



## **Petrography of ferrosyenites from the Cuddapah intrusive Province, Peninsular India**

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**Abstract:** *The paper deals with the petrographic details of the subalkaline ferrosyenites which are emplaced in the Cuddapah intrusive province (CIP) of peninsular India. These leucocratic rare rock types (colour index ranges 7 to 19 vol%) are found emplaced at Gundlapalle and Gokanakonda in the Guntur district and at Uppalapadu in the Prakasam district of Andhra Pradesh. All the ferrosyenites show equigranular, hypidiomorphic texture but mineralogically they are different, even though they are uniformly subalkaline in character. Ferrohedenbergite and its altered product called nontronite are found in Gundlapalle ferrosyenite, but fayalite along with clinopyroxene are found in Gokanakonda and Uppalapadu ferrosyenite. Again, at Gokanakonda, a second type of ferrosyenite is found with fayalite along with quartz.*

**Key words:** *Ferrosyenite, Hypidiomorphic Texture, Cuddapah intrusive province.*

### **1. Introduction**

Alkaline rocks are rare is a well known fact but when it comes to ferrosyenites, these rocks occur even more rarely in the world. In India one such occurrence of ferrosyenite was reported as early as in 1971 from Sivamalai, in Coimbatore district of Tamilnadu (Bose, 1971). In this paper the occurrence of ferrosyenites is reported from Gundlapalle, Gokanakonda and Uppalapadu plutons of Cuddapah intrusive province (CIP) in Andhra Pradesh. It must be stated here that the Prakasam alkaline province which was first proposed by Leelanandam (1981, 1989) subsequently renamed as Cuddapah Intrusive Province by Madhavan et al. (1995). The Gundlapalle syenite pluton occur towards the northern boundary of the intra cratonic Cuddapah basin and the eastern side of Gundlapalle village which is 12 km in distance from Piduguralla town of Guntur District.

The Gokanakonda and Uppalapadu ferrosyenites can be found towards the eastern side of the intra cratonic Cuddapah basin. The Gokanakonda ferrosyenites are located in the southern side of the Gokanakonda. The rock types present here are i) fayalite ± clinopyroxene (FC) syenite and ii) fayalite ± quartz (FQ) syenite. Both these rock types are medium grained leucocratic, which are more prominently exposed at Gokanakonda (fayalite ± clinopyroxene syenite) but less prominently at puvvada (fayalite ± quartz syenite), with Gundlakamma river separating both the rock types.

The Uppalapadu ferrosyenite occur within the Errakonda hill near Santhanuthalapadu village, which is close to Chimakurthy and Podili road. These syenites are mineralogically dissimilar and are leucocratic in nature, showing textural similarities.

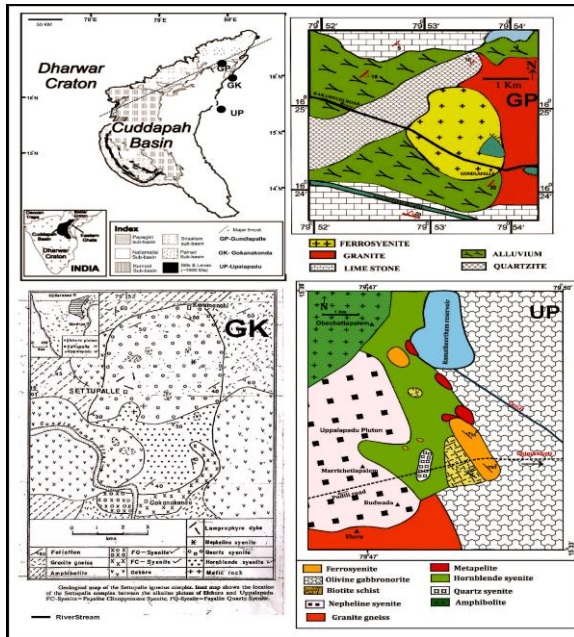
### **2. Field setup**

#### **2.1. Gundlapalle pluton**

The elliptical ferrosyenite pluton {16°24'N and 79°52'E} occurs as four mounds and is not well exposed even as it covers an area of about 3 km<sup>2</sup>. The pluton has a sharp contact with diverse lithological units with different age groups such as granite (eastern Dharwar) towards eastern side, Panyam quartzites towards western side and Narji limestones towards north and southern side belonging to (Palnad sub-basin) Kurnool group, where mostly the pluton is soil covered (Madhavan et al.1994). The pluton however, shows a sharp contact with the surrounding country rock (Fig:1 GP).

#### **2.2. Gokanakonda Pluton**

The ferrosyenites {16°01' N and 79°52' E} are hosted by Settupalle alkaline complex which occupies an area of 40 km<sup>2</sup>. The silica oversaturated and silica undersaturated Settupalle alkaline pluton from the Cuddapah intrusive province is confined to an extremely narrow linear belt which is close to the known basement fracture zone (Leelanandam 1989). The Gokanakonda (GK) subalkaline ferrosyenites occupy an area of 5 km<sup>2</sup> and are found towards the southern marginal portion of the Settupalle alkaline complex. Mineralogically, the ferrosyenite can be differentiated into two types (i) fayalite clinopyroxene syenite and (ii) fayalite quartz syenite. The fayalite ± clinopyroxene syenite is exposed on the eastern side and fayalite ± quartz syenite on the western side of Gokanakonda, with Gundlakamma river as the dividing line between these two ferrosyenites. The contact with gabbro and fayalite ± clinopyroxene syenite on the eastern side and fayalite ± quartz syenite on the western side is sharp (Leelanandam, 1989; T.P. Srinivas, 1990) (Fig.1 GK).



**Fig:1 LM (Location Map)-** Showing the locations of the three plutons with the background of Cuddapah Basin, Geological Maps of all the ferrosyenite plutons GK-Gokanakonda after Leelanandam et al. 1989. GP-Gundlapalle. UP- Uppalapadu.

**2.3. Uppalapadu Pluton**

The ferrosyenite {15°35'N:79°47'E} here is hosted by Uppalapadu alkaline complex and is combinedly enveloped by olivine clinopyroxenite, olivine gabbronorite, nepheline syenite, hornblende syenite, ferrosyenite, biotite schist and anorthosite, the pluton is spread in an area of 30 km<sup>2</sup>. The ferrosyenite has sharp contact in the north with metapelite and hornblende syenite and in the eastern side with olivine gabbronorite and with hornblende syenite and biotite schist on the western side (Krishna Reddy et al., 1997; Vijaya Kumar et al., 2007) (Fig.1 UP).

**3. Petrography and textural features**

The Gundlapalle ferrosyenite is a coarse to medium grained leucocratic equigranular hypidiomorphic rock which is mainly composed of ferrohedenbergite, alkali feldspar (microcline mesoperthite 82-83 vol % (as shown in Table. 2) with minor amount of hornblende, sphene, interstitial quartz, biotite, calcite and rutile (See Table 1). The presence of nontronite is an explicit evidence of extensive hydrothermal alteration of ferrohedenbergite to nontronite (golden brown colour) within the skeletal pyroxene crystals due to oxidation of hedenbergite (Eggleton 1975) (Fig.2a,b). Since, nontronite is a rare mineral its presence mentioned here with the evidence of its composition (SiO<sub>2</sub>-41.16. Al<sub>2</sub>O<sub>3</sub>-6.05. TiO<sub>2</sub>-0.04. FeO-34.59. MnO-1.25. MgO-1.71. CaO-0.19. Na<sub>2</sub>O-0.18. K<sub>2</sub>O-2.23. BaO-0.03. Cr<sub>2</sub>O<sub>3</sub>-0.08; Oxygens - 22. Si-6.577. Al-1.141. Ti<sub>2</sub>-0.008. Fe-4.160. Mn-0.170. Mg-0.408. Ca-0.030. Ma-0.068. K-0.455. Ba-0.002.Cr-0.010 (Madhavan et al., 1994).

The Gokanakonda ferrosyenites are coarse to medium grained, leucocratic in nature and show equigranular hypidiomorphic texture (as shown in Table 1). Based on mineralogical phenomena, the ferrosyenites are divided into two types as (i) fayalite clinopyroxene syenite which is composed of major amounts of alkali feldspars (72-75% see Table 2) and minor amounts of plagioclase, fayalite, ferroaugite, ferrohastingsite, amphibole, quartz, biotite and opaques (Fig.2c). (ii) fayalite quartz syenite which is composed of alkali feldspars 65-67% (see Table 2), quartz as essential and fayalite, amphibole, biotite, opaques as accessories minerals (Fig.2d).

The Uppalapadu ferrosyenite is coarse to medium grained, leucocratic in nature and shows equigranular hypidiomorphic texture (Table 1). In view of the mineralogy, the syenite consists of pyroxenes, fayalite, perthitic K-feldspar 67-69% (see Table 2), plagioclase, Fe-augite and inverted pigeonite, garnet, apatite and calcite (Fig.2e. f).

The Sivamalai ferrosyenite is greenish grey in colour, leucocratic and medium to fine grained, which under microscope shows an equigranular hypidiomorphic granular texture and is composed of olivine (Fayalite), alkali feldspar, clinopyroxene, plagioclase, amphibole, biotite and iron oxides. The modal composition of the area is given in the table 2. For comparison here the ferrosyenite studied from Sivamalai in Tamilnadu (Bose, 1971) has been included.

**4. Summary and Conclusion**

All the ferrosyenites of Gundlapalle, Gokanakonda and Uppalapadu plutons exhibit leucocratic nature and shows equigranular hypidiomorphic texture but mineralogically they are different from each other. After an extensive petrographic study on Gundlapalle ferrosyenites it is concluded that Fe-clinopyroxene (ferrohedenbergite) is associated with alkali feldspars which is a major mineral in that rock. The presence of ferrohedenbergite bearing syenite in Gundlapalle ferrosyenite is analogous to similar ferrosyenites of the world like Davidki Intrusion layered complex of Ukraine (Krivdik et al., 1986), Clinopyroxene quartz syenite from New Jersey (Young, 1972), Klokken gabbro-syenite intrusion Greenland, Alan et al.1975), Kiglapait Intrusion (Labrador Barmina and Ariskin 2002) and Uppalapadu ferrosyenite (Krishna reddy et al. 1997). All the ferrohedenbergite bearing syenites are quite different to Gundlapalle syenite as the latter is hydrothermally altered, which is proved by the evidence of conversion of ferrohedenbergite to golden brown nontronite. Most of the ferrosyenites in the world are genetically associated with gabbros, but in the case of Gundlapalle it is devoid of this kind of association.

The Gokanakonda ferrosyenites also show equigranular hypidiomorphic texture. Fayalite is the primary Fe-rich mineral in these rocks. Based on

mineralogical aspect the ferrosyenites can be divided into two types (i) fayalite clinopyroxene syenite (ii) fayalite quartz syenite, the magmatic differentiation process can be observed in the entire ferrosyenite pluton. The clinopyroxene is present only in FC-

syenite but not in FQ-syenite, because due to the early stage fractionation of Fe rich clinopyroxene and appearance of independent quartz as the end product in FQ-syenite.

**Table 1.** Texture and mineral assemblages of ferrosyenite from the following plutons

S.No.	Name of the Pluton	Grain size	Texture	Mineral assemblages
1	GUNDLAPALLE	Coarse to medium	Equigranular hypidiomorphic	Ferrohedenbergite, Alkali feldspars, Hornblende, Nontronite, Quartz, Biotite, Rutile, Calcite, Magnetite.
2	GOKANAKONDA	Coarse to medium	Equigranular hypidiomorphic	<b>FC-Syenite</b> -K-feldspars, Plagioclase, Fayalite, Ferroaugite, Ferrohastingsite, Quartz, Biotite, Opaques. <b>FQ-Syenite</b> -Alkali feldspars, Fayalite, Quartz, Amphibole, Biotite, Opaques.
3	UPPALAPADU	Coarse to medium	Equigranular hypidiomorphic	Pyroxene, Fayalite, Perthitic K-Feldspar, Plagioclase, Ferroaugite and Garnet, Apatite, Calcite.

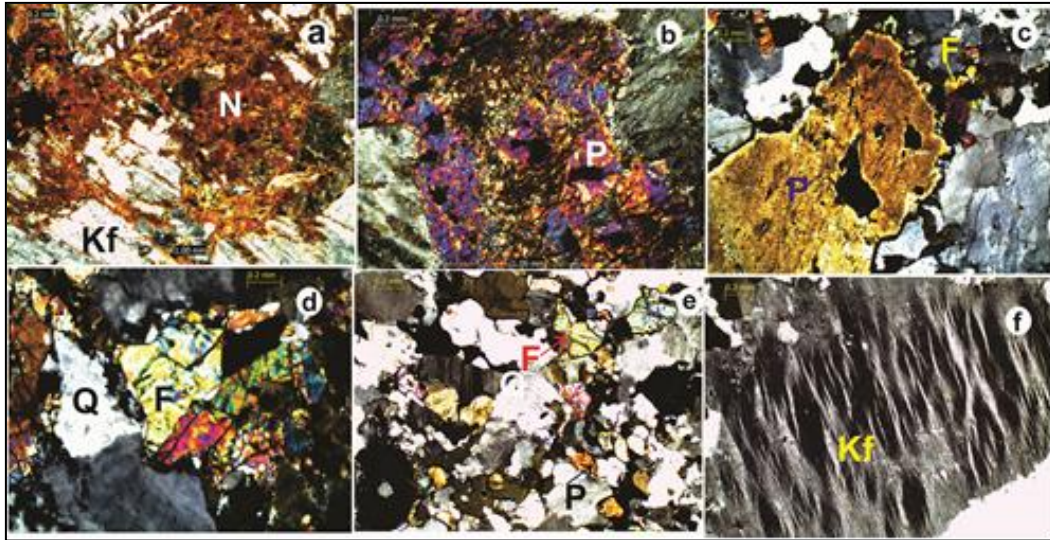
**Table 2.** Modal composition (Vol %) of the ferrosyenites from Gundlpalle, Gokanakonda, Uppalapadu and Sivamalai plutons

S.No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Minerals</b>															
Quartz	1.0	3.8	5.2	-	2.0	1.5	18	17	-	11.9	1.5	2.0	1.0	tr	0
K-Feldspar	83	80	82	88.0	72	75	65	67	75	54.1	69	68	67	68	
Plagioclase	-	-	-	-	9.0	7.2	7.6	6.5	8.4	24.5	11	9.0	12	8	88.2
Olivine	-	-	-	-	4.5	4.2	3.5	3.7	5.7	1.9	1.9	1.5	0.9	4	5.0
Clinopyroxene	7.2	4.0	3.2	6.0	6.5	7.0	-	-	6.6	-	8.0	10	2	3	1.0
Amphibole	3.1	2.5	2.1	2.8	1.5	1.2	-	-	2.0	1.7	3.2	3.0	2.5	9	0.5
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	8.0	-	-
Biotite	0.2	0.1	0.1	0.1	3.0	2.5	0.1	0.1	0.5	-	0.8	0.5	4.0	-	1.5
Nontronite	-	4.0	4.6	1.0	-	-	-	-	-	-	-	-	-	-	-
Magnetite	4.0	2.5	1.9	1.4	1.0	0.5	4.0	4.9	1.0	-	1.0	1.5	1.0	5	0.5
Sphene	0.5	-	-	0.2	-	-	-	0.2	-	-	-	-	-	-	-
Calcite	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Apatite	0.2	0.1	-	0.1	0.4	-	-	-	0.6	-	2.0	1.9	1.5	2	0.1
<b>Total</b>	99.4	97	99.1	99.6	99.9	99.1	98.2	99.4	99.8	94.1	98.4	97.4	99.9	99	96.8
<b>Colour Index</b>	15.0	13.1	11.9	11.5	16.5	15.4	7.6	8.7	15.8	3.6	19.0	16.3	9.5	21	9

1-4: Gundlapalle, 5-6: Gokanakonda, 7-8: PV- Puvvada, 11-13: Uppalapadu and 15: Sivamalai [ 4-Madhavan et al 1994. 9-FC syenite.10-FQ-syenite Srinivasan et al 1995. 14- Krishna Reddy et al 1997. 15-Subba Rao et al 1994).

The Uppalapadu ferrosyenite exhibits equigranular hypidiomorphic texture and is composed of fayalite and Pyroxenes. Most of the ferrosyenites in the world have genetic relation with gabbroic rock as seen in Gokanakonda and Uppalapadu ferrosyenite plutons but unlike at Gundlapalle. The presence of fayalite bearing syenite in Gokanakonda and Uppalapadu ferrosyenites can be compared with the famous ferrosyenite plutons of the world such as Coldwell (Roger et al.1977): Agnew Intrusion (Ontario) (Vogel et al.1999): Mont Megantic (Quebec. Tomas Feininger, 2003). Western Creek, Pikes Peak batholiths (Diane et al., 1999). Kambusi, Congo (Ramvegri et al., 1985).

Thus, all the three ferrosyenites of the CIP are Megascopically dark looking “due to the dark grey colour of the feldspar” but microscopically they are leucocratic. Studies reveal that all the three ferrosyenites are the products of fractional crystallization of a gabbroic/tholeiitic basaltic magma which must have crystallised under reducing low fO<sub>2</sub> conditions. (Madhavan et al., 1994; Leelanandam et al., 1989; Srinivas et al.1990; Krishna Reddy et al., 1997; Sai Krishna et al., 2017).



**Fig 2.** Photomicrographs of ferrosyenites from three plutons: **a** and **b** Gundlapalle, **c** and **d** Gokanakonda and **e** and **f** Uppalapadu (**a**) Microcline mesoperthite (Kf) and Nontronite (N) (**b**) Altered pyroxene is associated with skeletal pyroxene crystals (P) (**c**) fayalite (F) associated with pyroxene (P) (**d**) fayalite (F) associated with quartz (Q) (**e**) pyroxene crystals (P) associated with fayalite (F) (**f**) braided perthite (Kf).

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