CHAPTER 8

SUMMARY

AND

CONCLUSION
The thesis aims to critically analyse the geological aspects, geomorphological evolution, ground water potential, land use and land cover classification and planning, economic mineral resources and environmental problems of the region around Damoh (M.P.).

The area is distinguished by its marked peculiarity of scenery. Great undulating plains divided from each other by characteristically flat topped ranges of hills occupy the greater portion of conspicuous terraces, which at times can be traced to long distances. The highest elevation in the area is 500 metres from the mean sea level. The general slope of the region is towards north-east and it is in this direction where the lowest level of the ground is exposed at the height of 340 metres. The general strike of the sedimentary formation is NNE-SSW having a dip towards ESE in between 2°-10°. Sonar and Kopra are the perennial rivers while Sajali and Gadheri rivers are only seasonal ones. On the whole the relief may be said to be 'medium'.

The area of investigation is mainly covered by upper Vindhyan rocks of Bhandar and Rewa groups. Based on the study of aerial photographs with selected field checks, upper Vindhyan, Lametas and Deccan Traps in the study area have been mapped and a photogeological map on 1:50,000 scale has been prepared. The following sequence has been established in the study area.
Alluvium

Deccan Traps

| Flow 3 |
| Flow 2 |
| Flow 1 |

Lametas (Infra-Trappean)

| Chertified or silicified limestone |
| Compact limestone |
| Lametas having pebbles of sandstone |
| White limestone |

-- UNCONFORMITY --

Sills of Megaporphyrctic Basalt

UPPER VINDHYAN

Bhandar Group

| Upper Bhandar Sandstone |
| Sirbu Shale |
| Lower Bhandar Sandstone |
| Bhandar Limestone |
| Ganurgarh Shale |

-- UNCONFORMITY --

Rewa Group

| Upper Rewa Sandstone |

The lower most or basal formation of the study area is of the Upper Vindhyan. One of the most remarkable feature of the upper Vindhyan is its horizontal bedding. The Vindhyan, being the oldest rocks in the study region, even then they do not show any folding, faulting and tilting except at few places, this may be due to the reason that peninsular India has been a rigid shield which was unaffected by Himalayan orogeny. For the first time stromatolites have been reported from this area. The limestone beds of Bhandar group display a prolific development of stromatolites.
It requires a detailed study to come to conclusion, which is beyond the scope of present work. A intrusive sill of megaporphyritic basalt occurs in the upper Bhander sandstone on the either side of the road leading to Jabalpur from Damoh and also near Jamuniya, Amata and Imalia. Sedimentary structures like laminations, bedding, cross bedding, mud cracks, pot holes, ripple marks and limestone caves, are well preserved in the rocks of upper Vindhyans.

The Lametas are practically horizontal and no disturbance has been noticed in the region during the field investigations. In the study area, there is a great variation in degree of induration, amount of silica and Vindhyan pebbles in the Lameta limestone in the study area. They are broadly classified as follows. (a) chertified or silicified limestone, (b) compact limestone, (c) Lametas having pebbles of sandstone, (d) white limestone. The Deccan Traps occupying one-fourth of the study area forms an assembly of wide flat top topography. Individual Deccan Trap flow units have been mapped from aerial photographs of distinct map topography to subtle slope breaks, change in tone and texture to minor variation in type and density of vegetation in different flows and most importantly the physical and areal continuity of the lava flows along with field checks. In the study area three flows have been identified of different characters. Finally a table has been prepared to show photo-characters of different litho-units.
Structurally, the study area is much less deformed in comparison to the adjacent areas i.e. Jabera dome on the SSE side and Hirapur on NNE side because (1) the study area basically is a platform sediment deposited towards the end of proterozoic. Subsequently, during the palaeozoic and mesozoic, there has been no deposition in peninsula, except for Cretaceous deposits of Trichinapally, Bagh beds and Lametas as sporadic occurrences and Deccan Traps were extruded at mesozoic and cenozoic boundary and eruption centre lay at the west coast of India, (2) only those areas were effected, where the Vindhyans are near to the Narmada river. In the study area, the upper Vindhyan rocks generally do not exhibit any marked deformation. A low amplitude fold is noticed near Patharia which is very gentle syncline structure with dips of limbs 5° and the axial trace of macroscopic folds runs in NW-SE direction. The fold plunges to the SE sub-horizontally. These might represent second generation warps, superimposed on F₁ structures trending ENE. The pattern of interference is therefore of type 1 of Ramsay (1962, 1967). It is possible that both sets of folds may have formed during a single episode of constructional deformation with one side compression more prominent than the other ($\lambda_1 > \lambda_2 > \lambda_3$).

The study of unconformity has also been carried out. As the beds of different formations that are found in the study area are almost horizontal, we can safely say that the relationship can in most of the
cases be either unconformity or at the most dis-unconformity. An example of unconformity with overlap has been observed. To the west of Barpani first and second flows overlap on the hill of Vindhyans while further east the Lametas below the first flow came against the Vindhyans. Thus, the younger formation like the second flow comes directly in contact with Vindhyans.

Fracture trace mapping of the study region has been done on aerial photographs of 1:25,000 scale and later transferred to 1:50,000 scale base map to prepare the fracture trace map. Major geological boundaries have also been transferred on the fracture trace map to highlight the fact that the density, size and orientation of fracture trace are governed by geological factors. Methodical statistical analysis of the fracture traces have been carried out to prepare the fracture trace frequency and density maps. Fracture trace orientation frequency diagrams of all the litho-units have also been prepared and interpreted. A total 845 fractures of total 627 Kms. in length have been found scattered here and there. Application of fractures in ground water exploration has also been studied and new ground water zones have been predicted on the basis of fracture analysis.

Geomorphologically, the area attained a mature topography due to exposure to erosional processes from palaeozoic times onwards. In the study area, the upper Vindhyans and Deccan Traps are characterised by mesa &
butte topography, steep escarpment slopes, conical and rounded hills and rolling plains of pediment at the foot hills.

Among the exogenic geomorphic processes, mainly the fluvial processes have played a significant role in the terrain evolution. The present day landscape of the study area is carved out by Sonar, Kopra, Sajali and Gadheri rivers. The erosional processes are still active, eroding the loose and poorly consolidated alluvium, shales and hard rocks like sandstone and limestone exposed along the banks and periphery of river valleys. Seven geomorphic units and seven landforms with erosional processes have been identified after detailed study of aerial photographs and Landsat imagery. The seven geomorphic units are (i) Flood plain, (ii) Young alluvial plain, (iii) Terraces, (iv) Ravinous zone, (v) Old alluvial plain, (vi) Pediment, (vii) Denudational hill. Seven landforms with erosional processes are (i) River bluff, (ii) Point bar, (iii) Cut-off meander, (iv) Palaeochannel, (v) Butte, (vi) Mesa, (vii) Gully erosion. These are shown on a detailed photo-geomorphological map on 1:50,000 scale, prepared from aerial photographs with selected field checks.

Drainage has an important place in geomorphology. Morphometric analysis of four drainage basins, namely (i) Sonar-Gadheri basin, (ii) Sonar basin, (iii) Kopra basin and (iv) Sajali basin, have been carried out. The quantitative analysis of streams in drainage basins in
different lithologies have been tested. In the area, under study stream order, stream number, bifurcation ratio, stream length, weighted mean bifurcation ratio, weighted mean length ratio, drainage density and drainage frequency have been tested. Various laws are helpful in explaining the behavior of drainage in the area. It is noticed that mostly Horton's law holds good, but some sizable departure are noticeable, due to the different lithologies in the region under study. Since the four basins have many uncommon factors, influencing their drainage network i.e., underlying lithology and structure, a perfect similarity can not be expected in these drainage basins.

Three drainage patterns namely, dendritic, parallel and radial drainage patterns have been identified on upper Vindhyans and Deccan Traps. The drainage in the study area, to some extent is controlled by fractures. The adoption of the drainage to underlying structure and evolution of drainage have been studied.

The weathering characteristics of different rocks have also been studied. From the regional point of view, the region most affected by the action of mechanical weathering (a) The Bhandar escarpment, (b) The hill tops, (c) The river banks. It may be mentioned that the rest of the study area is mainly carved by transported soil and the underlying rocks are not exposed on the surface. On the contrary field studies
of the Deccan Trap region show that it is affected more by chemical weathering. Biological weathering in the region is not so significant as the other two processes of weathering. However, the effect of roots of trees penetrating along the joints of the rocks cannot be neglected.

In the study area, there are some marked differences in the characteristics of the river valleys in the upper Vindhyans and the Deccan Trap country, which is another effect of lithology on drainage. In the Deccan Trap country, the river valleys are shallow and are of open nature. On the contrary, the upper Vindhyan country, the valleys are deep, narrow with steep slopes.

The study region has remained buried under the Deccan Trap till the recent past. The Traps have kept buried the upper Vindhyan rocks for a quite long period. The Traps have been removed from the eastern part of the region, but the western areas still carry thick pile of Deccan Traps. Submerging the earlier Cretaceous relief below them and subsequent removal of the Traps causing resurrection of the pre-Trap topography. There are traces of at least three erosional surfaces in the study region identified with the help of superimposed profiles, altitude frequency histograms and field checks. The three erosional surfaces are (i) First surface (460-500 metres), (ii) Second surface (380-440 metres), (iii) Third surface (350-370 metres).
Neotectonic activity in the study area is evident by the presence of palaeochannels, unpaired erosional and depositional terraces, erosional surfaces, development of ravinous land, gully erosion, and cut-off meanders etc.

The geomorphic history of the region to a certain extent is the history of the work of the rivers and the changes which they have undergone. As soon as, the lava cooled, the lava surface came under the influence of denudational agents, and as the denudational cycle proceeded, the upper flows of the Traps were removed exposing the upper Vindhyan surface once again. It may be stated that the present topography is mainly the product of the intermittent uplifts and differential erosion of the rocks differencing in their geological structure. The conventional interpretation of the geomorphic history of the study region indicates that the region has experienced intermittent uplifts and atleast three erosional surfaces have been identified.

The study of fluvio-geomorphic cycle in the study region helps in understanding the geomorphic features which have developed due to fluvial action. The present landform characteristics are the outcome of running water and weathering. The study of erosion surfaces has also helped in tracing the evolution of landforms and drainage. The evidences show that atleast one cycle has completed on the Deccan Trap, the remanent of that cycle may be seen at the height of 480 mts. and
above. Since then at least two cycles of erosion were interrupted due to the Himalayan orogeny (Rai, 1968). During that period, the landscape had almost reached the late mature stage. The old upper Vindhyan topography which was obliterated due to the outpouring of the volcanic lava is being exhumed during the various cycles of erosion.

The synthesis of geomorphic characteristics of the study region brings us to the conclusion that during the last cycle of erosion, this part had passed the late mature stage and was entering into the old stage. But a new cycle starting after the pleistocene uplift (Rai, 1968) had put this region again in a little earlier period in cycle of erosion. How far this region will be reverted back in the cycle is difficult to assess? Because the Kopra is the tributary of Sonar and the Sonar is the tributary of Ken river and unless an intensive geomorphic study of the whole Ken basin or even further it is undertaken this prediction will be hypothetical rather than a factual one.

Based on the hydro-geomorphological characters eight hydro-geomorphic units have been mapped from the aerial photographs and are shown on photo-hydro-geomorphological map on 1:50,000 scale. These can be used to explore the ground water potential of the area. The mapped hydro-geomorphic units are flood plains, point bar, ravinous-terrain, terraces, palaeochannels, pediment, buried pediment and denudational hills. Ground
water potential of different hydro-geomorphic units like palaeochannel and buried pediment fall under the category of very good and good prospective zone respectively, flood plain, point bar and ravinous zone are moderate to good, while shallow buried pediment and terraces are moderate to poor, pediment and denudational hill are poor and mainly acts as run-off zone. The water-bearing characteristics of different litho units have also been studied.

In the chapter of land use and land cover planning and classification, five major categories have been mapped with the help of Landsat imagery and are shown on map of 1:50,000 scale. The United States geological survey (USGS) classification has been used as basic classification for different land use/land cover mapping and a new classification has been proposed for this area because the USGS classification has not been found fully appropriate in the author's study region. The major categories mapped are - (i) urban or built-up land (a) mixed urban or built-up land (b) villages (c) Industry, (ii) Agricultural land (a) Crop land, (iii) Forest land (a) Dense forest \( F_1 \), (b) Medium forest \( F_2 \), (c) Degraded forest \( F_3 \), (iv) Water (a) Streams, (b) Lakes, (c) Reservoirs, (v) Waste lands (a) Land with or without scrub, (b) Uplands with scrubs, (c) Ravinous lands, (d) Gully lands, (e) Bare exposed rocks, (f) Sheet rocks, (g) Quarries, (h) Mining areas, (i) Soil erosion areas. These categories have been identified on imagery by their imagery characters and
field characters. Various preventive measures for reclamation of the lands have also been predicted like-

1. Meticulous efforts should be taken to plan the Damoh city. 2. For agricultural fields check dams have been proposed keeping in mind that they could cover extensive agricultural fields. Due to over flooding, strong embankment should be constructed on the either banks of river. 3. The ponds should be used as artificial ground water recharge areas. 4. For waste lands bare exposed rocks should be used as quarrying areas, keeping in mind that it should not destroy forests. In degraded barren lands & soil erosion areas afforestation is the best techniques to keep the harmony of the environment. For gullied & ravinous lands - (a) Protection from grazing and illicit falling of trees. (b) Providing diversion bunds or trench above the head. (c) Smoothening the sides wherever necessary. (d) Vegetative gully plugs should be provided, the vegetation may be sachrum species ande Jatropha species. (e) The banks of the rivers should be lined to prevent seepage of water. This infiltrated water from the rivers helps in developing ravinous topography by sapping process. (f) Development of forest in the area where farming is not possible which helps in checking the soil erosion. (g) Shallow ravinous area can be made plain, manually for agriculture near the banks of Sonar & Kopra river. Geologic and geomorphologic controls in different land use patterns have also been studied the study of the effect of geomorphology on human life of
the study area concludes that there is a close correspondence between geomorphology and the economy of the inhabitants of the region.

All experiments lead to the conclusion that adoption of modern techniques are somewhat beyond means of local population and villagers have a long way to go before achieving any ameliorative land use fit for a lucrative exploitation of available resources.

The Landsat TM (F.C.C.) have been found particularly helpful in delineating the different categories of land use. It is evident that detail geomorphic cum geologic maps have been correlated with land use pattern. Further it is seen that lithology, structure and climatic conditions cause characteristic landform, subsequently giving rise to a particular type of land use pattern. Thus, the role of geology and geomorphology in controlling land use pattern is borne out.

In the study area, no big deposits of metallic minerals are reported. Except limestone, on that basis a cement factory is being operating at Narsingharh area. Rest of the rocks are being quarried only for building purposes and road metals.

The study area is almost free from environmental problems except Diamond Cement Factory which is situated at Narsingarh village on the bank of Sonar river. The studies of air quality, water, soil, plants and vegetation, dust fall and human health has been studied.
It's adverse impacts like dust fall, air pollution, water resources, human health, natural vegetation, noise generation and most importantly psychological impacts on peoples and the beneficial impacts are like, increase in gross economic product, job opportunities, improvement in infra-structural facilities etc. have been studied. Finally some solutions have also been predicted for the better environmental management of this area like -

(1) To establish stable communities to vegetation on the dumps, dissimination of seeds is the easiest and best method. Broadcast seeds provide even and relatively dense strands of vegetation in a comparatively short time which will not be achieved through transplantation techniques. The seeds of the following plant species are recommended for seeding the contoured overburden-dumps in the limestone mining area- Dub grass, Marhua or Finger milleh, Kaner, Mehdī, Kikaror babul and Kathjamun. (2) The only air pollutant of significance emitted by DCW is suspended particulate matter or dust from Klin-emissions and various crushing and material grinding operations. The particulates emitted are mildly alkaline in nature, rich in calcium and having significant Mg and Fe, but much lower silica than road dusts. Keeping these in view, the following species are chosen for various categories - (a) Primary dust-attenuating : Vilayati Babool, Kala Siris, Kaner and Subabool. (b) Secondary dust-attenuating : This purpose could be served by a wide variety of trees like Neem, Karanj and Subabool would be ideal. But Guava, Amla,
Sharifa and Jamun shall be equally suitable and being fruit trees are more likely to get care and attention from people. (c) To protect the residents of DCW staff colony a strip plantation in the space between the industrial complex and residential area is also very necessary. (3) Water pollution may be control by sealing of the source of mine water or not allowing the mine water to enter river, pond or stream. Water treatment by various methods like flocculation, reduction, oxidation etc. will be good. (4) Regular water spraying on transport roads. (5) Water spraying arrangement can be made at the unloading hopper of crusher and spraying of water on Rotor. Using dust collector and blower in the crusher. (6) The dust can be reduced during blasting by inserting water filled plastic bags or water ampoules before and after the charges. (7) The pits could be used as ponds, which in turn acts as artificial ground water recharge areas and could also help plantation in the surrounding area.

On balancing, current limestone mining by Diamond Cement Works, appears to have caused more adverse impacts than the favourable ones, particularly one gives due weightage to the social and psychological impacts and focuses only on local area and not on regional/national interest. But it may be stressed that these adverse impacts are largely due to flaws in planning and management and can be easily converted into positive and highly favourable balance by adopting proper measures.
Practical constraints shall have to be kept in view, at every step when implementing the above proposals. An important aspect to be remembered while developing plantations in and around the Diamond Cement Works, shall be the protection of plants from grazing animals and from fuel and fodders of others. This will need a constant vigilence and protective measures. The watering of plants during the early phase of their growth will also be very essential. To obtain best result and easy start for the sampling, the planting should preferably be done in monsoon season.