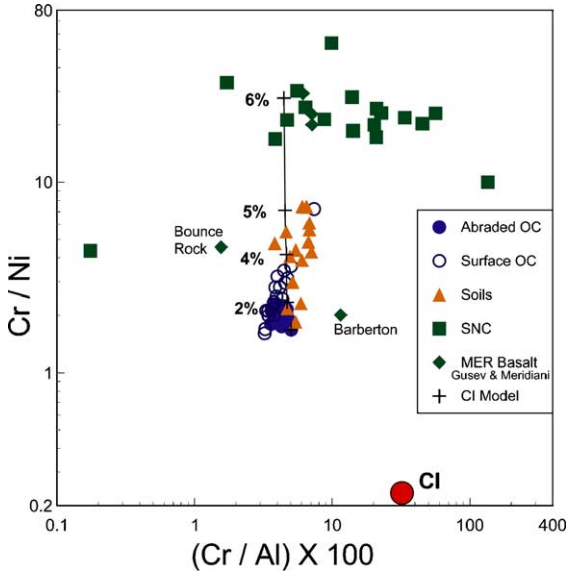

Fig. 3. Plot of Cr/Ni vs. Cr/Al(X100) for abraded outcrop rocks. Also shown are unabraded outcrop surfaces, Meridiani soils and basalt-ultramafic compositions from SNC meteorites, Gusev basalts and Meridiani basalts (Barberton and Bounce Rock). Note that only Barberton (which was too small to be abraded by the RAT) has Cr/Ni ratios and Cr/Al ratios that are within a factor of two of the Meridiani outcrop. Also shown is the effect of removing a composition equivalent to CI meteorites from outcrop compositions. Removal of about 6% of a meteoritic component moves the data into the field of typical SNC meteorites. However, the Cr-Ni-Al relationships of the outcrop are not so distinctive in comparison to known Mars basaltic compositions or basalts in general [42] as to demand a meteoritic component in the provenance.

outcrop could be related to one of the known compositions, such as Barberton or Bounce Rock, by some relatively simple igneous differentiation process but insufficient data exist to evaluate this possibility in any rigorous manner.

Another consideration is the potential role of meteoritic debris in the provenance of these sedimentary rocks. For sedimentary rocks older than about 3.8 Ga, the potential for a significant meteoritic component increases significantly. For example, on the Moon the meteoritic component of lunar soils is about 2% on average and approximates to a chondritic composition [39] and there is reason to expect that the meteoritic flux is greater for Mars at any given time [40]. On the other hand, geochemical evidence for significant meteoritic components in terrestrial sedimentary rocks older than 3.0 Ga is limited (e.g., [41]). The effect of removing from the outcrops a composition equivalent to an average CI chondritic meteorite is shown on Fig. 3. Cr/Ni ratios increase to values typical of basaltic shergottites with removal of about 6% chondritic component. However, because Meridiani igneous rocks Bounce Rock and Barberton have Cr/Ni ratios within a factor of 2 of Meridiani outcrop and Cr/Ni ratios of about 2 are not unusual for basaltic rocks in general [42], there is no requirement of a meteoritic component in the provenance.

4.3. Provenance of chemical components

Because these rocks are interpreted as reworked evaporitic sandstones with a strong diagenetic overprint, evaporitic minerals that have been identified or inferred probably do not reflect an equilibrium assemblage with respect to any single fluid and may not include all minerals that existed within this depositional system. Nevertheless, several lines of evidence indicate that chemical constituents of these rocks precipitated from fluids that were derived from the alteration of olivine-bearing or -normative basalts under low pH conditions. Evidence can be summarized as follows:

1. Identification of jarosite is strong evidence that fluids were at pH<5 since that marks the effective upper stability level of this mineral;
2. Occurrence of hematite as a diagenetic mineral suggests low pH environments. Near surface environments of Mars are thought to be oxidizing and so Fe transport would be enhanced at low pH;
3. Experimental studies of alteration of synthetic martian basalt [16,43] indicate that Mg release is greatly enhanced during dissolution of olivine-bearing basalts or olivine-normative basaltic glasses but inhibited during alteration of olivine-free (pyroxene and feldspar-dominated) basalts;
4. Fluid-rock modeling [17] suggests that the inferred evaporite and diagenetic mineral assemblages of Mg-sulfate>Fe-sulfate=Ca-sulfate and hematite can be derived from low pH fluids that have interacted with such rocks. In fluids derived from olivine-free basalts, Ca-sulfates dominate over Mg-sulfates, which does not appear to be the case at Meridiani where Mg-sulfates appear to dominate.

5. Diagenetic features

Evaporites are highly susceptible to extended and complex histories of post-depositional diagenetic processes [44,45] and the sedimentary rocks at Meridiani Planum are no exception. However, it is worth noting that, in spite of the highly reactive character of the chemical constituents, in only a few places so far observed do diagenetic processes appear to be so per-