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Development of Mudcracks in a Partially-Dried Tropical Pond

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Abstract

Mudcracks formed in a partially-dried, tropical rain-water pond display distinctive crack patterns. The development of these cracks are governed and influenced by their position within the pond (which determines the thickness of the top mud layer), the rate and extent of drying that they undergo, and the length of exposure to drying period. Two generations of cracks were recognised – a first generation of mudcracks which developed within the top mud layer and a second set which forms within the underlying silty-mud layer. The first generation mudcracks begin its development at the pond margin areas where the mud layer is thin and the rate of drying is rapid. These cracks are then progressively propagated towards the pond centre where the rate of pore water expulsion (evaporation) from the thick, water-laden layer of mud is much slower. Rapid drying within the pond margin areas accelerate the development of several orders of shallow and wide cracks, and result in the formation of well-dried, small and thin concaving mud polygons. In the region at the centre of the pond, the thickness of the mud layer retards the drying process, thus resulting in the formation of widely-separated, deep and narrow cracks which join up to form large polygons. The development of the second generation of cracks are restricted to the pond margin areas. Prolonged drying result in the contraction of the underlying silty-mud layer exposed by the earlier, wide-opening first generation cracks. These second-level cracks may develop as central fissures on first-generation crack terraces.

Kejadian Retakan Lumpur di Kolam Tropika Yang Separa Kering

Abstrak

Retakan lumpur yang terbentuk di kolam air hujan tropika yang separa kering akan menunjukkan corak retakan yang tertentu. Pembentukan retakan ini dipengaruhi oleh kedudukannya dalam kolam (yang menentukan ketebalan lapisan lumpur atas), kadar dan tempoh pengeringan serta tempoh terdedah semasa pengeringan. Dua generasi retakan dikenalpasti — generasi pertama retakan lumpur terbentuk dalam lapisan atas lumpur dan set kedua terbentuk di bawah lapisan lodak-lumpur. Retakan lumpur generasi pertama mula terbentuk di kawasan sempadan kolam yang lapisan lumpurnya nipis dan kadar pengeringan yang cepat. Retakan ini berterusan ke arah tengah kolam di mana kadar penyejatan air pori daripada lapisan lumpur tebal berair lebih lambat. Pengeringan cepat dalam kawasan sempadan kolam mempercepatkan pembentukan beberapa order retakan cetek dan lebar menghasilkan bentuk poligon lumpur kering penuh, kecil dan nipis. Di kawasan tengah kolam, ketebalan dalam lapisan lumpur melambatkan proses pengeringan maka ia membentuk retakan lebar-terasing, dalam dan ketat yang bergabung membentuk poligon besar. Pembentukan retakan generasi kedua hanya terhad di sekitar kawasan sempadan kolam. Pengeringan lampau menyebabkan pendedahan lapisan bawah lodak-lumpur oleh retakan lebar generasi pertama. Retakan lapisan kedua boleh terbentuk sebagai fisur tengah teres retakan generasi pertama.

INTRODUCTION

Mudcracks, or dessication mudcracks, commonly form in fine grained sediments and if present in the rock record, are widely used as indicators for subaerial exposure. Mudcracks may develop on floors of dried-up ponds, lakes and playas, on river floodplain and in intertidal and supratidal areas. These structures often occur as open fissures or partially-filled vertical cracks.

Dessication cracks are preserved in rocks, in most cases, on the bedding surfaces of interbedded, red sandstone-mudstone successions, and less often in thinly-bedded carbonates.

Mudcracks in general are also known to form by some subaqueous processes. These type of cracks are known as synresis cracks, and they form either by shrinkage of clay that has flocculated rapidly (White, 1961) or as responses to changes in salinity that causes shrinkage in montmorillonitic clays (Burst, 1965). To date, there is no characteristic feature that has been recorded to distinguish between subaqueous and subaerial mudcracks.

MUDCRACKS IN A PARTIALLY-DRIED TROPICAL POND

The dessication mudcracks described and discussed in this paper were recorded in Miri from a small pond near a housing construction site. The triangular-shaped, partially-dried pond measures about 3 m x 3 m x 3 m. The pond was created as a result of heavy rainfall, and it displayed progressive drying-up features from the edge (dried-up part) towards the watery, partially-dried central areas. The

most distinctive feature here is the development pattern of mudcracks which is governed by differential drying-up of the pond, and is described below.

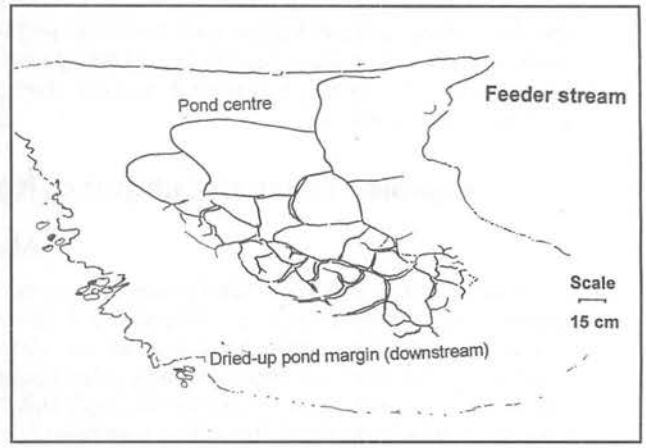
Smaller mudcracks polygons at the margin areas, larger ones at the centre

Figures 1a and b show the broad view of the partially dried-up pond. The lighter coloured parts are the downstream, pond margin areas that have undergone an advanced stage of desiccation. The darker region with large polygons, displaying smooth and bowed edges are the trough, central part of the pond. The pond was fed by a stream from the apex of the triangular, delta-shaped complex. Two main dessication mudcrack patterns can be differentiated here. The pond margin areas, which are completely dried up (almost complete expulsion of pore waters) display a mosaic of small, curved-edged polygons formed by a network of cracks, while the central region (the darker colour is directly related to the pore water content) areas are characterised by increasingly larger, 'semi-circular' polygons (Fig. 2 & 3). The smaller pond-margin polygons have the greatest lengths ranging from 15 cm up to 40 cm; the largest polygon at the centre of the pond measures more than 200 cm. In general, the size of the polygons show an increasing trend from the downstream edge to the centre of the pond.

Wide and shallow cracks at the downstream, pond margin areas; narrow deep cracks at the central and near upstream areas

At this partially dried-up stage, the size of the opening of the cracks, and the depths of the cracks are also different for the two main types of mudcracks. Margin-area crack openings are between 1 cm to 3 cm wide, but are generally very shallow (less that 1 cm). On the other hand, the deep penetrating cracks of the central areas may reach depths of

1a



1b

Figure 1: a) Photograph showing a broad view of the triangular, delta-shaped partially dried-up pond. The black camera case acts as the scale. The mouth of the feeder stream is at the apex of the pond, at the top right-hand corner. The lighter coloured portion, with a mosaic of cracks, is the downstream pond margin region referred throughout the paper. b) A diagrammatic sketch of the pond, showing the different parts of the pond and the different classes of cracks.

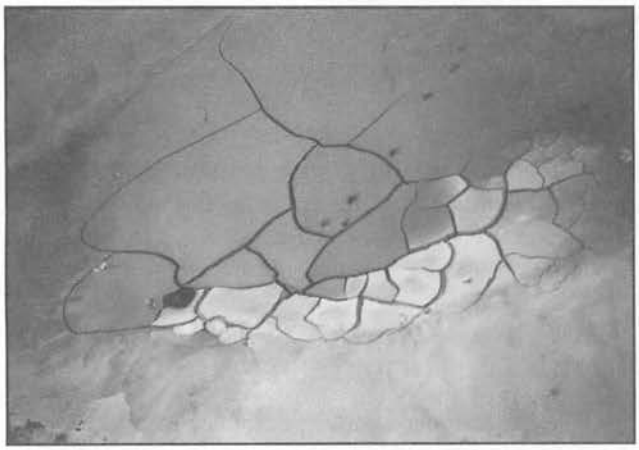


Figure 2: Photograph showing a close-up view of the pond surface. The dried-up mosaic of downstream pond-margin cracks are the lighter coloured region at the bottom; the dark-coloured, wet pond centre display large polygons bounded by deep cracks. The camera case and the cat footprints serve as the scale.

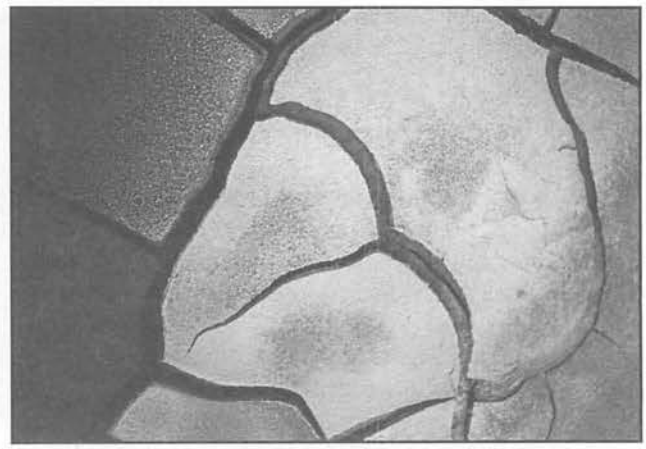


Figure 3: A close-up view of dried-up pond margin cracks. Notice the width of the top level, first generation cracks, and the second level, second generation cracks that 'breaks up' in the middle of the top level cracks. The width of the widest crack is about 3.0 cm.

more than 8 cm, but with openings of less than 1 cm. The depth of these cracks are essentially governed by the thickness of the mud layer. The mud layer in the trough areas are thicker than the margin areas.

Some of the shallow pond margin cracks are filled with coarser-grained materal (silt and sand).

Completely connected first order (and some second order) cracks; incomplete, tail-like later cracks

Well-dried, mature mud cracks surfaces commonly display multiple orders of cracks development (Reineck and Singh, 1975). According to Reineck and Singh (1975), the first order, earliest formed crack are usually wide and deep, whereas the secondary and tertiary cracks are less well developed (in terms of width of opening and depth of penetration) and runs across the area bound by the first order cracks. In the Miri examples examined here, at least three orders of cracks can be recognised. The earlier formed, first order cracks are recognised by their complete connectedness to other cracks; it is the joining-up of these cracks that form the polygons. The overall pattern of the crack system suggests that some of these 'well-connected' cracks are probably second order cracks that have joined up with the bounding first order cracks. This suggests that the second order cracks are responsible for the partitioning and thus reduce the sizes of the polygons.

Late cracks (third order?) are distinguished by their tail-like, sometimes bifurcating form and partial connection (Fig. 2) – i.e. one end is joined to the polygon-bounding crack while the tail-end remain 'dangling' somewhere in the middle part of the polygon. Some of these tail-end cracks show early bifurcation. These higher order cracks are generally limited to the dried-up, margin areas of the pond (Fig. 1, 2 & 3). These bifurcating or trifurcating cracks are incomplete cracks formed due to partial shringkage (Shrock, 1948; Schäfer, 1954 in Reineck and Singh, 1975)).

In other words, it can also be stated that early (first order) cracks are longer (very visible in Fig. 1) and more curved than later cracks. The development and length of second and higher order cracks are limited by the extent of the first-order, bounding-crack polygons.

Advance stage, second generation deep-level, pond margin cracks

Figure 3 shows the development of second generation, deep level cracks that originate from the surface of the flat terrace created by the opening of the shallow level (first, and possibly also second order) cracks. These deep-level cracks are limited to the dried-up pond margin areas. On closer examination, it was observed that these cracks have developed in a lithologically different silt-mud layer below the top mud layer. They are all positioned more or less in the middle of the terrace of the earlier, upper cracks. Obviously, their development has been very much influenced by the prolonged exposure of the underlying silty layer to the advanced stage of drying-up.

DISCUSSION AND CONCLUSION

Figures 4 a and b are diagrammatic (partly interpretative) cross sections of the pond showing the lithological distribution and the location of the different types of cracks. In Figure 4a, the pond is differentiated into two main sectors – pond margin (downstream edges) and pond centre (and feeder-stream mouth area). The position of the boundary between the pond centre and marginal areas is selected arbitrarily – in the field, the boundary is too subtle to be recognised. This boundary is probably demarcated by the sudden change in the gradient of the slope, which then determines the thickness of the mud layer. The figure also shows the distribution and estimated thickness of the mud layer (the main host for the dessication cracks) and the underlying silty mud within the pond.

Figure 5 is a flow chart showing the different classes of mudcracks identified within the pond. The following key conclusions can be made concerning the development of the mudcracks in such a tropical pond:

1. Two generations of mudcracks can be identified : i) First generation mudcracks developed within the top muddy host, and is found almost throughout the pond surface; ii) A second generation set of mudcracks form within the lower silt-mud layer, and is restricted to pond margin areas only. The first generation mudcracks can be classified into two spatial grouping – pond margin and pond centre mudcracks. Pond margin

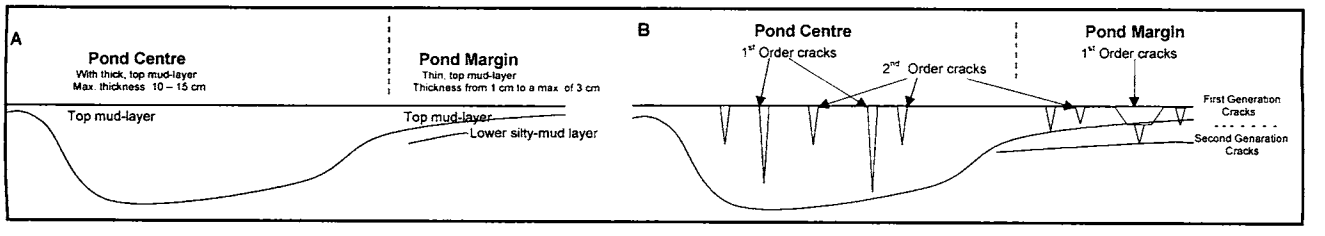


Figure 4: Diagrammatic (and interpretative) cross-sections of the partially dried-up tropical pond in Miri. Lithological distribution within the pond. The boundary between the pond centre and downstream pond margin is interpretated to coincide with a sharp, downward and 'basinward' plunge of the slope. The position and 'structure' of the different classes of mudcracks, as described in the text.

Figure 5 Classification of the different types of mudcracks recorded from the partially-dried tropical pond in Miri

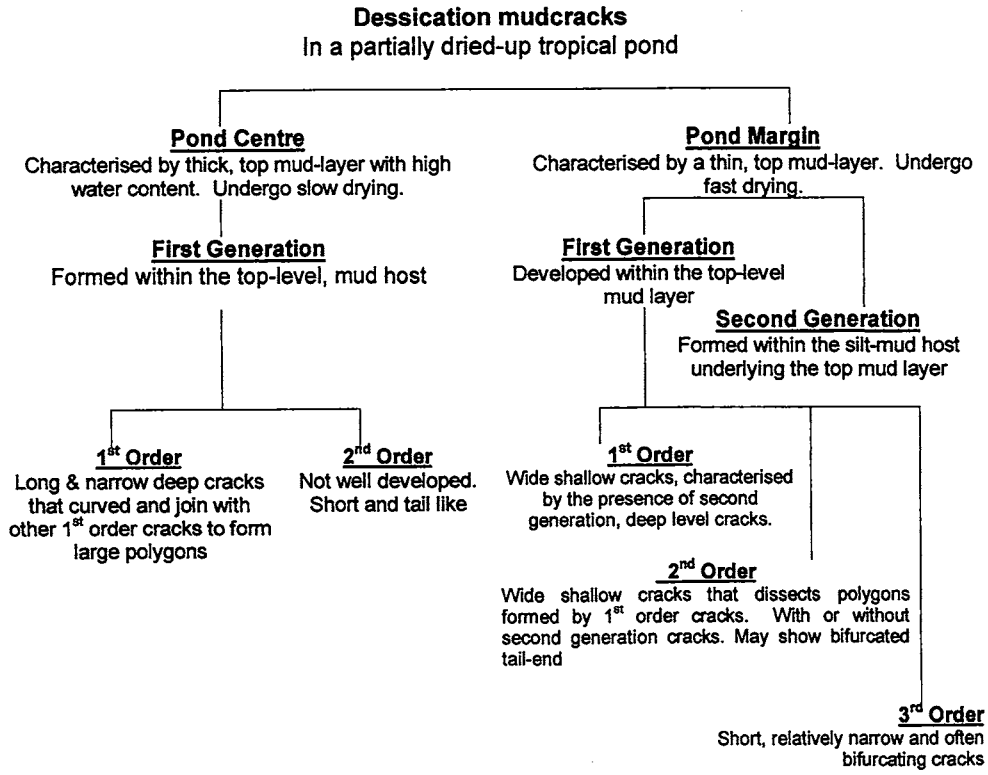


Figure 5: Classification of the different types of mudcracks recorded from the partially-dried tropical pond in Miri.

mudcracks are characterized by well-dried, small, mature and complete polygons formed by shallow and wide-opening cracks. Pond centre cracks developed in wet mud (plastic, partially dried mud) and are characteristically deep and narrow.

2. First generation, pond margin mudcracks form small polygons. These polygons are formed by a network of several orders of mudcracks. First order mudcracks form the initial, large polygons. Later, higher order cracks form within the initial polygons and eventually dissect them to form smaller polygons. Higher order cracks are less well developed within the centre of the pond.
3. Second generation cracks, which form in the silty-mud layer below the top mud layer, developed in the centre of the wide terrace formed by the early pond margin mudcracks. Their development indicate prolonged and possibly complete drying.
4. If the pattern of mudcracks described here is preserved in the rock record, it may be used to determine the local basinward and landward direction.

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REFERENCES

Burst, J. F., 1965. Subaqueously formed shrinkage cracks in clay. *J. Sediment. Petrol.*, 35:348-353.

Reineck, H.E. and Singh, I.B., 1975. *Depositional sedimentary environments*. Springer-Verlag, Berlin. 439p.

Schäfer, W., 1954. "Geführte" Trockenrisse. *Natur Volk*, 84:14-17.

Shrock, R. R., 1948. *Sequence in layered rocks*. McGraw Hill, New York, 507p.

White, W. A., 1961. Colloid phenomena in sedimentation of argillaceous rocks. *J. Sediment. Petrol.* 31:560-570.