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Sedimentalogical and structural control on groundwater resources in and around Mekelle city, Tigray region, northern Ethiopia

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Abstract

Present study tries to highlight the sedimentalogical and structural controls on groundwater resources in and around Mekelle City and understand the lithological variations and their effects on the quality of groundwater and define the boundaries of the fresh, brackish and saline water aquifers. Mekelle is the capital town of Tigray Regional State in northern Ethiopia. It is situated in the Mekelle basin in general and Mekelle outlier in particular, comprising Mesozoic sedimentary successions and younger intusives. The Mesozoic sedimentary successions have Adigrat Sandstone Formation (at the base resting at places unconformably on basement Precambrian or thin Paleozoic rocks) followed by Antallo Limestone Formation, Agula Shale Formation of Jurassic age and Amba Aradam (or Upper) Sandstone Formation of Cretaceous age in ascending order. These are later intruded by younger dolerite dykes/sills, known as Mekelle dolerite dykes during Tertiary (of Oligocene age, 31-26 Ma). These sedimentary successions about 3 km thick seems to have been produced due to Mesozoic transgression and regression during Triassic to Early Cretaceous. These successions start with clastics at the base, followed by carbonates (± marl), carbonate (± evaporites) in the middle and another clastics (at the top). Thus, the Mesozoic sedimentary basin of Ethiopia is a repository of almost a complete cycle of sedimentation which started in Triassic and ended in Lower Cretaceous.

Compositionally, Adigrat Sandstone, at the base of Mesozoic succession, about 1000m

thick, is iron cemented, multi-storied sand bodies with thin, iron-rich mud-drapes of laminated mudstone. Antallo Limestone, overlying Adigrat Sandstone is also more than 1000m thick carbonate dominating unit with subordinate amount of marls. Overlying the Antallo Limestone unit is Agula Shale unit, although thin compared to others, is a mud dominated, variegated unit and consists of evaporites indicating an arid-evaporatic environment. The youngest Amba Aradam Sandstone is coarse, conglomeratic sand dominated unit with iron cement. The intrusives are hypabyssal, a medium-grained rock with doleritic composition. Structural features like joints, fractures, karst etc. are common in sedimentary lithologies. Development of spherical lumps due to weathering and presence of typical columnar joints are common in dolerite. Structurally, the basin has experienced many changes due to the faults which were active during the end of Mesozoic and early Tertiary, resulting in the development of Mekelle outlier. The outlier is bounded by two normal faults, one near Wukro in the north showing southward down throw and another near Mai Nebri showing northward down throw. The faults which were active during Mesozoic and later show W-NW trend producing en echelon belts, while the faults which were active during Precambrian show N-NE trend parallel to the strike of the basement rocks (metasediments). Most of these W-NW trending faults are normal faults with moderate dips. Most of them like Wukro, Mekelle, Chelekwot etc show southward while some like Felega Mariam fault shows northward dips. Major displacement has taken place after deposition of Agula Shale but before Amba Aradam Sandstone. The downward movement or down faulting of these faults has resulted in the formation of a depression / valley which facilitated complete preservation of Mesozoic succession in the down throw block and removal of younger part of the succession in the upthrow side.