

4. GEOLOGY

4.1. Pre-Spud Geological Well Prognosis

Well Name: Kilgour North 1

Target Formation: Reward Dolomite, Barney Creek Formation and Coxco Dolomite

Elevation: 75.06 m KB

Table 3: Geologic description of the Formations:

| Formation | Top [m] | Probable Content |
|---|---------|---|
| Balbirini Dolomite | Surface | The Balbirini Dolomite is a unit of dolostone, mainly dolarenite, and minor dolomitic sandstone, dolomitic siltstone, potassium-rich mudstone, and volcanic rocks; stromatolites and pseudomorphs after gypsum, anhydrite, and halite are common sedimentary features. |
| Looking Glass Formation | 14 | Completely silicified by weathering and has a marked secondary porosity. The original lithologies appear to have consisted of dololite with chert nodules (in places slightly phosphatic), dolarenite and dolomitic quartz arenite (cross-bedded in places), intraclast conglomerate, and stromatolitic dolostone. |
| Stetton Sandstone | 40 | The Stetton Sandstone consists mainly of very fine to medium-grained, slightly micaceous pale green and grey quartz glauconitic; the absence of dolomite is an unusual character for rocks of the McArthur Group. |
| Yalco Formation | 75 | Yalco Formation is a unit of intensely chertified dolostone and unusual globular and biscuit-shaped stromatolites that distinguish it from other formations. |
| Lynott Formation - Donnegan Member | 228 | Dolomitic siltstone, fine to coarse grained dolomitic sandstone and dolarenite; thin-bedded, commonly rippled and cross-bedded; small botryoidal quartz nodules (cauliflower chert and enterolithic chert). |
| Lynott Formation - Hot Spring Member | | Thin-bedded dolomitic siltstones and silty dololite with interbeds of fine-grained sandstone, certified stromatolitic dolostone, dolarenite, sandy dolarenite and dolomitic sandstone; siltstone and dololite commonly contain chert pods; sandstones rippled and cross-bedded; stromatolites mainly stratiform and domal; common desiccation cracks, tepee structures and pseudomorphs after sulphate evaporates and halite. |
| Lynott Formation – Carabirini Mbr | | Thin bedded dolomitic siltstone and shale, in part carbonaceous and pyritic; silty dololite, dololite; minor fine grained dolarenite and lenses of slump breccia; uncommon ripples and evaporate mineral casts. |

| Formation | Top [m] | Probable Content |
|--|---------|--|
| Umbolooga Subgroup Reward Formation | 1398 | Dololutite, stromatolitic dololutite, silty dololutite and dolarenite with lesser sandy dolarenite, dolorudite and sandstone; laminated, thin to massive bedded, cross-bedded, brecciated and slumped; pseudomorphs after sulphate evaporates; onkoids, ooids, small silica spheroids; pseudomorphs after pyrite (pyritohedron). |
| Barney Creek Formation | 1826 | Thin bedded to laminated, dolomitic, carbonaceous and pyritic shale and siltstone, doloutite, rare breccia and sandstone; occasional gypsum casts; talus slope breccia adjacent to Emu Fault. |
| Teena Dolomite | 1889 | Grey crystalline dololutite with radiating, needle-like gypsum crystal pseudomorphs normal to bedding; rare conical stromatolites; thin intervals of dolomitic shale and siltstone. |

4.2. Along Hole and True Vertical Depth of Seismic Marker and Reservoir Horizons

Table 4: Well Log formation tops for Kilgour North 1, TD = 1142.77 m.

| Geologic Tops | Drilling Depth [m] | Structural Tops |
|---------------------------|--------------------|-----------------|
| Balbirini Dolomite | 20 | 0 |
| Looking Glass Formation | 40 | 20 |
| Stretton Sandstone | 120 | 40 |
| Yalco Formation | 220 | 120 |
| Lynott Formation | 816 | 220 |
| Reward Formation | 860 | 816 |
| Lynott Formation (repeat) | 891 | 860 |
| Reward Formation (repeat) | 1142.77 | 891 |

4.3. Geological Interpretation of the Well Data

4.3.1. Adjusted Lithology Description

Balbirini Dolomite

The Balbirini Dolomite unconformably overlies the Batten Subgroup and, locally, the Umbolooga Subgroup, both of the McArthur Group. The Balbirini Dolomite is a unit of dolostone, mainly dolarenite, and minor dolomitic sandstone, dolomitic siltstone, potassium-rich mudstone, and volcanic rocks; stromatolites and pseudomorphs after gypsum, anhydrite, and halite are common sedimentary features.

In Kilgour North 1 - DOLOMITE: moderately weathered, light grey to brown, with minor light grey chert, calcareous in part, iron-ferruginous oxidized in part, no fluorescence, no visible porosity.

Looking Glass Formation

The Looking Glass Formation is almost completely silicified by weathering and has a marked secondary porosity where solid and liquid hydrocarbons occur in vughs and pores at the top of the formation. The original lithologies appear to have consisted of dololite with chert nodules (in places slightly phosphatic), dolarenite and dolomitic quartz arenite (cross-bedded in places), intraclast conglomerate, and stromatolitic dolostone.

In Kilgour North 1 - DOLOMITE: weakly weathered, buff, light grey to grey, calcareous in part, iron-ferruginous oxidized in part, no fluorescence, no visible porosity, cubic pyrite.

Stretton Sandstone

The Stretton Sandstone consists mainly of very fine to medium-grained, slightly micaceous pale green and grey quartz glauconitic; the absence of dolomite is an unusual character for rocks of the McArthur Group.

In Kilgour North 1 - DOLOMITE: light grey to grey, massive, no fluorescence, no visible porosity, cubic pyrite with DOLOMITIC GRAINSTONE: medium grained, dark brown, dolomite grained, carbonaceous matrix, pyrite throughout matrix, no fluorescence, no visible porosity.

Yalco Formation

Rocks of the Yalco Formation are generally fine-grained and parallel-bedded aphanitic dololite and dolarenite with abundant nodules and laminae of early diagenetic chert and minor interbedded lithic sandstone. The rocks have an unusually knobby appearance, which is the combined result of the interbanding of the components and a large amount of nodular chert.

The dolostones are commonly stromatolitic. The stromatolites are preferentially silicified and white, and are conspicuous against the brown-weathering aphanitic dololite containing them. Finely laminated spheroidal oncolites or pisolites with cores of dololite are present in places.

The dololomite also contains a host of distinctive and environmentally significant sedimentary features. Among these are intraclast breccias.

In Kilgour North 1 the Yalco Formation consisted of light grey to dark grey, light brown to dark brown, blocky, microcrystalline dolomite, carbonaceous in part, small calcite filled fractures, cross-laminated in part, pyritic in part, no fluorescence, no visible porosity.

Lynott Formation

The Lynott Formation, a unit of dololomite, dolarenite and dolomitic siltstone and sandstone, is generally the thickest and most widespread of the formations which make up the Batten Subgroup. This formation is comprised of the Donnegan, Hot Spring and Caranbirini Members as you progress down stratigraphy, respectively. The Lynott Formation is seen as a regressive sequence.

Donnegan Member: Typically comprises buff to red-brown, thin bedded, often ferruginous, fine-grained dolomitic sandstone with interbeds of dolomitic siltstone and dololomite. A characteristic feature of the Donnegan Member is the presence of botryoidal quartz nodules (cauliflower cherts) which have probably formed by replacement of anhydrite nodules. The quartz nodules range from a few millimetres up to 10 cm in diameter, often have an enterolithic structure, and exhibit displacive growth along fractures and bedding planes. Pseudomorphs after gypsum and mud cracks are common at various levels.

Hot Spring Member: The base of the member is taken to be either the first coarse sandstone bed or prominent stromatolitic dolostone bed in the conformable succession with the Caranbirini Member. It ranges up to about 350 m in thickness, although exposures in the southeast are poor and shallow-dipping, making it difficult to estimate true thickness. The Hot Spring Member is a variable unit including dolomitic siltstone, silty dololomite, stromatolitic dolostone, dolarenite, sandy dolarenite and dolomitic quartz sandstone and thin beds of intra-clast breccia. The most common rock type is thin-bedded dolomitic siltstone which is often deeply weathered and silicified. Sedimentary structures include cross-bedding, ripple marks and rare mud cracks. Stromatolitic horizons are silicified and form prominent beds of blue-grey, often banded, chert.

Caranbirini Member: The Caranbirini Member is typically a poorly exposed unit of very thin-bedded to laminated, buff to yellow and grey, dolomitic siltstone and shale with interbeds of massive and laminated dololomite, similar in appearance to the Barney Creek Formation. It is usually deeply weathered and leached and occurs in low, rubbly, often flaggy outcrops. Pink to dark red and purple weathered pyritic shales, sometimes with small nodules of iron oxides after pyrite, form in the upper parts of the unit, whereas white, weathered, bituminous shales are common lower in the unit. There are rare, thin inter-beds of fine-grained, cross-bedded sandstone and dolarenite, but coarse sandstone and stromatolitic dolostone are absent. The upper part of the unit is more dolomitic and is characterised by small, vertical to inclined, chert and calcite-filled irregular fenestrae which may represent evaporate casts. Emergent, evaporitic conditions at this level are indicated by the presence of ripple marks, mud cracks, hopper halite casts, small chert spheroids and tepee structures.

In Kilgour North 1 the Lynott Formation consisted of grey, greenish grey dolomite and light brown to brown dolomite which is silty in part. Grey-green argillaceous dolomite with minor siltstone and dolomitic mudstone around 500 m was present. Green-grey to red-brown dolomitic siltstone, sandy in part, towards the bottom of the formation at 816m.

Umbolooga Subgroup

The top of the Umbolooga Subgroup consists of the Reward Dolomite, Barney Creek Formation (HYC Pyritic Shale Member, W-Fold Shale Member), Coxco Dolomite and Teena Dolomite progressing down stratigraphy, respectively.

Reward Dolomite

The Reward Dolomite is a widespread, highly variable dolostone unit which marks the top of the Umbolooga Subgroup. The thickness ranges from a few tens of metres in the west to several hundred metres in the vicinity of the McArthur River mine. The contact with the Barney Creek Formation is generally conformable and often gradational. The lower part of the formation consists of pink, buff and grey, laminated and thin bedded dololite with interbeds of dolomitic siltstone and sandstone, sandy dolarenite and sandy intraclast breccia. Dolomitic beds often contain small chert spheroids. Thin beds of potassium-rich, pink, siliceous, possibly tuffaceous material occur at some levels. The upper part of the formation is marked by a zone of intense silicification. In the west it is deeply weathered, silicified, chaotic breccia containing large, unsorted, angular dolostone clasts in a coarse, poorly sorted sandstone matrix with thin interbeds of dololite and dolomitic sandstone. The Reward Dolomite often contains minor base metal mineralisation along the disconformity where the dololite is black and has a bituminous odour when broken. The Reward Dolomite was deposited in an environment similar to the Barney Creek Formation, very shallow water to emergent conditions under which sediments accumulated in small bodies of standing water.

In Kilgour North 1 the Reward Dolomite is light grey to white dolomite, with no visible fluorescence, no visible porosity. The unit contained minor black dolomitic mudstone, calcareous, with abundant pyrite and minor galena. The sediments contained residual fluorescence ring in some parts.

Barney Creek Formation

The Barney Creek Formation is a unit of dolomitic shale, siltstone and dololite which is usually only poorly exposed in low, discontinuous rubbly ridges in the west, northeast and southeast of the McArthur River Region. The formation is usually less than 150 m thick but thickens to about 700 m near the Emu Fault Zone near the McArthur River deposits. The formation is divided into three members: the HYC Pyritic Shale Member, W-Fold Shale Member and the Cooley Dolomite Member. The Cooley Dolomite is restricted to the HYC Sub-basin to the west of the Western Fault, and 20 km north, near the Caranbirini Waterhole so is unlikely to be found in this well.

HYC Pyritic Shale Member: The HYC Pyritic Shale Member mainly consists of very thin-bedded to laminated dolomitic siltstone characterised by high carbonaceous content. Pyrite is the major sulphide component with galena and sphalerite present in the HYC deposit. Sedimentary structures include scour marks, flame structures, soft sediment

slumping and graded bedding. Sedimentary breccias are recognised in the areas around the HYC deposit in close proximity to the Emu Fault Zone.

W-Fold Shale Member: The lowermost member, W-Fold Shale Member, consists of green and red, dolomitic siltstone and shale with interbeds of green vitric tuff. The proportion of tuffaceous material increases toward the top of the member.

In Kilgour North 1 the Barney Creek Formation units were not found as hole was abandoned due to water.

Teena Dolomite

The Teena Dolomite is a recessive dolostone unit with the upper part of the formation called the Coxco Dolomite Member. The Formation is up to 70 m thick in the southern McArthur River Region.

Coxco Dolomite Member: The Coxco Dolomite Member is almost certainly evaporitic and is a massive, dark grey, sometimes vaguely bedded dololomite unit. It contains numerous interbeds of pink, buff or orange-weathering, potassium rich, possibly tuffaceous, and mudstones in the area adjacent to the McArthur River deposits. The Coxco Dolomite Member is characterised by the presence of acicular crystal casts which typically take the form of radiating aggregates of needles, rarely more than 2 mm in diameter and up to 6 cm long. Minor disseminated sphalerite, galena and chalcopyrite have been noted at several localities in the Coxco Dolomite Member.

In Kilgour North 1 the Teens Dolomite units were not found as hole was abandoned due to water.

Lower Teena Dolomite: The lower Teena Dolomite was probably deposited in a hyper saline lacustrine environment in which very shallow water and emergent conditions alternated. It consists of very thin bedded, massive, dark pink and grey dololomite. To the east near the McArthur River, the unit has greater sand and silt content and contains beds of ooids and intraclast breccia including flake breccia. Some of the sandy intervals contain cross-beds and ripple marks. Thin beds of stromatolites including conical, domal, columnar and stratiform types are often present near the top and bottom of the unit. Thin beds of pink, cryptocrystalline, possibly tuffaceous siliceous rock are present at some levels.

In Kilgour North 1 the Teens Dolomite units were not found as hole was abandoned due to water.

4.3.2. Reservoir Quality

Based on the results of the logs and limited shows, the reservoir is considered at this location for hydrocarbon potential to be poor.

4.3.3. Source Rock Quality

Not determined.

4.3.4. Hydrocarbon Indications

Very minor shows of gas recorded on mud-log in the Lynott and Reward Formations.

4.3.5. Trap integrity

Very poor trap integrity, reservoirs were breached and filled-to-spill with water.

4.4. Relevance of the Well Data to the Evaluation of the Hydrocarbon Potential of the Area

No major shows were recorded in this wellbore, however the area still has high potential for both conventional and unconventional oil and gas accumulations.