The development of the Geological Reference Model for some key infrasctutural project in Indian Himalaya

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In the last years Geodata Engineering S.p.A. has been involved in design of some infrastructural key - projects located in the Indian Himalaya. In each study the definition of a detailed and reliable Geological Reference Model (GRM) has been essential for a proper development of the projects and for the assessment of the risks connected to the construction. Define the geological context where a project is located means to identify some reference scenarios and conditions, pointing out limits and uncertainties for which the appropriate design countermeasures should be taken.

The development and improvement of a GRM passes through a multidisciplinary study conducted in sequential steps using different methodologies (bibliographic study, remote sensing analysis, geological and structural surveys, geophysical surveys, drillings, sampling and testing, etc...). In this context the geological survey plays a role of paramount importance because it let to define an appropriate reference model starting from the earliest design phase with reduced time and costs. Furthermore, the geological survey can easily cover the entire project area defining both the main potential geological hazards occurring in the site of the project and the most critical area to be studied with additional site investigations (location and characterization of tectonic disturbed zones, water inflow, presence of karst phenomena, potential presence of noxious and dangerous gases, high temperature expected at tunnel level, etc...).

The vastness and complexity of the Himalayan Region reflects also on the job of the geologists working as specialists for the design of large infrastructures. One of the main difficulties that must be faced defining a detailed GRM arise from the scarcity, in several areas, of a reliable geological model, built and accepted by the scientific community, usable as a base for the studies. Consequently, in some contexts followed in Himalaya by Geodata it has been necessary develop the GRM starting from few scientific reference papers, while in other cases the available scientific papers illustrated heterogeneous or contrasting geological conditions (i.e. definition of different geological Formations, discrepant position and characteristics of tectonic structures, etc..).

To face this problem Geodata's geologist had to perform exhaustive and detailed geological mappings to identify the main lithological, stratigraphic and structural characteristics of the different project areas. Specifically, the geological maps have been drawn up according to a rigorous approach based on the following logical steps:

1. on site identification and location of outcrops and geological features (mapping);
2. on site description of the rocks exposed at the surface and the geometric relationships of the different lithologies (mapping) (Figure 1);
3. the on-site checking of the main structures described in the bibliography and better geometry definition according to the scale of mapping (mapping);
4. the on-site checking and integration of geological and geomorphological features defined by the Remote Sensing Analysis (mapping);
5. checking and homogenization of data collected by different components of the mapping team (mapping / desktop);
6. checking and homogenization of all collected data (lithology, structures, etc..) with the available bibliographic reference (mapping / desktop);
7. drawing of representative geological maps and sections.

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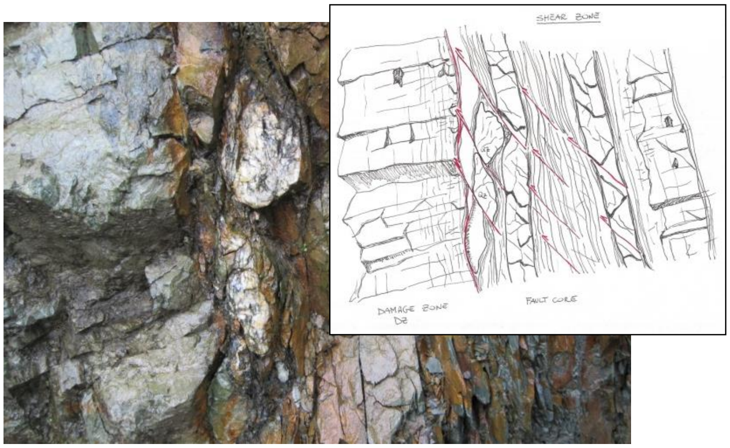

Figure 1. Picture and conceptual sketch of a relevant shear zone referred to the Main Boundary Thrust (MBT) in West Bengal. In evidence the main fault plane cut by recent minor brittle structures. Geodata, 2010.

As result of these activities, detailed geological maps (Figure 2) have been done so far in the following sectors of the Indian Himalaya:

- Sub Himalaya (Siwalik Group) and Lesser Himalaya (Darjeeling Group) in Sikkim and West Bengal *(Broad Gauge Rail Link between Sivok in West Bengal and Rangpo in the State of Sikkim with future connectivity to Gangtok)*
- Sub Himalaya (Murree Formation) in Jammu & Kashmir *(Rehabilitation, Strengthening and four Laning of Chenani to Nashri Section of NH-1A, from km 89.00 to km 130.00 - new alignment - including 9 km long tunnel - 2 lanes - with parallel escape tunnel, on BOT - Annuity - basis, on DBFO Pattern in the State of Jammu & Kashmir)*
- Higher Himalaya (Ramsu Formation and Machal Formation) in Jammu & Kashmir. *(Detailed Design Consultancy, 3D Monitoring & Supervision of Tunnel T-74R - between km 134 & 145 - in connection with construction of Dharam-Qazigund Section of Udhampur-Srinagar-Baramulla New BG Railway Line Project).*
- Kashmir Basin (Panjal Volcanic Group, Nagmarg Group, Madmatti Group) in Jammu & Kashmir *(Consultancy service for Detailed Feasibility Study and Framing Up of Phase Wise Proposal –DPR- for construction of 18 Km long Highway Tunnel across Razdhan Pass on Bandipur-Gurez road in Jammu&Kashmir State in India).*
- Lesser Himalaya (Subathu Formation, Tal Group, Krol Group, Baliana Group, Jaunsar Group, Garhwal Group) in Uttarakhand. *(Development of New Alignment including Refinements, Geological & Geophysical mapping, Final Location Survey and detailed Abstract Cost Estimating of 125 km long Broad Gauge New Rail Link Between Rishikesh and Karanprayag via Devprayag in the State of Uttarakhand, India).*

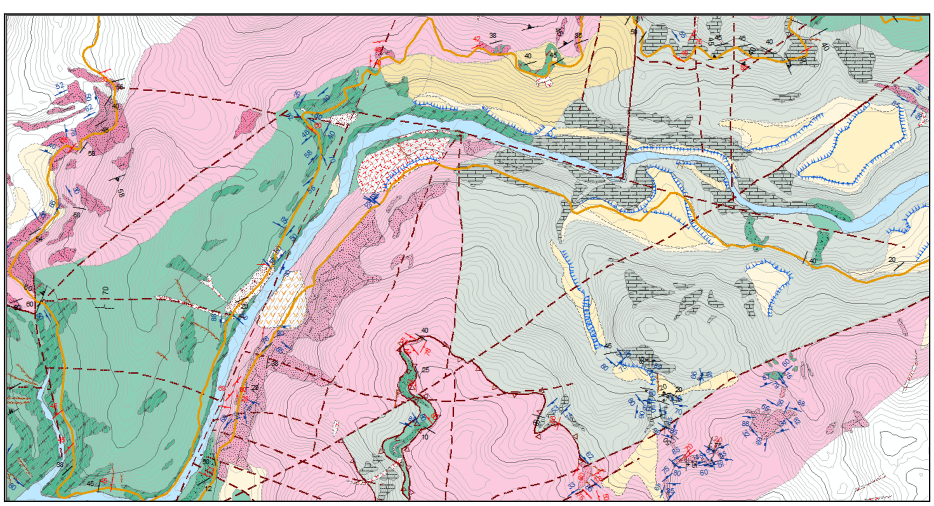

Figure 2. Extract of detailed geological map in a sector of Garhwal Group in Uttarakhand. Geodata, 2013