Spatial greenstone-gneiss relationships: evidence from mafic-ultramafic xenolith distribution patterns

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ABSTRACT

The distribution patterns of mafic-ultramafic xenoliths within Archaean orthogneiss terrain furnish an essential key for the elucidation of granite-greenstone relations. A complete gradation in scale exists between synclines, large-scale outliers and outcrop-scale xenoliths of mafic and ultramafic metavolcanic rocks. Accordingly, most greenstone belts constitute "mega-xenoliths" rather than primary basin structures. Transition along strike and across strike between stratigraphically low greenstone sequences and xenolith chains demonstrate their contemporaneity, as shown for example in Fig. 1 where the relationships between the Holenarsipur greenstone belts and associated xenoliths in southern India are portrayed. Regional to mesoscopic-scale characteristics of xenolith swarms and their relations with early greenstone units are well expressed in parts of the Pilbara Block, Western Australia. Xenolith distribution patterns in dome-arcuate syncline gneiss-greenstone terrains define subsidiary gneiss domes within the batholiths. These terrains represent least deformed cratonic "islands" within an otherwise penetratively foliated deformed gneiss-greenstone crust. The oval gneiss domes are thought to have developed originally by magmatic diapirism - evidenced by intrusive relations and contact aureoles - followed by late-stage solid state uprise related to isostatic adjustments. The late vertical movements were associated with development of major shear zones along tectonized boundary zones of batholiths, where interdigitated deformed gneiss-amphibolite schist intercalations were derived by the attenuation of xenolith-rich orthogneiss. The deformation process involved interthrusting and refolding of the interleaved plutonic and supracrustal units. The exposure of high grade metamorphic sectors is related to uplift of deep seated zones of the batholiths along reactivated faulted boundaries. Transitions from granite-greenstone terrains into gneiss-granulite suites involve a decrease in the abundance of supracrustal enclaves and an increased strain rate. Whereas early greenstone sequences are invariably intruded by tonalitic/trondhjemitic/granodioritic gneisses, stratigraphically higher successions may locally overlap older gneiss terrains and their entrained xenoliths unconformably. The contiguity

of xenolith patterns suggests their derivation as relics of regional mafic-ultramafic volcanic crustal units and places limits on horizontal movements between individual crustal blocks.

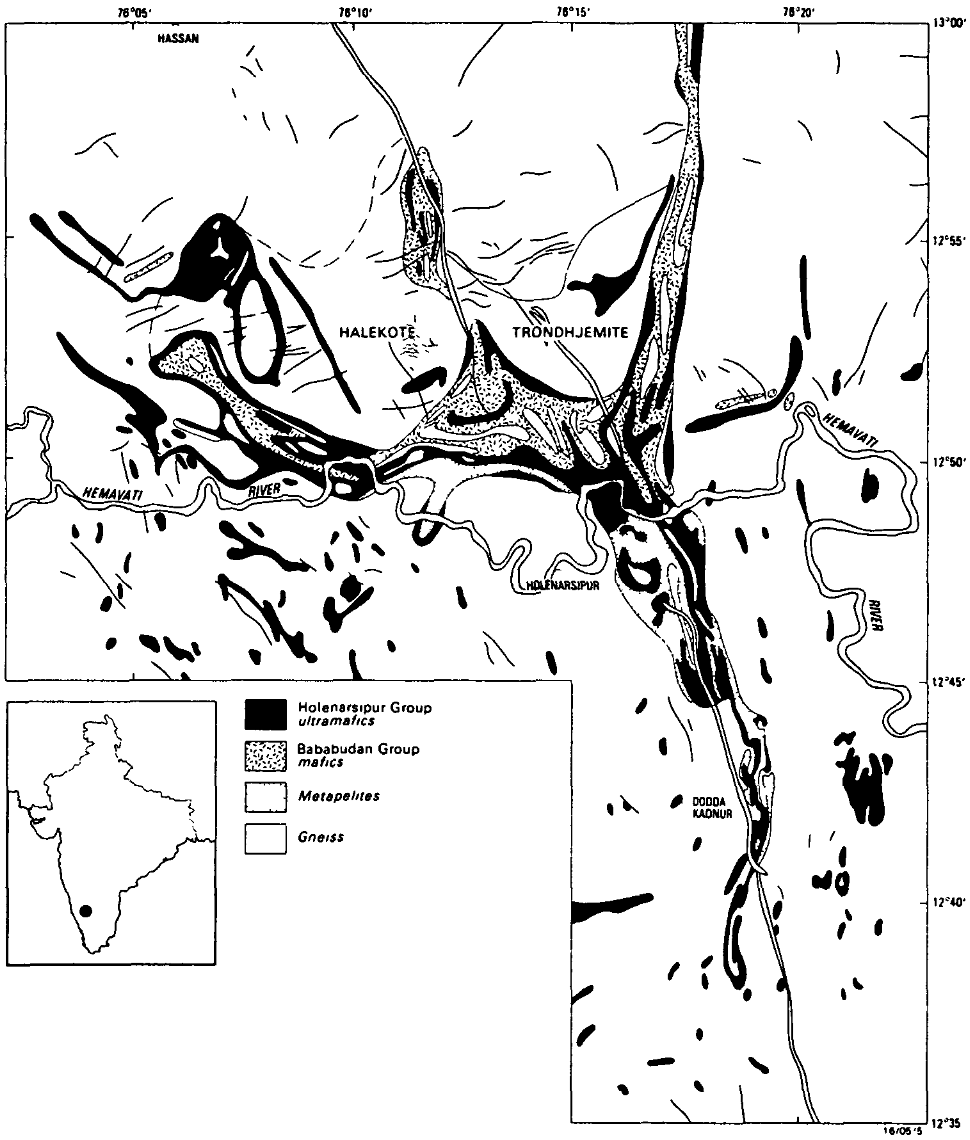

Fig. 1 - A geological sketch map of the Holenarsipur greenstone belt, Karnataka (after Naqvi, 1981, J. Geol. Soc. India, 22:458-469)

Alternative models of granite-greenstone relations are portrayed in Fig. 2. Model 1 applies to late greenstone belts overlapping sial whereas model 2 to early belts or stratigraphically basal volcanic units believed to be derived from simatic crust. Major detachments along gneiss-greenstone boundaries and local overfolding and thrusting suggest horizontal tectonic translations. These are overprinted by the dominantly vertical tectonic movements related to the diapriric (magmatic and post-magmatic) uprise of the tonalite/trondhjemite plutons. The contiguous temporal-spatial grid outlined by the xenolith swarms constrains major lateral movements of individual blocks relative to each other, placing limits on plate tectonics interpretations.

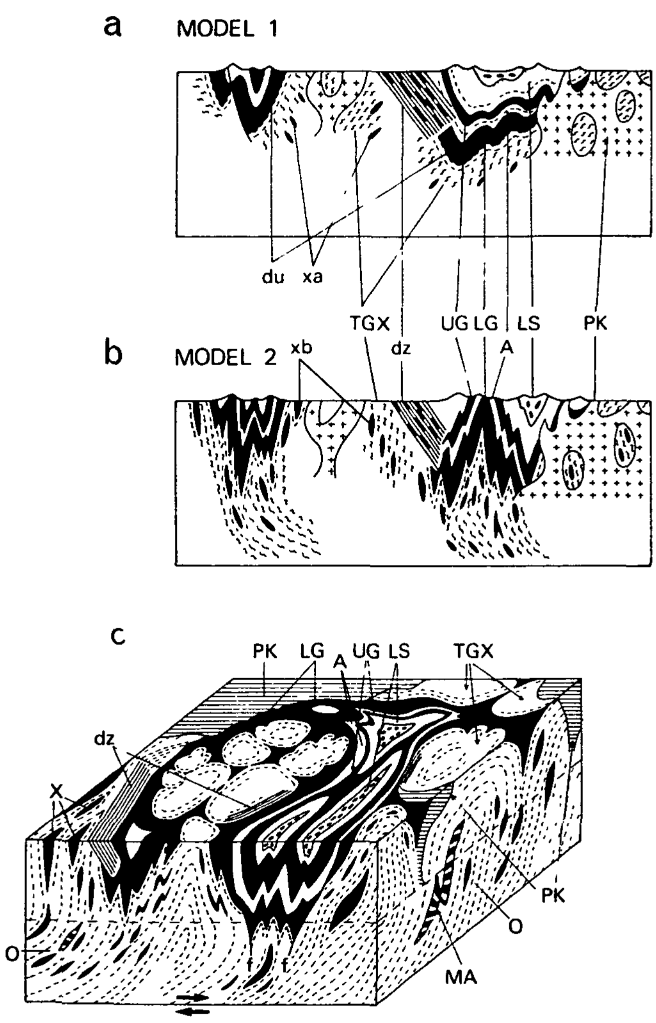

Fig. 2 - Alternative models of gneiss-greenstone relationships.
a - model 1 - gneiss-greenstone basement-cover relations, involving deformed unconformities (du).
b - model 2 - gneiss-greenstone relations involving primary and deformed intrusive contacts.
c - model 2 portrayed in block diagram, showing transition from granite-greenstone to gneiss-granulite terrain with crustal depth.
LG - lower greenstone
UG - upper greenstone
A - acid volcanics & sediments; TGX - Na-gneiss with xenoliths;
PK - late granites;
dz - deformed zone;
LS - late sediments;
O - orthogneiss;
MA - mafic and anorthositic inclusions;
x, xa, xb - xenoliths