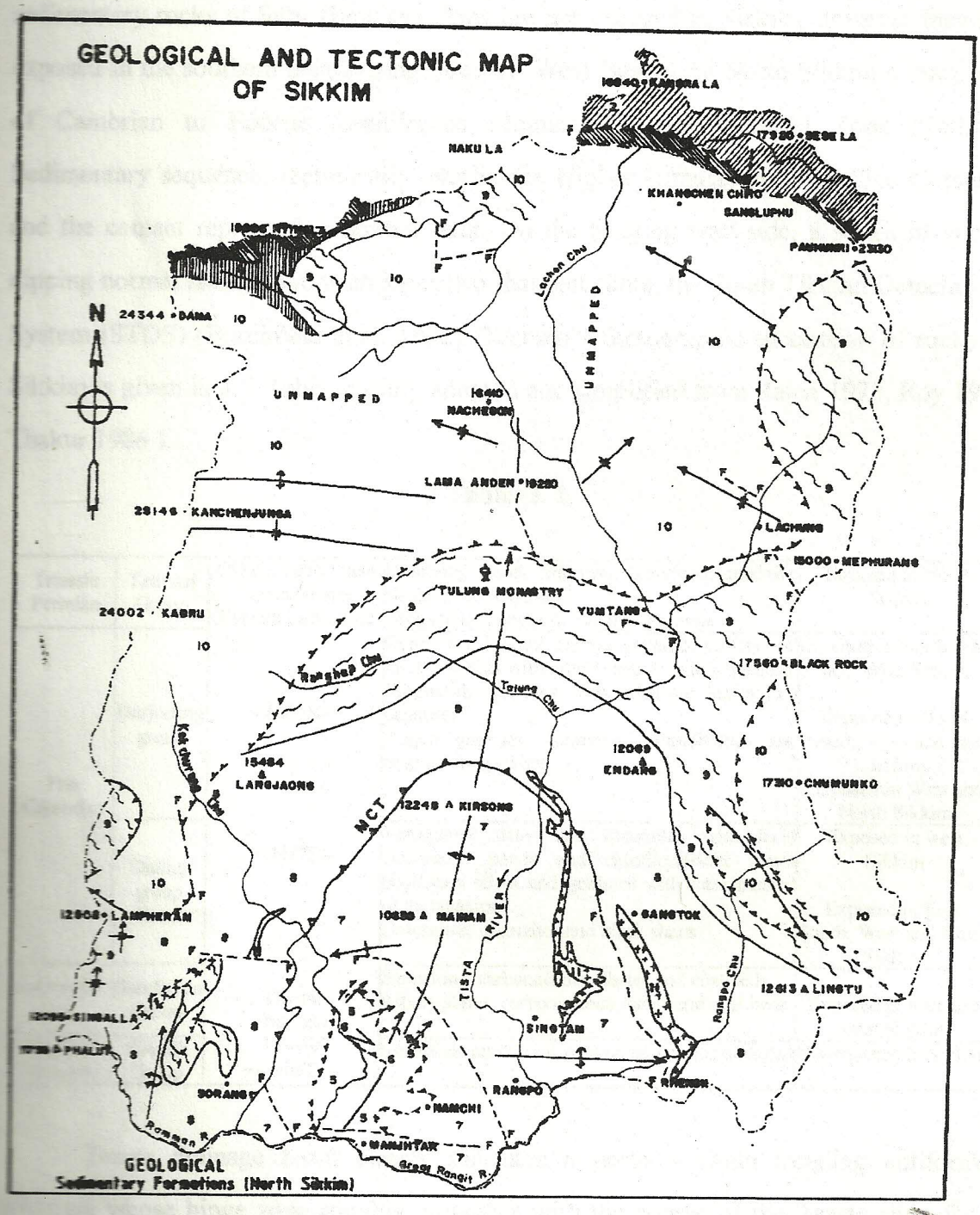

Fig. 3.3Geology and Tectonic Map of Sikkim (after Raina and Srivastava1981)

Gondwana (Carboniferous to Permian), Buxa (Late Proterozoic) group of rocks are also exposed in the core of the culmination in Rangit valley, and a few isolated out crops of Gondwana also occur in South - Eastern Sikkim. The Siwalik (Miocene Pliocene) sedimentary rocks of Sub- Himalaya Zone are not exposed in Sikkim, however they are exposed in the southern neighboring area of West Bengal. In North Sikkim a thick pile of Cambrian to Eocene fossiliferous sediments of the Tethyan Zone (Tethyan Sedimentary sequence) tectonically overlie the Higher Himalayan Crystalline Complex and the contact represents a normal fault. On the hanging wall side, a series of north-dipping normal faults, have been identified that constitute the South Tibetan Detachment System (STDS) (Burchfield et.al. 1992). Tectono - Stratigraphic succession of rocks of Sikkim is given in 3. I Table (mainly adapted and simplified from Raina 1975, Roy 1976 Thakur 1986).

Table. 3. I

Triassic Permian	Tethyan Group	Chho Lhamo Lachi Series Mount Everest Limestone	Quartzite, shales, limestone,Brecciated quartzite, slates, pebble beds. Areaneous limestone. Flaggy limestone.	Exposed in North Sikkim
Pre-Cambrian	Darjeeling group	--STDS--	Quartzites, impure marble, grphititc schists and mica – schists with granite and granite – gneisses Migmatitic gneisses with calsilcate lenses and pegatites Augen gneisses, quartzites, amphibolites and migmatitic gneisses	Exposed in North, East and West Sikkim Exposed in North, South, West and East Sikkim Exposed in West and North Sikkim
	Daling group Buxa	-- MCT---	Variegated slates and quartzites with local clacareous bands and chlorite,sericite slates phyllitees schist and gneisses with inter banded of metabasics Dolomites, quartzites and black slates	Exposed in west Sikkim Exposed in East, South, West and North Sikkim
Carboniferous	Gondwana Group	— Thrust — Damuda	Sandstone, carbonaceous Shales and coal beds Pebbly slates, carbonaceous shales and coal beds	Exposed in East and west Sikkim
Miocene Pliocene	Siwalik Group	Talchir — MBT—	Sandstone and shales with conglomerate horizons	Not exposed in Sikkim

Teesta drainage basin clearly indicates a north – south trending antiformal structure whose hinge zone roughly coincides with the course of the Teesta river for a considerable stretch, from the foothill to the central crystalline axis (Fig 3.4). Darjeeling and Kalimpong located on the western and eastern flanks of Teesta river respectively represent two east-west trending major synformal flexures which are cross- fold counterparts of the north – south Teesta antiform (Fig 3.1). Besides, there are a number of

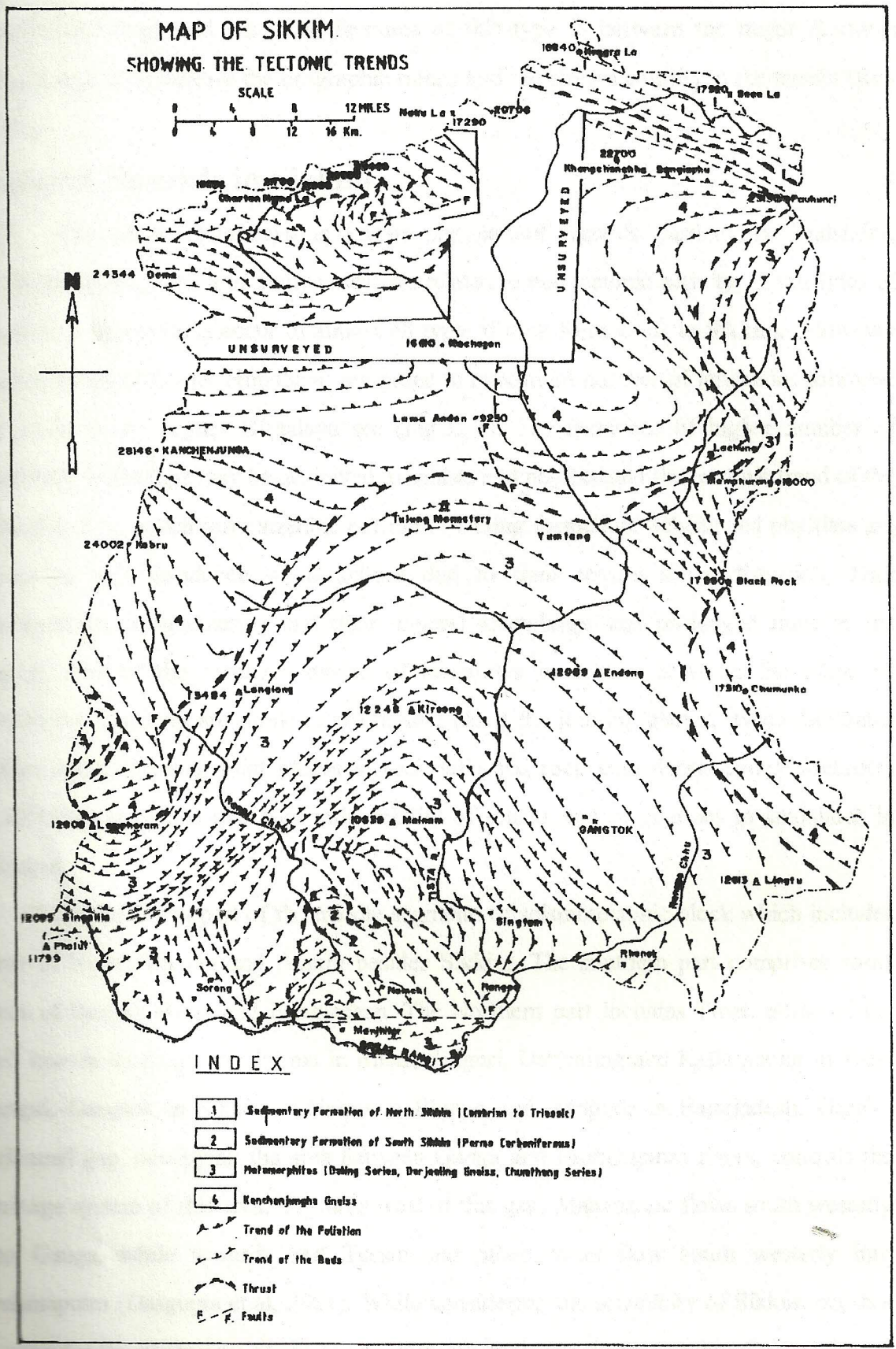

Fig.3.4. Tectonic Trends of Sikkim(after Raina and Srivastava1981)

broad north-south and east-west flextures of this type in between the major flextures which apparently control the orographic trends and the stream courses in the terrain (Roy 1975).

Natural Hazards in Sikkim

The eastern Himalaya is known for natural hazards particularly landslides, earthquakes etc., which in many cases are related to neo tectonic activity . Landslides of almost all descriptions occur in almost all type of rock formations in Sikkim. However Daling group of Lesser Himalaya are prone to maximum number of landslides followed by gneisses of Higher Himalaya see (Fig.3. 3). The incidence of higher number of landslides in Dalings may be attributed to schists and phyllite and the tectonic trend of the area (Fig 3.4), which form sizeable portion of Daling formation. Schists and phyllites are prone to high incidence of landslides due to their severe shear distortion, high susceptibility to weathering and their mineral assemblage and prolonged rains in the region. One of the common modes of landslides in schists is along the plane of schistosity. Genisses are prone to weathering along the jointing planes, which facilitates failure resulting along joint planes in rock falls and rock cum debris slides. Mehrotra et.al.(1994) have also observed vulnerability of schists and of gneisses to landslides in this area.

Sikkim forms part of the middle segment of seismotectonic block which includes parts of Nepal, Bhutan and Assam besides Sikkim. The southern part comprises some areas of Bengal, Bihar and Bangladesh. The Northern part includes Tibet. Some of the well known localities are: Purnia in Bihar; Siliguri, Darjeeling and Kalimpaong in West Bengal, Gangtok in Sikkim, Thimpu in Bhutan and Rangpur in Bangladesh. Garo – Rajhamal gap, occupying the area between Ganga and Brahmaputra rivers, controls the drainage system of this area. Towards west of this gap, Mahananda flows south westerly into Ganga, while towards east Teesta and other rivers flow south westerly into Brahmaputra (Dasgupta et.al, 2001). While considering the seismicity of Sikkim one has to consider the seismicity of the entire seismotectonic block cited. Main Central Thrust (MCT) and Main Boundary Thrust (MBT) traverse this block. Good number of earthquakes are commonly of 4.5 – 5.5 magnitude range, having shallow focus (<40km),

are located between Main Boundary Thrust (MBT) and Main Central Thrust (MCT). Focal mechanism solutions indicate that the earthquakes to the south of MBT are generated by strike-slip motion and normal faulting, and to the north by reverse faulting with strike-slip motion. Temporal variation of seismity during the 30 years, from1964 to 1993, examined by Reen De (2000), shows that there are several bursts of seismic activity for a year or two preceded each time by a quite period for 3 to 4 year. There were three large earthquakes from 1964 to 1993, with a magnitude of 5.8, 6.0; and 6.7 and separated by gaps of about 15 years. The recurrence period of earthquakes is about 10 – 15yrs. On 20th November 1980 Gangtok was strongly shaken by earthquake which damaged many concrete structures. The Bihar – Nepal earthquake of 1998 (M 6.7) was distinctly felt in Darjeeling and Sikkim. The isoseist VII passed through Darjeeling and Gangtok town in an approximate NE - SW direction (Sinha and Chatterjee 1993). Earthquakes disturb the mountain slopes, and trigger landslides. Many weak zones develop due to the seismic deformations which in turn affect the stability of slopes in the area.