of the groundwater system by a high ionic strength fluid which was more dilute than (or chemically distinct from) the original evaporite-forming fluid. Jarosite, which occurs within the sediment, is a plausible candidate for the parental evaporite mineral that could spontaneously break down to form hematite or goethite during a pH-raising recharge event [17]. An alternative possibility is that another reactive iron-rich mineral, such as the ferrous sulfate mineral melanterite, is the parental mineral and transforms to ferric oxide during recharge of more oxidizing groundwater. Although melanterite has not been identified at Meridiani, it is a plausible late stage evaporite mineral [17]. Melanterite has the advantage of being very soluble and could perhaps more readily be dissolved with little effect on the other less soluble evaporite minerals.

Throughout the sequence, concretions provide one important nucleus for the second distinct episode of cementation and accordingly this episode, which included formation of blocky isopachous cement, cemented zones around concretions and nodular textures, unambiguously post-dates formation of the concretions. Although this event post-dates the concretions, there may be no need to call on an entirely distinct groundwater recharge event. Concretions crystallized very quickly upon recharge of relatively high pH or more oxidizing groundwater. Formation of later cements and associated recrystallization, along with pore enlargement, could have occurred more gradually as the groundwater table physically subsided, at times remaining stationary to give rise to stratigraphic diagenetic fronts, such as that at the Whatanga contact.

The relative age of the secondary crystal moldic and sheet-like vug porosity is less clear-cut. Available textural evidence suggests that the secondary porosity (crystal molds and vugs) post-date the concretions. There is no textural relationship between the second generation of cements and the secondary porosity. However, in places the overgrowths on the concretions appear to post-date the sheet-like vug porosity. Where the rocks have abundant nodular textures, the secondary porosity, if originally present, is completely obliterated. Accordingly, the secondary porosity likely predates the formation of the second generation of cements. On the other hand, it is likely that these pores were greatly enlarged during formation of the diagenetic fronts represented by the Whatanga contact.

As noted above, the formation of the concretions was probably a significant porosity-forming event. The proposed reactions also lower pH and, in the case of melanterite breakdown, liberate significant amounts of water. Accordingly, an intriguing possibility is that the formation of the concretions also produces secondary porosity due to loss of jarosite or melanterite and dissolution of other relatively soluble evaporitic minerals.

Late stage features include fractures and fracture fillings, veins and polygonal fracture surfaces. Regardless of whether these features are wholly or partly diagenetic in origin or formed in response to meteorite impact processes on Meridiani Planum, these processes appear to have taken place long after deposition and burial. The presence of a lag of concretions on the Meridiani plains suggests that the modern surface is erosional and part of the stratigraphic section was removed. The presence of a second size mode of concretions in the overlying soils on Meridiani Planum also suggests that part of the eroded section was formed and/or diagenetically altered under somewhat different conditions.

6.3. Evolution of the groundwater table

Characterizing how the groundwater table within the Burns formation evolved, both physically and chemically, could have important implications for understanding the mechanisms which modulate groundwater flux during the deposition and diagenesis of the Burns formation [see discussion in [2]). The history of sedimentation and diagenesis suggests that the groundwater table evolved in a complex manner with at least four episodes of groundwater recharge taking place on the scale of the 7 m of Burns formation section studied.

The first was the infiltration of groundwater to the surface to produce the playa lake where the sand-sized grains that make up the Burns formation were formed. The top of the groundwater system must have been at high ionic strength to produce the evaporative minerals that cemented basaltic mud into sand-sized grains. The mineralogy of the evaporative cements is not known with certainty and accordingly the chemistry (notably pH, oxidation state and mineral saturation states) is not constrained. A second infiltration took place after deposition of the lower dune facies to provide the deflation surface, marking the boundary (Wellington contact) between the dune and sand sheet facies [2]. There are no chemical analyses from rocks that are unambiguously from the lower dune facies (Fig. 1b) and so it is not known with certainty if the composition of this lower unit differs from the overlying units. The best available constraints on composition of the lower Burns unit comes from MiniTES measurements that suggest the mineralogical composition of the lower Burns unit is similar to the middle and upper Burns