CHAPTER - X

GEOLOGICAL EVOLUTION OF THE AREA

NEED FOR ALTERNATIVE MODEL

The author has rallied a variety of evidence based on his own data from the Ambamata area as well as its environs, as also on the work of Desai et al. (1978) and Sychanthavong (1978), to build up an evolutionary history which provides an alternative to the existing picture. As Sychanthavong (1978) has rightly pointed out, the geological framework of S. Rajasthan and N. Gujarat, based on classical concepts of isostasy, geosyncline and mountain building, when examined in detail, fails to explain quite a few facts of the geology of this region.

The Delhi System according to most previous workers is supposed to have been deposited in an autogeosyncline within a cratonic landmass made up of Aravalli, B.G.C. and Bundelkhand granite. This does not appear to be valid. The basement rocks (Aravallis) to the east and west of the Delhi synclinorium are not identical. Also the 'unconformable' contacts on the two flanks are quite different. An inverted unconformity with pebbly and conglomeratic quartzite is recorded in the east, while the western contact is nowhere in any manner indicative of an unconformity. It is further seen that the Alwar sequence, well exposed in the east, is absent in the west. Also the grade of metamorphism of Alwar Series is much low as compared to that of Ajabgarhs. These two facts clearly point to the possibility that Alwars and Ajabgarhs do not belong to the two successive stages of deposition in an autogeosyncline, as envisaged by Heron and others.

Further, a striking and important anomalous features of the Precambrian geology of Western India is the progressive increase of metamorphism from east to west, irrespective of the age and structural setting of the rocks. The Aravallis in the east show a low grade. The Delhis also in the eastern part are relatively less metamorphosed, but on going westward, they show an increasingly higher metamorphic grade, so much so that in the west, near the contact with Aravallis, they are almost granulitic. The Aravalli rocks also here are of high grade metamorphic assemblage. This phenomenon of increasing metamorphic grade from east to west cutting across the Delhi synclinorium, cannot be explained by the existing concepts.

The structural framework of the Delhis in this part also points to a different evolutionary model. The recognition of two co-axial NNE-SSW foldings F_1 and F_2 with associated longitudinal dislocations, and the subsequent superimposition of WNW-ESE folding F_3 has necessitated a reinterpretation.

A PROTO-PLATE TECTONIC MODEL

Sychanthavong (1978) has applied the concept of proto-plate tectonics for the Precambrian evolution of the north-western Peninsular India.

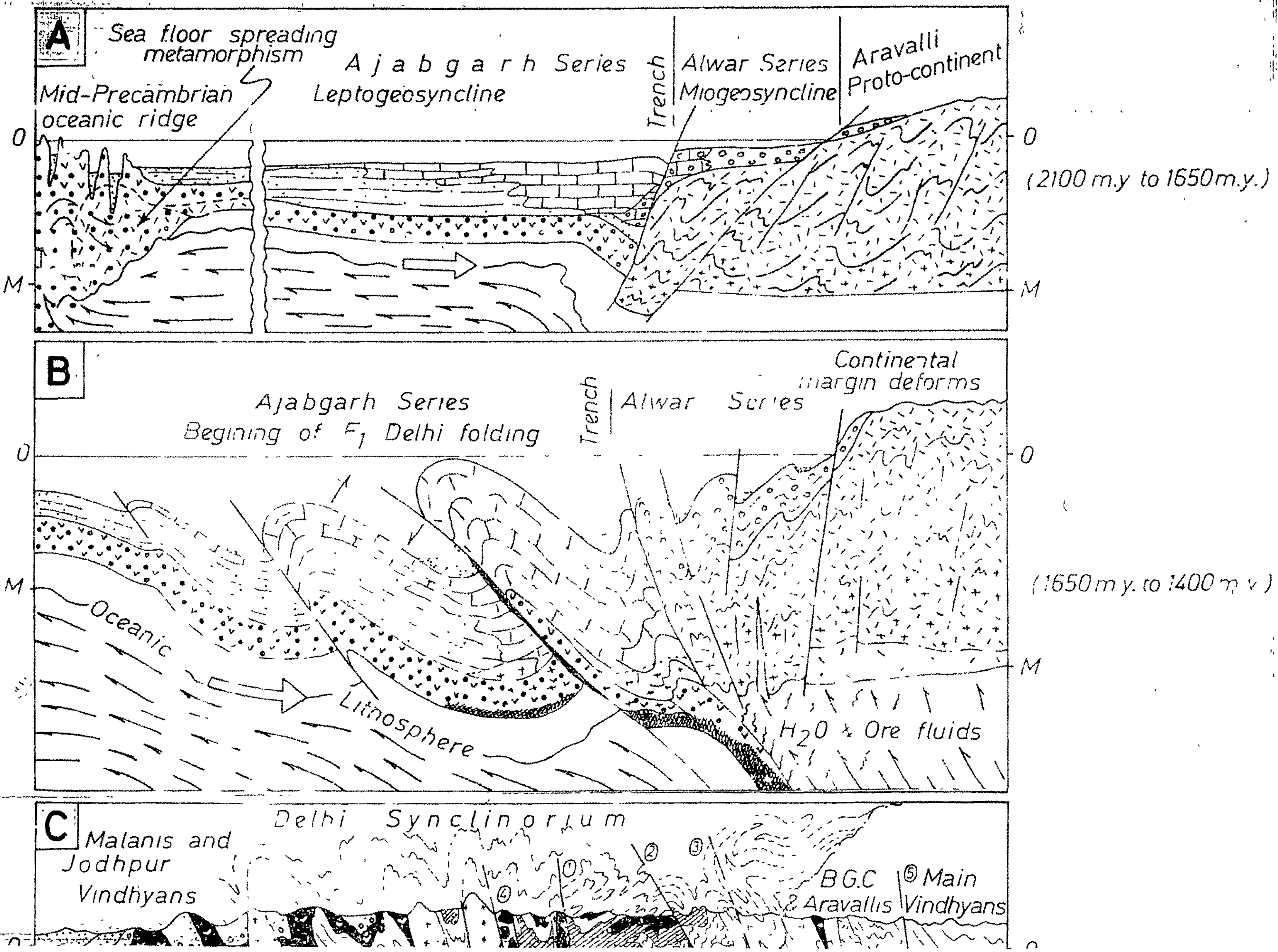
In recent years, the plate-tectonic mechanism has been invoked by several workers to explain Pre-Mesozoic orogenies. Global tectonic processes analogous to those operating in more recent time have been considered operative in Precambrian also (Smith, 1976). About a decade back Goodwin (1968) came out with a suggestion that the Archean greenstone sequence represented remnants of ancient ocean floor, and visualised a sea floor spreading process during Precambrian times. More recently, Green (1975), on the basis of experimental studies, have suggested that Komatiite sequences represent Archean mid-oceanic centres. A number of workers (Condie, 1972, 1973; Katz, 1972, 1974; Dewey, 1976; Burke et al., 1976 and others) have in more recent years, invoked the proto-plate tectonic concept even for Precambrian orogenies. Burke, Dewey & Kidd (1976) have come with very convincing argument in favour of proto-plate tectonics. They have analysed all the available published palaeomagnetic data on Precambrian rocks by plotting them on 'Equal-Area Polar Stereogram' to test the validity of the geological evidences of ancient plate collisions. The validity of proto-plate tectonics has received support from Miyashiro (1972a, 1972b and 1973) who has put forth the "Concept of Paired and Unpaired Metamorphic Belts".

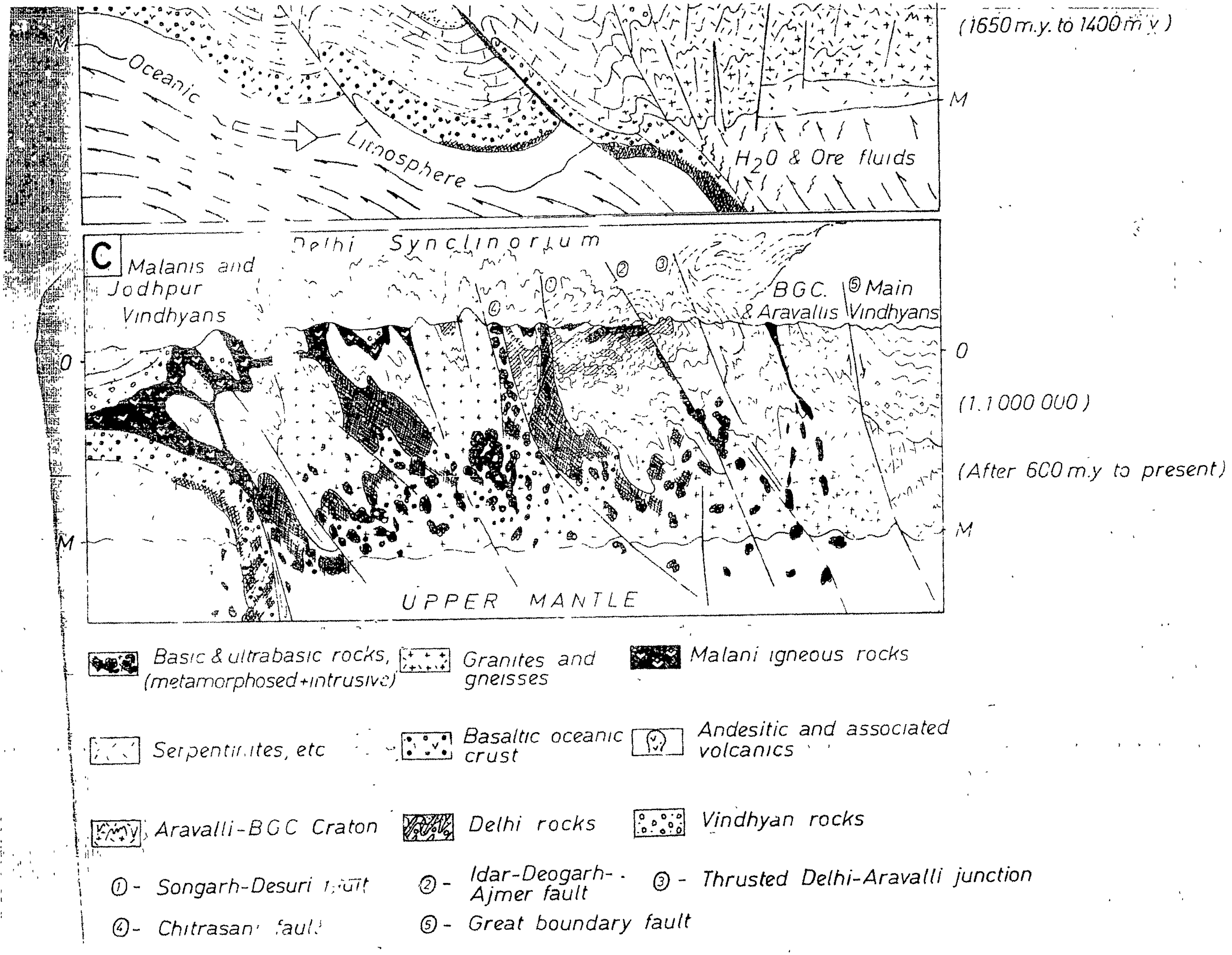
The salient points of the Sychanthavong's (1978) evolutionary model, have been summarised below (Fig. X.1)

1. During Precambrian time, there existed three Indian proto-continents, viz. Aravalli, Singhbhum and Dharwar (Naqvi et al., 1974), the Narmada suture marking the joining the line of Aravalli proto-continent with Singhbhum and Dharwar proto-continents. The paleomagnetic data (Athavale et al., 1970; Bhimasankaram and Pal, 1970) from different parts of Indian shield, reveal that the three proto-continents have behaved as one

TECTONIC MODELS

Fig. X-1: (NOT TO SCALE) (After Sychanthavong, 1978)




(1650 m.y. to 1400 m.y.)
M
Oceanic
Lithosphere
H$_2$O & Ore fluids
C
Malanis and Jodhpur Vindhyans
Delhi Synclinorium
BGC. & Aravallis
5 Main Vindhyans
O
(1.1 000 000)
(After 600 m.y to present)
M
UPPER MANTLE
Basic & ultrabasic rocks, (metamorphosed + intrusive)
Granites and gneisses
Malani igneous rocks
Serpentinites, etc
Basaltic oceanic crust
Andesitic and associated volcanics
Aravalli-BGC Craton
Delhi rocks
Vindhyan rocks
1 - Songarh-Desuri fault
2 - Idar-Deogarh-Ajmer fault
3 - Thrusted Delhi-Aravalli junction
4 - Chitrasani fault
5 - Great boundary fault

unit since 1600 m.y. But prior to this, evidence exists of the southward drift of the Aravalli proto-continent.

2. Prior to 2100 m.y., the Aravalli proto-continent must have been a part of a much larger northwestern protocontinent which broke down and started drifting southeastward towards the Dharwar and Singhbhum proto-continents. This process of drifting, initiated near about 2100 m.y. continued upto 1600 m.y. and it was during this interval that the Delhi rocks were deposited. At 1600 m.y., the subduction of the oceanic plate beneath the Aravalli proto-continent along the trailing edge started, underthrusting and squeezing the Delhi sediments against the Aravalli proto-continental margin. The orogenic upheaval that folded and lifted up the Delhi System, thus appears to have taken place during 1600 m.y. to 600 m.y. This is evidenced by the age of granites and other intrusive rocks associated with Delhis.

3. The Ajabgarhs were deposited in a leptogeosyncline over the oceanic plate, while the Alwars were simultaneously deposited over the continental shelf of the Aravalli proto-continent, characterising miogeosyncline, the two being deposited at the same

time. The junction line between the Alwars and Ajabgarhs (Idar-Deogarh-Ajmer fault zone) thus represents the trench and the margin of the trailing edge of the Aravalli proto-continent.

4. The F_1, F_2 and F_3 foldings in the Ajabgarhs represent successive stages of deformation related to the continued plate movement and subduction. F_1 obviously comprises the most important folding event. F_2 folds were due to the continued squeezing from the NW, and are found to be co-axial with F_1, having developed on account of the similar stresses which gave rise to F_1.

5. In the initial stage of the development of F_1, two major dislocations viz. <u>Chitrasani-Bali Thrust</u> and <u>Songarh-Desuri-Phulad Thrust</u>, developed parallel to the subduction zone. Further squeezing resulted into the uplift of geanticlines and co-axial refolding of F_1 by F_2. It was during this uplift, that the granulitic rocks together with pockets of olivine dolerites etc. were pushed up along the <u>Chitrasani-Bali Thrust</u> in the form of hot solid blocks. The granulites comprise high grade metamorphites derived from the oceanic crust material and the lower portions of the Delhis, while the intrusive bodies of olivine bearing gabbros and dolerites represent partially melted oceanic

crust at still deeper level. At the same time, along the Songarh-Desuri-Phulad Thrust, were pushed up folded Ajabgarhs, such that in the geanticlinal structure flanking the thrust, occur narrow cores of F_1 occupied by ortho-amphibolites, the metamorphosed high stresses oceanic crust.

6. The stresses responsible for F_3 and E-W, WNW-ESE and ENE-WSW fauting were perhaps generated due to a north-eastward push given by the East African (Pangean) continent at 600 m.y. (Burke, Dewey & Kidd, 1976).

7. The folded Ajabgarhs are intruded by granites, mafics and ultramafics, and the author has visualised the intrusion of these igneous rocks along the thrusts that developed on account of plate movement. The mafic and ultramafic intrusive bodies in the Ajabgarhs obviously, represent molten and differentiated fraction of the oceanic crust. The granitic rocks (a fair proportion of which is hornblende) are supposed to comprise the acidic and granitised fraction of basic oceanic crust together with granitised pelitic sediments immediately overlying. it.

EVOLUTIONARY MODEL FOR AMBAMATA

The various observed facts for the Ambamata area ideally fit with the revised model that author has built, taking into full account the concept of proto-plate tectonics. The geolocical details as obtained by Sychanthavong (1978) in the east and by Desai et al. (1978) in the west, are adequately connected and explained to provide an integrated picture of the successive events.

The author's findings fully substantiate the postulation that the Ajabgarhs are resting over basaltic rocks, now seen as ortho-amphibolites. The entire sequence points to its deposition directly over the oceanic plate. The structural pattern very clearly shows three fold episodes. In the extreme northwest corner, is encountered the tectonic contact which separates the medium pressure amphibolite facies rocks from the high grade granulitic rocks of Balaram-Abu Road area described by Desai et al. (1978). This tectonic plane referred to as Chitrasani Bali fault (Sychanthavong, 1978) is supposed to comprise one of the deep mantle dislocations and a later subduction zone, along which the dehydrated and metamorphosed derivatives of the oceanic crust, and the overlying Delhi sediments, have been pushed up.

With this background, the author has recorded various geological events that have affected the Ambamata area, and chronologically listed them as under :

I. Deposition of pelitic and calcareous sediments (Ajabgarhs) over an oceanic basement.

II. Initiation of orogeny and F_1 folding, and metamorphism of sediments as well as the underlying basaltic basement.

III. Transformation of pelitic sediments into gneisses (granitisation) and of the basement into ortho-amphibolites. Metamorphism of pelitic and calcareous sediments to medium pressure amphibolite facies assemblages.

IV. Squeezing and emplacement of ferromagnesian-free granitic melt (migma) along the axial plane of F_1 syncline. Ascent of emanations from the mantle (and/or oceanic crust) rich in base metals, along F_1 axial plane fractures and their fixation in Calc-magnesian metasediments.

V. F_2 folding immediately following the F_1. In fact, F_1 and F_2 were more or less connected events.

VI. Emplacement of dolerites as sills along the pre-existing foliation planes, axial plane fractures.

VII. Superimposition of F_3 over F_1 folds giving rise to the existing outcrop pattern.

VIII. Emplacement of biotite granite, cutting across all pre-existing rocks and structures. Hydrothermal changes in metapelites and metadolerites.

IX. Development of narrow WNW-ESE dykes and veins of oligoclase basalt.