Fluid Inclusions in the Ca-Mg Carbonates in Kumaun Lesser Himalaya and Focus on the Basin Fluid System

Prabha Joshi[1] and Rajesh Sharma[2]
[1]*Anjuman-I-Islam's Kalsekar Technical Campus, New Mumbai, India, prabha_geo@rediffmail.com*
[2]*Wadia Institute of Himalayan Geology, Dehradun, India. rajesh_fluid@rediffmail.com*

Introduction: The Ca–Mg carbonate rocks of the Deoban Formation in Kumaun Lesser Himalaya have been extensively studied for field, petrography, and geochemical characters whereby the dolomitization after calcite precursor is well established. Many microlithotypes are identified in them, which are fine grained and preserve the original organic and inorganic fabric. Lack of substantial compaction is evident by the fenestral structure (Fig.1). Polygonal mud cracks and parallel lamination in these carbonates signify their exposure as well as deposition in a quiet, shallow marine tidal flat environment. The studies of the fluid evolved in these carbonates and circulated in the basin have not been comprehensive. Present study aims to understand the basinal fluids contributed in the formation of various lithofacies from limestone-dolomite-magnesite to talc. In the present work representative samples from Jhiroli area in Kumaun Lesser Himalaya have been studied.

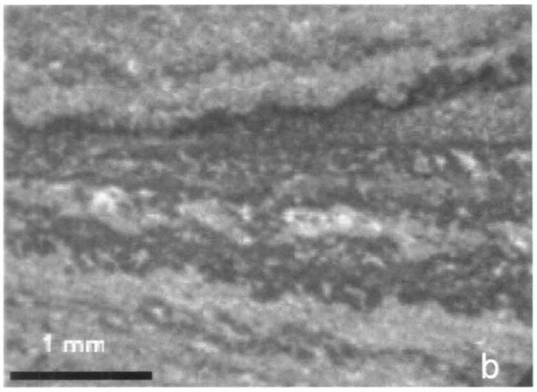

Figure 1: *Laminated dolomite showing fenestrae at the base of laminae.*

Geological Setting: The autochthonous units of the Precambrian sedimentary rocks in the Inner Lesser Himalaya are represented broadly by Damtha and Tejam groups. The studied carbonate rocks in the Kumaun Inner Lesser Himalaya are part of the Deoban Formation of Tejam group. These are exposed between the North Almora Thrust in the south and Berinag Thrust in the north. The Deoban Formation is constituted by stromatolitic dolomite, limestone and slates, and is sandwiched between the areno-argillaceous lithounits of the Rautgara towards the base and quartz arenites with interbedded basic volcanics of the Berinag Formation at the top.The carbonate rocks of Deoban Formation are significant because they consist of magnesite and talc deposits.

Fluid Inclusion Petrography: The fluid inclusions observed in limestone-dolomite-magnesite are classified into four types.

Type I -These are biphase inclusion in limestone, dolomite and magnesite. They are very small ($<2\mu$), therefore their microthemometry was not possible. The vapour bubble in some of these inclusions cover about 10 volume% suggesting a likely low homogenization temperature. They do not consist of any salt daughter crystal indicating that low-moderate saline aqueous fluid is trapped. Type I inclusions are the earliest record of the fluid event in carbonates.

Type II -These inclusions are aqueous biphase filled with 10 to 25 vol% vapour and 75 to 90 vol% aqueous liquid(Fig. 2). They occur in random distribution in magnesite and dolomite. At times they are found in co-occurrence with type III inclusions. These inclusions represent late diagenetic fluid, associated with neomorphic changes leading to spar dolomite and quartz recrystallization, and the formation of magnesite.

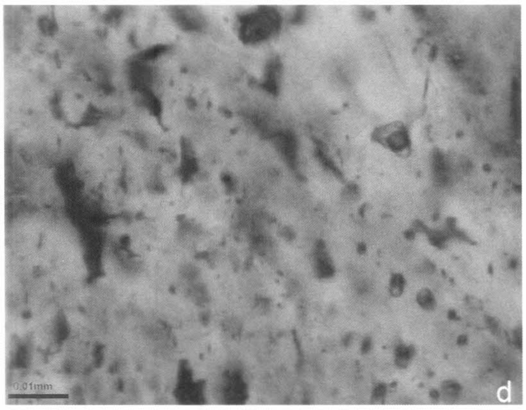

***Figure 2:** Photomicrograph showing Type-II primary inclusions in magnesite representing late diagenetic fluid.*

Type III -These inclusions are filled with H_2O-CO_2 fluid. They mostly occur in groups, planar arrays (Fig 3) and in trails. They are commonly biphase, but a meniscus between aqueous and carbonic liquid is also seen at room temperature(cf. 21°C) in some of them.Their size is about 10 to 20μ. They occur within magnesite associated with talc, and are not observed in dolomite and limestone.

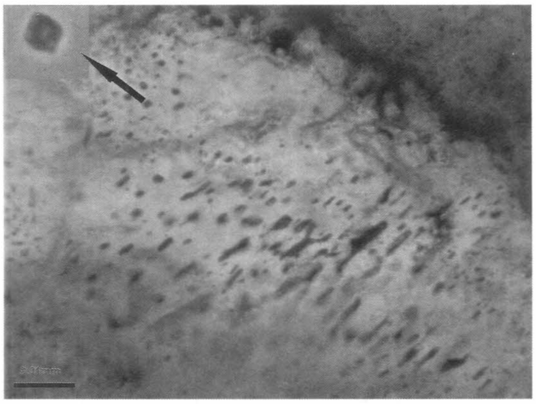

***Figure 3:** Photomicrograph showing Type-III aqueous-carbonic inclusions in magnesite.*

Type IV - A relatively higher density fluid is represented by type IV fluid inclusions trapped along the cleavage and secondary planes in magnesite, dolomite and vein magnesite.

Microthermometry: Microthermometry of suitable type-II inclusions show that peak of the homogenization temperatures increases from dolomite (260-280°C) to magnesite (300-320°C, Fig. 4). Quartz also show peak homogenization (300-320°C) matching to that of magnesite. The type II fluid inclusions present in recrystallized dolomite record eutectic temperature from -21.5 to -22.6°C attributing the presence of NaCl ± KCl saltsin the aqueous fluid.Type II inclusions in magnesite recorded temperature of eutectic within a large range of -22 to - 46.2 °C, which corroborate the H_2O + NaCl ± KCl + $MgCl_2$ ± $CaCl_2$ fluids in these inclusions. The overall estimated salinity and density range are 3.6 to 16 wt% eq.NaCl and 0.62-0.9g/cm^3 respectively.The melting temperatures of carbonic fluid in type III inclusions indicate it is CO_2 with minor CH_4. Micro Raman spectroscopy confirm the presence of CO_2, but Raman band for CH_4 was not obtained.

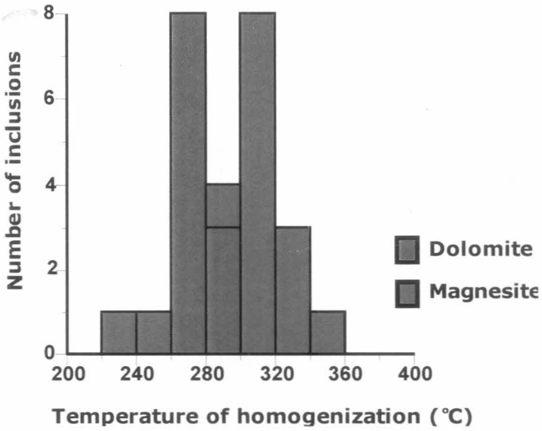

***Figure 4:** Histogram of homogenization temperature of type-II inclusions in magnesite and dolomite.*

The homogenization temperatures of CO_2 fluid range from 20.9 to 30.9°C corresponding to the CO_2 density between

0.53 and 0.76 g/cm^3. Their total homogenization varies from 290 to 370°C. Type IV inclusions are secondary, present in dolomite, magnesite and vein magnesite. They represent the last stage of fluid circulation in basin and are interpreted to be linked with deposition of vein magnesite along the cracks and fractures of the sparry magnesite. The fluid show similar density in all the minerals but a higher salinity up to 19.1 wt% NaCl eq.in vein magnesite. Their first melting upto -34.1°C points to the presence of $MgCl_2$ in the fluid.

Discussion and conclusions: The early diagenetic fluid was a low saline aqueous fluid represented by type I inclusions. The dolomite of the study area characterizes first stage replacement of calcite, wherein low saline aqueous fluid with H_2O+NaCl$\pm$KCl$\pm MgCl_2$composition was dynamic.The salinity (3.6-16 wt% NaCl eq.) and density (0.62-0.9g/cm^3) derived for type-II inclusions is common for basinal fluids (Huraiova et al., 2002).It is attributed that the Mg^{++}rich basinal fluid stimulated magnesite formation replacing early formed dolomite, as corroborated by the fluid composition: H_2O+NaCl $\pm$KCl+$MgCl_2\pm CaCl_2$. The salinity of this fluid reached to 16wt% NaCl eq., probably because of protracted fluid in the basin and resulting enrichment of Ca/Mg in the basinal fluid system. It is attributed that prolonged stay of this fluid and associated magnesite re-crystallization promoted the coarse granularity of the magnesite.The longevity of fluid circulation also raised the salinity of the basinal fluids. In a subsequent stage there was a rise in the temperature of the basin as the burial conditions increased, thereby quartz and magnesite present in the system reacted to form talc as per the following reaction given by Anderson et al (1990) : $3MgCO_3$ + $4SiO_2$ + H_2O= $Mg_3Si_4O_{10}(OH)_2$+ $3CO_2$. Fluid inclusion evidence of this decarbonation reaction is present in the form of restricted occurrence of type III inclusions filled with H_2O - CO_2 fluid (Joshi and Sharma, 2015) predominantly in talc mineralized pockets. This was internally generated fluid, without any extensive fluid influx. It is apparent that the X_{CO2} played significant role in talc formation, therefore talc has not developed extensively in all areas such as in Jhirouli magnesite. The late stage fluid circulated in the fractures, and was evolved in salinity and density because of continuum in circulation through fractures.

References

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