4. Possible localized cementation/recrystallization in the upper unit, leading to a reduction of porosity and hardening of the rock. This may simply be a more extensive version of the fine-grained pore-filling cements (type 1) or may represent recrystallization.

Where grains are visible on outcrop surfaces and in freshly exposed (RATed) surfaces, outlines commonly are not distinct and material with grain sizes below MI resolution (<100 μm) is present between grains (Fig. 5a). With only few exceptions, grains that can be resolved are of relatively uniform size and, consistent with cross-bedding evidence for reworking by wind and water, primary clastic grains are both well sorted and moderately well rounded. Accordingly, the fine-grained intergranular material is interpreted to be pore-filling cement rather than a separate population of fine grains. In several places there is considerable differential erosion between laminations and the cements appear to form sheets that effectively define the laminations and obscure grain boundaries. Generally, individual grains can be recognized, however, the degree to which grain boundaries are well-defined is highly variable and likely related to the amount of pore-filling cement and degree of recrystallization (Fig. 5b). The crystal sizes of these cements are below the resolution of the MI and accordingly no additional textural information is available.

A second generation of millimeter-scale cement forms around many spherules (Fig. 5c–e). In Eagle crater and the upper parts of the stratigraphic section at Endurance crater, the layer of cement typically is on the order of 1–2 mm thick and appears to be blocky and is isopachous. The formation of the overgrowths, which are significantly larger than the size of grains, resulted in a localized loss of primary fabric suggesting recrystallization of original grains and pore-filling cement. During erosion of outcrop surfaces, this cement is relatively resistant or is shielded from erosion by resistant spherules and commonly forms a pedestal to the spherules (Fig. 5c,d). The presence of isopachous cements is characteristic of the phreatic and/or capillary fringe zones in aeolian sediments that have been submerged beneath the water table [34].

Working down the stratigraphic section (top to bottom), the nature of the cement surrounding spherules changes markedly. Within the middle unit, it can reach up to 4 mm in thickness and consists of a distinctive zone of cemented sand grains that form overgrowths on the spherules (Fig. 5e,g). Where this occurs, there are also many similar-appearing nodules (Fig. 5f,g). The nodules also appear to be cemented sand grains but in this case they do not form overgrowths to spherules. Thus, although spherules form the nucleation site for a second generation of cements, lower in the section at Endurance crater, other nucleation sites must also exist because there are far more nodules than spherules.

It is possible that the isopachous blocky cements, spherule overgrowths and nodules represent multiple distinct cementation events or alternatively they could represent different expressions of fundamentally the same diagenetic process controlled by variations in porosity, permeabilty, sediment composition, grain size, fluid residence time and so forth. A complex history of cementation is characterisitc of the phreatic and capillary fringe zones in many aeolian environments because the hydrological regime can be highly dynamic in such settings [34,46].

At one location, on the rock Ellesmere near the bottom of Endurance crater there is one observation that provides *suggestive* evidence for radial fibrous textures surrounding spherules (Fig. 5h) and possibly filling fractures. The observation comes from a high-resolution Pancam image taken from several meters distance. The Microscopic Imager was unable to confirm this texture because it was not safe for the rover to approach the rock. Radial fibrous textures could form as primary cement or as a secondary recrystallization product. The second of these options is suggested because the thickness of the feature surrounding the spherule in Fig. 5h is significantly greater (about 4–5 mm) than the isopachous blocky cement described above and accordingly is likely to replace grains surrounding the spherule. In either case, such textures, if confirmed, would provide strong supporting evidence for post-depositional fluid-saturated conditions such as those found in marine or meteoric phreatic conditions [47,48].

In most places, diagenetic processes do not obscure primary sedimentary fabrics in any significant way. Two exceptions exist. At the boundary between the middle and upper units (Whatanga contact) there is a marked darkening of outcrop color (Fig. 6a,b) and depositional fabrics are obscured and in places even obliterated (Fig. 6b,c) over a zone of up to about 50 cm [2]. The pattern of diagenetic cementation and recrystallization is basically the same as elsewhere but at this location it is particularly intense and is accompanied by a large amount of secondary porosity. A similar, but somewhat less developed, zone of recrystallization also occurs about 50 cm above the Whatanga contact (see Fig. 1b). Two possible explanations are differential diagenetic effects acting on primary lithological differences, such as porosity and grain size (e.g., [49]), or a