Journal of Nepal Geological Society, 1995, Kathmandu, Vol. 11, Special Issue, pp. 53-57

Granites from Mustang and Surrounding Regions (Central Nepal)

Patrick Le Fort[1] and Christian France-Lanord[2]

[1]C.N.R.S., Géodynamique des chaînes alpines, Institut Dolomieu, rue Maurice Gignoux, Grenoble, France

[2]C.N.R.S., Centre de Recherches Pétrographique et Géochimique, Nancy, France

ABSTRACT

Two Himalayan leucogranite plutons of northern central Nepal have been recognized, mapped with the help of satellite imagery, sampled and analyzed. The 1600 km^2 Dolpo-Mugu may be the largest High Himalaya leucogranite, and the 325 km^2 Mustang leucogranite is a North Himalaya circular pluton cut in half by the Thakkhola graben. Both are very similar to the Manaslu granite. They have provided much of the filling material for the graben after a high rate of denudation.

The western side of the Thakkhola graben is dominated by two leucogranite plutons that are fairly well delineated on the Landsat TM scenery. We have sampled them during a 1993 geology tour, and mapped them using the satellite picture (Fig. 1). They cover an area of, respectively, more than 1600 km^2 for the southern one (Dolpo-Mugu granite) that fringes the northern slopes of entire Dolpo region, and some 325 km^2 for the semi-circular northern one (Mustang granite). The Dolpo-Mugu granite appears to be one of the largest High Himalaya leucogranites. The Mustang granite is cut by the western fault system of the Thakkhola graben; its original circular shape, typical of the North Himalaya granite belt in general, and the pluton east of Xungru (Fig. 1) in particular, has been cut in half.

Three mentions of the presence of granite along the Thakkhola graben have been made in the literature, although the two plutons have never been distinguished before. Hagen (1968 and 1969) briefly describes the occurrence of granitic material that is intrusive into the sedimentary metamorphosed series on the western side of the Thakkhola graben (our Dolpo-Mugu pluton). On his map, Hagen also shows an occurence of granite on the eastern side of the Thakkhola graben, but makes no report or description of it in his text; although we have not visited this area, a binocular inspection from the opposite side does not seem to reveal any such occurence. Fuchs (1967) gives a short description of the granite body that fringes the northern side of Dolpo, intruding the Cretaceous series. PLF has received a sample collected by Fuchs, but, with abundant micaceous schlieren, it resembles more of a border facies than a true homogeneous granite. Finally, Krummenacher (1971) dated two pebbles by K-Ar method: a muscovite from a pegmatite at 24 Ma and a muscovite from a granite at 15 Ma. According to Krummenacher, the younger age would come from a younger terrasse, filled with granite that has been eroded more recently from a deeper level in the granite.

The Dolpo-Mugu pluton intrudes metasediments, largely carbonaceous, and invades them with numerous dykes (cf. Hagen, 1968). According to Colchen (personal communication, 1994), the metasediments are mainly Permo-Carboniferous at the western edge of the Thakkhola graben, in the vicinity of Gompa Ghar. The leucogranite has been emplaced at relatively high pressure in the sillimanite + staurolite field. P-T estimates on the metamorphic auréole (2.6±0.6 to 4±1.0 kbar and 575±25 °C, Guillot et al., 1994a) have yielded values very close to those of the Manaslu granite (2.3±0.3 to 4.0±0.3 kbar and 530±30 to 570±20 °C, Guillot et al, 1994b). The Mustang pluton seems to have a sharp contact and, in the boulders, to be associated to augen gneiss of the 500 Ma type, petrographically and chemically very similar to the Formation III augen-gneiss of the

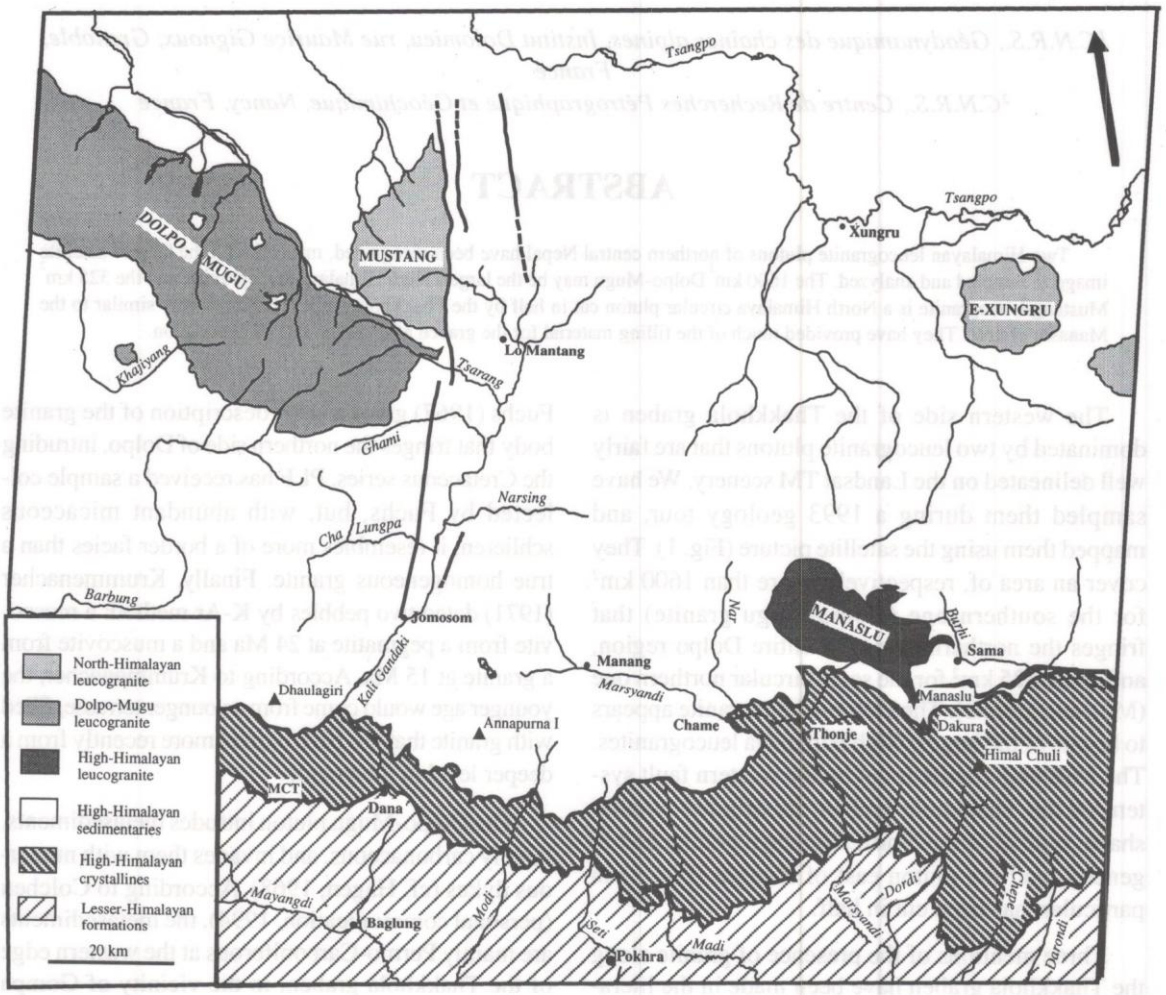

Fig. 1 Geological sketch map of northern central Nepal up to the Tsangpo valley. The southern part is simplified from Colchen et al. (1986). The northern plutons are drawn from Landsat TM image 142-040 of november 7th, 1989 with personal complementary observations in the field, in the Mustang valley. Mugu-Dolpo leucogranite is a large pluton, intermediate between the North- and the High-Himalayan belts (Debon et al., 1986) of leucogranites.

Tibetan slab (Le Fort et al., 1986). The association of North Himalayan leucogranites with Formation III augen gneisses is a very common feature of the belt (Le Fort et al., 1986).

The leucogranites themselves are very similar to the Manaslu leucogranite: two-mica tourmaline dominated by muscovite, with a variable grain size (tenth of mm to almost a cm), and a more or less conspicuous foliation. Until recently, only pebbles of leucogranite from the Thakkhola formation had been documented and analyzed (France-Lanord and Le Fort, 1988). The chemistry of the two plutons is quite identical and very similar to that of the Manaslu leucogranite (Fig. 2). They are adamellites in the classification of Debon and Le Fort (1988). A few generally slight differences include the more calcic than usual border facies of the Mugu-Mustang that we have sampled at outcrop, probably because of the assimilation of limited country rock material within the granite. Here follows the comparison of Mustang (6 samples, column 1) and Manaslu (circa 200 samples, column 2) for major and some trace elements (analyses by K. Govindaraju, C.R.P.G., Nancy, ICP for major and ICP-MS for trace elements, see Table 1).

Table 1 Comparison of Mustang and Manaslu granites

	Mustang	Manaslu
SiO_2	74.61	73.64
Al_2O_3	14.09	14.87
Fe_2O_3t	0.62	0.83
MgO	0.13	0.11
CaO	0.83	0.47
Na_2O	4.35	4.05
K_2O	4.59	4.56
TiO_2	0.06	0.10
P_2O_5	0.14	0.13
I Loss	0.82	0.84
Sum	**100.26**	**99.27**
Ba	151	213
Rb	343	286
Sr	69	76

One notes the slight but significant higher contents in Si, Ca and Na (as well as Rb), and the lower content in Al and Fe (as well as Ba) for the Mustang leucogranite compared to the Manaslu one. The higher Si content is a characteristic of the North Himalayan leucogranites. Mineralogically the differences correspond to a higher proportion of plagioclase and a lower proportion of biotite in the Mustang leucogranite. The higher content in plagioclase, may reflect higher PT conditions of melting in the source zone, whereas the lower biotite content may be due to a higher percentage of melting and less restitic biotite being dragged up with the melt.

They have both provided a large amount of the Thakkhola graben filling since the rifting began. The granite pebbles that fringe the Tibetan trails of Mustang have long been recognised; the Tibetan inhabitants have piled them up on huge white heaps along the routes, especially at notches and near sacred places. They all come from the western side of the Thakkhola graben. The oldest Tetang fm already contains pebbles of tourmaline granite, along with Cretaceous Kagbeni quartzite, and Liassic Jomosom limestone (Colchen et al., 1980 and 1986), probably late Pleistocene, the petrography of which remains remarkably similar to the present one.

Given the pressure estimates of their emplacement around 20 Ma, the leucogranites have been unroofed fast enough to reach the surface, start to be eroded, and provide some of the material to fill the Thakkhola graben, around 5 Ma ago. This necessitates average rate of denudation of around 1mm/a for a maximum of 15 Ma. The plutons being located to the north of the high range, where erosion is much less efficient than to the south, tectonic denudation on large normal faults is probably necessary to explain such average rates. The Thakkhola rifting only started after most of the denudation was achieved.

All together three types of plutons occur in the region: (1) the lenticular slab of the Manaslu High Himalaya leucogranite conformably overlying the High Himalayan crystallines (or Tibetan Slab) and intruding up to the Jurassic (see Le Fort, 1981; Le

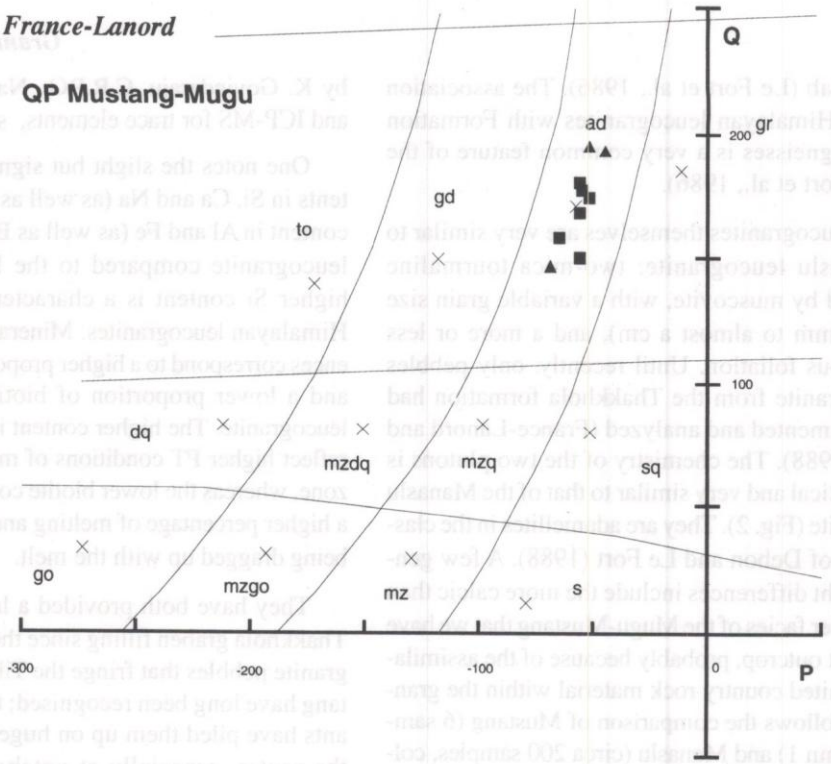

Figure 2 Plotting of the Mustang (6 squares) and Mugu-Dolpo (3 triangles) leucogranites in the "nomenclature diagram" of Debon and Le Fort (1988). The Q and P parameters, respectively corresponding to the quartz abundance and the feldspar composition, are in gram-atoms x 10^3 in 100 g of rock. All samples analysed fall in the adamellite pigeon hole.

Fort et al., 1987), (2) the circular bodies of the North Himalayan leucogranite belt (Debon et al., 1986), and (3) the unique huge elongated pluton of Dolpo-Mugu, intrusive up to Cretaceous.

ACKNOWLEDGEMENTS

The expedition has particularly benefitted from the kind organisation of Mr P.P. Prasai from Natraj Travel & Tours, the help of Mr A.P. Gajurel from Tribhuvan university, and the providing of the Landsat assemblage by Dr D. Banert, BGR. The authors are extremely grateful to each of them. PLF has been supported for field work by a contract from Commissiariat à l'Energie atomique (CEA, France).

REFERENCES

Colchen M., Fort M., and Freytet P., 1980, Evolution paléogéographique et structurale du fossé de la Thakkhola-Mustang (Himalaya du Népal), implications sur l'histoire récente de la chaîne himalayenne. C.R. acad. sci. Paris, v. 290, pp. 311-314.

Colchen M., Le Fort P., and Pêcher A., 1986, Notice explicative de la carte géologique Annapurna-Manaslu-Ganesh (Himalaya du Népal) au 200.000ème (bilingue: français-english). éd. Cent. natl. rech. sci., Paris, 138 p.

Debon F., and Le Fort P., 1988, A cationic classification of common plutonic rocks and their magmatic associations: principles, method, applications. Bull. minéral., v. 111, pp. 493-510.

Debon F., Le Fort P., Sheppard S.M.F., and Sonet J., 1986, The four plutonic belts of the Transhimalaya-Himalaya: a chemical, mineralogical, isotopic and chronological synthesis along a Tibet-Nepal section. J. Petrol, v. 27, pp. 219-250.

France-Lanord C., and Le Fort P., 1988, Crustal melting and granite genesis during the Himalayan collision orogenesis. Trans. Royal Soc. Edinburgh, v. 79, pp.183-195.

Fuchs G., 1967, Geological map of the Dolpo region and the Dhaula Himal, 1:100,000. Osterr. Akad. Wiss., Wien, 113 p.

Guillot S., Pêcher A., and Le Fort P., 1994a, Contrôles tectoniques et thermiques de la mise en place des leucogranites himalayens. Comptes rendus acad. sci. Paris, in press.

Guillot S., Le Fort P., Pêcher A., Roy-Barman M., and Aprahamian J., 1994b, Contact metamorphism and depth of emplacement of the Manaslu granite (central Nepal); implications for Hima-

layan orogenesis. Tectonophysics, in press.

Hagen T., 1968, Report on the geological survey of Nepal. II-Geology of Thakkhola, including adjacent areas. Mém. soc. helv. sci. nat., v. 86 (2), 160 p.

Hagen T., 1969, Report on the geological survey of Nepal: preliminary reconnaissance. Mém. soc. helv. sci. nat., v. 86 (1), 185 p.

Krummenacher D., 1971, Géochronométrie des roches de l'Himalaya. In: "Recherches géologiques dans l'Himalaya du Népal, région de la Thakkhola", éd. Cent. natl. rech. sci., Paris, ch. VI, pp.187-202.

Le Fort P., 1975, Le granite du Manaslu. In: "Recherches géologiques dans l'Himalaya du Népal, région du Nyi-Shang", ch.3, éd. Cent. natl. rech. sci., Paris, pp. 49-65.

Le Fort P., 1981, Manaslu leucogranite: a collision signature of the Himalaya. A model for its genesis and emplacement. In: "Granites and rhyolites", F. Barker ed., J. geophys. res., v. 86 B11, pp.10545-10568.

Le Fort P., Debon F., Pêcher A., Sonet J., and Vidal P., 1986, The 500 Ma magmatic event in southern Asia, a thermal episode at Gondwana scale. In: "Evolution des domaines orogéniques d'Asie méridionale (de la Turquie à l'Indonésie)", P. Le Fort, M. Colchen , and C. Montenat eds, Sci. de la Terre, Nancy, mém. v. 47, pp.191-209.

Le Fort P., Cuney M., Deniel C., France-Lanord C., Sheppard S.M.F., Upreti B.N., and Vidal P., 1987, Crustal generation of the Himalayan leucogranites. Tectonophysics, v. 134, pp. 39-57.