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Towards an improved conceptual model for low-temperature geothermal systems in North Iceland.

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Geothermal energy provides an important source of energy for Iceland's inhabitants. Direct use of low-temperature waters is an important source of energy for space heating. Overwhelmingly, the thermal waters are of meteoric origin with a few exceptions where the waters are mixed with modest amounts of seawater.

In the Miocene formations of the Eyjafjörður region in Northern Iceland some geothermal fields have been in production for almost 50 years, others have been added more recently. Many of the geothermal systems, particularly those servicing the town of Akureyri, are being exploited close to their long-term capacity. This is driving a re-evaluation of the current conceptual models for low-temperature systems. The basaltic crust hosting the geothermal systems is comprised of lava-flows intercalated with thin sedimentary horizons and/or scoria beds. The stratigraphic pile is crosscut by basaltic dikes. Reflecting their meteoric origin, fluids from the low-temperature geothermal fields in this region are typically isotopically depleted, even compared to local precipitation.

An improved conceptual model is emerging where comparatively thick, relatively clay-rich horizons intercalated between lava-flows play an important role in the hydrology of the uppermost crust. Permeability in the crust is almost entirely secondary and tied to recent vertical and sub-vertical fractures. Crystalline basalts (surface-flows and intrusions) comprise more than 97% of the thickness of the uppermost crust (3 km). In the absence of fracture-filling material precipitated from crustal fluids, the crystalline basalts are incapable of regaining cohesion across newly formed or re-activated fractures. However, clay-rich horizons can regain cohesion and form a hydrological seal or barrier that compartmentalizes the crust. Thus, hydrological reservoirs, or units, may form at different levels in the crust separated by these clay-rich seals that prevent or delay significant mixing between reservoirs. Communication between reservoirs can occur where fractures are associated with dikes crosscutting the lava-pile and/or in areas of faulting, causing significant displacement of crustal blocks and/or the formation of fault breccias. Our understanding of the sub-surface hydraulics is expected to improve by incorporating these ideas into our models and they may shed light on the puzzling behavior of tracers, both natural and man-made.