

KARSTIC PHENOMENON IN THE CARBONATE ROCKS OF THE INDRAVATI SERIES OF MADHYA PRADESH WITH THEIR GROUNDWATER POSSIBILITIES*

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In the calcareous and magnesian limestones of the Indravati Series in Bastar district of Madhya Pradesh, solution effects are widespread in the form of etched, uneven and pitted surfaces, grikes¹, clints and lapiés, solution cavities, grottes², hums³ and caverns⁴ and sinkholes of various shapes and dimensions. In areas of both the limestones, the soil cover and the laterites upto five metres in thickness are characterised by shrinkholes in line with the sinkholes of the underlying rocks, thus providing image swallowholes on the surface. There are also resurgences in the limestones serving as perennial springs.

The low topographic areas of resurgences have been developed locally with tubewells for rural water supply. These are limited to 90 m in depth with a discharge of about 1,500 lph for a drawdown of 15 m, the static water level being generally limited to 14 m b.g.l., and with scope for improving their discharges by proper development.

The presence of perennial springs and the development of tubewells in the low topographic areas of the limestones lead to the inference of intricate karstic condition on a regional scale, at least down to 90 m in depth, with sinkholes of the high topographic areas in line with the karstic resurgences of the low topographic areas. It is the perennial springs that feed the major rivers, the Indravati and the Sabari, rendering them perennial.

The karstic structures of Bastar are of particular significance for utilising them as a source of water supply after due and adequate exploration followed by systematic development.

INTRODUCTION

The Purana rocks occurring in parts of Jagdalpur and Kondagaon *tahsils* of Bastar district of Madhya Pradesh, and lying between the north lat. 18° 45' and

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¹ Grike, Gryke, (English): A vertical or subvertical fissure in a limestone pavement developed by solution along a joint. Synonym (German) Kluftkarren.

² Grottes, Grotto, (French): 1. A small cave, natural or artificial; 2. A room, in a cave system of moderate dimensions but richly decorated.

³ Hum, Karst inselberg. Residual hill of limestone on a fairly level floor, such as the isolated hills of limestone in poljes. In some tropical areas, used loosely as synonym for mogote,

⁴ Cavern. A cave, often used poetically or to connote larger than average size.

19° 30' and east long. 81° 30' and 82° 15', are ascribed to the Indravati Series (Dutt 1963), which has generally been recognised as equivalent of the Raipur Series of the Chhatisgarh region of India. The Indravati Series comprises the lower Tirathgarhs, the middle Kangars and the upper Jagdalpurs.

The Tirathgarhs comprising the conglomerates, the sandstones and the subarkoses cover an area of about 500 sq. km with a maximum thickness of about 270 m. The Kangars comprise shales and limestones and the Jagdalpurs consist of shales and dolomites with a total coverage of about 2,600 sq. km and a maximum thickness of 290 m. While the Tirathgarhs form the fringe of the saucer-shaped basin, the Kangars and the Jagdalpurs occupy the central part of it. The rock formations in general have low centripetal dips of less than 10°.

DEFINITION

The term 'Karst' (Kettridge 1959) is essentially derived from the limestone plateau on the eastern coast of the Adriatic Sea in Europe. It is synonymous with the term 'Carso' of Italian origin. In both cases, it has been used as a synonym of limestone cavern showing ideal development in a vertical direction. Since then the term 'Karst' has become classic and of universal application to all cavernous limestones of calcareous countries.

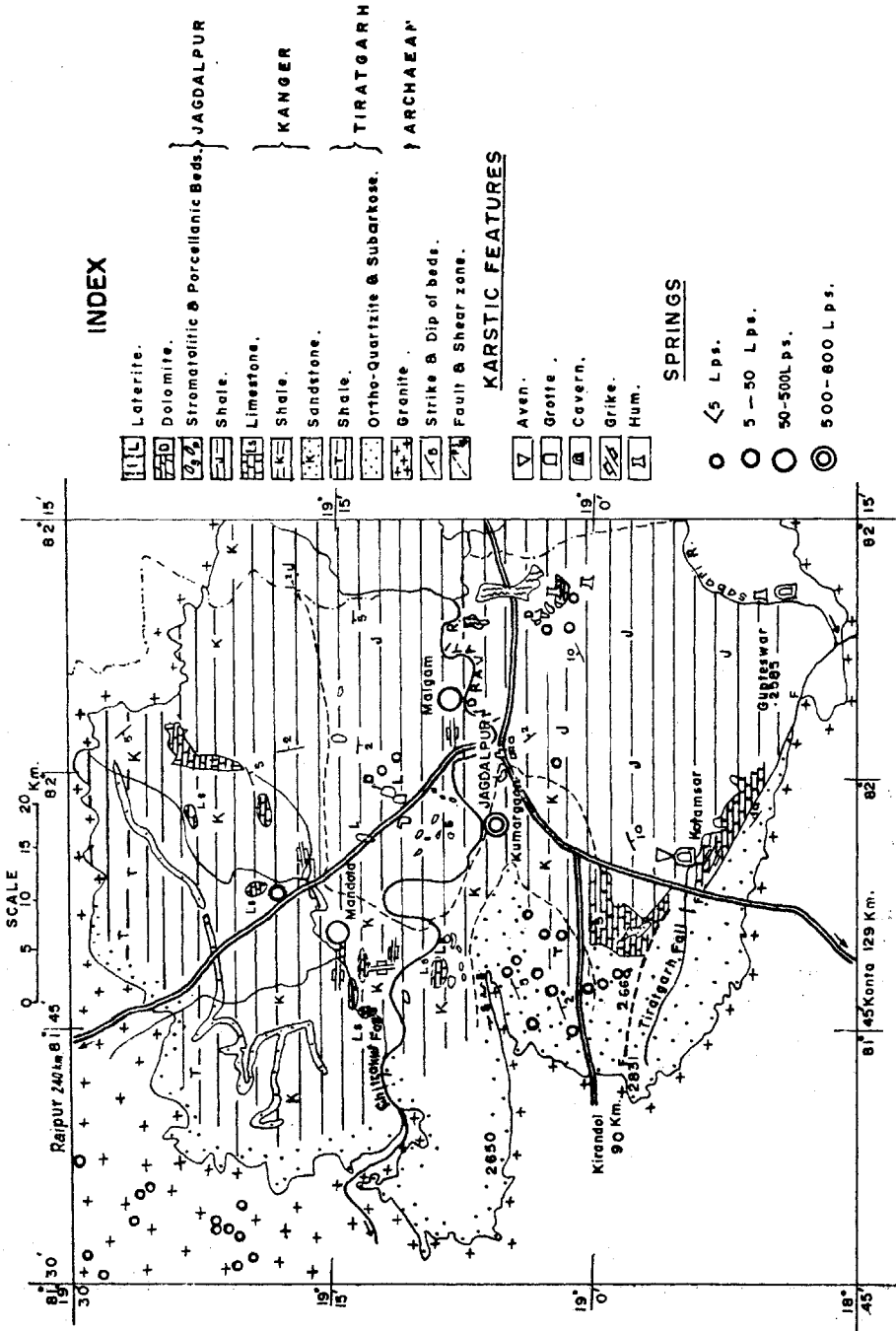
In its wider sense, it thus relates to a roughly etched and uneven surface characterised with depressions due to solution effect, sinkholes of simple and intricate nature interspersed with abrupt ridges and irregular protuberant rocks, caverns and also the underground drainage in places of surface streams.

The limestones of Indravati Series, both calcareous and magnesian, have a tendency to develop karsts as in Southern Europe and Northern Africa, where the phenomenon can be observed in all its grandeur with majestic growth of multitude of structures.

KARSTS OF BASTAR

In Kondagaon and Jagdalpur *tahsils* of Bastar district, the authors have observed in recent years (1968-70) certain karstic features during the course of their systematic hydrogeological work. The etching effects on the limestones of both calcareous and magnesian varieties are observed here. The cavities are developed along the bedding planes and also along the vertical joints with development of grikes, clints and gaping joints. A thin protective film of a millimetre forms a patina on the limestone surfaces. There are both gaining and losing streams, and also the sinkholes and the resurgences. Borehole data in certain cases confirm this. Even in the soil cover and the laterite cappings overlying the limestones imprint of the karstic phenomenon can be observed.

Rough, uneven, etched and pitted surfaces are prevalent in the limestones in the low topographic areas. On an otherwise protected surface is noticed a thin characteristic protective film of about a millimetre in the form of a patina under which the limestones are all fresh and unaltered. It is only when the patina is eroded that the etched and pitted surfaces are observed as seen in the bed of the Markandi river, about 25 km north-east of Jagdalpur (19°06' : 82°02' : 65-I/4).



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Along the bedding and/or the vertical joints are noticed blebs of cavities, which vary in size from just a widened joint to those of blebs of about 20 cm in width. Solution cavities are also pronounced in the dolomitic limestones of Jagdalpur as seen in an exposure, a kilometre southeast of Bastar ($19^{\circ} 13' : 81^{\circ} 56' : 65\text{--E}/16$). The outcrops located about three kilometres west of Machkot ($19^{\circ} 01' : 82^{\circ} 13' : 65\text{--I}/4$) in the dolomitic limestones show rough surfaces with huge protuberant hums and hummocks attaining a height of some 30 m, each displaying etched surfaces with grikes, clints and lapiés and solution cavities.

In bedded limestones, the steep or almost vertical joints have a general trend of N-S and /or E-W. The grikes and clints are developed with large gaping cavities of more or less extensive nature as seen in the Markandi river bed, about 25 km north-east of Jagdalpur (Pl. XVI, Figs. 1, 2 and Pl. XVII, Fig. 4). The grikes are upto 1.5 m in width with intervening clints assuming the shapes of flutings to simulate lapiés to a depth of about nine metres as observed in some open wells.

The next step in the development of a cavity is the formation of a sinkhole and there are several of them noticed in the area. Some of these sinkholes end in grottes (Pl. XVI, Fig. 3) and in the Kanger limestones there is often majestic development of caverns. The Gupansar cavern located about 1.5 km south of Kotamsar ($18^{\circ} 52' : 81^{\circ} 56' : 65\text{--F}/13$) is the majestic cavern of its type, where an aven (Pl. XVII, Fig. 8) leads to the cavern, about 45 m deep, located in the flaggy Kanger limestones. It has at least three irregular benches of cavitation, with relatively smooth steep walls and growth of stalactites and stalagmites along its lower benches. Another cave is (Pl. XVII, Fig. 6) located at Gupteswar ($18^{\circ} 54' : 82^{\circ} 14' : 65\text{--J}/1$), about 15 m deep, in the Jagdalpur stromatolitic magnesian limestone along the Bastar (M.P.)-koraput (Orissa) border with majestic development of 'Grand statuary of Karst' as exposed in the bed of Sabari (Kolab) river (Pl. XVIII, Fig. 7). It may be mentioned at this stage that much remains to be known about these caves and caverns, and more so about their mode of carving.

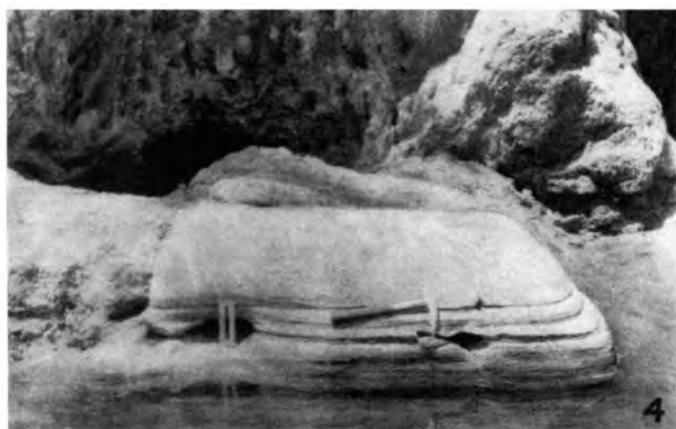
The limestones in the area are rich in groundwater potential, and the low-lying areas are often flooded with water with tiny sluggish brooklets emerging from the alluvial debris of the low grounds, marked further by luxuriant growth of vegetation.

There are springs emerging out of the limestones at Kumargaon ($19^{\circ} 06' : 81^{\circ} 57' : 65\text{--E}/16$); Pl. XIX, Fig. 9), Mandota ($19^{\circ} 14' : 81^{\circ} 40' : 65\text{--E}/16$) and Chepka ($19^{\circ} 17' : 81^{\circ} 55' : 65\text{--E}/15$) yielding about 800,300 and 70 lps, respectively. At Malgam ($19^{\circ} 08' : 82^{\circ} 54' : 65\text{--I}/4$), a spring of the capacity of 50 lps has been noticed in the dolomitic limestones of Jagdalpur. All these springs are located in low topographic areas, each with about half a dozen or more orifices from the bowl-shaped depressions, upto 75 m in outer diameter and three to five metres in depth. In addition to these, there are also a few springs of smaller capacities of about five lps.

Further, there are 'losing streams' like that of Markandi, where considerable amount of water is lost along the strike of the limestone through the grikes and the solution cavities. In this connection, it may be mentioned that the disappearance of a stream is noticed at Ratma ($19^{\circ} 11' : 81^{\circ} 49' : 65\text{--E}/16$) in the proximity of the massive limestones, displaying discrete sinkholes down to about four metres.



FIG. 1-3. 1, Grike and clint; Jagdalpur magnesian limestone ; 6 km NW of Jagdalpur on Jagdalpur-Raipur road, Bastar district, M. P. ; 2, Interconnected grikes in the river bed; Kanger limestones; Markandi river bed, 25 km NW of Jagdalpur on Jagdalpur-Raipur road, M.P.; 3, Grotte; Jagdalpur stromatolitic limestone; S.E. of Bastar, and 15 km NW of Jagdalpur on Jagdalpur-Raipur road in Bastar district, M.P.



FIGS. 4-6. 4, Blebby clints along the bedding planes: Kanger Limestone; Markandi river bed, 25 km NW of Jagdalpur on Jagdalpur-Raipur road, M.P.; 5, Patina on the Kanger Limestone; Markandi river bed, 25 km NW of Jagdalpur on Jagdalpur-Raipur road, M.P.; 6, Grand Statuary of Karst showing hums and interconnected grottes; Jagdalpur stromatolitic limestone; Sabari (Kolab) river bed at Gupteswara along the Bastar (M.P.)-Koraput (Orissa) border.

The effect of these springs can be observed in the rivers fed by them. The Indravati and the Sabari are both perennial, and the former has a much larger drainage area than the latter; but the discharge of the Sabari is relatively higher than that of the Indravati in winter and summer months. This is apparently the case of a larger contribution to the river (i.e. the Sabari) by the karstic resurgences.

The low topographic areas with karstic resurgences are locally developed with tubewells for rural water supply. These tubewells are limited to 90 m in depth. The static water levels in them are generally limited to 14 m b.g.l. with an average yield of about 1,500 lph for a drawdown of 15 m.

In areas of both the limestones, the soil cover and the laterites upto about five metres in depth, are further characterised by shrinkholes, in line with the main sinkholes of the calcareous rocks underneath. Such swallowholes in the overlying soil cover can be described as image swallowholes (Pl. XIX, Fig. 10) to distinguish them from the swallowholes of the limestone rocks. They are roughly circular or semicircular in shape with a diameter of about a metre and a depth of half a metre.

All these evidently lead to the development of karstic phenomenon on a regional scale with a syphon of subsurface drainage. Naturally if the boreholes



FIGS. 7-8. 7, Entrance to Gupteswara Cavern; Jagdalpur Stromatolitic Limestone; east of Sabari (Kolab) river at Gupteswara in Koraput district, Orrissa; 8, Aven leading to Gupansar Cavern; Kanger Flaggy Limestone; 12 km east of 30th km/stone on Jagalpur-Konta road, Bastar district, M.P.



FIGS. 9-10. 9, Karstic resurgences in the bowl-shaped (60 m in diameter) depression with a discharge of 800 lps; Kanger Flaggy Limestone; Komargaon, 5 km west of Jagdatpur on Jagdalpur-Chitrakut road, Bastar district M.P.; 10, Shrinkholes (or foxholes); soil cover over the Raipur Limestone; South of km/stone 234/6 on Raipur-Saraipalli road, M.P.

drilled in the area are developed properly and adequately and rendered them free from accumulated clayey matter, they are likely to improve considerably in their discharges.

CONCLUSION

Karst is thus intricately developed in the limestones of Bastar on a regional scale with sinkholes in the high topographic areas in line with the karstic resurgences

of the low topographic areas, the latter feeding the springs and the perennial rivers of the area like the Indravati and the Sabari. It may be mentioned at this stage that the study of the karsts leading to the formation of the subsurface drainage will be of considerable significance for its interpretation for groundwater and for harnessing it suitably after due exploration.

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