Subsidence history and future subsidence in the Batu Arang area, Selangor Darul Ehsan — some further thoughts

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Coal mining has been carried out in the Batu Arang area for some 45 years, from 1915 to 1960, with both surface and underground workings. The coal was mined from two main seams; the Upper Seam (some 15 m thick) and the Lower Seam (about 8 m thick). These seams, which are stratigraphically some 65 m apart, are interbedded with shales, clays, siltstones and sandstones of a Late Oligocene to Miocene age that have been termed the "Coal Measures". These gently dipping sedimentary rocks outcrop is in the form of a plunging syncline and is also unconformably overlying meta-sedimentary rocks of mainly quartzites and phyllites of an Upper Palaeozoic age. The "Coal Measures" are at the same time unconformably overlain by a probable Pleistocene sequence of boulders, pebbles and sub-angular fragments of quartzite in a sandy to gravelly matrix that have been termed the

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"Boulder Beds". The strata of the "Coal Measures" are cut by a few normal faults and contain closely spaced (usually 2 to 5 cm apart) joints that are mostly developed perpendicular to bedding. Laboratory determined uniaxial compressive strengths of coal samples range from about 0.5 to 10 MPa; these strengths being mainly influenced by sample size.

Mapping of past and present features of ground surface subsidence, including depressions and sinkholes (pits), as well as their effects on man-made structures, shows that their development is closely related to the underground coal workings. The depressions have developed as a result of the gradual down-warping (or convergence) of overburden into underground openings, whilst the sinkholes have formed where the caved overburden material has been able to move laterally into adjacent openings.

The most recently occurring depressions and sinkholes are developed over the shallower, earliest underground coal workings, as well as those made during the Second World War, and in a few cases over post-War workings. Depressions and sinkholes developed in earlier times also show a similar relationship and this is to be expected in view of the limited roof support and stowage in these workings. In a few cases, depressions and sinkholes have developed over bricked or timbered underground workings.

Several factors are responsible for the development of the depressions and sinkholes, though the most important one has been the decrease (with time) of the strengths of the coal seams and overburden materials respectively. In view of this temporal relationship, it is concluded that several sites in the area will continue to be affected by the development of depressions and sinkholes.

In this presentation, some further and after thoughts from the earlier reports are highlighted with suggestions on various alternative remedial measures to rehabilitate or conserve the immediate affected premises.