(~7 m). At the time of writing, *Opportunity* is carrying out a long traverse to the south of Endurance crater in an attempt to extend the lateral and stratigraphic extent of these sedimentary rocks.

Squyres et al. [1] and Grotzinger et al. [2] have discussed the stratigraphic and sedimentological settings of these rocks. Grotzinger et al. [2] *informally* named this sequence the "Burns formation" and divided it into lower, middle and upper units. The unit is named after the Burns Cliff within Endurance crater, which in turn is named in honor of the late Roger Burns, a renowned planetary scientist [24]. The lower unit, characterized by high angle planar cross beds, is interpreted to represent an aeolian dune facies. The sharp contact (Wellington contact) that separates lower and middle units appears to be a deflation surface controlled by the position of a paleo-water table. Low angle strata of the middle unit are thought to represent an aeolian sand sheet facies. The contact between the middle and upper units is not a facies boundary but rather a zone of recrystallization within the sand sheet facies (Whatanga contact) interpreted to represent the capillary fringe of a stagnant paleo-water table and thus a diagenetic boundary. The upper unit grades upward from the sand sheet facies into sedimentary rocks characterized by more complex bedforms including small-scale festoon cross-lamination and wavy bedding, the former being diagnostic of deposition by water currents. This unit, accordingly, is interpreted to represent an intermittently damp to wet interdune facies. No textural evidence has been found for crystallization of evaporite minerals within or at the bottom of a free-standing water column and all of these rocks appear to have been reworked by aeolian or subaqueous currents.

The locations of major features, rocks and other targets that are discussed in this paper are shown in Fig. 1. Fig. 1a is a Mars Orbital Camera image of the *Opportunity* landing site and vicinity showing craters and the major features and rocks encountered on the Meridiani Plains and discussed in this paper. Fig. 1b is a composite stratigraphic section of the Burns formation from Grotzinger et al. [2] showing the stratigraphic position of many of the analyzed targets.

3. Constraints on bulk mineralogy

No petrographic or textural evidence has been found that unambiguously identifies any mineral. In places, near-euhedral pores exist that appear to have monoclinic crystal forms (see below). The best constraints on mineralogy of pristine Meridiani outcrops come from a combination of chemical composition and Mössbauer spectroscopy of abraded rock surfaces (using the RAT, rock abrasion tool), thermal emission infrared spectroscopy (Mini-TES) of rock surfaces and visible through near infrared panoramic camera (Pancam) images. Clark et al. [25; also see 26–28] summarized the geochemistry and mineralogy of these sedimentary

Table 1
Constraints on mineralogy of the Burns formation

Mineral[+]	Weight %	Comment
Chemical Constituents	60 ± 10	From S and Cl mass balance.
Hematite	6	35-40% of iron as hematite from Mössbauer. At least one-half of hematite is in spherules.
Jarosite*	10	20-35% of iron as jarosite from Mössbauer.
Mg-Sulfate*	18 ± 5	From variation associated with Mg and S correlation; Mini-TES spectrum best fit with Mg-and Ca-sulfates.
Other Sulfates*	10 ± 5	From S mass balance; likely to include Ca-and possibly other Fe-sulfates; Mini-TES spectrum best fit with Mg-and Ca-sulfates.
Chlorides	≤2	Possible presence based on Cl abundance; Cl may not be separate mineral but solid solution with sulfate or mixed anion salt.
Secondary Silica	15 ± 10	Presence is inferred from geochemical mass balance (e.g., Si/Al ratios) which indicates as much as 25%; Mini-TES should detect if abundance >5-10%.
Siliciclastic Constituents	40 ± 10	Consistent with S, Cl mass balance and Al abundance.
Olivine	trace	From Mössbauer; may not be intrinsic to outcrop.
"Pyroxene"	5-10	From Mössbauer; assumes Fe contents typical of pyroxenes in SNC meteorites. The mineral assignment of pyroxene is not a unique interpretation for octahedrally coordinated Fe(II) and likely to be other phase(s).
Other	35 ± 5	Includes other igneous and altered igneous components and possibly sheet silicates; Fe-bearing components dominated by Fe(III) and so likely altered.

+-All mineralogical constraints are on a volatile-free basis. Chemical constituents likely are hydrated and so their proportions would accordingly be greater than indicated above.

*-Total sulfate mineralogy is constrained to be about 35–40% on an anhydrous basis based on SO_3 content, with exact amount depending on the mineralogy.