Fluid geochemistry and Natural Gas Hazard (CO_2, Rn) in the urban area of Rome (central Italy)

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The city of Rome is located in the Roman Comagmatic Province, where large sectors experience a huge degassing both from soils and aquifers [1, 2]; gas composition is dominated by CO_2, that can act as a carrier for other minor components such as N_2, CH_4, H_2S and Rn. Gases are produced at depth (throughout mantle degassing and/or decarbonation processes) and upraise towards surface through fault and fracture systems, thus characterising well defined enhanced permeability belts. Gases exhaled from soils and aquifers can enter houses, potentially reaching harmful indoor levels [3]. Indeed, some gases (CO_2, H_2S) can have a short-term toxicity, while others (i.e. radon) can cause lung cancer at prolonged exposures. As a consequence, an evaluation of the level of Natural Gas Hazard (NGH) to which these areas are exposed, is required. By now, detailed information on CO_2 and Rn distribution in ground waters was assessed for the volcanic complexes around Rome [1, 4], allowing to discriminate areas where deep fluid upraise and where analysis of indoor-gas levels has to be carried out, in order to lessen their impact on human health. Such an investigation is still lacking for the urban sector of the Italian capital, where about 2500000 people habitually live.

A detailed geochemical study in ground waters started in 2011 and is currently going on in the roman area; 128 water wells and 16 springs were investigated for their chemical and isotopic composition. The preliminary investigation allowed us to recognise and mark off areas in which deep fluids upraise, generally characterised by the presence of hypothermal and CO_2-rich waters. In particular, the role of deep CO_2 as a sound marker of deep tectonic structures in this sector of central Italy, is emphasised. Waters rich in deep CO_2 are located in the southern and in the north-eastern sectors of Rome, that can be considered as potential NGH-prone areas; hypothermal waters have been found in the south-western part of Rome. Radon-rich waters roughly mimic the CO_2 distribution and circulate mainly in the southern sectors of Rome. So far, no H_2S-rich groundwater has been found.

[1] Pizzino *et al* (2002) *Nat. Haz.* **27**: 257–287. [2] Frondini *et al* (2008) *Glob. and Plan. Change* **16**: 89–102. [3] Annunziatellis *et al* (2003) *J. Geochem.Explor.* **77**, 93-108. [4] Cinti *et al* (2010) *Chem. Geol.* **284**: 160–181.

Petro-geochemical evidence for vapour transport in andesite shear fractures

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The andesitic Soufrière Hills Volcano (SHV), active since 1995, emits large fluxes of volcanic gases (dominantly H_2O, CO_2, SO_2, HCl). The gas is largely decoupled from the flux of magma to the surface, indicating efficient magma-vapour segregation. Effective open-system degassing at dome forming eruptions may control eruption style. However, evidence for vapour transport through magma is not often preserved in the erupted rocks. We present the first petro-geochemical evidence for metal-bearing vapour transport in shear zones in SHV andesite and a model for their formation.

Andesite blocks in deposits from SHV contained narrow shear zones (2 m x 2-10 cm), with alternating low porosity, fine-grained (~30-70 μm) and higher porosity, coarser-grained (~100-350 μm) bands. The higher porosity (7-19% vol) bands consist of broken and comminuted crystals compositionally identical to mineral compoisitions in the SHV andesite. However, the low porosity (~1%) bands have elevated zones of oxides (<8% vol) and cordierite. Bulk ICP-MS analyses indicate that metal concentrations (Cu, Ni, Pb, Au, Ag and Zn) are greatly enhanced relative to the surrounding andesite. For example, Cu and Au concentrations are >10 times higher than in the andesite host. Cu is present as Cu-Fe sulphide inclusions in Ti-magnetites and plagioclase phenocrysts. We also demonstrate that trends in metal enrichment in the shear zones match well with published experimental metal vapour/melt partition coefficients.

The enhanced metal and volatile concentrations in the shear zones indicate that these zones acted as permeable pathways for metal-bearing gas in the shallow volcanic system. The shear fractures formed in response to brittle failure at high magma strain rates and viscosity, along which metal-bearing vapour or fluid was transported. The gas pathway survived until frictional heating at the slip surface created a partial melt upon which volatiles and metals were resorbed, thus preserving the geochemical signature of the magmatic gases. The subsequent recrystallization of the peraluminous partial melt on cooling resulted in the highly unusual presence of volcanic cordierite.

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