ing paths (0.1–400, 400–0.1 MPa). Then the data are subtracted so that the change between the pressure-steps and the hysteresis at particular pressure can be visualised in differential stereographic diagrams.

Using the V_P and A_P values measured at the highest confining pressure or computed with averaging method (taking into account the elastic parameters of constituent mineral phases, their volume fractions and lattice orientation distribution) we are able to distinguish the influence the deformation-induced lattice re-orientations from the pore-related properties.

The typical observed trends for crack-related V_P are:

a/ highest V_P values parallel to mineral lineation, lowest values normal to metamorphic foliation

b/ largest increase in V_P with increasing confining pressure normal to metamorphic foliation, lowest increase parallel to mineral lineation

c/ hysteresis (the difference between the values measured at particular pressure within pressure-increasing vs. pressure-decreasing path) is the same as in b/ and is usually non-zero at least up to 200 MPa.

For A_P the typical features are:

a/ highest A_P values parallel to mineral lineation, lowest values normal to metamorphic foliation

b/ largest increase of A_P with increasing confining pressure parallel to metamorphic foliation

c/ lowest hysteresis parallel to lineation (the directions of highest values of hysteresis can lie inside or outside the metamorphic foliation).

Although for A_P the patterns of the non-processed data are similar to V_P, the differential patterns are often opposite. The behaviour of V_P can be interpreted as a result of the closest arrangement of minerals parallel to mineral lineation and the loosest normal to metamorphic foliation. For the observed A_P changes other explanation has to be found, which would take into account the relations between the spacing of pores (e.g. cleavages, microcracks) and amplitude/frequency of the transmitted signal.

The anisotropic patterns of V_P and A_P changes due to the closing of oriented pores and other voids highly correlate with the macroscopic structural features of the rock (preferred grain-shape orientation, fracture cleavage, lineations) and are sensitive to them. In such cases where the structural features associated with porosity can not be observed directly, the above outlined relations between elastic properties of the rock and structural features seems to be applicable as a tool for the examination of the spatial distribution and orientation of pores in rocks. It can contribute to numerous domains of geoscience such as the investigation of crustal seismic anisotropy in seismological survey or the assessment of possible ways of contaminant transport through the low-porosity rocks in nuclear waste reservoir sites.

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Deep Structure, Seismicity Pattern and Subduction Generated Concentration of Metals in Continental Wedges Overlying Convergent Plate Margins

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Detailed studies of the seismicity pattern of convergent plate margins, based on the data of International Seismological Centre (ISC) and their relocations (Engdahl et al., 1998) have made possible to differentiate the earthquake foci in the subducted oceanic plate from those occurring in the overlying continental wedge. The analyses of the geometry of distribution of the latter earthquake foci have shown that they are not distributed randomly, but are arranged into fracture zones (Hanuš and Vaněk, 1979, Hanuš et al., 1996). These seismically active fracture zones generally correlate spatially with some geologically defined faults.

The comparison of the distribution of the seismically active fracture zones with the distribution of large mineral deposits and important mining districts has revealed that the majority of largest accumulations of ores occurring in active convergent plate margins are situated in the outcrops of these fracture zones. We verified this statement on the example of the central part of the Andean South America (Hanuš et al., 2000, Hanuš et al., 2001a) (Fig. 1) and of the western part of the Indonesian island arc (Hanuš et al., 2001b). The validity of this correlation is being investigated in the regions of central and southern Mexico and Middle America. The main results of the finding of spatial relationship between the distribution of hypogene mineral deposits and deep rooted seismically active fracture zones, representing the paths for a long-term transportation of hydrothermal solutions from the subducting lithosphere to the Earth's surface could be applicable in interpreting the development of a fossil plate boundary, e.g. the Carpathian arc.

The establishment of the spatial correlation of the occurrences of large accumulations of metals with the distribution and orientation of the outcrops of seismically active fracture zones could help to solve some important problems of the following branches of Earth sciences:

1) **Seismology**: The occurrences of hypogene ore deposits of different age (covering a period of several tens of MA), witness to long-lasting existence and activity of pertinent fracture zones. The occurrence of dated poly-stage hydrothermal mineralization points to the probability that these zones were active before any following stage of mineralization and that the activity of fracture zones was responsible for preparing open

spaces for successive deposition of ore minerals. Systematic geochronological studies of well defined partial vein fillings seem to represent one of the most prospective ways for extrapolating paleoseismic speculations into the history of geodynamics of the Earth.

2) **Hypogene metallogeny**: Suggested long-term tectonic activity of fracture zones, enabling repeated deposition of ore minerals and the occurrence of mineral deposits of different age in the outcrops of active fracture zones seems to solve the serious problem of long-lasting metallogenic activity and of accumulation of enormous amounts of metals in very restricted domains in the Earth crust. The re-opening and episodic clastic deformation of mineral deposits due to the tectonic activity generated by long-lasting discontinuous subduction process could clarify also the formation of large accumulations of ores in the regions of fossil convergent plate margins.

3) **Plate tectonics**: The establishment of different age of the products of Andean metallogeny made possible to delineate four stages of the metallogenic activity (Sillitoe, 1981, 1988, Davidson and Mpodozis, 1991). These geochronologically defined stages of mineralization correlate well with the idea of four subduction cycles that we have derived by means of seismological evidence (Hanuš et al. 2000). The discontinuous course of metallogenic activity thus strongly supports the hypothesis of cyclicity of the subduction process (Hanuš and Vaněk, 1991, 1996), which allows to clarify some hardly explainable seismic phenomena, e.g. anomalous clustering of earthquake foci, reactivation of paleoplates buried for several tens of MA in the upper mantle and isolated groups of deep earthquakes which cannot be geometrically attributed to active subducting slabs.

4) **Prognoses of mineral exploration**: The fact that the majority of economically important mineral deposits occur in the outcrops of seismically active fracture zones can serve as an important prognostic indicator at active convergent plate margins. The substantial area of the outcrops of seismically active fracture zones has been recently covered by volcanic products (lava flows, ash and scoria falls) and by young lacustrine as well as eolic sediments. The covered parts of seismically delineated fracture zones represent the most prospective regions for discovery of hidden ore deposits of economic value.

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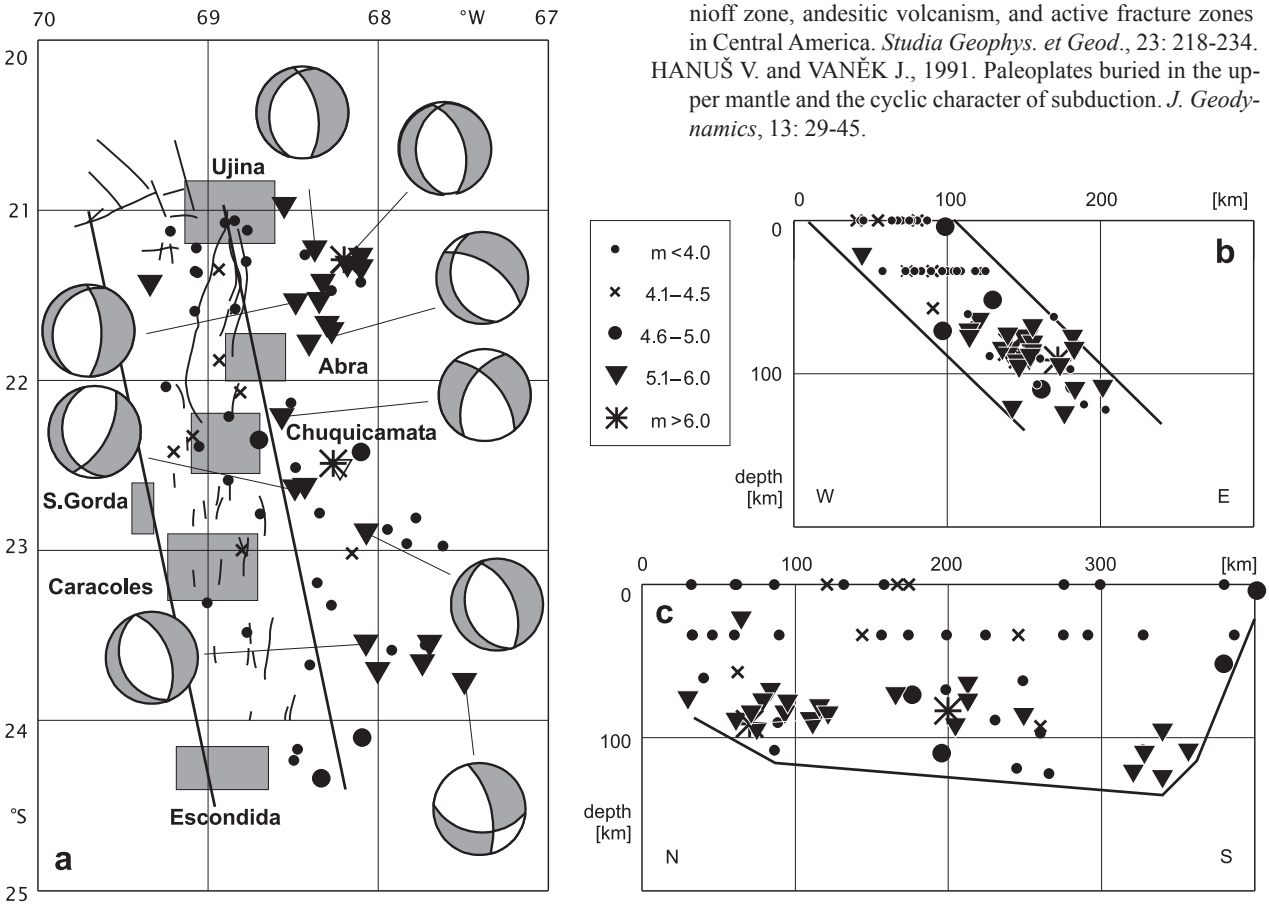

Fig. 1. Location of the Domeyko fracture zone (Andes) with associated earthquakes – epicentral map (a), transverse section (b) across and longitudinal section (c) along the fracture zone. The extent of the Domeyko fracture zone is delimited by heavy lines. Faults observed on the surface are denoted by lines and individual mining districts of the region by grey quadrangles in (a). Diagrams of available focal mechanisms (lower hemisphere projection) are based on HCMTS data. m - ISC earthquake magnitude.

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Correlation of Lithologically Contrasting Rocks from the Kutná Hora-Svratka Region, Czech Republic

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New mapping and geological research is focused on the northwestern part of the Kutná Hora Crystalline Unit, parts of the Oheb and Podhořany crystalline units, Rataje Mica-Schist Zone, Svratka Crystalline Unit and the outer margin of the Strážek part of the Moldanubian Zone of the Bohemian Massif. Some parts of these units were ascribed to the Gföhl Nappe (Matte et al., Synek and Oliveriová 1993). Criteria used for mutual delineation of the units are in some cases outdated, and mostly not useful for modern intrepretation of tectonometamorphic evolution of this part of the Variscan terrane. The main target of the present project of the Czech Geological Survey, Prague, is to distinguish metamorphicaly and tectonicaly uniform or contrasting segments aligned along the NE margin of the Moldanubian Zone and to contribute to the concept of tectonic evolution of the area.

The first stage of the project is focused on study and evaluation of older data, new sampling, and acquiring new petrological, geochemical and structural data from the Kutná Hora, Svratka, and Strážek crystalline units. The reliable older information by Koutek (1933, 1964), J. Losert (1967, 1971), M. Fišera (sheet 1:25 000 Vilémov with complete documentation), Z. Pouba (et al. 1987), J. Fiala et al. (1982), M. Holub (1985), J. Strnad (1972), the archive documentation of exploration (e.g., Mikuš et al., 1988), and modern geochemical isotope studies (Beard et al., 1991, Brueckner et al., 1991, Medaris et al., 1995) is compiled and combined with resampled geological material. Garnetiferous and garnet-free serpentinized peridotites (Machart, 1984), eclogites (Medaris et al., 1995, 1998), calc-silicate rocks (Němec, 1991, Pertoldová et al., 1998), amphibolites (Kratochvíl 1947, Novák a Vrbová 1994), granulites and orthogneisses from the Plaňany, Malín, and Běstvina units, Kouřim Nappe, Štemberk-Čáslav Varied Unit and the Strážek part of Moldanubicum, and the Svratka Crystalline Unit are studied and compared.

Geochemical processes

A large-scale muscovitization of highly variable intensity can be traced from Kouřim and Plaňany units in the West to Havlíčkův Brod at the SE. It affects orthogneisses, migmatites, mica-schists, gneisses, and other metasediments. The second proces is fluid-related leaching of alkalis, leading to regional sillimanitisation in quartzofeldpathic rocks. Four stages of sillimanite growth of regional extent, overprinting older mineral assemblages, has been recognized: regional growth in matrix, nodular (Losert, 1965, Fiala et al., 1982), locally pseudomorphing Al-rich minerals, and a late deformation-related stage. A metasomatic growth of sillimanite nodules post-dates dominant foliation in leptynites, orthogneisses and biotite paragneisses, and may indicate thus a certain stage of evolution of one tectonic segment along the Moldanubian margin. Contrasting types of sillimanite require different tectonic regimes and P-T conditions.

Another factor which is interesting with respect to the regional tectonic evolution is occurrence and migration of boron. Two main B–bearing minerals, turmaline and dumortierite, and white micas as the third host mineral, indicate inscreased activities of boron (and fluorine) along the entire tectonic boundary. Migmatites, some orthogneisses, quartzofeldpathic, pegmatite accummulations and alpine-type veins of the Kutná Hora–Svratka region host all the three minerals, providing thus the opportunity for study of the B- and F-rich fluid distribution in the units studied in context with other geochemical changes.

The rock-forming minerals indicating the geochemical changes are detectable along several units studied. An important feature of the changes mostly overlap lithological boundaries. The above given features indicate regional geochemical changes related to the presence of metamorphic fluid and tectonic setting.

Structural and tectonic problems of the Kutná Hora Crystalline Unit

Geological setting of the Kutná Hora Crystalline Unit (KHCU) has been interpreted as a multiply metamorphosed and intensely refoliated sequence of metamorphic rocks comprising advanced migmatites, orthogneisses, granulites, migmatitized par-