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COMMENTARY:

An Evaluation of Coastal Geomorphology of the Eastern Ghats in Terms of Lithological Control: Observations Made Out of Field Studies

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Abstract : *Assessing coastal dynamics and vulnerability along India's Eastern Coast is largely controlled by two dominant 'litho' units following significant findings from geological field studies conducted in various Eastern Ghats segments, from Orissa to Tamil Nadu. These studies are essentially related to lithological studies. The litho units, respectively, are called Khondalite and Charnockite in these two states. It is significant to remember that these two rocks occur concurrently on the Eastern Ghats and even extend as far as Sri Lanka. There are two specific places of tourist interest close to Puri as Udaygiri and Khondogiri. The rock composition of Khondogiri ('giri' means hill) is Khondalite. Two additional litho units, known as Anorthosite and Noritic Gabbro, are found at the Chilka Lake, further downhill from Puri. They are found together as huge outcrops. Together, the Charnockites and Khondalites are found in the land areas of Balugaon, which is in the eastern portion of Chilka Lake. Based on the mineral paragenesis of both rocks, we can conclude that the minerals found in Khondalites are more weathering-susceptible according to Goldich's series of mineral weathering susceptibility. As they contain more stable minerals than Khondalites, chondrites are a more stable litho unit. As a result, the majority of Khondalite outcrops are plateau-type, containing lateritic cap rock and bauxite mineralization. The Charnockites exhibit an NNE-SSW strike direction and are found as continuous outcrops forming hill ranges. These variations in outcrop patterns have been found in Vishakapatnam, more specifically in the vicinity of Seemachalam. Such observations can be clearly seen at Gopalpur-on-Sea in terms of differential weathering and the creation of cliff structures as geomorphic units, starting from Udipi and moving towards the Bay of Bengal. These rocks are submerged beneath the water at Chennai's Marina Beach and are invisible. The strong coastal dynamics are to blame for this.*

Key words: *Coastal Dynamics, Vulnerability, Easter Ghats, Charnockites, Khondalites.*

Discussion

It is highlighted in the abstract that the two separate litho-units, namely Charnockite and Khondalite, have a significant influence on the coastal geomorphology. Tell us about each of their individual mineral paragenesis right away.

Charnockite is composed of Quartz (SiO2), Alkali Feldspars (K Al Si_3O_8 and N Al Si_3O_8), Biotite (a complex Fe Mg Silicate), and Orthopyroxene (basically Hypersthene $(Mg\ Fe)_2\ Si_2\ O_6$).

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The percentage of orthopyroxene can reach up to 40–50% in basic charnockites, while the percentage of quartz can reach up to 30–40% in acid charnockites. We are here discussing free quartz grains and not mineral silicates. Along the Eastern Ghats, Acid Charnockite varieties form outcrops of large hill ranges because the more free quartz is present in the rock, the more resistant the rock is to intense weathering.

Conversely, Khondalite is ultimately composed of sillimanite (Al_2SiO_5), K-Feldspar ($KaAlSi_3O_8$), Biotite (a complex Fe Mg silicate), and a significant quantity of Garnet ($Fe_3Al_2Si_3O_{12}$) crystal. The shape of garnet crystals is dodecahedron and is isometric. Grains of fibrous sillimanite encase the garnet crystals. Garnet crystals are released by sillimanite grain during weathering. The Fe (Iron) present in Garnet form laterite and present a cap rock. Sillimanite grains lose their SiO_2 part and become rich in Al_2O_3, which now acts as a Bauxite (Al_2O_3) deposit.

The Eastern Ghat is almost entirely covered in simultaneous occurrences of Khondalite and Charnockite. Figure 1 of the following Geological Map of Orissa illustrates a typical pattern. The presence of the Charnockite as a Charnockite-Migmatite unit is evident if we document the event. In these types of geological outcrops, the term “migmatite” is not very noticeable. This is because granitic melts that intrude into pre-existing rocks or groups of rocks are what are known as mixture rocks, such as migmatites. Therefore, it can be concluded that there is evidence of granite magmatism as well (though this phenomenon of magmatism is not being discussed separately as it is outside the purview of this research article).

Two other litho-units are examined; these are easily visible at Chilka Lake and the nearby Balugaon area, and they are located along the Coromandel coast. Chilka Lake is regarded as a lagoon, and since lagoons are thought of as lakes that are cut off from the sea (in this case, the Bay of Bengal), the impact of coastal erosion is almost non-existent. Anorthosite and gabbro, specifically Noritic gabbro, are these litho-units. These two litho-units combine to form massive, continuous outcrops on a large scale. Actually, the boatmen would gladly take anyone visiting Chilka Lake on a boat ride to witness these incredibly beautiful and majestic Anorthosite Massif outcrops. The majority of the Anorthite variety of the Plagioclase group of minerals make up the Anorthosites, which are classified as monomineralic rocks. With a chemical composition of Ca Al_2 Si_2 O8, anorthite is known to be moderately resistant to weathering. It’s hypidiomorphic granular texture—which is defined as the interrelationship between the grains present in a rock—and monomineralic nature also contribute to the rock’s close-knit grain structure. However, gabbro, especially noritic gabbro, is made up of orthopyroxene (Mg Fe)$_2$ Si2O6) and the Bytownite to Labradorite variety of Plagioclase group of minerals. Its chemical composition varies from Ca Al_2 Si_2 O_8 to Na Al Si3 O8, and it is moderately susceptible to weathering to form low altitude hills

The overall distribution of all such litho-units in terms of Geological Map is shown in Figure 2.

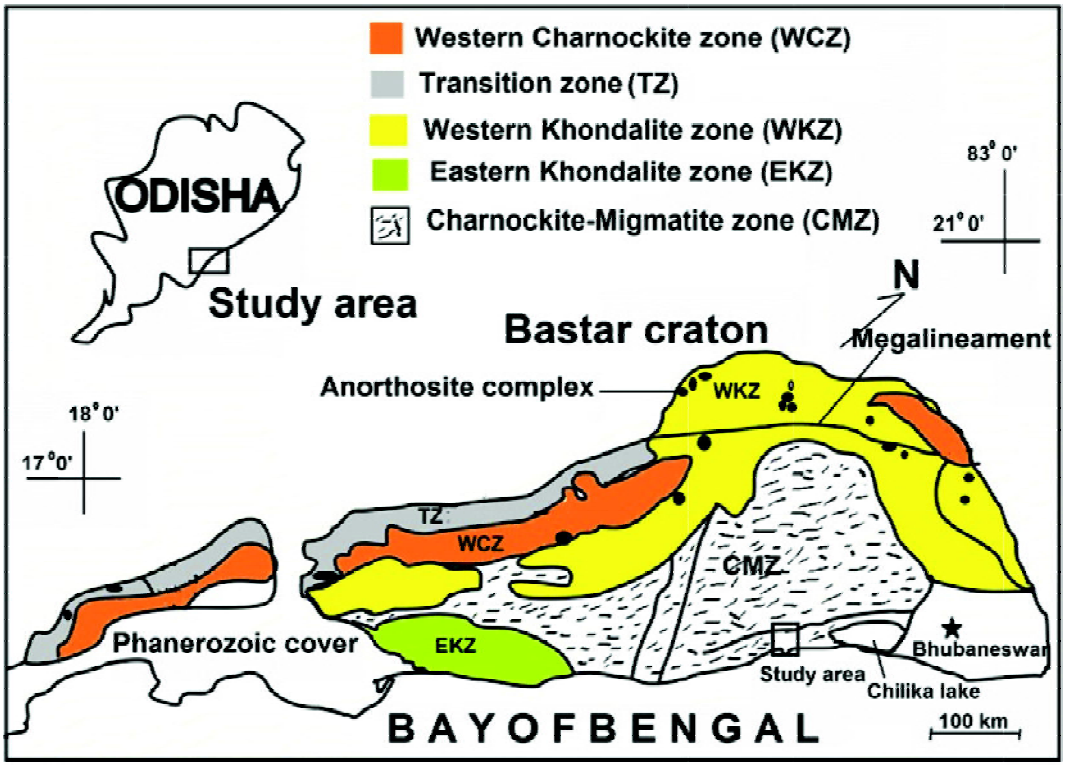

Figure 1: Source: *Geological map of Eastern Ghat Mobile Belt comprising different litho-units along the eastern coast of India enclosing the study area* (Revised version, Rao and Misra 2009)(**Nimelan et al., 2020)**

A detailed examination of Figure 2 also demonstrates the presence of numerous additional litho-units, including Layered intrusive, Ophiolite Melange, and Alkaline Complex. Let's take a quick look at the characteristics of these other litho-units. Our understanding of geology clearly indicates that such a diverse range of lithological assemblages would lead to the formation of diverse geomorphological attributes in terms of coastal geomorphology. Generally speaking, rocks like syenite and nepheline syenite make up alkaline complex. With a composition that ranges from $KAlSi_3O_8$ to $Na\ AiSi_3O_8$, Syenite is almost entirely composed of alkali feldspars, which are abundant in the rock and highly susceptible to chemical weathering, which converts the feldspars to kaolin. The likelihood of weathering increases due to rainfall in the Eastern Ghats and continuous wind movement from the nearby Bay of Bengal. The percentage of silica in the Nepheline Syenite indicates that it is an undersaturated rock. We know that when silica (SiO_2) is scarce, the Feldspathoid variety Nepheline ($Na\ AlSiO_4$) forms instead of albite ($Na\ Al\ Si_3\ O_8$). Because rocks

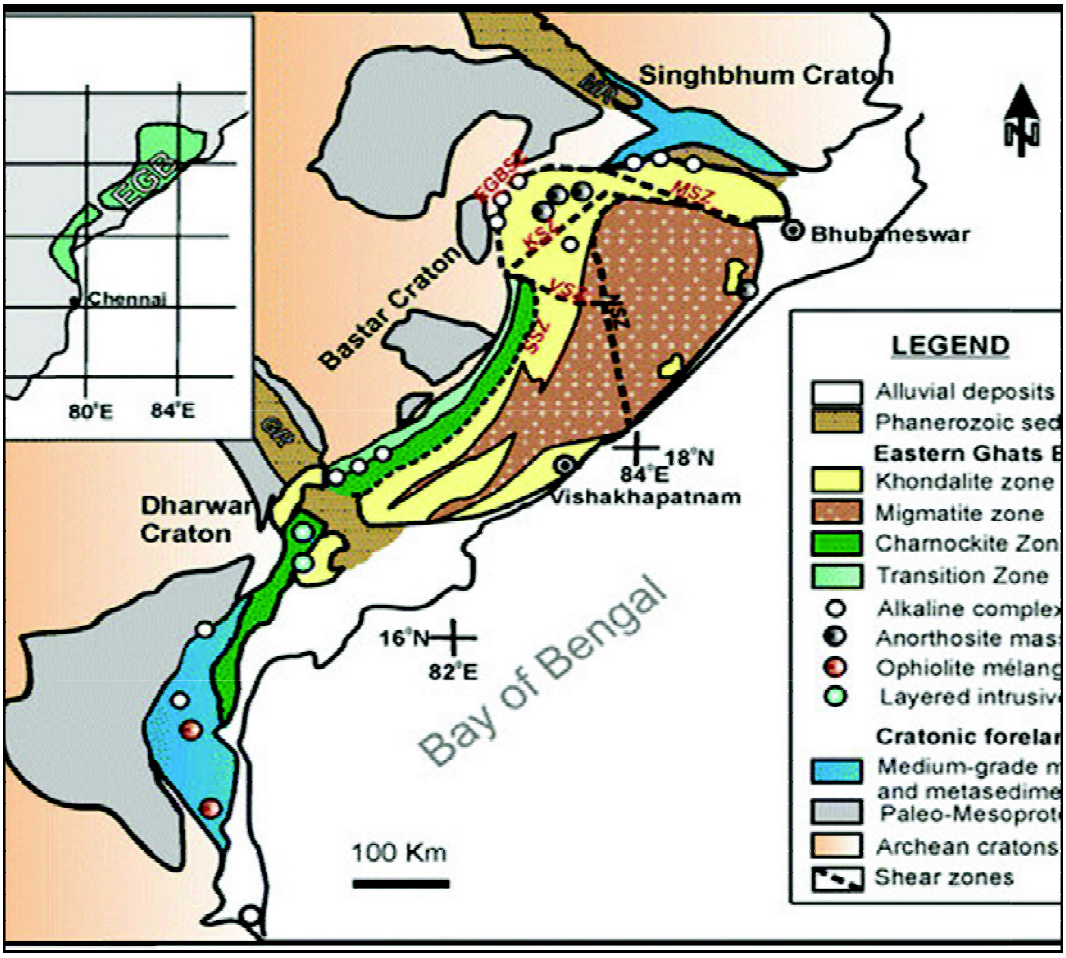

Figure 2: Sources have been drawn from *Generalized map of Eastern Ghats Belt* (modified after Ramakrishnan et al. 1998). Inset shows the position of EGB in present-day India. The present study area (marked as star) belongs to the central migmatitic zone according to **Ramakrishnan et al. (1998)** and domain 2 of **Rickers et al. (2001)**

contain less silica, they are more susceptible to weathering, which causes low-lying, continuous hills to form. The presence of ophiolite mélange is the intriguing aspect of the geological setup. The ophiolites are considered to be directly mantle derived rock and as it is identified as a tectonic melange, it may be visualized that certain large-scale tectonism had influenced the coastal dynamics to allow the emplacement of these mantle derived rocks.

The assemblage of rocks along with Alkaline plutons is clearly visible in the geological field studies of Andhra Pradesh and Kerala, South India, conducted by Takashi Myazakhi et al. (1999) (Figure 3). The close inspection notes that the term "granulite" has been mentioned in the index. This term has not yet been brought up in the discussion by the current author. Actually, the

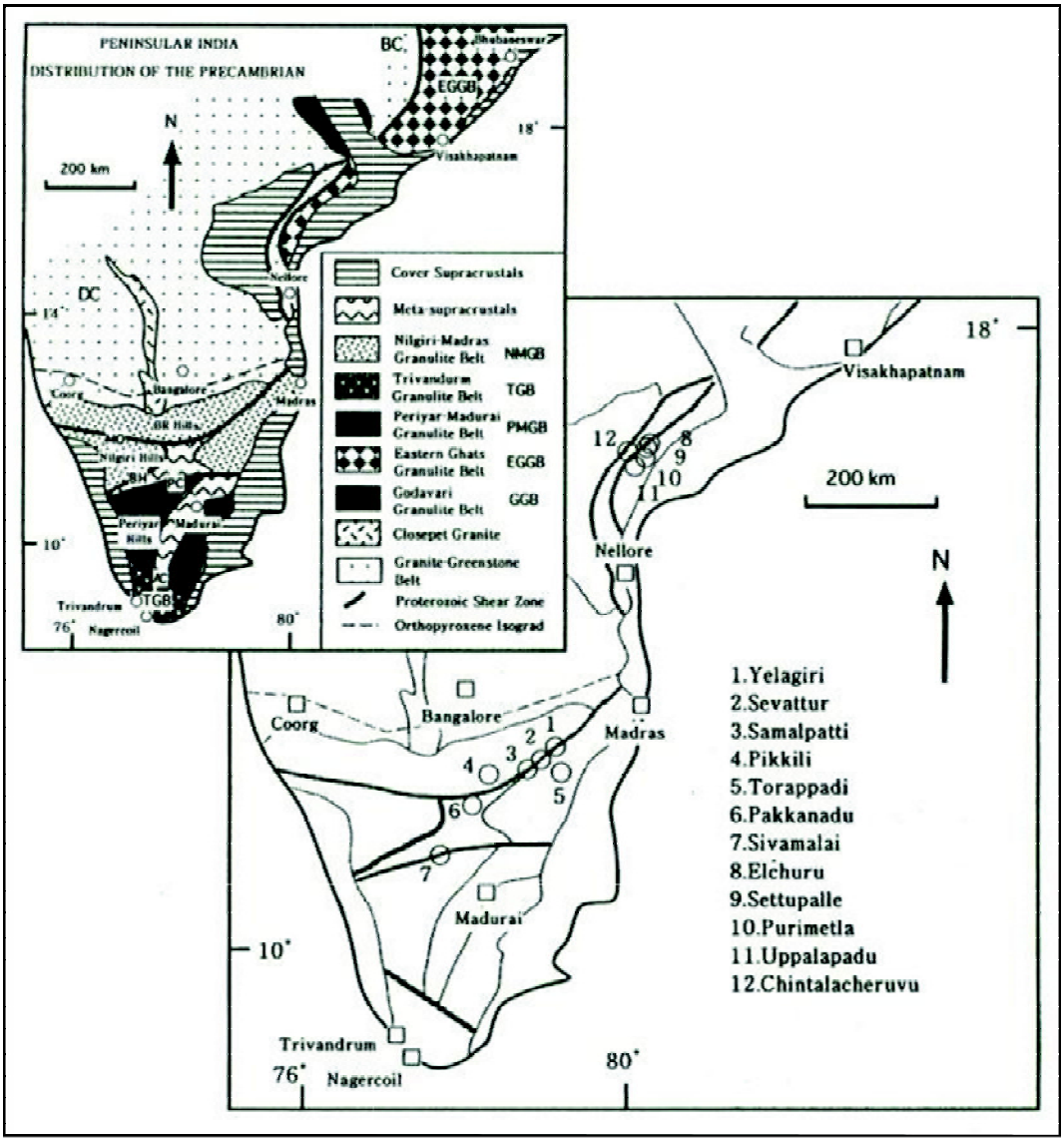

Figure 3:

term "granulite" refers to the highest grade of metamorphism that occurs before ultra metamorphism (ultra metamorphism is the process by which rocks melt to form anatectic or newly generated melt). The metamorphism of two distinct parent rocks with two different bulk chemistries results in the production of both Charnockites and Khondalites, a phenomenon known as Granulite Facies metamorphism, which is represented by the Eastern Ghats.

If we further pay our attention to different morphologies of varying litho- units, we gather ample information from the research paper of Ratnakar and Leelanandam (1989). The Figures 4,5,6 are presented here from their paper. All the figures are self-explanatory from the respective captions. The figures are shown below:

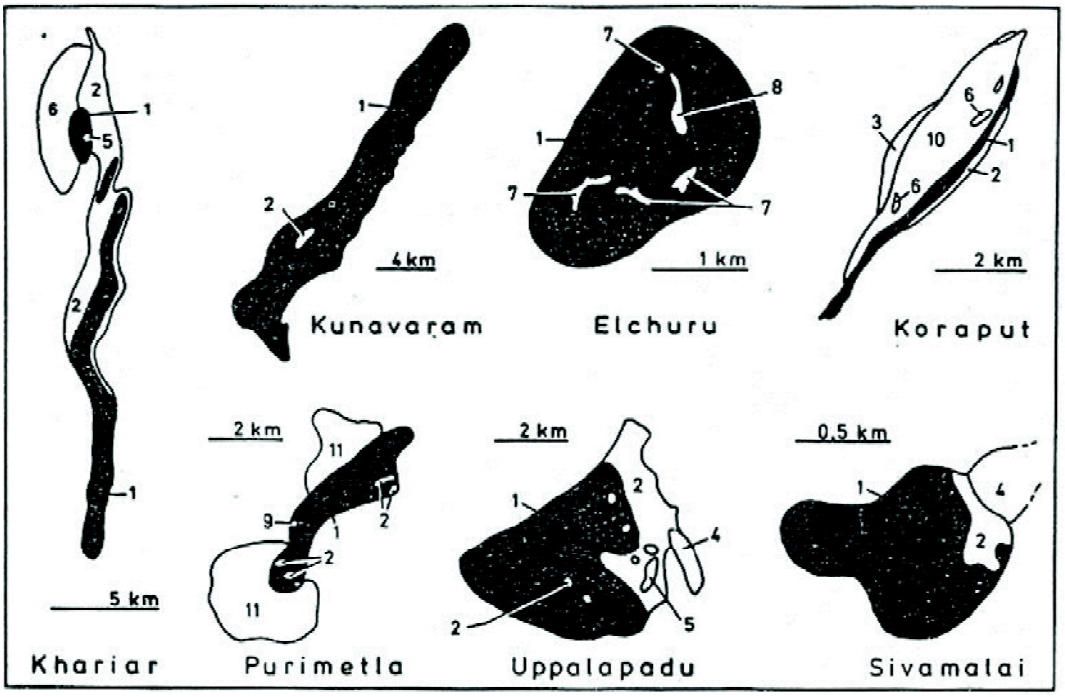

Figure 4: Shows the shapes and lithology of the important silica-undersaturated alkaline plutons from the Eastern Ghats. The nepheline syenite is shown in black to indicate its relative proportion to other rock types in each pluton. 1. Nepheline syenite. 2. Syenite, 3. Calc-alkali syenite, 4. Ferro (/olivine) syenite, 5. Quartz syenite, 6. Alkali granite, 7. Mesocratic malignite, 8. Shonkinite. 9. Malignite, 10. Alkali gabbro, 11. Tholeiitic gabbro. The quartz syenites of Kunavaram. Purimetla and Sivamalai, and carbonatites of Elchuru and Kunavaram plutons are not shown.

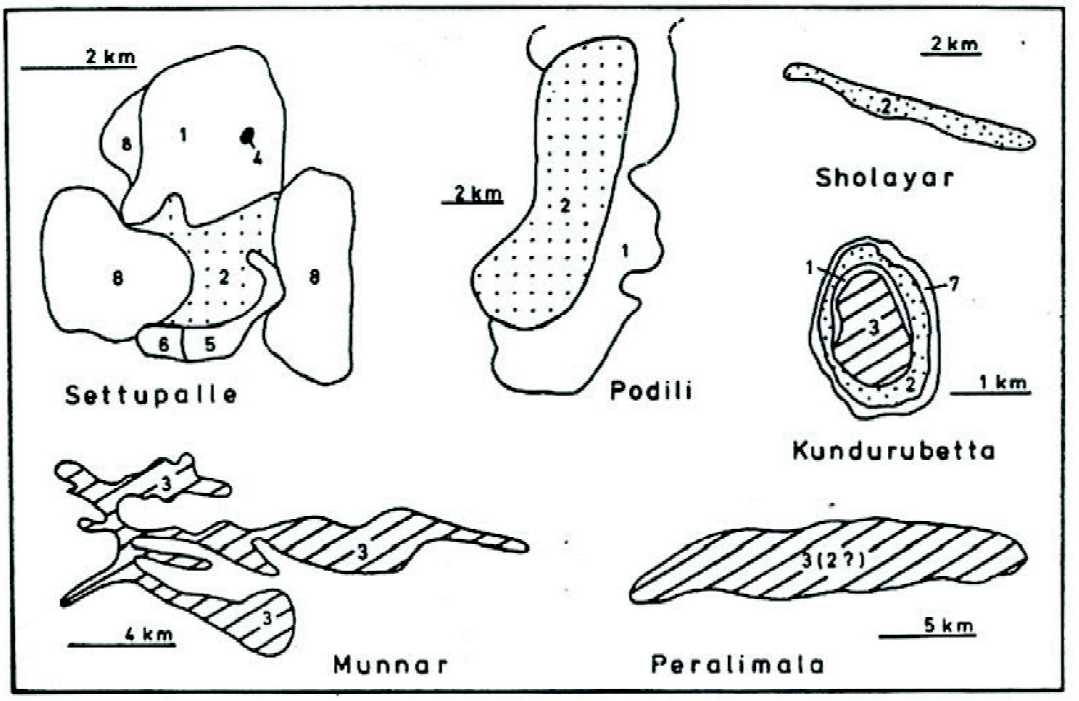

Figure 5: Shapes and lithology of some of the silica-saturated and -oversaturated plutons from the eastern and southern Peninsular India. The syenite is 'stippled' and alkali granite (/granite) is 'ruled' to indicate their relative abundance to the other rock types in each pluton. 1. Quartz syenite, 2. Syenite, 3. Alkali granite/granite, 4. Nepheline syenite, 5. Fayalite syenite, 6. Fayalite- quartz-syenite, 7. Mafic syenite, 8. Tholeiitic gabbro.

Conclusions:

From the foregoing discussion, it can be concluded that:

a. Though the Eastern Ghats are essentially composed of two major litho-units Charnockites and Khondalites, there are other litho-units as well;

b. The minerals present in such litho-units vary in their chemical compositions and they vary in their susceptibility to chemical weathering in terms of Goldich's series of weathering.

c. The geomorphological characteristics, including shapes of the concerned litho-unit outcrops change accordingly.

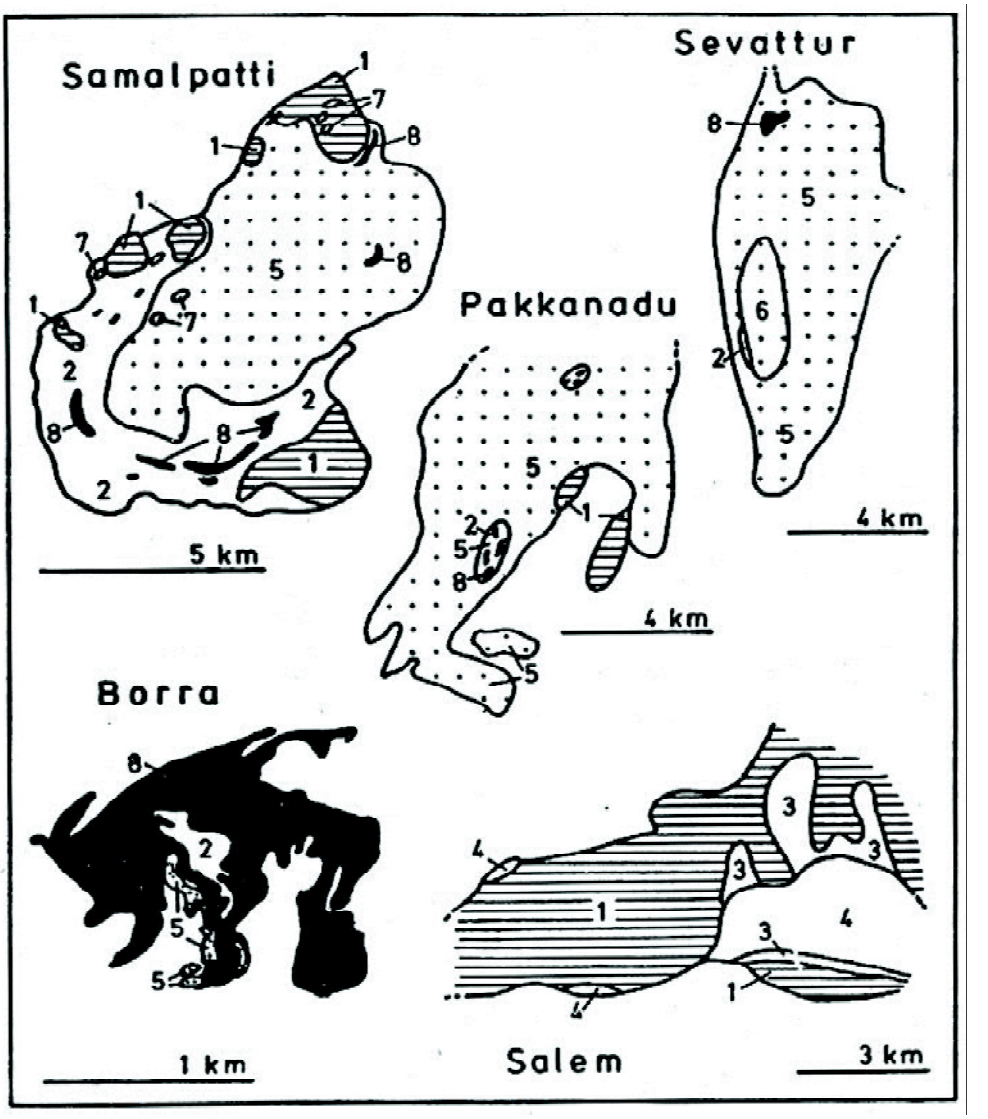

Figure 6: Shapes and lithology of the ultramafic rock-syenite-carbonatite complexes from the eastern and southern Peninsular India. The syenite is 'stippled', carbonatite is shown in black and dunite is ruled. 1. Dunite, 2. Pyroxenite, 3. Peridotite, 4. Shonkinite, 5. Syenite, 6. Mela-syenite, 7. Pegmatite, 8. Carbonatite.

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