APPENDIX I: FINITE STRAIN MEASUREMENT METHODS

Our strain analysis used three classes of objects: 1) deformed sand grains in low-grade metagreywacke; 2) deformed pebbles in metamorphosed conglomerate; and 3) mafic enclaves in plutons. All of our strain studies were conducted in the Tana Glacier and the Slide Pond - Slender Lake areas.

Use of deformed sand grains as strain markers was limited to rocks below middle greenschist facies because at higher grades a combination of high strain together with obliteration of sand grains by new grain growth obscures original sand grains. All of these samples are from the Slide Pond - Slender Lake area. For these analyses, oriented samples were collected and cut into three mutually perpendicular thin sections. Using set of microcomputer programs developed by W.A. Yonkee, deformed sand grains in each section were digitized from photomicrographs, and 2-d strain was estimated using both the object shapes by the Rf/phi method and grain center distributions by the modified Fry method of Erslev (1988). In all cases, the center-center strains were indistinguishable from the Rf/phi strains and only the later are reported here. 3-d strain ellipsoid shape was determined using the method of Owen (1985).

In all upper greenschist to amphibolite facies rocks, finite strain estimates are from deformed pebble conglomerate that occurs at scattered horizons along the Tana Glacier and at one locality at the southern end of the Slide Pond - Slender Lake area. The conglomerate represents the coarse basal part of thick turbidite units, and the pebbles include argillite rip-up clasts and a variety of lithic clasts. Because of the potential for a strong depositional fabric in the argillite rip-up clasts, these objects were measured separately where possible. However, in the highest grade metaconglomerate recognized (91APa-78, Table 1), the distinction between argillite and lithic clasts was difficult and some argillite clasts may be included in the data.

Finite strain estimates from pebble conglomerates were determined both in the field and from oriented samples (Table 1), although the method of analysis is similar. For all of these measurements, the finite strains are large, and as a result, object shapes clearly show the positions of the three principal ellipsoid axes. Measurements, therefore, can be readily made of ellipticities in the principal planes of the ellipsoid. This facilitates determination of the ellipsoid, particularly from field measurements. That is, the requirement for measurements in three nearly perpendicular sections is relaxed and 2-d strain need only be estimated in two principal planes with measurements in a third principal plane serving as an internal check. In the field, these surfaces were provided by extensive exposures of the S_2 foliation surface (XY plane of the finite strain ellipsoid), and numerous joint surfaces developed perpendicular to the prominent L_2 elongation lineation (YZ section of the finite strain ellipsoid). For oriented samples, these surfaces plus the XZ section of the ellipsoid were produced using cut slabs. The procedure used to determine 2-d strain on each surface was to first estimate the ellipticity of each object by measuring a long and short axis for each object (measured with either a fine-grid ruler in the case of field measurements or an ocular scale in a binocular microscope in the case of cut slabs). These ellipticity data were then averaged as a harmonic mean (e.g. Ramsay and Huber, 1983) for all of the objects. Where possible, we attempted to determine ellipticities of a minimum of 50 objects per section, but physical limitations of exposure or sample size did not allow that number in some cases (Table 1). Although not ideal, this method can be justified because of the high strains in these rocks. In particular, dispersions in phi--position of the long axis of the strain ellipse--were trivial (<5°) in all of the field measurements and in cut slabs were only significant on ZY sections of the ellipsoid. Thus, in high strain cases such as these, the harmonic mean of the ellipticities is a reasonable estimate of the finite strain (e.g. see Ramsay and Huber, 1983, p.80).

The third class of objects used for strain determination are mafic enclaves within syn-tectonic plutonic rocks. All of these determinations were made in the field using arbitrarily oriented surfaces produced by jointing and glacial scouring. For these objects we selected large surfaces where numerous objects were exposed, then measured ellipticities of each object on the surface, estimated the average pitch of the long axis of the objects on the surface, and finally calculated the harmonic mean of the ellipticities of all of the objects on the surface as an estimate of the strain ellipse on that surface. Data from three or more such surfaces were then used as input to a program using the method of Owen (1985), and a finite strain ellipsoid was determined.

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Table 1: Strain Data for Tana River Region

Site	Rock type	X	Z	Y	X/Z	Trend/ Plunge of X	X Y Plane	2-D method & object type	Description of data & [Metamorphic grade]
Domain 1									
90ASn-27	greywacke	1.35	0.79	0.93	1.71	119/29	310/80N	R_f/ϕ sand grains	3 mutually ⊥ sections, n>75 for all sections [subgreenschist facies]
90ASn-26	greywacke	1.36	0.78	0.94	1.74	120/06	296/59N	R_f/ϕ sand grains	3 mutually ⊥ sections, n>75 for all sections [subgreenschist facies]
90ASn-24	greywacke	1.79	0.53	1.06	3.38	107/01	288/70N	R_f/ϕ sand grains	3 mutually ⊥ sections, n>75 for all sections [subgreenschist facies; chlorite zone]
Domain 2a									
90ASn-21b	greywacke	1.37	0.75	0.98	1.83	119/03	296/37S	R_f/ϕ sand grains	3 mutually ⊥ sections, n>75 for all sections [subgreenschist facies; chlorite zone]
90ASn-23	greywacke	2.15	0.62	0.75	3.47	102/00	282/30S	R_f/ϕ sand grains	3 mutually ⊥ sections, n>75 for all sections [subgreenschist facies; chlorite zone]
90ASn-8	pebbly greywacke	2.63	0.52	0.73	5.1	288/05	286/51N	H.Mean of Rf lithic clasts	2 cut slab surface = principal sections (#1, n=45; #2,n=59) [biotite zone]
90ASn-13b	pebbly greywacke	3.0	0.46	0.73	6.5	288/08	295/50S	H.Mean of Rf lithic clasts	2 cut slab surface = principal sections (#1, n=79; #2,n=79) [biotite zone]
Domain 2b									
91APa-23	pebbly greywacke	2.06	0.59	0.82	3.49	287/07	292/53S	H.Mean of Rf lithic clasts	3 cut slab surface = principal sections (#1, n=58; #2,n=60;#3, n=50)[biotite zone]
91APa-84a	pebbly greywacke	3.69	0.41	0.66	9.0	277/00	277/77S	H.Mean of Rf lithic clasts	3 cut slab surface = principal sections (#1, n=55; #2,n=61;#3, n=44) [garnet zone]
91APa-84b	pebbly greywacke	2.39	0.64	0.65	3.73	277/00	277/77S	H.Mean of Rf lithic clasts	2 cut slab surface = principal sections (#1, n=100; #2,n=60) [garnet zone]
"	"	3.0	0.38	0.89	7.9	277/00	277/77S	H.Mean of Rf argillite rip-ups	2 cut slab surface = principal sections (#1, n=60; #2,n=17) [garnet zone]
91APa-85	pebbly greywacke	2.54	0.56	0.70	4.5	288/00	288/85N	H.Mean of Rf lithic clasts	2 cut slab surface = principal sections (#1, n=80; #2,n=55) [garnet zone]
"	"	4.3	0.40	0.59	11	288/00	288/85N	H.Mean of Rf argillite rip-ups	2 cut slab surface = principal sections (#1, n=80; #2,n=40) [garnet zone]
91APa-40	argillite pebble conglomerate	17.6	0.062	0.92	280	110/04	300/69N	H.Mean of Rf argillite rip-ups	2 field surfaces ~ principal sections (#1, n=15; #2,n=16) low reliability site [lower amphibolite facies: garnet zone]

<u>Domain 3</u>									
91APa-37	argillite pebble conglomerate	9.6	0.20	0.53	48	106/03	080/06S	H.Mean of Rf argillite rip-ups	2 field surfaces ~ principal sections (#1, n=28; #2,n=31) [staurolite zone]
91APa-89	conglomerate	4.6	0.29	0.73	16	273/00	horizontal	H.Mean of Rf lithic clasts	2 field surfaces ~ principal sections (#1, n=5 #2,n=56) limb of F2 fold at site 91APa-35 [amphibolite facies, staurolite zone]
91APa-35	conglomerate	3.8	0.29	0.73	13	282/07	292/35S	H.Mean of Rf lithic clasts	2 field surfaces ~ principal sections (#1, n=40; #2,n=40) site in core of F2 fold [amphibolite facies, staurolite zone]
"	"	3.0	0.30	1.1	10	282/07	280/85N	H.Mean of Rf argillite rip-ups	2 field surfaces ~ principal sections (#1, n=29; #2,n=39) site in core of F2 fold [amphibolite facies, staurolite zone]
89ASn-96	conglomerate	4.2	0.34	0.70	12	284/00	284/38N	H.Mean of Rf lithic clasts	2 field surfaces ~ principal sections (#1, n=41; #2,n=16) [staurolite zone]
"	"	5.4	0.26	0.72	21	284/00	284/38N	H.Mean of Rf argillite rip-ups	2 field surfaces ~ principal sections (#1, n=20; #2,n=31) [staurolite zone]
91APa-78	conglomerate	9.9	0.12	0.87	83	282/19	268/52N	H.Mean of Rf lithic clasts	1 field surfaces along S2 foliation (n=34) + 1 cut slab ⊥ to L (n=55) [upper amphibolite: staurolite out]
<u>Intrusive rocks</u>									
91APa-33	syn D2 sill	4.4	0.24	0.93	18	090/02	278/20N	H.Mean of Rf mafic enclaves	2 field surfaces ~ principal sections (#1, n=25; #2,n=18) [upper amphibolite: staurolite out]
91APa-32	syn D3 dike	1.8	0.61	0.91	3.0	097/20	285/70N	H.Mean of Rf mafic enclaves	3 field surfaces: #1, 008/23W, n=11; #2,326/36NE, n=18; #3, 301/43S, n=17 [upper amphibolite: staurolite out]
91APa-30	syn D3 dike	2.6	0.39	0.99	8.3	283/12	285/80S	H.Mean of Rf mafic enclaves	4 field surfaces: #1, 003/18E, n=12; #2,018/36W, n=29; #3, 280/18N, n=16; #4, 036/37NW, n=26 [upper amphibolite: migmatite front]
91APa-48	syn D3 pluton	4.8	0.11	1.84	44	124/04	306/58N	H.Mean of Rf mafic enclaves	3 field surfaces: #1, 305/58N, n=11; #2,035/90, n=6; #3, 000/18E, n=6 [upper amphibolite: migmatitic gneiss]

abbreviations: H. Mean of Rf = Harmonic mean of axial ratio (Rf)