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Integration of helicopter magnetometry, horizontal boring and surface geology to detail subsurface structure along Nikoro tunnel

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The study area is a mountainous terrain (200-600 masl), to the NW of Kitami city in NE Hokkaido. Geologically, it belongs to the Tokoro belt, which comprises the Late Jurassic Nikoro Group and the overlying Saroma Group of Cretaceous age. The Nikoro Group, a part of an accretionary prism, is made up of greenstone, pyroclastics and hyaloclastite, occurring intermittently with pillow lava, chert and limestone. The Saroma Group, of marine origin, comprises conglomerate and sandstone/mudstone. The strata strike N-S with 30-50 degree easterly dips, the faults show NE-SW orientation. A cupriferous iron sulfide deposit, with lenticular bodies, occurs in shear zones within hyaloclastite, and with Fe content of up to 30-37 percent, may contribute significantly to the bulk magnetic susceptibility (MS).

Core samples of rocks/sediments obtained from horizontal boring, which preceded excavation, along the Nikoro Tunnel alignment were observed for geological and petrophysical parameters for geotechnological classification. According to MS (in 1E-3 SI units), the rocks/sediments may be arranged in the following order: (i) Nikoro Group: massive basalt (11.4), crushed basalt (3.6), hyaloclastite (7.2), Pillow lava (5.3), metabasites (3.8), mixtites (1.7), chert (0.04); (ii) Saroma Group: conglomerate with basaltic andesite clasts (22.2), sandstone/mudstone (4.2). From thermal variation of MS, pure magnetite (Curie point CP: 580 C) occurs in hyaloclastite (with/without pyrobreccia) and basalt. The basaltic rocks (including breccia) contain Ti-poor magnetite (CP: 535 C) and cation-deficient magnetite or maghemite (CP: 590 C). Isothermal remanent magnetization data suggest presence of magnetite and hematite (1:99 by volume) in hyaloclastite, but magnetite and pyrrhotite (3:1) in basalts.

Total field magnetic intensity data gathered by a helicopter (flying azimuth: 100-115 degree; sensor height: ca. 60m above ground) over a 7.5 x 2 km zone over the Shin-Saroma (4,110 m) and Nikoro (910 m) tunnels alignments are available. Within a 1600m long zone over the Nikoro tunnel alignment (910 m; corresponding to 208-1,118m of the magnetic profile), the total field magnetic intensity map, after reduction to pole, reveals significant lateral variations: (i) a broad maximum, in its western one-third, related spatially to massive basalt; (ii) moderate to minimum values in the central part attributed to moderately magnetic hyaloclastite with sporadic occurrences of basalt and weakly magnetic hyaloclastite; (iii) a nearly isometric maximum over the Saroma Group sediments, to the east of their unconformable boundary with the Nikoro Group; and (iv) a low intensity zone at the easternmost end.

A central magnetic profile, with N100E bearing, over the Nikoro tunnel was intuitively spline-fitted to obtain a regional component - assumed to correspond to a 2D step, whose western end extends to infinity but the other east-dipping edge coincides with the physical boundary of the Nikoro and Saroma Groups. In this model, the magnetic property of the step is determined by susceptibility contrast of hyaloclastite (moderate MS; dominant in the Nikoro Group) and the sandstone/mudstone (weak MS; dominant in the Saroma Group). The residual anomaly was modeled using Mag2DC package (after G.R.J. Cooper) for a subsurface model reflecting real geology. Magnetization was assumed to be merely by induction in the pdf (intensity: 49475 nTl, I0: 58 deg, and D0: 351 deg.). Interactive forward and inverse modeling reveals: the residual anomaly in the eastern one-third of the profile corresponds to a single thick dipping dyke (massive basalt) or two or more thin dipping dykes of differing lithologies (massive basalt and other pyroclastics), whereas the maximum over the unconformable Nikoro-Saroma boundary corresponds to a E-dipping conglomerate, thin at the top but increasingly thick at greater depths, as shown by observations along the tunnel.