# The Kondapalli Layered Complex, Andhra Pradesh, India: geology, mineralogy and chemistry

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The Kondapalli Layered Complex (KLC) consists of dominant gabbroic and anorthositic rocks, with subordinate ultramafic rocks (orthopyroxenites, websterites; clinophyroxenites; dunites and harzburgites) which contain chromitites (with orthopyroxene, clinopyroxene or amphibole, but not with olivine or plagioclase); the complex does not contain wehrlite, lherzolite and troctolite. The KLC occurs as minor bands and lenses within a region dominated by charnockites; it is variably deformed and it is cut by rare metadolerite dykes. The KLC represents a discontinuous stratiform-type complex and its disrupted fragments contain different components in disproportionate amounts (Leelanandam, 1991).

Most of the KLC displays layered characters, and it essentially consists of plagioclase, orthopyroxene and clinopyroxene in different combinations, with variable proportions and with diverse textural relationships. The inferred order of crystallization was ol, ol + opx, opx(±plag), opx + cpx(±plag), cpx(±plag), opx + cpx + plag, plag(+cpx + cpx). In chromitites, chromite is not only enclosed by, but also encloses, pyroxene and amphibole; suggesting overlapping periods of crystallization of different phases. The rocks in general exhibit textures showing much subsolidus re-equilibration and cumulate textures are well preserved with adcumulus growth as the dominant form of post-cumulus enlargement. Variable deformational textures are particularly conspicuous in the ultramafic rocks, and also in those rocks occurring along the marginal portions and local shear zones. The quartz-bearing (anorthositic, enderbitic and other felsic) rocks, with conspicuous deformational and cataclastic textures, are interpreted as contaminated or mixed rocks occurring at the tectonized junction zones between the KLC and enclosing charnockites. Symplectic and coronitic textures are typically absent in the rocks from KLC. The KLC is the only one of its type in the entire Eastern Ghats mobile belt of Peninsular India (Leelanandam, 1990).

The 45 whole rock analyses from the KLC represent a fairly extended spectrum in chemical fractionation. The remarkably wide variations in the chemistry of the ultramafic rocks (Table 1) reflect the dramatic changes in modal mineralogies and cumulate nature of the mineral phases. In the chemical variation diagrams, a great similarity is noticed between the differentiation trends for KLC and other layered complexes. A major chemical hiatus exists between the ultramafic and gabbroic groups, and a major one between the gabbroic and anorthositic groups. A rather regular reciprocal relationship between the ($MgO + Fe_2O_3^t$) and ($CaO + Al_2O_3$) contents exists among the ultramafic rocks, and also among the gabbroic-anorthositic rocks.

TABLE 1. Ranges of bulk rock composition

| Wt.% | Ultramafic rocks & mafic gabbros (15) | Gabbros & anorthositic gabbros (9) | Gabbroic anorthosites & anorthosites (12) |
|---|---|---|---|
| $SiO_2$ | 39.68–53.45 | 48.43–53.07 | 47.61–49.80 |
| $TiO_2$ | 0.04–3.44 | 0.13–1.31 | 0.10–0.23 |
| $Al_2O_3$ | 0.48–15.07 | 15.18–20.78 | 26.14–30.10 |
| $Fe_2O_3$ | 1.04–5.78 | 0.69–1.69 | 0.11–1.62 |
| FeO | 4.28–20.88 | 4.00–11.28 | 1.20–4.68 |
| MnO | 0.10–0.37 | 0.08–0.20 | 0.03–0.10 |
| MgO | 6.85–47.52 | 5.19–9.23 | 1.78–4.46 |
| CaO | 0.21–19.66 | 7.78–12.05 | 12.24–15.24 |
| $Na_2O$ | 0.20–2.07 | 1.05–3.82 | 1.86–2.88 |
| $P_2O_5$ | 0.01–0.14 | 0.02–0.50 | 0.01–0.06 |

The mineral analyses of 4 olivines ($Fo_{95-87}$), 19 orthopyroxenes ($Ca_{0.3-1.7}Mg_{93.3-50.5}Fe_{6.4-47.9}$), 13 clinopyroxenses ($Ca_{39.3-51.2}Mg_{53.7-36.0}Fe_{3.5-19.5}$), 11 amphiboles ($Ca_{27.4-30.3}Mg_{67.5-37.6}Fe5.0-34.2$), 13 plagioclases ($An_{100-76}$; $An_{54}$) and 13 chromites with $(100Mg/(Mg+Fe^{2+}) = 66-26$; $100Cr/(Cr+Al) = 48-75$; $100Cr/\Sigma^{3+} = 73-35$; $100Fe^{3+}/\Sigma R^{3+} = 3-36$; $100Al/\Sigma R^{3+} = 23-40$) from the KLC represent considerable chemical variation. There is a compositional break between the minerals from chromitites and ultrafamic rocks, and between the minerals from ultramafic rocks and gabbroic-anorthositic rocks (Leelanandam, 1991). The compositional variations of the minerals, though dramatic in some cases, are grossly correlatable to the nature of the host rocks and to the mode of their occurrence (as cumulus or intercumulus phases, lamellae or inclusions).

The KLC exhibits several peculiar mineralogical features: (1) pure Ca-end member of the plagioclase series ($An_{100}$) as an intercumulus phase in amphibole-zoned spinel- (garnet)- bearing orthopyroxenites; (2) nearly pure K-feldspar ($Or_{>90}$) exsolution rods or blebs in the high calcic plagioclase ($An_{>90}$). Often zoned ($An_{66-92}$) and untwinned, in the tectonized quartz-bearing anorthosites; (3) twinned plagioclase ($An_{42}$) exsolution lamellae in the orthopyroxene ($En_{45}$) from the deformed enderbitic rocks which contain antiperthites ($Or_{5-3}Ab_{53-44}$ $An_{42-53}$) and which exhibit no coherent relationships between the En contents of orthopyroxenes, An contents of plagioclases and the acidity ($SiO_2$%) of their host rocks; (4) inter- and intra-granular compositional variation and different zoning patterns in chromite of the chromitites and ultramafics; and (5) dense networks of fine exsolution lamellae of Cr-, Al- and Mg-rich chromite in $Fe^{3+}$- and $Fe^{2+}$-rich host chromite. Some of these unique features demand high solidus temperatures at moderately high pressures under essentially anhydrous conditions, and preclude the possibility of any simple and straightforward magmatic history for the KLC. Chilled margins, contact metamorphic zones, xenoliths and late differentiates (such as ferro-diorites and granophyres) are not observed for the KLC. The rare metadolerite dykes ($851 \pm 28$ Ma, whole rock K-Ar age) which cut the KLC contain: intensely clouded plagioclase ($An_{58}$) with rare zoning ($An_{44-65}$), bent twin lamellae and wavy extinction in curved laths; clinopyroxene with clouding and zoning; subordinate orthopyroxene and relict olivine; secondary hornblende and biotite; and insignificant amount of garnet.

It is tentatively suggested that two parental magmas gave rise to the KLC: (1) a magnesian liquid to yield a variety of the ultramafic rocks; and (2) an alumina- rich tholeiitic liquid to give gabbroic and anorthositic rocks. Certain features suggest a moderate activity of water in the magma (at least on a local scale in the very early stages), and the prevalence of oxidising conditions (high oxygen fugacity) at least for restricted periods. These features include the abundance of amphibole (with complex chemical substitutions) in certain chromitites, its occurrence is some ultramafic rocks (together with the presence of magnetite bands in green spinel and ilmenite-hematite intergrowths) and its general presence in the gabbroic and anorthositic rocks, besides the preponderance of $Fe^{3+}$ over $Fe^{2+}$ in the rare Fe-rich chromite associated with orthopyroxene.

The KLC magmas have intruded dry country rocks (granulites) at depth (lower to middle crustal levels) under moderately high pressure, probably at a time just after peak metamorphism, and cooled slowly together with the enclosing granulites. Substantial subsolidus re-equilibration has taken place in all the rocks under nearly identical physical conditions characteristic of the granulite facies metamorphism.

## References

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