present-day erosional surface and thus cut across primary bedding. Accordingly, the polygonal structures post-date sedimentation and so do not represent desiccation features contemporaneous with deposition. Possible origins include impact-related fracturing, various septarian processes, synaeresis cracks, diagenetic volume changes associated with mineral transformations or dehydration, relatively recent desiccation of surface deposits that post-date the formation of the crater.

In terrestrial settings, all such features would most likely be interpreted as diagenetic in origin (e.g., [65–67]). However, on Meridiani Planum, the relationship between meteorite impact craters and outcrop exposure provides alternative explanations. Evaporitic sedimentary materials on Earth are highly prone to dissolution and karsting and incipient karsting can be difficult to distinguish from impact-related brecciation [67]. Another possibility is that the fracture patterns result from regional cracking during mineral dehydration and/or water expulsion. For example, the dehydration of hydrated magnesium and ferrous sulfate minerals, with the general formulas $MgSO_4 \bullet nH_2O$ and $FeSO_4 \bullet nH_2O$, are controlled largely by relative humidity and they lose approximately 10–15% of their volume for every water molecule removed. In any case, many of these processes are not mutually exclusive. Karsting commonly initiates along joint or fracture systems, such as those that could form on a more regional scale during impacts.

An important avenue of future research will be to map the orientation of fractures and polygonal features and compare them to regional structural features (craters, regional depressions such as Anatolia and bedding). For example, if they form a regional pattern unrelated to impact craters, it might suggest a diagenetic origin or influence.

6. Geological/diagenetic history

The provenance and diagenetic histories that can be inferred from the preserved mineralogical, chemical and textural relationships in the Burns formation are generally consistent with those expected for the dune–sand sheet–interdune depositional setting suggested by Grotzinger et al. [2]. Observed diagenetic textures dominantly reflect phreatic and capillary fringe zone environments. In this depositional setting, vadose zone diagenetic processes are most effectively preserved in the dune facies above the water table [34]. In addition, diagnostic vadose zone textures, such as meniscus and pendant cement, are commonly very fine scale and thus would be difficult to resolve by the *Opportunity* instrument suite. Such cement would also be readily overprinted by recrystallization and new mineral growth during subsequent recharge of groundwater. The contact between the lower dune and middle sand sheet facies of the Burns formation is interpreted to represent a deflation surface and thus marks erosion of the overlying vadose zone of the dunes to near the water table level [2].

The proposed geological and diagenetic history is summarized in Table 2 and Fig. 14 and discussed in greater detail below.

6.1. Syndepositional–early diagenesis

Low pH and the basaltic provenance resulted in a magnesium- and iron-rich hydrological system that produced a highly distinctive evaporitic and diagenetic mineralogy, including jarosite and hematite, Mg-sulfates and possibly other ferric and ferrous sulfates and chlorides [17,25]. There are no good terrestrial analogs that characterize both chemical and physical conditions. Iron-rich acid playa lakes are found in Australia and have some mineralogical similarities with the Burns formation, such as the presence of jarosite and hematite [15]. However, the terrigenous components of these sediments are quartzose and indeed it is the lack of buffering capacity of the associated siliciclastic sediments that permit low pH to be maintained in the Australian acid lakes. Evaporite-rich dune–interdune systems, such as those preserved in the Quaternary-aged White Sands deposits of southwestern U.S.A. [34] and the interdune sabkhas in the Saudi Arabian sand seas [32] have many physical and textural features in common with Meridiani, as does the Prungle Lake lacustrine–aeolian system of southeastern Australia [68]. On the other hand, the chemical components in these systems are dominated by Ca-sulfates and halite, typical of a high pH, iron- and magnesium-deficient evaporitic setting.

In terrestrial aeolian settings, reworking of evaporitic material that forms in penecontemporaneous, dry playa lakebeds, either as pure evaporite minerals (typically gypsum) or evaporite-cemented siliciclastic debris, commonly is the source of sand-sized grains. The large basaltic terrigenous component in the Burns formation is most readily explained by the second of these processes, thus suggesting that an active playa environment must have existed at the time of sand production [2]. Aeolian and subaqueous activity then reworked the grains into the preserved dune–sand sheet–interdune system [2].