissance Orbiter HiRISE camera. North is at the top.

Instruments of Opportunity's Athena payload were used to investigate materials within the Shoemaker formation. These include the bedrock outcrop Chester Lake near the southern end of Shoemaker Ridge, as well as several bedrock targets near Greeley Haven at the northern end. These outcrops are separated by more than half a kilometer but are similar in physical appearance and elemental chemistry; we interpret them to represent the dominant surface rock type of Cape York.

Chester Lake and all the rocks near Greeley Haven have similar textures, with dark, relatively smooth angular clasts up to ~10 cm in size embedded in a brighter, fractured, fine-grained matrix. Pancam spectra of the matrix are variable owing to irregular amounts of dust and soil but all exhibit a gradual decrease in reflectance toward 1000 nm. The clasts can exhibit specular reflections, have a relatively deep absorption at 934 nm, and a shallow 535 nm absorption relative to the matrix materials. This is consistent with a relatively unoxidized basaltic material containing low-Ca pyroxene.

The elemental composition of Chester Lake and the rocks near Greeley haven is similar to that of "Laguna class" basaltic soils examined by Spirit at Gusev Crater. There is little horizontal variation in composition within the rocks, and the composition of the clasts is similar to that of the matrix.

We interpret all of these rocks to be breccias formed during the Endeavour Crater impact. The consistent elemental composition of these materials, and the apparent compositional similarity of the clasts to the matrix, suggest that they are monomict breccias, with clasts and matrix representing a single lithology from the target material. While we cannot assess the degree of shock metamorphism of the clasts or the presence of glass in the matrix, we note that the distinctive texture of these rocks is similar to those of typical suevite breccias common in impact settings on Earth and the Moon.

Near the southern end of Shoemaker Ridge, Opportunity encountered Odyssey crater. Odyssey is ~20 m in diameter, and is partially surrounded by blocky ejecta. The ejecta block Tisdale was investigated in detail.

Tisdale differs texturally and compositionally from Chester Lake and Greeley Haven rocks. Because it was excavated from Odyssey crater, it may represent a deeper unit within the Shoemaker formation. Tisdale is a breccia, with poorly sorted, closely packed angular to rounded clasts up to several cm in size. It lacks the extensive fine-grained matrix of Chester Lake and other rocks, and shows lithic fragments down to the limit of Microscopic Imager resolution.

The upper surface of Tisdale is dusty, but cleaner surfaces are exposed on the sides. The clasts compris-

ing Tisdale exhibit spectral variability beyond that expected from discontinuous dust coatings, including positive and negative near-infrared spectral slopes and some 903 nm absorptions. Small, localized spots in Tisdale and nearby rocks exhibit 860 nm and 535 nm absorptions possibly consistent with a ferric iron-bearing phase and/or minor hydrated Mg/Fe silicates. Based on its textural and color properties, we interpret Tisdale to be a lithic breccia that is possibly polymict.

The major element chemistry of Tisdale is similar to that of Adirondack class basalts encountered by Spirit at Gusev Crater. Zinc abundances, however, are notably higher (more than 0.5 wt%). We suggest that the high Zn concentration in Tisdale could be an indicator of hydrothermal activity, perhaps initiated by the impact event.

Cape York is surrounded by a low topographic bench that is cut by a number of small light-toned veins. Opportunity investigated one of these veins, named Homestake (Fig. 2), on the bench near the northern end of Cape York. Homestake forms a discontinuous, flat-topped ridge 1-1.5 cm wide and ~50 cm long.

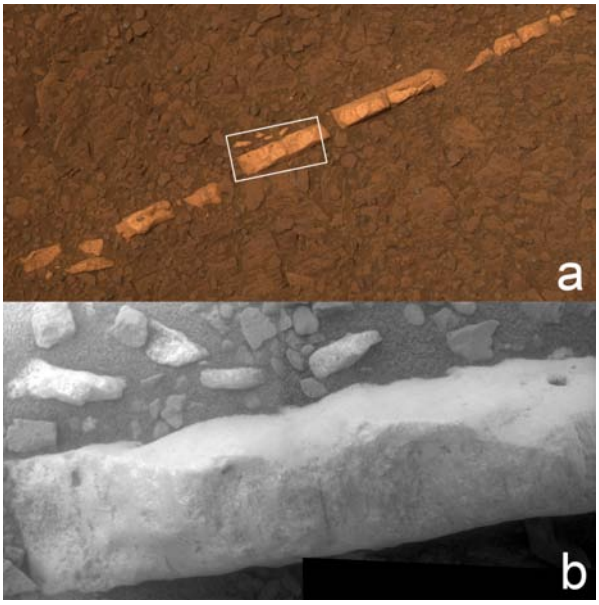

Fig. 4: Pancam approximate true color image (a) of the vein Homestake acquired on Sol 2769, sequence p2574. Scale across the image is about 40 cm. Inset shows location of Microscopic Imager mosaic (b) acquired on Sol 2766

The elemental chemistry of Homestake is dominated by CaO and SO_3, in a ratio consistent with $CaSO_4$.

Calcium sulfates can have a range of hydration states. Pancam's longest wavelength filter (1009±19 nm) provides the ability to remotely detect and spatially map certain hydrated minerals, based on the presence of the $2\nu_1 + \nu_3$ H_2O combination absorption band and/or the $3\nu_{OH}$ overtone absorption band centered near ~1000 nm in many minerals containing bound H_2O and/or OH^-. Hydrated mineral signatures are detected strongly in Homestake, suggesting that gypsum may be the dominant $CaSO_4$ phase present. Gypsum veins have been reported in a variety of settings on Earth, where their formation is invariably attributed to precipitation from water in fractures.

We attribute the formation of these veins at Cape York to precipitation from fluids originating in the underlying Noachian crust. Gypsum should be one of the first minerals precipitated from sulfate-rich fluids due to its low solubility, potentially accounting for its presence near the source of the fluids. The observation of these veins provides some of the strongest evidence to date for aqueous processes at Meridiani Planum.