# Appendix 5. Core description, East McKay I-78 well.

**UWID: 300/I-78-6450-12530/0 [NT]**

**STATUS: Susp (same as O&G Susp)**

**LAHEE: EXP**

**SPUD: 2013/01/27**

1820.0-1961.0 m in 4 cores.

Core preservation: disintegrated throughout (to the top of Hume Limestone)

Core #1

1820.0-1821.0 Mudrock: brownish black silty shale to shaly siltstone, hard to subfissile, prominently pyritic (feels heavy), split along subhorizontal conchoid surfaces with rare upright conchoid surfaces. Lamination is poorly seen. Pyrite occurs as "pyrite dust" and concentrations of streaks and tiny nodules cross-cutting and partly following lamination. No continuous pyrite laminae. Pyrite also occurs as straight and crisscrossing filaments <0.1 mm in diameter. Shiny pyrobitumen flakes rarely occur along lamination planes.

1821.0-1822.4 Mudrock: very dark brownish gray silty shale to shaly siltstone, subfissile, with notably less pyrite than above. Lamination is poorly seen. Pyrite occurs as occasional streaks and seams. Pyritic crisscrossing and branching filaments are also present.

1822.4-1824.4 Porcellanite: very dark gray to black, hard, pyritized and heavy in upper 20 cm and relatively light-weighted with little pyrite in main lower part. Distinct by monolithic appearance with extensive upright and concave/convex conchoid fracturation. These monolithic intervals are intercalated with thinner brownish black more fissile "interbeds". Lamination is expressed in paler gray chalcedony (?) streaks/lenses alternating with darker interstreaks. These paler-colored lenses are 0.1-2.2 mm thick and no more than 1 cm wide. Rare pyritic streaks and very rare continuous laminae. Local occurrence of pyrobitumen lobes and flakes. A horizon with preserved pyritized cup-shaped to spherical microfossils in the middle (0.1-0.2 mm in diameter). Base is very gradational.

1824.4-1828.9 Shale: dark gray to black, subfissile, less silty than above, weakly to moderately pyritic. Lamination is mostly poorly seen and expressed in paler gray streaks similarly to 1822.4-1824.4 m. On bedding planes these streaks often appear as collapsed shale or silica flakes of subangular outline (photo). This flakey pattern is typical for fissile shale. Pyrite occurs as "dust" with occasional concentrations; pyrite streaks or

laminae are lacking. Water adsorption faster than above, shale is slightly expanding underwater. Base is gradational, through hardening and increase in pyrite content.

1828.9-1830.1 Siliceous shale: brownish dark gray to black, somewhat harder than above; low-contrast alternation of harder less fissile and softer more fissile shale. In difference to the overlying interval, pyrite forms streaks, in harder monolithic intervals even continuous laminae. Spacing between these pyritic laminae is 2-4 mm. Several cm-thick horizons of enhanced pyritization (about 50% and more pyrite content in rock). Flakey pattern on fissility planes is common. Small and rare pyrobitumen streaks; rare sub-mm sized organic flakes (coal detritus?). rare upright fractures in harder intervals.

1830.1-1831.5 Siliceous shale to porcellanite: very dark gray to black, low-contrast alternation of heavier, slightly more fissile and more pyritic rock (shale) and lighter monolithic rock (porcellanite). Porcellanite intervals feature conchoid an upright fractures. Porcellanites seem to be finely crystalline (faint granular texture with isodiametric grains less than 0.05 mm in size). Some porcellanite intervals are darker colored and more pyritic. Pyrite occurs as "dust", streaks, and occasional continuous laminae. Flakey pattern in shales is overall less developed than above.

1831.5-1832.72. Mudrock: brownish black, subfissile, slightly more fissile than above. Regular siliceous and pyritic streaks and laminae; flattened conchoid fracture surfaces. Paler gray flakes seem to be chalcedony segregations.

Core # 2

1834.00-1834.4 Calcareous shale to limestone: hard and monolithic, distinctly laminated calcisiltite. Slow HCl fizzing. Lamination emphasized by whitish calcareous silt and ?collapsed silica flakes. Very few visible pyrite. This interval may represent a graded bed with sharp scour base (the base itself not preserved in a shattered core).

1834.4-1844.3 Mudrock: brownish black and notably homogeneous non-calcareous silty shale; hard to subfissile; in upper 1.0 m dominantly shaly siltstone. Lamination is mostly defined by silty intercalations in muddy rock with minor thin intervals showing pyrite streaks and laminae. In very homogeneous mudrock lamination is obscure. Occasional upright fractures, some with etched stylolitized surfaces. Pyrite moderately developed, occurs as dispersed "dust", minor streaks, small concretions, and occasionally as straight filaments (photo). Rare very fine sand-sized pale colored grains dispersed in homogeneous mudrock. Low-amplitude horizontal stylolites in harder siliceous shale intervals. Thin (10-25 cm) porcellanite intervals, most distinct at 1839.25 m, 1842.35 m, and 1842.8 m. These porcellanites are distinct by relatively light weight, no fissility, and extensive development of conchoid fracture surfaces.

NB: no stellate calcite crystals encountered in the section so far – an artifact from bad (shattered) core preservation?

1844.3-1845.2 Porcellanite: dark neutral gray, intercalated by brownish gray and heavier siliceous shale. The porcellanite has a siltstone or fine-grained recrystallized fabric; porcellanite s dominant in upper 1/2, and in lower ½ is alternating with subfissile shales

in nearly equal proportion. The upper part is least pyritic (pyrite only as "dust"), the lower part gradually becomes more pyritic and more distinctly laminated and heavier. Conchoid and upright gently stylolitized fractures.

1845.2-1845.6 Siltstone: very dark gray, shaly and siliceous, very hard, weakly to moderately calcareous, microlaminated. Calcite is micritic or microsparitic (no grains are discernible with hand lens), encased in shaly-siliceous matrix as suggested by rapid dying of HCl fizzing. Distinctly heavier than the overlying porcellanite. In lower one-half, calcareous siltstones seem to alternate with non-calcareous, slightly more pyritic mudrocks.

NB: Porcellanites are also different from mudrocks by their neutral dark gray color; mudrocks are brownish black.

1845.6-1846.25 Mudrock: brownish black, very homogeneous fine-grained (politic). Lamination obscure due to lack of lithologic contrasts between laminae. Pyrite as dispersed "dust", pyritized laminae and streaks are very rare.

1846.25-1848.00 Siltstone/porcellanite: neutral dark gray to black, non-calcareous, faintly laminated, shuttered with conchoid fractures, with minor subfissile (hockey-puck) intervals of brownish black mudrock. Siltstone aspect is detected by very fine-grained granular aspect with minor mica admixture.

NB: core at 1848.0-1851.4 is very shattered and bed limit picking may be quite imprecise.

1848.00-1849.7 Siliceous mudrock: silty shale to shaly siltstone, very dark brownish gray, hard, broken predominantly into angular pieces with important conchoid fractures. Minor subfissile (hockey-puck) shards. In difference to porcellanites at 1846.25-1848.00 m, this rock is heavier due to dispersed "pyrite dust" and regularly spaced pyrite streaks. Rare 0.5-2 cm thick seams of heavy pyritization. Upright and inclined at high angles striated low-amplitude stylolites (compressive strike-slip deformation). Some of these surfaces bear smears of calcite spar (weakly developed veining).

1849.7-1851.6 Mudrock: brownish black silty shale with minor hard intervals bearing upright fracturing/thin veining and conchoid surfaces. Somewhat fewer pyrite streaks than in the overlying interval.

1851.6-1853.5 Mudrock: brownish black very homogenous subfissile shale with thin (<0.2 mm) siltstone lenses and laminae. These siltstone streaks constitute no more than 3% of the rock. Rare sand-enriched graded laminae up to 3-4 mm in thickness occur in lower 0.5 m of the interval. The sand grains are whitish and spherical, may represent radiolaria. Pyritization weaker than above (rare streaks), and the rock is slightly lighter weighted. Two oblique sets of very low-amplitude stylolites, roughly at right angle to each other, crisscrossing lamination and 40-45°.

1853.5-1855.35: Mudrock to siliceous shale: alternation of subfissile brownish black mudrock and black hard siliceous shale. The latter is gradational to porcellanite from

which is different only by presence of pyrite streaks and moderate "pyrite dust". Lower ½ is dominated by subfissile siliceous shale. Lamination is emphasized by thin pyritic and whitish (chalcedony?) streaks; no continuous laminae are seen. Oblique stylolites with finely slickensided surfaces are also present.

1855.35-1855.7 Dolostone(?): dark brownish gray, weakly calcareous (light and patchy fizzing), very argillaceous and with mudrock intercalations, tight, with residual microlamination at 15-20° angle to the horizon. Crystalline structure is mostly finely crystalline (< 50μm), in top with medium crystalline seams (100-200 μm) and a seam of brownish spar. Angular termination of laminae against horizontal lamination in underlying shale can be seen in base indicating possible allochthonous origin of this dolostone (slumping down slope from a carbonate platform?).

1855.7-1858.0 Mudrock: brownish black, predominantly hard subfissile shale with intercalations of hard siltstone to porcellanite. The interval is distinct by regular pyritic and partly whitish siliceous streaks locally extended into laminae. Conchoid fractures common.

1858.0-1858.9 Siltstone-sandstone alternation: dark brownish gray microlaminar siltstone to very fine-grained sandstone with rare coarser (fine-grained) laminae. The rock is hard, distinct by very even fissility planes; conchoid fractures are poorly developed. 15-20 cm in the middle is distinct by development of whitish laminae with poorly discernible individual grains (recrystallized radiolarian material?). This middle part is also very weakly calcareous. Silt-sized whitish grains are also dispersed throughout the interval imparting to the rock lighter color than above and below. This middle part also contains laminae-displacing chalcedony windows. Dark-colored sand-sized angular grains are also present – conodonts? One collapsed macrofossil – ammonoid? Rare stratiform pyrobitumen streaks. The interval is less pyritic than above.

1858.9-1861.1 Mudrock: brownish black, non-calcareous, hard, subfissile, dominantly argillaceous siltstone in the upper part and moderately fining downward into silty shales with siltstone laminae. Water adsorption very low, shale is not expanding underwater. Different from the overlying interval in regular pyritic streaks and continuous laminae. The latter are mostly developed in lower two-thirds of the interval where they are very regularly spaced at 4-5 mm. Flattened conchoid fracturing is common correspondently to increased content of mud-grade fines. These conchoid surfaces undulate along lamination/fissility planes. Base indicated by decline of pyritic laminae.

1861.1-1866.6 Mudrock: brownish black, hard, non-calcareous, weakly subfissile, distinct by rarity of pyritic streaks and laminae. Mostly silty shale with intervals of monolithic argillaceous siltstone. Lamination is expressed in sub-millimeter thick laminae of paler colored (cherty?) grains, conical and cup-shaped microfossils. Pyrite is evenly dispersed as very fine "pyrite dust". Some cherty laminae show moderately enhanced pyritization. Rare upright fractures lined with brownish sparitic calcite-dolomite.

1866.6-1868.1 Mudrock: hard, brownish very dark gray alternation and shale and fine-grained argillaceous siltstone, similar to 1861.1-1866.6 m but different by more distinct lamination defined by pale-colored isometric and collapsed cherty grains of less than 80 μm in size. Isodiametric grains may represent radiolarians, and collapsed are probably chertified styliolinids. The top is admitted by a distinctly laminated 10 cm thick interval with enhanced pyritization. The rock is hard, with conchoid surfaces; upright fractures are common.

1868.1-1873.2 Mudrock: brownish black, very hard, locally subfissile, non-calcareous, remarkably homogeneous and looking massive. Alternation of silty shales and muddy siltstones; lamination expressed rarely as non-disturbed pyritic and cherty streaks. Siltstone and shale forms low-contrast alternation of 10-50 m thick beds. Infrequent pyrite nodules in cubic and "swallow tale" habit. Evenly dispersed very fine (almost invisible) micropyrite. Rare upright stylolites and upright fracture planes.

Core in lower 1.7 m (1871.55-1873.2 m) is marked on a box as "rubble" and is may be partly mixed up.

Core # 4.

1938.0-1938.7 Shale: brownish black, subfissile, locally slickensided, alternation of non-calcareous and calcareous. Top of core contains large (> core diameter) pyritic-calcareous nodule. Unevenly distributed styliolinid cones: rare and collapsed in non-calcareous shale beds and non-collapsed conical in calcareous interbeds. Regular pyritic streaks in less calcareous/non-calcareous intervals. Infrequent weakly pyritized styliolinid beds and rare graded beds in calcareous (less compacted) interbeds. The thickest styliolinid bed (1.5 cm) occurs at 1938.5 m. Upper part shows extensive hydrothermal veining with fractures filled by whitish layered calcite and ?dolomite.

1938.7-1939.1 Argillaceous limestone: dark gray, graded bed with calcareous shale in top and grading to limestone to base. Regular pyritic streaks but no continuous seams. Calcite reside in the form microsparite in matrix, in lower 15 cm becomes coarser crystalline (about 0.15 mm), and in the base has coarse crystalline vertically elongated (fans?) forming layered cone-in-cone pattern. Infrequent styliolinid cones. Base is sharp, probably diagenetic or altered from a primary calcisiltite graded bed.

1939.1-1940.55 Shale: brownish black, relatively hard, subfissile, moderately calcareous to non calcareous, with important conchoid fracturing. The non-calcareous intervals tend to be finely fractured producing small lenticular and cuspate flakes with conchoid sides. Moderate pyritization in the form of streaks and dispersed "pyrite dust". Many fractures are cemented by whitish (hydrothermal) dolomite. Rare collapsed styliolinids and spherical forms.

1940.55-1940.65 Limestone: dark gray, argillaceous, finely sparitic (0.07-0.125 mm), with sparite crystals/aggregates sometimes resembling "stellate aggregates". Lamination is not distinct, apparently overprinted by authigenic calcite spar growth. The interval

thickness changes abruptly across the core with partly slickensided oblique base indicating that this is probably an oblate calcareous nodule rather than a bed.

1940.65-1941.45 Shale: very similar to 1939.1-1940.55 m, moderately to weakly calcareous (calcite in micritic form), mostly homogeneous, locally with pyrite streaks and small pyrite segregations with diffused boundaries. The interval shows important veining - a network of upright and oblique fractures cemented by white sparry calcite.

1941.45-1941.65 Porcellanite: black, light-weighted, shattered along conchoid fractures into curved elongated cm-sized chips. Important calcite veining as above. Some chips show non-compacted (!) styliolinid cones. The matrix is mostly non-calcareous, becomes moderately calcareous and more pyritic in base.

1941.65-1941.95 Calcareous shale: brownish black, subfissile, more pyritic than above, with lamination emphasized by partly pyritized and chertified seams of collapsed styliolinids. The interval with thickest (up to 1 cm) styliolinid laminae occurs at 1941.75 m (photo and thin section). The base is very calcareous, with minor sheaths/laminae of upright cone-in-cone crystals.

1941.95-1942.2 Limestone: dark gray, argillaceous, with cone-in-cone texture. The coarsest crystalline cone-in-cone texture is developed in upper 3-4 cm. Scattered non-compacted styliolinid cones in lower one-half. Base is sharp but diagenetic (base of cone-in-cone texture). Robust calcite veining and minor pyrite streaks and small nodules.

1942.2-1944.85 Mudrock: black, weakly to moderately calcareous, subfissile, with important flattened conchoid fracturing (concave-convex decompaction fractures); locally very weakly expanding in water. Silty shales to muddy siltstones under the microscope. Pyrite occurs as “dust”, pyritic-cherty streaks, and rare laminae. Rare intercalations of shattered porcellanite (probably less then 10-15 cm in thickness). Styliolinid laminae are up to 2 cm thick, the thickest ones tend to be less compacted (preserved cones) and pyritized inside. The interval is fossiliferous: numerous styliolinid seams and lenses; a level enriched in black rounded collapsed fossils 0.1-02 mm in diameter at 1942.25-1942.3 m - possible megaspores or *Tasmanites*. Styliolinids are different in size, rarely up to 1-2 mm long cones. Possible fish remains at 1943.8 m.

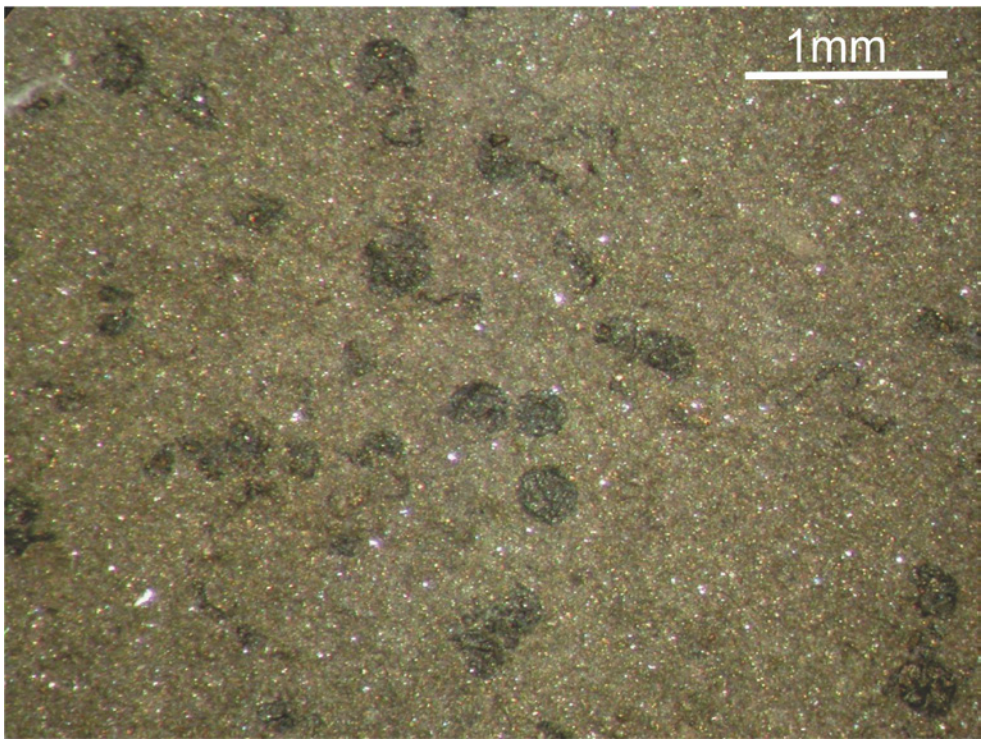


**Figure I-78-1. Spherical organic microfossils *Tasmanites* 1942.27 m MD**

1944.85-1945.7 Siliceous mudrock: very dark gray, mostly non-calcareous, fractured, subfissile. Alternation of light-weighted less pyritic and heavier more pyritic intervals. The light-weighed intervals are more fractured (shattered) and comply with porcellanite lithofacies. The fractures are often slickensided and covered with skins of sparry calcite. Lamination manifested by pyritic-cherty streaks.

1945.7-1946.6 Calcareous mudrock: similar to 1942.2-1944.85 m, with even more abundant partly pyritized seams of collapsed styliolinids.

1946.6-1948.1 Siliceous mudrock to porcellanite: very dark gray, non-calcareous, pervasively fractured, slickensided and shattered into rubble, light-weighted; rare thin interbeds of pyritic shale. Lamination is expressed in faint regularly spaced pyritic laminae and streaks.

1948.1-1950.35 Calcareous mudrock: brownish black, subfissile, with important concave-convex conchoid fracturing along fissility/lamination (decompaction fracturing?), weakly to moderately pyritic. Pyrite occurs as isodiametric subspherical and cubic grains 0.1-0.5 mm in diameter (possible framboids) and small authigenic nodules. Lamination is emphasized by paler brownish streaks of unclear composition (cherty-pyritic?) and laminae/lenses of collapsed styliolinids. Calcite resides in calcareous fossil and to lesser extent in matrix. The styliolinid cones abundant, locally avoided compaction and cemented inside by brownish pelitomorphic calcite; minor pyritized cones. The

thickest observed non-compacted styliolinid lamina is 2 mm thick. Two beds of cone-in-cone limestone: (1) at 1948.7 m (12 cm thick) and (2) at 1950.05 m (10 cm thick). The upper con-in-cone bed is coarser crystalline. In both limestone beds lamination is distinct but styliolinids are mostly poorly preserved because of authigenic calcite growth overprint.

1950.35-1950.6 Mudrock: gray to brownish gray, subfissile, alternation of calcareous and non-calcareous siliceous. The siliceous shale is lighter-weighted and slickensided. Base is very gradational.

1950.6-1954.15 Calcareous mudrock: brownish black silty shale, intercalated and intergraded with argillaceous limestones. The description of the calcareous mudrock matches that of 1948.1-1950.35 m. The interval contains two main beds of cone-in-cone limestone at 1951.8 m and 1953.25 m. These two beds have thickness about 10 cm and are very coarsely crystalline in base an top and finer crystalline in the middle.

1954.15-1755.35 Siliceous mudrock: gray to brownish gray silty shale to argillaceous siltstone. The core is rubbly. Alternation of non-calcareous siliceous mudrocks and somewhat calcareous mudrocks. The siliceous mudrocks are light weighed, intensely slickensided and fractures, probably grading to porcellanites. Fractures are short, dominated by shear pattern. The slickenside surfaces locally break the rock into mm- to cm- sized micronodules and small lenses. These surfaces are often covered with skins of brownish sparitic calcite which makes the rock fizz although the intranodular matrix is non-calcareous. Calcareous interbeds are similar to the overlying intervals, constitute no more than 1/3 of the interval. Lamination expressed as regularly spaced pyritic laminae and streaks. Infrequent non-compacted styliolinid cones.

1955.35-1955.7 Calcareous shale to argillaceous limestone: very dark brownish gray, hard calcilutite-calcisiltite with few biomorphic skeletal laminae up to 2 mm in thickness. These laminae are composed of a mesh of styliolinid cones and small ammonoids. Calcareousness and rock hardness grows to base. Rare oblique and straight calcite veins. Possible presence of small bioclasts of thick-walled brachiopods.

1955.7-1956.0 Limestone: gray, hard and monolithic, tight. Distinctly laminated fining-upward alternation of calcisiltites and fine-grained calcarenites with admixture of styliolinid cones and rare small bioclasts of benthic fauna. Lamination at 20º angle to core perpendicular. A thick upright vein of brownish gigantocrystalline calcite along the entire interval. The benthic bioclasts include brachiopods, spheres, and tiny echinoderm sclerites. Lamination tends to bundle into 1-3 mm thick rhythms divided and dark-colored mudrock laminae (top elements of micro-rhythms). Each bundle contains 5-25 individual laminae.

1956.0-1956.2 Limestone: dark gray, argillaceous, bioclastic, split by a gigantocrystalline calcite vein. A sharp gently undulating discontinuity at 1956.12 m (scour surface?) divides the interval into the upper styliolinid calcarenite (packstone) and the lower very calcimudstone (underbed). The upper calcarenite shows random orientation of skeletal particles and few remnants of lamination (BI 3-4). The lower underbed is mostly

laminated, darker colored, and more argillaceous. Both upper and lower parts contain common admixture of small pelmatozoan ossicles and work brachiopod fragments. Weak pyritization in the form of tiny (< 1 mm) rhomboids and nodules. Some cones are pyritized inside. A thick calcite vein locally opens with pyrobitumen fill in the middle. This pyrobitumen fill also contains whitish visually zonal idiotopic dolomite crystals.

1956.2-1956.6 Shale: black, non-calcareous to very weakly calcareous, intensely fractured and slickensided, with sigmoidal shear openings cemented by milky white calcite. Lamination is poorly seen. Thin seams of chertified collapsed styliolinids in lower part. Calcite partings along different-scale fractures make the rock fizz. Thin microlamination probably emphasized by pyrite.

1956.6-1956.68 Argillaceous limestone: dark gray, monolithic, grading into the overlying shale; contains bioturbation-disturbed laminae of styliolinids with admixture of tiny benthic bioclasts. The calcimudstone matrix between laminae is very dark and homogeneous, probably cryptolaminated. BI 1-2. Pyrite content very low. Base is disconformable.

HUME FORMATION

1956.68-1957.5 Limestone: brownish gray, crudely mottled, hard and tight, unevenly chertified. Texture: stromatoporoid-bryozoan-pachyporid boundstone with non-compacted wackestone matrix and cm-sized frame cavities. The latter are filled by the massive bioclastic wackestone and lined with dark alteration haloes (alterations probably associated with non-deposition in top of Hume Fm.). Large (> core diameter) in situ bulbous stromatoporoids, thick in situ branching bryozoans, thin-walled brachiopods and gastropods. Few stromatoidal forms lining frame cavities, but no morphologically distinct marine cements. Early lithification is indicated by lack of matrix compaction. The top is rugged, with amplitude about 8 cm in a 9 cm thick core, covered with a skin of ductile non-calcareous black shale and contains a least one deeply penetrating pocket filled by the same back shale. The top in coarsely stylobrecciated to the depth of 15 cm. A 1-2 mm thick discontinuous pyritic crust just under the top. Base by downward decline of chalcedony.

1957.5-1959.7 Limestone: similar boundstone texture with large frame cavities and overhands, but chalcedony crusts and nodules are lacking. The rock is mostly micritic. He primary boundstone framework consists of a light beige bioturbated wackestone, and cavity fills of darker colored, locally geopetal bioturbated wackestone. Syngenetic brecciation and rugged syngenetic discontinuities are common. Centers of some cavity fills are penetrated by pyritized shale stringers. The interval 1956.68-1959.7 m is overprinted by a network of calcite veins (cemented fractures).

Base of cored interval.