locally contain either incommensurate or commensurate structures of the following types:

i) pervasive faults on (010), (110), and (100). The first two types are more common, and can be readily explained by removal of structural sub-units on these planes. DLS models of the fault structures confirmed that these faults are crystallographically viable.

ii) ordered domains (possibly related to the incommensurate faults) with no characteristic ordering scheme, i.e., we observed a number of different periodicities of the extra reflections. Because we sometimes found intensity maxima on streaked diffraction patterns from samples that contained the incommensurate structure, the different ordering schemes may be due to long wavelength modulations of the fault structure

The faults on (010) formed by the addition of tetrahedral sites in ferrierite are also of interest as this fault is rather similar to the mordenite structure. Intergrowths of mordenite caused by small shifts on the (010) ferrierite faults may then account in part for the typical occurrence of these two zeolites in the same rock.

METEORIC HYDROTHERMAL CIRCULATION ALONG THE TRAPDOOR RING FAULT SYSTEM OF THE BONANZA CALDERA, N.E. SAN JUAN VOLCANIC FIELD, COLORADO

№ 51704

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The Oligocene Bonanza caldera developed on the summit of a large composite volcano, built from andesite and dacite lava flows and lahars collectively known as Rawley Andesite (RA). The caldera collapsed in a trapdoor fashion along a curvilinear system of listric-normal ring faults located several km inside the western topographic rim. Petrographic and whole-rock (WR) O-isotopic studies were carried out on RA sample suites collected along several west-to-east traverses (~2 km in length), from the topographic rim across the exposed portion of the ring fault system.

All analyzed RA samples are profoundly hydrothermally altered and texturally recrystallized to assemblages containing calcite and chlorite, and some samples contain abundant epidote or green/brown smectite. Furthermore, all samples are significantly depleted in ^{18}O ($\delta^{18}O_{WR}$ = +4.0 to -0.6 o/oo, relative to SMOW), compared to petrographically unaltered RA samples taken from peripheral areas of the Bonanza volcanic field ($\delta^{18}O_{WR}$ = +7.8 ± 0.8 o/oo). O-isotopic profiles for the traverses are irregular, but show a general pattern of decreasing $\delta^{18}O$ to the east. Locally, very steep O-isotopic gradients are measured (5 o/oo in samples 500 m apart), implying extreme fluid channeling and/or tectonic juxtaposition of propylitically altered rocks from different levels of the volcanic pile. The most important fluid pathway(s) along the ring fault system probably lies to the east (calderaward) of our easternmost samples, where outcrop is poor. The ^{18}O depletions measured in RA samples from the ring fault zone (1) imply that widespread propylitic alteration at Bonanza developed during circulation of heated, dominantly meteoric fluids, and (2) demonstrate the utility of oxygen isotopes in studies of caldera structure and paleohydrology.

ENRICHMENT OF ARSENIC, ANTIMONY, AND TUNGSTEN IN THE WATERS OF SOME MODERN HIGH-TEMPERATURE GEOTHERMAL SYSTEMS

№ 50127

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Waters from active geothermal systems at Roosevelt Hot Spring, Utah; Lassen National Park, California; Steamboat Springs, Nevada; and Valles Caldera, New Mexico, contain anomalously high concentrations of As, Sb, and W. These trace elements and the trace elements Hg, Au, and Tl (whose concentrations were not determined in the analyzed waters) are characteristic of the upper portion of epithermal disseminated deposits; hence, their presence suggests that these active geothermal systems could be modern analogues of fossil geothermal systems that produced gold deposits of this type. Two features shared by both fossil geothermal systems that produced epithermal disseminated gold deposits and some modern high-temperature geothermal systems are (1) abundant evidence of boiling and (2) anomalous concentrations of As, Sb, and W in the systems. These similarities suggest there might be a relationship between the process of boiling and the enrichment of certain characteristic trace elements in some ancient and modern geothermal systems. If As, Sb, and W are relatively soluble in dense, high-temperature, high-pressure steam, boiling at 200° to 300°C might partially separate these trace metals from a liquid phase and selectively enrich them in the upper portion of the geothermal system, where the density and therefore the transporting ability of the vapor are low. Changes in the stability of aqueous complexes of all metals, in particular As, Sb, and W, in response to changing chemical and physical conditions are probably important in controlling the distribution of these trace metals in the upper portion of geothermal systems.

EFFECTS OF UNRECOGNIZED OLIGOCENE EXTENSION IN CENTRAL NEVADA ON THE INTERPRETATION OF OLDER STRUCTURES

№ 52069

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Stratigraphic relations in central Nevada demonstrate that the Ordovician to Devonian deep-water rocks of the Roberts Mountains allochthon(RMA) were thrust over Devonian miogeoclinal rocks along the Roberts Mountains thrust (RMT) during the late Devonian and early Mississippian. However, workers in central Nevada have often ignored the effects of later deformations, and many of the faults interpreted to be segments of the RMT actually place rocks of the RMA down onto deep structural levels of the autochthon and cut bedding at high angles. Thus, they appear to be normal displacement faults. In the northern Toiyabe Range, these faults are overlapped by the 28.5 ± 1.1 m.y. old tuff of Hall Creek (K-Ar, sanidine) which in turn has been tilted 35°SE. Removing this tilt restores the low-angle faults to 40-45°NW dips which, together with their normal displacement, indicates that they formed as normal faults and have since been rotated to low angles.

A second set of west-dipping normal faults cuts the first set and tilts rocks as much as 35°. Movement on these two sets of faults has produced significant extension (locally as much as 250%) and has strongly disrupted and tilted the RMA and other units. Although the RMT may be locally present, it has been cut and offset by these later faults and most of the faults now mapped as the RMT are low-angle normal faults.

Similar low-angle normal-displacement faults are present throughout central Nevada and it is likely that this area underwent much more extension in the Oligocene than previously thought. This extensional event has increased the width of pre-Tertiary paleogeographic features and has resulted in exaggerated estimates of the offset on pre-Tertiary faults such as the RMT. This extensional event has gone largely unrecognized because it occurs prior to the eruption of the latest Oligocene and early Miocene ignimbrites which blanket this area and which are only gently tilted.

METEORITES, ACCRETION AND EARLY PLANETARY HISTORY

№ 33206

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An interstellar dust-gas cloud collapsed into a chemically-inhomogeneous solar nebula, as evidenced by the unequilibrated chondrites. The enstatite-, ordinary-, and carbonaceous chondrites may indicate increasing oxidation away from the Sun. Meteorites with metamorphic and igneous textures testify to high-temperature processes on planetesimals. Each terrestrial planet grew within 10^8 years, first from nearby slow planetesimals of reduced material, and then from planetesimals accelerated by gravitational deflection. Deflections by Jupiter nearly emptied the asteroid zone, and the growth of Mars and Mercury was stunted by Jupiter and the Sun, respectively. Planetesimals rich in oxidized materials and volatiles (including H_2O and CO_2) hit the inner planets as the outer planets completed accretion, but the volatiles were retained only by the Earth, Venus, and partly by Mars. During growth, the inner planets melted into a metal-sulfide core, an Mg-silicate mantle, and a volcanic crust rich in basalt. Fronts of high-pressure minerals advanced throughout the Earth's mantle, and $MgSiO_3$-perovskite began to dominate the lower mantle. Heat was released by volcanic activity; did a world-wide magma ocean develop? All early crust was destroyed for the first 750 m.y. by igneous and sedimentary processes, coupled with destruction by impacts of planetesimals. Basaltic material and volatile elements were returned to the mantle. The reduced state of the early mantle is being modified by the downward movement of oxidized species. Most of the C and N may be in the core. Continents were stabilized by flushing of H_2O by CO_2. Venus lost its hydrogen, and the high surface temperature excludes low-grade metamorphism, and inhibits high-pressure transitions. All simple models for the Moon are inadequate. Climatic changes and prolonged volcanism are important for Martian geology
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CRYSTAL STRUCTURE OF LOW CRISTOBALITE AT 10, 293 AND 473 K: VARIATION OF FRAMEWORK GEOMETRY WITH TEMPERATURE

№ 33205

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The crystal structure of low-cristobalite (SiO_2) was refined at 10, 293 and 473 K from time-of-flight neutron powder diffraction data. The two Si-O distances and one Si-O-Si angle change considerably: 10 K, 1.60%(1) and 1.617(1) Å, 144.7(1)°; 473 K, 1.605(2) and 1.590(2) Å, 148.4(1)°. The angular distortion of the SiO_4 tetrahedron is greater at 473 K than at the lower temperatures. Root-mean-square displacements of Si and O are greater for cristobalite than for quartz and coesite at room temperature. The negative correlation between Si-O distance and Si-O-Si angle for cristobalite is similar to that for quartz held at a higher temperature (~350 K). Any adjustment of the Si-O distance for riding motion between Si and O atoms would reduce the variation of Si-O distance with temperature and with Si-O-Si angle. Furthermore, adjustment of the Si-O-Si angle for rocking of the oxygen atom out of the Si-O-Si plane could improve the correlation between secant (Si-O-Si) and the isotropic chemical shift for ^{29}Si nuclear magnetic resonance in silica polymorphs (JVS and C.S. Blackwell, Nature 303, 223, 1983). The temperature variation of the crystal structure of low cristobalite cannot be modeled by simple tilting of rigid tetrahedra., and the nature of the thermal motion (e.g. rocking) must be explored. Crystal structure data should be collected at low temperature to test models of chemical bonding, and avoid the uncertainties from thermal motion.